Paternal Preconception Health and Care in Australia: Health Behaviours, Health Beliefs, and Health Service Use.

by Tristan Cameron Carter

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy (Public Health)

under the supervision of

Associate Professor Amie Steel, Dr Danielle Schoenaker, and Distinguished Professor Jon Adams.

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Tristan Cameron Carter, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy (Public Health), in the School of Public Health, Faculty of Health at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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“I have conquered the treacherous journey into the unknown, and like most before me almost didn’t make it. The first step was to believe I told myself……

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The rose forever grows beyond the wall.

FORMAT OF THIS THESIS

Presented herein is a Thesis by Compilation; An endeavour to emulate a project of research structured as a cohesive integration of traditional thesis chapters and chapters incorporating published articles and works submitted with academic journals currently under peer review. Where relevant, each chapter preamble refers to the published article associated with the chapter. Published articles are included in the Appendices and formatted to journal specifications. Authorship details and a statement of contribution from each author for the publications and chapter sequence contained within this thesis are detailed below.

PUBLISHED AND SUBMITTED WORKS INCLUDED IN THIS THESIS

There are six manuscripts incorporated into the thesis, three have been published, two remain under peer review, and one manuscript is formatted ready for journal submission. The manuscripts incorporated into this these are as follows:

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OTHER PUBLISHED AND SUBMITTED WORKS BY THE THESIS AUTHOR IN ADDITION TO THIS THESIS

Prior and during PhD candidature, the thesis author was a project collaborator and manuscript author for no less than eight additional manuscripts pertaining to subject matter external to this thesis. Authorship extends to being lead author for three manuscripts. All manuscripts have been submitted with academic journals, three manuscripts are published, and five manuscripts are currently under the peer review process. Publications in addition to the works included within this thesis are:

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4. Steel A ,Carter T, Foley H, Adams J. Community perspectives of the role of health professionals in providing preventive health information to the community. *Australian and New Zealand Journal of Public Health*. (Under review). Submitted 17th April, 2025.

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A statement of contribution for each manuscript author relevant to this thesis.

I hereby declare my contribution to each of the publications listed above.

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List of Abbreviations

1) [AGD] Anogenital distance
2) [ALL] Childhood acute lymphoblastic leukemia
3) [AMSTAR] Assessing the Methodological Quality of Systematic Reviews.
4) [BMI] Body Mass Index
5) [CASP] Critical Appraisal Skills Programme
6) [CBCL] Child Behaviour Checklist
7) [CFI] Comparative Fit Index
8) [COPD] Chronic Obstructive Pulmonary Disease
9) [CRL] Crown-rump length
10) [EV] Embryonic volume
11) [FEV1] Forced expiratory volume in one second
12) [FFQ] Food frequency questionnaires
13) [FVC] Forced vital capacity
14) [GP] General Practitioner
15) [HREC] Human Research Ethics Committee
16) [ICSI] Intracytoplasmic sperm injection
17) [IVF] In-vitro fertilization
18) [LGA] Large for gestational age
19) [LMUP] London Measure of Unplanned Pregnancy
20) [NFPCP] National Free Pre-conception Check-up Projects
21) [NIHR] Health and Social Care Research
22) [NOS] Newcastle Ottawa Scale
23) [NSAID] Non-steroidal anti-inflammatory
24) [OTC] Over the counter
25) [PICO] Population, Intervention, Comparison, Outcome
26) [POHaD] Paternal Origins of Health and Disease
27) [PRISMA] Preferred Reporting Items for Systematic Reviews and Meta-Analyses
28) [PROSPERO] Prospective Register of Systematic Reviews
29) [RACGP] Royal Australian College of General Practitioners
30) [RHINESSA] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study
31) [RMSEA] Root Mean Square Error of Approximation
32) [SEM] Structural Equation Modelling
33) [SGA] Small for gestational age
34) [STI's] Sexually transmitted infections

35) [SRMR] Standardised Root Mean Square Residual
36) [STROBE] Strengthening the Reporting of Observational studies in Epidemiology
37) [TAHS] Tasmanian Longitudinal Health Study
38) [TLI] Tucker Lewis Index
39) [TPB] Theory of Planned Behaviour
40) [TTM] Ten to Men
41) [TTP] Time to pregnancy
42) [UTS] University of Technology Sydney

Abstract

Background

Health before a pregnancy, preconception health, is an important consideration due to the potential influences that an individual's health can have on adverse pregnancy and offspring outcomes. However, males may not always consider their health behaviours have an impact on the success of their partner's pregnancy and the health of their future child. This issue must be addressed to support the involvement and engagement of male reproductive partners toward their preconception health and preconception care.

Methods

This thesis aims to explore Australian males' preconception health behaviours, and beliefs and intentions towards preconception care, sampling males in three distinct stages of the preconception period. These stages are as adult males i) who became first-time fathers, ii) planning pregnancy or attempting pregnancy, iii) with a pregnant female partner. This study employed a four-phase design incorporating a review of contemporary evidence investigating paternal preconception modifiable risk factors for adverse pregnancy and offspring outcomes (Phase 1). Phase 2 (n=572) included an analysis of preconception health behaviours for first time fathers while Phase 3 (n=156) covered preconception health beliefs and intentions of expectant partners. Phase 4 included the preconception health services utilisation of males planning pregnancy (n=66) or attempting pregnancy (n=36).

Results

Phase 1 project results reveal an association between paternal preconception smoking and increased risk of adverse infant outcomes, such as birth defects and leukemia. Chapter findings also reveal an association between an increasing BMI and offspring bodyweight. Phase 2 results report many males who became a father for the first time were more likely to meet the guidelines for daily safe alcohol consumption (85.7%) than other males (80.6%) p=0.002 but less likely to meet the recommendations for moderate physical activity (55.9%) in the previous seven days compared with others who did not become a first-time father (60.8%) p=0.01. Phase 2 results also detail a commonality in the sociodemographic characteristics of expectant partners with many males who intended pregnancy being aged between 30-39, in a committed relationship, and without financial manageability issue. Phase 3 results reveal a large proportion of Australian males who undertook physical activity in the three months before conception (71.3%). The results from this phase also report the beliefs of expectant partners toward alcohol avoidance during the preconception period

being associated with a greater intention to avoid alcohol. However, most expectant partners consumed alcohol in the three months before conception (62.0%). Phase 4 results reveal a significant proportion of males attempting pregnancy utilised western herbal medicine treatments (13.9%) compared with other males not attempting pregnancy (5.7%) p=0.02. A significant proportion of males planning a pregnancy in the next 12 months utilised yoga practice (18.1%) compared with other males not planning a pregnancy in the next 12 months (8.8%) p=0.01.

Conclusions

This thesis presents a cohesive body of research that underscores the public health importance and necessity towards integrating males into preconception care strategies. Such integration is essential to adequately enable their future engagement, awareness, and education regarding preconception health. This comprehensive evaluation of male preconception health behaviours and risk factors offers generalisable insights with significant implications for improving public health outcomes related to male preconception health and pregnancy planning.

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1 INTRODUCTION

1.1 BACKGROUND

Health represents vitality and natural harmony as a dynamic balance between the physical, mental, spiritual, and social wellbeing of an individual (1) in order to sustain a quality of life within a population free from chronic ailments. An individual's health may be directed and influenced by numerous factors which relate to their health literacy, their physical and social environments, the health services and treatments they use, and health behaviours they undertake daily and during their life course. Such determinants or indicators of health (2) will also be guided by an individual's health beliefs and their behavioural intentions alongside any cultural, social, and societal norms that inform and are relevant to their health.

Undertaking health behaviours such a regular exercise or regular health checkups can support disease prevention, and allow for early detection of asymptomatic presentations (3), and facilitate optimal health for pregnancy and offspring outcomes. Regarding modifiable health behaviours in the context of health conditions and chronic disease, many behaviours are considered high risk, and public health burdens (4) associated with non-communicable diseases [NCDs] (5-8). Noncommunicable diseases (NCDs) such as obesity are prevalent in Australia and represent a substantial health burden for males with economic and social implications (9, 10). Health behaviours including smoking and excessive alcohol consumption pose risks to health and offspring outcomes and can have negative long-term health consequences (11) for individuals and their offspring.

Preconception health is especially important due to the direct and indirect influence an individual's health and behaviours may have on pregnancy and offspring health characteristics, and ultimately on generational health and wellbeing (12, 13). Health is also relevant within the interconception period, or the preconception period in-between pregnancies (14). Preconception health can be supported through preconception care interventions. Such interventions can enable couples or individuals to assess and even modify their environments and behaviours and allow practitioners to review medical history, identify any previous pregnancy complications, and evaluate lifestyle and behavioural factors such as physical activity or smoking, and mental health (15).

Research acknowledges that the health behaviours of an individual will influence their preconception health and the health of their offspring. Regarding females, the association between preconception health behaviours and pregnancy and offspring outcomes are explicitly reported.(16, 17). Understanding the influence of male preconception health behaviours toward pregnancy and offspring outcomes is expanding. In the context of males,

evidence suggests their sperm quality and potential changes to the epigenetic profiles of spermatozoa (18, 19) can alter foetal development (20). However, males do not always consider themselves as relevant stakeholders when addressing issues related to optimal preconception health (21). Furthermore, many individuals do not seek preconception information and care (22) from health professionals despite a range of health professionals positioned to provide information and advice relevant to preconception health (23).

The preconception health, beliefs, intentions, and health behaviours of both reproductive partners are pertinent to pregnancy and offspring outcomes. However, maternal health and behavioural factors are the primary focus and have received most research attention (24). The important influence of males as the reproductive partner in a pregnancy is not targeted by health practitioners for preconception care (25) despite males contributing 50% of the genetic constitution to their offspring and having influence towards pregnancy and offspring outcomes (26). This preconception care gender disparity is reported in paradigms such as the Paternal Origins of Health and Disease [POHaD] (18). In the Australian context, perceptions of preconception health by the general public may be influenced by cultural ideologies, such as Australian masculinity, machoism (27, 28), and male gender stereotypes, and male gender stereotypes (29).

Preconception research primarily explores the influence of maternal health and care on pregnancy and offspring outcomes, extensively investigating public health issues such as alcohol consumption (10, 30), smoking (12, 31), nutrition (12, 31) and body composition (26, 32). Furthermore, a scoping review of preconception health behaviours reported only 11% of all studies included male participants (33), and a systematic review of preconception care guidelines found only six of the 11 guidelines provided preconception care guidance for males (34). There is also limited evidence to support the effectiveness of preconception interventions in primary care settings for males (35) or to support their preconception health beliefs and behavioural intentions. Additionally, compared with females, few resources and national strategies address male preconception health and preconception, such as Australia's National Preventive Health Strategy (36) and the National Men's Health Strategy (37). Consequently, from the male perspective, preconception care and fertility are often perceived as maternal health issues difficult to discuss (38). Equally, many males often possess limited awareness of their roles and responsibilities regarding preconception health and care (39, 40).There is an understated and belated acknowledgment in balancing our gaze on preconception health and care to include men (41), especially considering the male-female interdependence towards the success of conception and the development of a healthy child.

1.1.1 Research aims and objectives

While there is growing evidence suggesting the clinical relevance of men's preconception health behaviours, details regarding the prevalence of those behaviours are limited. Equally, the attitudes and intentions of men towards preconception care are under-examined at best. A scoping review of preconception health behaviours identified the need for further research to address current knowledge gaps by exploring the general public's understanding, behaviours and intentions of preconception health and care to ultimately facilitate the effective translation of knowledge into practice (33). From this, the following research question is proposed:

"What are Australian males' preconception health behaviours, and attitudes and intentions towards preconception care?"

The proposed exploration of Australian males during preconception strives to uphold bi-directional translational research, a continuing cycle of new knowledge in which ideals of paternal preconception care are addressed with the potential to further research and ultimately translate to clinical practice thus improving health care and/or public health (42). The research aim and objectives listed below align with objectives of the National Men's Health Strategy 2020-2030 which endeavour to build an evidence base to refine the knowledge of male health and thus strengthen the capacity of the health system to ultimately improve the health and wellbeing of Australian men (37).

Aim: To explore Australian males' preconception health behaviours, and beliefs and intentions towards preconception care.

Research Objectives

1) Explore Australian males' beliefs and intentions toward pregnancy planning and preconception health and care.
2) Identify the prevalence of clinically relevant preconception health behaviours of Australian males.
3) Explore the social determinants associated with Australian males engaging in preconception health behaviours.
4) Identify the health service utilisation and preferences of Australian males during the preconception period.
5) Examine health information received by Australian males during the preconception period and toward pregnancy planning and preconception health and care.

1.1.2 Thesis structure

Presented herein is a thesis by compilation; a project of research structured as a cohesive integration of traditional thesis chapters and chapters incorporating published articles and works submitted with academic journals currently under peer review. A brief overview of each chapter is outline below:

Chapter 1 provides background and contextual information of the research project to support the subsequent chapter sequence. An overview is provided of health behaviours and health information seeking, and how they apply to preconception health and preconception health behaviour interventions, such as preconception care.

Chapter 2 reviews the health beliefs, attitudes, and intentions of males towards pregnancy planning and preconception health and care. This research is presented as a systematic review currently under peer review with *BMC Public Health*.

Chapter 3 describes the research methodology used to investigate the preconception health behaviours, and attitudes and intentions towards preconception care including the conceptual framework, methodological approach and details for each of the four project phases.

Chapter 4 the initial presentation of results which includes a review of paternal preconception modifiable risk factors for adverse pregnancy and offspring outcomes. This research is presented as a review of contemporary evidence from observational studies and is published with *BMC Public Health* 2023;23(1):509.

Chapter 5 builds upon the results from chapter 4 to explore the preconception health and health behaviours of Australian males who became a first-time father in the previous 12 months. This research is submitted to the journal Health Education and Behaviour and is currently under peer review.

Chapter 6 examines the preconception health, heath behaviours, and information and health advice seeking among of expectant male reproductive partners in the context of their pregnancy intention. The results from this chapter are presented as a cross-sectional study published with *BMC Primary Care*. 2025;26(1):36.

Chapter 7 investigates the preconception health beliefs and intentions among expectant male reproductive partners which may predict three key health behaviours including i) regular exercise, ii) alcohol avoidance, and iii) healthy diet. Chapter results are presented as a cross-sectional study published with *Archives of Public Health*. 2025;83(1):182.

Chapter 8 explores the preconception health, treatments, and health services utilisation among males either attempting pregnancy or planning pregnancy. This research is presented as a cross-sectional study under peer review with *BMC Reproductive Health*.

Chapter 9 discusses the research findings presented within an integrated discussion which contextualises the research results relevant to the research aim and objectives. Relevant findings in this chapter cover i) the information and advice seeking of males during the preconception period, ii) health services utilisation, iii) health behaviours, and iv) beliefs and behavioural intentions.

Chapter 10 concludes the thesis and incorporates a summary of the central thesis findings as they relate to Australian males' preconception health, health behaviours, attitudes, and intentions.

1.2 HEALTH BEHAVIOURS AND HEALTH BEHAVIOUR CHANGE

1.2.1 Health behaviours

Health behaviours are the actions or habits an individual adopts that can have direct or indirect influence on their health (43). Health behaviours and risk factors can be classified as modifiable or non-modifiable (44) and can be broadly characterised as being 1) therapeutic interventions administered by a primary health professional (45) or 2) actions which are self-directed (46). Public health messages (43, 47) and health behaviour research often portray health behaviours in the context of risk factors for chronic illness, and commonly address behaviours relevant to nutrition and dietary intake, physical activity, overweight and obesity, tobacco smoking, alcohol consumption, recreational drug use (43), immunisations, and psychological stress management, (33). Therefore, health behaviours are pivotal as they can act as both a benefit and detriment to maintaining and optimising health (48).

Behaviours and risk factors such as smoking, excessive alcohol, insufficient physical activity, and overweight and obesity (16) may contribute towards health conditions including cardiovascular disease, cancer, mental health, injury, diabetes, and asthma. The association between such health behaviours and health conditions is reported by the World Health Organization [WHO] (49) and many of these heath conditions are also recognised as national health priorities in Australia (50). Consequently, modifiable health behaviours often present as risk factors for burden of disease. In the Australian context, a combination of tobacco, alcohol, and illicit drug use contributed to 16% of the total health burden in 2015 (51). The burdens associated with smoking are complex as smokers often report not having

the motivation, willpower, and/or strength to successfully quit (52). The health burden persists as smoking is ingrained into the domestic, social and working lives of smokers who consider their habit an indispensable characteristic which is even more relevant for couples who smoke (53).

Modifiable health behaviours may also present as risk factors for health conditions, such as obesity, which is acknowledged as a public health risk factor (54) characterized by a sustained body mass index [BMI]. Key contributing risk factors toward obesity include excessive fast-food consumption (55), unhealthy alcohol consumption (56), and sedentary behaviours (57). Indeed, regular fast-food consumption during childhood and adolescence is associated with lower vegetable consumption (58) and the development of an unhealthy attitude and relationship with food which extends into adulthood (59). An individual with obesity can signpost numerous other ailments (60), including NCDs (61). Globally, an estimated 39% of adults are overweight and 13% are obese (62), which is a serious public health burden acknowledged to influence numerous adults aged 18 years and over worldwide. In the Australian context, obesity and overweight affect 66% of Australian adults aged 18 years and older and is also a predominant public health burden (63). National policies in countries such as Australia (64) and the United States (65), and global strategies including the Global Action Plan on Physical Activity 2018-2030: More Active People for a Healthier World (66) endeavour to prevent and manage obesity. In Australia, the 10 year National Obesity Strategy 2022-2032 is a framework to prevent, reduce and treat the condition (64).

1.2.2 Social determinants of health

The social determinants of health refer to the non-medical factors that influence health outcomes through the living and working conditions of an individual. Such determinants are one of the key health indicators which are recommended to be used to effectively measure and report health at a population level (67). The social determinants of health include socioeconomic position, housing, education, conditions of employment, wealth management, and their social support and standing (2). These determinants will have a direct influence on the health and behaviours of individuals, on their health-related quality of life (68), and on their access to medical and social services. An individuals' occupation, income, and education will influence their health care utilisation (69). Such determinants are key factors to their socioeconomic position (2) and their ability to take leave from work to attend medical appointments or to pay for any out-of-pocket expenses . However, in some world regions, professionals and managers with higher income occupations less often report consulting a health professional (69). In addition, working and housing conditions can impact physical

and mental health and well-being and can influence familial relationships and social inclusion within communities and society - all aspects of an individual's health. The social determinants of health are especially relevant to health behaviours (70) as they influence exposure to health related information, engagement with the health care system, health service utilisation, and treatment options (68). Such determinants extend beyond individual health to familial health, and intergenerational health.

1.2.3 Health behaviour change

Health behaviour change is the process an individual can undertake to modify their health behaviours to enhance their overall health and wellbeing now and into the future (71). Such behaviour changes may include engagement with health-promoting activities, such as regular physical activity. The emphasis on regular physical activity is reflected in national public health initiatives including the Preventive Health Strategy [2021-2030] (36), and the Women's and Men's Health Strategies [2020-2030] (37) (72) which highlight insufficient physical activity as a key risk factor for chronic diseases (73) and report increasing physical activity as a focus area. However, some health behaviour changes are associated with the limiting or avoidance of health risks to mitigate the onset of chronic disease, such as smoking cessation (74) or alcohol restriction (75).

An individual's decision to change their health behaviours can be enabled following health information provided by a GP or other primary health care professional who may offer advice on the associated risks with undertaking specific behaviours (76). An individual's health behaviour change can also occur in response to information from their close relatives, family, and friends or work colleagues with lived experiences (77). However, the extent to which health services utilisation may influence an individual's health behaviour changes, is an emerging area of public health research which require immediate attention. In contrast, an individual's decisions regarding health behaviour changes can be made without expert health advice or influence from others which presents a barrier to accessing expert information, especially for addictive or habitual behaviours which may prove very difficult to change, such as smoking, alcohol, or caffeine cessation (33).

1.2.4 Health beliefs and intentions

An individual's health behaviours are influenced by their underlying health beliefs and behavioural intentions towards engaging in such health behaviours. In the context of health behaviours and health behaviour change, health beliefs refer to an individual's perception regarding the consequence of undertaking a specific health behaviour, being the influence toward their health (78). An individual's health behavioural intentions refer to the extent at

which they are willing to make health behaviour changes to optimise their health. An individual's health beliefs and behavioural intentions are important underlying factors which can be understood through their interrelationship. Although, gender differences in terms of heath beliefs are apparent in the research (79, 80).

There are numerous frameworks that attempt to model the relationship between an individual's cognitive processes, such as their beliefs and intentions, and their health behaviours (81). One framework to address the interrelationship between health beliefs and behavioural intentions is the Theory of Planned Behaviour (TPB), a widely utilised belief-behaviour theory and reasoned action framework (82). The TPB (78) models the belief-behaviour connection and is commonly utilized to determine and even predict behaviour by measuring beliefs and behavioural intentions (see Figure 1.1). Applying health research utilising the TPB allows researchers to identify the behavioural intention of individuals which can be utilised to establish the motivations behind certain preconception health behaviours to support behaviour change.

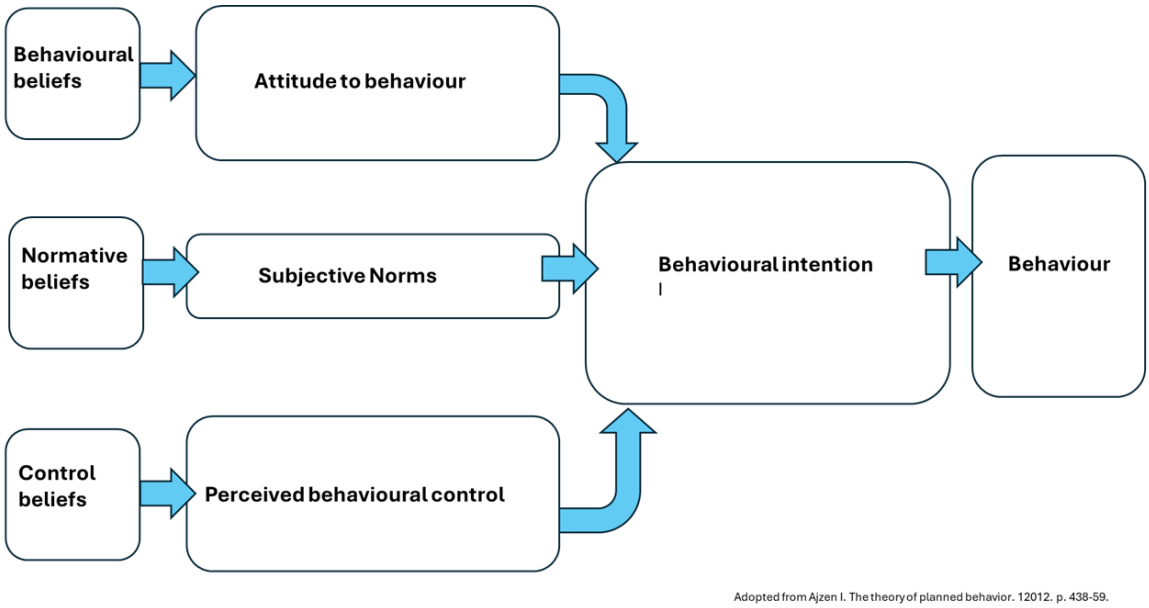


Figure 1.1 The Theory of Planned Behaviour (TPB)

The TPB suggests an individual's behaviour is influenced by underlying factors, including their attitudes towards the behaviour, being a set of collective behavioural beliefs, alongside others' expectations of the behaviour (subjective norms and normative beliefs). Other underlying factors include the perceived ability to control the behaviour (perceived behavioural control and control beliefs) (83). These factors combine to determine an individual's behavioural intentions which underscore actual behaviour.

Health research utilising the TPB allows researchers to identify the beliefs, attitudes, and behavioural intentions of individuals which can predict a range of health behaviours.

Understanding such factors can guide health care models to support behaviour change. The TPB is easy to understand and can apply to a wide range of behaviours, offering a simple structure between behaviours and belief, attitudes, and intentions which can explain the complexity of human behaviour (82). The TPB has been utilised in studies which address behaviour education on the nutritional behaviours of overweight and obese women (84). Few studies examine the male's behavioural intentions using the TPB (85).

1.3 HEALTH INFORMATION SEEKING AND INFORMATION ACCESS

1.3.1 Health information access

Health information is diverse. There are various sources of health information accessible to the general population who can access such information using several tools, and within numerous settings (86). Individuals invested in their health may decide to seek and source health information independently using marketing materials or various printed and hardcopy resources, or using textbooks, through media, telephone services or through discussions with close family and friends (86, 87). Participation in social clubs and community programs are potential avenues which can offer valuable mental, emotional, and physical support and social networks when seeking health information (88). Although, an individual's health information access and availability will be facilitated by their health literacy status (89), and as such health information and access does not imply health knowledge or the ability to adopt health behaviour changes.

In the global context, health information obtained online is prevalent considering the vast number of internet users (90). The integration of AI technologies highlight the importance and further need for individuals to effectively obtain, identify, analyse, and apply health information (91). Similarly, in the Australian context, most individuals maintain an online presence (92), which indicates that the Australian public are now accustomed to the conveniences of regular internet use and obtaining health information using digital platforms. As such, many Australians will actively seek health related information from web-based sources, which may include websites, blogs, and social media (93). Health information access online is as a user-friendly, cost-effective, and convenient initial point of contact.

However, there are also barriers to health information access. The availability of health information online is influenced by digital infrastructure, network accessibility and by the breadth of resources. Further, the relevance and reliability of online information will vary in nature depending on the source (94, 95). Information sourced using the internet and social media can also be problematic when used to incorrectly self-treat or self-diagnose (96, 97).

Therefore, consumers should approach online information regarding their health with caution due to the risks for misinformation.

Challenges to access information also arise when the information is only available in specific formats, such as only in hard copy, or exclusively within specific settings, for instance only when using the internet. Uptake of health information may also be constrained by an individual's ability to find online information that is relevant to their own clinical needs (98). This limitation can be offset by them identifying online health information source that have been verified by a health professional (e.g., GPs, medical specialists, and professionals supporting reproductive health), or by consulting with these types of health professionals for qualified care. Individuals can still explore, confirm, or even challenge a health professional's information and advice, however they also have the opportunity to do the same to online information with the support of a qualified expert, if they are under the care of a health professional during this time. Conversely, individuals who do not consider their health may not be proactive in accessing health information or resources and may be challenged to discuss their health, or matters relevant to their health behaviours, attitudes, and intentions, even when seeking expert advice or consulting with a health professional.

1.3.2 Health information seeking and advice

In addition to independently sourced health information, frontline and primary care health services and health practitioners, such as general practitioners (GPs), are also key contact points for health information (99). For many individuals, consulting a primary care doctor, such as a general practitioner (GP), will be the entry point for primary health services, and is typically the most common form of interaction with health services (100). In Australia, statistics report that 82.6% of the population consulted with a general practitioner in 2023-24 which suggests that many Australians are exposed to some form of expert health information or advice using this avenue (101). However, consultations with a health professional do not always translate into health information sharing (101). Beyond GPs, numerous individuals may seek information or advice from other primary care health professionals, including pharmacists, and seek information from within other primary health care settings by consulting traditional healers, Chinese medicine practitioners, naturopaths and western herbalists, and chiropractors (102, 103). Although, health information provided by one health practitioner can underscore, extend or conflict with information provided by other practitioners.

Consequently, all primary care providers have a professional responsibility to consider health information dissemination as a core component of their role, especially given the frequent engagement of frontline and primary care health services and practitioners who

manage a diverse range of health issues and conditions. Indeed, health practitioners should be trained to facilitate patient enablement and education through information dissemination (104). However, barriers are reported by primary care practitioners regarding information dissemination which include identifying the information needs of the patient, and managing issues with patient information overload (105). Ideally, an individual's engagement with information and advice will incorporate information diversity and therefore include information which is independently sourced in addition to information which is sourced through consultation with primary care health practitioners, medical specialists, and allied health services.

1.4 PRECONCEPTION HEALTH

1.4.1 Preconception health

Preconception health is defined as the health of an individual during their reproductive life years prior to the conception of their initial offspring. Preconception health can be considered within three perspectives 1) biological perspective: the days to weeks before development of the embryo, 2) individual perspective: encompassing the weeks to months before pregnancy, and 3) public health perspective: addressing risk factors in the months to years before conception (106). Such diversity in perspectives may explain why the preconception literature evidences a shortage of high-quality preconception care guidelines (34), and fails to supply a valid and reliable tool to comprehensively reflect preconception health knowledge (107). Nevertheless, across all perspectives, maintaining ideal health prior to the conception of offspring, during the preconception period, is of paramount importance for the future of population health and indeed intergenerational health and wellbeing. The individual's preconception health perspective is a particularly important period to address health and to foster decisions which will enable health behaviour changes during the preconception period. From the male's perspective, the development of healthful sperm is essential for a healthful pregnancy and offspring outcomes and occurs continuously with an approximate cycle between 64 and 90 days (108). Therefore, a suitable period to initiate health behavior change should be a minimum of three months prior to pregnancy, time to allow for safe and effective alterations in sperm mobility and motility. The individual's preconception health perspective will be the focus of the research within this thesis, unless overwise stated.

The public health or life course approach to preconception health is only starting to emerge in national policies and campaigns. A life course approach to preconception health (109) highlights the pivotal and vulnerable times, such as puberty and during adolescence, when individuals may experiment with modifiable health behaviours such as smoking (110),

alcohol consumption (111), illicit substance abuse, and unhealthy eating habits (112), often without regard toward the health consequences. The health behaviours of individuals during adolescence are an important point of epidemiological consideration, especially considering the potential for negative health influences and health ramifications for their offspring.

1.4.1 Preconception health behaviours

The health behaviours of individuals prior to conception can provide beneficial or detrimental influence to their health and to pregnancy and offspring outcomes (26). Health behaviours and the risks relevant to preconception health are often reported in unison. Although, the health behaviours of women planning or attempting pregnancy often do not mirror those of the man, which is possibly exacerbated by men being less likely than women to attend a primary care consultation (113). Many risk factors relevant to health cannot be altered and are innate characteristics of an individual, such as their age, ethnicity, genetics, or family history. The modifiable health behaviours of an individual can be controlled and therefore are facilitated through a decision making process to consider behaviours which are beneficial to health, such as physical activity, or harmful to health and present risk, in the case of smoking or exposure to environmental hazards (114). Indeed, adverse pregnancy and offspring outcomes have been associated with high-risk modifiable behaviours, including consumption of alcohol (10), smoking (115) and drugs, exposure to bis-phenol A [BPA] and toxic personal care products (116), chronic stress (117), inadequate sleep (116), unhealthy body composition (26, 117), and inadequate physical activity (16).

The preconception period for an individual is a critical time when behaviour change can be addressed. High-risk modifiable behaviours, such as smoking or alcohol consumption, can influence many factors relevant to reproductive health, such as or the creation of healthy sperm (20), and can negatively impact female fertility (118) and pregnancy outcomes (26). Therefore, an individual may institute such changes to their behaviours to improve reproductive health and ensure healthful outcomes for any future pregnancies and offspring. In the context of males, dietary changes and food bioactive compounds can influence epigenetic mechanisms relevant to sperm reproduction and fertility (20) and must also be considered. In addition, males must also consider their current health behaviours and risk factors in regard to sperm preservation and therefore become aware of health behaviours, such as placing a mobile phone within vicinity of the genitals, which may have effects on healthy sperm production (119).

Research investigating pregnancy planning behaviours of Swedish males indicate only 17% make a lifestyle adjustment before pregnancy to improve health for fertility (120), despite both maternal and paternal preconception health behaviours and lifestyles influencing

pregnancy and offspring outcomes (18, 121, 122).(18, 121, 122) However, in couples with a clear pregnancy intention and receiving preconception information, paternal health behaviours, including smoking, alcohol and eating habits, are more likely to be altered to optimise pregnancy outcomes (87).

Nevertheless, managing preconception health behaviours to optimise preconception health can present numerous challenges. One approach to understand preconception health behaviours may be to examine the social determinants of health which are key drivers of health behaviours that relate to the living and working conditions of an individual (43) (refer to section 1.2.2).

1.4.2 Preconception health across cultures

The principles of preconception health bridge countries and cultural boundaries (123), therefore such ideals should be considered global issues relevant to public health in all world regions. The awareness and general knowledge of preconception health by individuals, health services, health practitioners, researchers, and policy makers across all countries and cultures is fundamental to advance the benefits of preconception care for the global community.

Global research reports a limited awareness of relevant preconception health issues by women in the UK (39), including those across a diverse range of ethnicities and backgrounds, such as Pakistani, Indian, African, Caribbean, and Caucasian. Similar gaps in awareness have been identified by pregnant American women and their male partners in a prenatal clinic when discussing their pregnancy related health (25, 124, 125). In Australia, women and health practitioners(22) (25, 124) have also reported a limited awareness of relevant preconception health issues. A multi-country study, comprising Kenya, Malaysia, South Africa, United Kingdom, and the United States, found fewer than 15% of respondents from each country have a ‘good’ knowledge of preconception health (123). Preconception health awareness and knowledge as it relates across countries and cultures remains consistently reported in the research literature; namely, there is a limited awareness of preconception health generally alongside a limited awareness of the risks and benefits of care strategies. However, there is variation in the levels of preconception health knowledge and awareness between countries (123). Preconception health is globally relevant, however, its importance and relevance are not always acknowledged or duly recognised by stakeholders who can offer influence, such as policy makers or healthcare providers, and its optimisation is hampered by issues such as pregnancy ambivalence and unplanned pregnancy.

1.4.3 Opportunities and challenges for preconception heath

Preconception health and care is multifaceted which presents several opportunities and challenges to achieving optimal preconception health. An expanding preconception research landscape provides valuable opportunities to investigate important public health issues relevant to optimal preconception health and care - for instance – health behaviour changes or mental and emotional wellbeing support. Health services and health practitioners play a key role to advocate for preconception health and care awareness to their clients so they can initiate preconception health behaviour change to optimise their health. In addition, policy makers have an opportunity to formulate and refine effective preconception strategies to direct optimal preconception health globally (126).

Numerous challenges present which hinder opportunities to optimise preconception health. With respects to preconception health policy, health promotion, and health services, many countries, including Australia, do not have a national framework to guide collaborative action in this area. Consequently, the importance of preconception health is only emerging in the public health domain and in health services. From the individual's perspective, one in four pregnancies are unintended (127) which complicates pregnancy timing and spacing, and neutralises the delivery of preconception care. In addition, preconception populations are inconsistently defined in the literature which often does not consider both women and men (128). Consequently, information and resources are often directed at reproductive-aged females only (129). This targeted approach presents mixed messages for preconception care gender equity and equality (41) and provides yet another challenge to correctly reporting preconception attributes and behaviours to optimise the health of males. In addition, the views of some Australian women deem preconception health as important yet only consider it necessary when planning pregnancy (130) or experiencing difficulties conceiving (131). Optimising preconception health is not considered over the life course.

Opportunities and challenges for preconception health from the perspective of health practitioners reveal that GPs report preconception knowledge gaps and limited time and demand for delivering preconception care (25, 132). Numerous GPs are also not confident in their knowledge of modifiable risk factors affecting male fertility (25). This lack of confidence is also reported by other health professionals such as midwives and nurses (124). The challenges raised by health professionals foster further public health challenges when promoting preconception health awareness in the public health domain. Other barriers also present within the context of social, psychological, and cultural factors to facilitate behaviour change (133) and achieve optimal health. Efforts to optimise individuals' preconception

health represent an emerging area of research aimed at enhancing opportunities and addressing the associated challenges.

1.5 PRECONCEPTION HEALTH POLICY AND PROMOTION

Preconception health policy and health promotion have been identified as key public health strategies which may address the improvement of preconception health (67). A health policy for preconception health will address the strategic requirements to maintain and sustain optimal health during the preconception period and may be structured to target different aspects of preconception health (67). Complementing this, preconception health promotion involves raising awareness regarding the influence of health prior to pregnancy on pregnancy and offspring outcomes (67).

1.5.1 Preconception health policy

Globally, public health policies with the potential to influence preconception health are heterogenous. A study investigating preconception policy, guidelines, and recommendations across six European countries identified national guidelines specific to preconception health for only three (134, 135). However, all countries were found to support pregnancy guidelines and antenatal care.

In Australia, a national policy and framework that explicitly addresses preconception remains a public health priority. In Australian context, preconception health is promoted indirectly through a broad range of public health policies which address preventive health (36), sex-specific health (37), or health conditions such as obesity (64). The Preventive Health Strategy [2021-2030] directly targets preconception health with a focus on improving the prevention of risk factors (36). Similarly, the National Men's Health Strategy [2020-2030] reports a brief but direct emphasis on preconception health and the influence of preconception health on the risk of chronic conditions in the next generation (37).

1.5.2 Preconception health promotion

While a global consensus on aspects of preconception care has been established (136), public health promotion with a focus on preconception health and care remains in its early stages. There is an urgent need to widely promote preconception health (67). A limited number of countries, including the United States (137) and the UK (138), have incorporated the provision for preconception care into national health initiatives and promote preconception health as a priority. The UK preconception partnership, for instance, has

been developed to promote and improve preconception health and care in the UK (139). In Australia, public health initiatives that directly target health before pregnancy are limited.

Internet use is widespread globally (90), and its role in promoting preconception health awareness is increasingly relevant. As such, online resources can encourage individuals to enable health behaviour change during the preconception period. Several websites and organisation with online content are available that advance preconception health promotion.

1.5.2.1 Pre-pregnancy planning [Australia]

Family Planning Australia is a national organisation with an online presence that promotes sex neutral preconception health and care approaches by providing information via a website to address pre-pregnancy planning and healthy pregnancy (140). In order to promote preconception health and enable health behaviour change, the website content provided by Family Planning Australia focuses on actions taken by individuals to address health behaviours relevant to nutrition, physical activity, vaccinations, smoking and alcohol consumption.

1.5.2.2 Preconception health for men [Australia]

The Australian Government promotes sex specific preconception health promotion through initiatives such as Healthy Male (141) or websites such Your Fertility (142) and Australian networks such as the Plus Paternal network (143). The website content for Healthy Male promotes a basic awareness of preconception health with a focus on fertility and includes recommendations to boost fertility and identifies some of the knowledge gaps relevant to male fertility.

The Your fertility website promotes preconception health by offering a preconception checklist for males which focuses on health behaviour changes to address modifiable risk health behaviours and risk factors such as weight management, regular physical activity, and smoking or alcohol cessation. Other behaviours such as keeping the testes cool and booking a preconception health consultation with a GP.

1.5.2.3 Planning for Pregnancy [USA]

The United States Government promotes female specific preconception health with a focus on planning for pregnancy (144). Similarly to other websites which promote preconception health, information from this website highlights preconception health by focusing on actions which an individual can take to facilitate health behaviour changes and address modifiable health behaviours. Recommendations from the website include consulting a health care

provider, supplementing with folic acid, smoking and alcohol cessation and avoiding hazardous substances.

1.5.2.4 Reproductive health and pregnancy planning [UK]

Similarly to the United States Government, the Government of the United Kingdom also promote female specific preconception health with a focus on pregnancy planning and the life-course approach (145). The website reports a volume of information that includes risk factors relevant to unplanned pregnancy and also address aspects both preconception health and preconception care, infertility. In addition, the website also includes information relevant to the health professionals who support health behaviour changes.

1.5.2.5 Preventing a lifetime of loss [UK]

Tommy's is a registered charity in England and Wales that provides sex specific information online focused on the whole pregnancy journey (146).(146). The website provides a range of information and relevant to planning pregnancy, being pregnant, giving birth, and after the birth. Resources available on the website include a planning for pregnancy tool and ovarian calculator.

1.6 PRECONCEPTION HEALTH BEHAVIOUR INTERVENTIONS

1.6.1 Preconception care

From an individual's perspective, preconception health is optimised through preconception care is the provision of social, behavioural, and biomedical health interventions to women and couples prior to conception with the aim to improve health outcomes in the short and long term (136). Preconception care is administered during the preconception period and is therefore relevant across the different preconception health perspectives and the life course of an individual.(147). The initiation of preconception care can be facilitated by health practitioners simply asking one key question 'would you like to become pregnant in the next year' (148)? In the context of males, the question may be altered to 'are you or your partner planning pregnancy in the next year'? However, limited research exist regarding males being questioned by their health practitioners to determine if they are planning a pregnancy in the next 12 months (148).

A focus on preconception health and pregnancy planning, through preconception care, has the potential to address key public health issues which are associated with ambivalent or unintended pregnancy and adverse pregnancy and offspring outcomes. At the population

level, preconception interventions have made a substantial impact for public health across the globe, including folic acid fortification, iodine supplementation, weight management, smoking cessation, and alcohol consumption (15). Preconception care also addresses the prevention, screening, and management of chronic conditions (149) and targets behavioural changes to risky behaviours such as excessive alcohol consumption and smoking. As a key public health domain, preconception care holds relevance to clinicians, researchers, and policy makers, with strategies that have the potential to benefit individuals and populations by providing meaningful support and information with the capability to framework and ultimately improve population health (15). Preconception care, whether therapeutically administered or self-directed, is a key tool to empower and enable individuals to enact preconception behaviour change and optimise their health in preparation for healthy pregnancy and offspring (150).

Preconception care is a drastically underutilized intervention all too often ignored (151, 152). In order to address risk factors relevant to pregnancy and offspring outcomes, such as obesity (64), nutrition imbalances, and drugs such as alcohol and tobacco (37), countries without an established preconception framework have the responsibility to implement future public health initiatives. Such initiatives can directly address preconception health or indirectly address preconception health through the lens of preventive health and care (36).

Effective preconception care strategies can focus on preconception health behaviours and behavioural change by managing and regulating an individual's modifiable risk factors to reduce the risk of health conditions such as obesity. Preconception care strategies may include treatments to optimise health and incorporate health behaviours to mitigate risk, such as physical activity, changes in diet, downregulation of tobacco and vaping, adjusting sleeping patterns, and curbing excessive alcohol consumption (131).

1.6.2 Preconception health and care in the Australian context

Within the Australian health care system, individuals have the opportunity to access universal healthcare, delivered by general practitioners (GPs), medical specialists, allied health services, and nurses (153). Prescription-only pharmaceuticals are commonly prescribed by GPs through the pharmaceutical benefits scheme (PBS) which provides a government subsidy for certain pharmaceutical medicines that Australians can readily access (154). Prescription-only pharmaceuticals are dispensed by pharmacists, via a prescription provided by the GP, or medical specialist (154). The health care system in Australia also includes supporting primary health networks and community health services, individuals have the opportunity to access universal healthcare, delivered by GPs, medical specialists, allied health services, and nurses (153). Prescription-only pharmaceuticals are

commonly prescribed by GPs through the pharmaceutical benefits scheme (PBS) which provides a government subsidy for certain pharmaceutical medicines that Australians can readily access (154). Prescription-only pharmaceuticals are dispensed by pharmacists, via a prescription provided by the GP, or medical specialist (154). The health care system in Australia also includes supporting primary health networks and community health services who can cater to indigenous communities (155), and can provide care to remote and rural areas. The facilitation of preconception care in the Australian context is reflected in the views of GPs who are often the first point of contact for such care.

Despite both the National Men's (37) and Women's Health Strategies 2020-2030 (156) and the Royal Australian College of General Practitioners [RACGP] (157) stating the need for increased attention of preconception care in primary care, in Australia, currently there is no national implementation plan or conceptual framework for preconception care. Research reinforces this need in the Australian context by suggesting such care strategies are not proactively considered in primary healthcare settings (93). Although the Australian Government promotes planning for a healthy pregnancy and mentions the preconception period, or an individual's life course, as a crucial time to make life changes in preparation (158), including to consult with a GP. The absence of a national policy or coordinated framework limits preconception knowledge and awareness in the Australian context (132, 159) and does not translate into public awareness and behaviours (87, 120). The future of preconception health and care in Australia can be envisaged to empower individuals to act upon preconception information and resources, and to access health services which can tailor effective interventions that enable Australians to optimise their health behaviours while limiting any modifiable risk factors associated with adverse pregnancy and/or offspring outcomes.

The social determinants of health are recognised as predictors of overall health which is a matter of interest relevant to the Australian context and to preconception health considering the prevalence of long-term chronic health conditions is estimated to effect from 60% (160) to 80% (161) of the Australian population. In addition to the long-term chronic health conditions, numerous Australians live with acute infirmity or permanent disability. Although, a large subset of individuals with chronic health conditions will also include adult males who are indifferent to preconception and reproductive matters, such as Australians over the age of 65 (seniors). Senior Australians often report at least one chronic health condition (82%) (162) and report the comorbidity and multimorbidity of chronic disease at a comparable rate (52%) (162) to the general population.

1.6.3 Preconception health beliefs and intentions

Individual's may have preconceived beliefs and intentions regarding pregnancy and their health beforehand. Such beliefs will shape an individual's attitudes towards preconception health (83). However, an individual's sex will influence their pregnancy intentions and preconception health beliefs and attitudes. Emerging research highlights the importance of understanding beliefs and intentions concerning preconception health behaviours (21, 163). This research suggests an individual's preconception beliefs and intentions may be instrumental in elucidating preconception health behaviours. Numerous studies reporting reputable findings using the TPB (84, 164, 165), however, many studies utilising the TPB investigated reproductive females only (84, 166, 167), and few studies report predictors towards preconception care.

1.6.3.1 Preconception beliefs

The preconception health beliefs of an individual can cover a range of domains, including health behaviours, and are important to understanding and individual's behavioural intentions. Given the limited preconception health awareness in the general population (87), such preconception heath beliefs may be overlooked, and many individuals may not perceive the need to address their health before conception. Research identifies a sex disparity in preconception health beliefs. Such research suggests that both males and females place a greater emphasis on the female to undertake preconception health behaviours than males (21). These gender stereotypes and beliefs upheld by each gender impedes preconception care gender inclusivity and diminishes the importance of both men and women being critical to optimal reproductive outcomes.

1.6.3.2 Behavioural intentions

Behavioural intentions are closely linked to an individual's preconception beliefs, as outlined in the TPB. However, there is limited evidence to support behavioural intentions in the context of pregnancy and preconception health. The current evidence reporting behavioural intentions for preconception care includes a multi-study cross sectional study across five countries (123). The pooled results indicate that approximately 80% of male participants expressed willingness to engage in preconception care, compared with 92% of female participants, highlighting potential gender differences in behavioural intentions.

1.6.3.3 Pregnancy intention

Pregnancy intention, or the conscious decision for pregnancy, is a defining concept for preconception health and care as it can influence the effective engagement and utilisation of care strategies across the globe (168). Intention for pregnancy is a determining factor to distinguish planned pregnancy from ambivalent and unplanned pregnancy and can enable individuals to alter their health behaviours and utilise preconception care to optimise their health (169). On the contrary, individuals or couples with an unintended or ambivalent pregnancy cannot take full advantage of opportunities to advance their preconception health and undertake health behaviour change in the best interest of pregnancy and offspring health. On the contrary, individuals or couples with an unintended or ambivalent pregnancy cannot take full advantage of opportunities to advance their preconception health and undertake health behaviour change in the best interest of pregnancy and offspring health.

Pregnancy intention measurements can vary (170) across countries and cultures. The Desire to Avoid Pregnancy (DAP) scale (171) is an example of a prospective approach to pregnancy intention yet utilisation of this method is limited to some settings across Europe and Africa (170). In contrast, a retrospective measure of pregnancy intention is the London Measure of Unplanned Pregnancy which (LMUP), a psychometrically validated instrument for use in many countries (172), utilised to measure the degree of pregnancy planning/intention. Regardless of the pregnancy intention measurement, research indicates that the majority of participants from various countries have indicated a high likelihood, and therefore potential intention, to access preconception care, if available (123).

1.6.4 Enablers and barriers to optimal preconception health and care

A preconception health care focus on both reproductive partners can contribute towards optimal pregnancy outcomes by facilitating health behaviour change to improve the health practices and outcomes for men, women, and their families. Evidence suggests that male preconception and prenatal involvement can generate positive health outcomes for fathers, mothers and infants, and is a strong indicator for postpartum involvement (173). However, male preconception and prenatal involvement can be hindered by numerous factors including paternal unemployment, and the parent's relationship with fathers less likely to be involved prenatally if there is conflict with the mother (174) or the couple are not romantically involved and/or co-inhabiting (173). Within the context of health services, efforts to address preconception health and care are constrained by limited funding to support. Additionally, many practitioners report limited knowledge and competence in addressing preconception care issues (25, 124).

Particularly in light of the current obesity epidemic (175), and its implications for pregnancy and offspring outcomes, there is a need for health practitioners to normalise preconception care discussions with males (176). Ultimately, paternal preconception health and care offers significant potential benefit for Australian males and for the health of future generations in Australia as a proactive approach to inform and prepare optimising health when planning or attempting pregnancy and over the lifespan (177).

1.7 RESEARCH SIGNIFICANCE

The consideration of male preconception health and inclusion of males into preconception care is an undervalued albeit essential research area and notable public health topic given the role of preconception care to facilitate intergenerational health and wellbeing (178).(178). By acknowledging that a male's responsibilities and health influence commences in the preconception period (179), there is a need to actively include male partners in parenthood preparation (180), to integrate males into preconception care, and advocate for coordinated paternal preconception care delivery.(180), to integrate males into preconception care, and advocate for coordinated paternal preconception care delivery. This thesis explores paternal preconception health and care for Australian males, complementing the National Men's Health Strategy 2020-2030 (37) and the National Preventive Health Strategy 2021-2030 (36) which call for increased attention to address both preconception health and fatherhood. The National Men's Health Strategy 2020-2030 promotes male empowerment over all stages of life in order to strengthen the capacity of the health system to provide quality care for males. The strategy also calls for an evidence base to be generated to support male health. Similarly, the National Preventive Health Strategy 2021-2030 highlights the importance of health and wellbeing at all stages of life and the importance of the preconception period for males and females (36). The significance of this thesis research project is embodied within the key objectives of both strategies.

This body of research will not only contribute to the preconception knowledge base but also has the capability to inform and direct clinical practice decisions and guide the development of evidence-informed policy. Research results will grant healthcare professionals and males access to up-to-date evidence-based information regarding paternal preconception health exposures and outcomes. By addressing high-risk health behaviours, paternal preconception care broadly promotes intergenerational health and preventive health behaviour change.

1.8 CHAPTER SUMMARY

This chapter highlights the pivotal role of the male reproductive partner during the preconception period and serves to prelude a comprehensive exploration of the preconception health, health behaviours, beliefs, and intentions of Australian males, including the health services they utilize and their information exposure. The aim and objectives of this project are informed by existing research gaps and aligned with national public health strategies that emphasize the critical role of preconception care as a preventive health measure. These strategies acknowledge that greater attention to preconception health promotion is warranted.

The preconception period spans the life course, shaping health outcomes from one generation to the next. As an expanding field of public health research, preconception health beliefs, intentions, and behaviours among males, remain insufficiently reported. Preconception care interventions offer key opportunities for couples and individuals to make informed decisions about their lifestyle choices and to foster behaviour change that can enhance health in preparation for pregnancy. However, compared to females, males may be less inclined or less readily engaged in discussions and forums addressing preconception health and care. Furthermore, many males may not actively consider preconception or reproductive health, often due to factors such as pregnancy ambivalence or a lack of explicit intention to conceive. Health practitioners and health services frequently encounter challenges in effectively involving males in preconception efforts

This chapter serves as an outline and introduction for a systematic review of the existing literature on the health beliefs, attitudes, and intentions of Australian males in relation to pregnancy planning, preconception health, and preconception care.

2 THE HEALTH BELIEFS, ATTITUDES, AND INTENTIONS OF MALES TOWARD PREGNANCY PLANNING AND PRECONCEPTION HEALTH AND CARE

2.1 CHAPTER INTRODUCTION

The thesis aim and objectives focus on the preconception heath beliefs, intentions, and behaviours of Australian males. To address the research purpose, this chapter presents a systematic review of the preconception literature to explore the health beliefs, attitudes, and intentions of males toward preconception health and pregnancy planning.

The systematic literature review presented in this chapter is currently under review in *BMC Public Health*.

2.2 INTRODUCTION

An individual's health before conception - preconception health - can be optimised through the provision of biomedical, behavioural, and social health care interventions which aim to improve pregnancy and offspring outcomes in the short and long term (181). The preconception period is considered within three separate perspectives; 1) throughout the days to weeks before conception (biological); 2) from the time of conscious intention to conceive – typically weeks to months before conception (individual), and 3) through an individual's life-course (public health) (182). For an individual or couple with the intention to conceive, the process of pregnancy planning is an opportunity to address health related issues such as bodyweight and health behaviours including diet, smoking, alcohol consumption, recreational drug use, and physical activity to enhance overall health for future generations (15). However, a gender imbalance exists with preconception health research and practice primarily targeting males underdeveloped (33, 183).. The available evidence detailing the health behaviours of males during preconception, such as smoking or excessive alcohol consumption, suggest paternal behaviours can have a direct influence on pregnancy and offspring health (114). To inform how males can be supported to make healthy behaviour changes during the preconception period and while planning pregnancy, it is important to firstly understand their beliefs, attitudes, and intentions towards preconception health and care and pregnancy planning.

The belief-behaviour relationship, as defined in the theory of planned behaviour (184), proposes that beliefs towards a behaviour (behavioural beliefs) collate to interact attitudes toward the behaviour and in turn contribute toward the willingness to conduct the consequent behaviour (intention) (184). The belief-behaviour relationship is considered

relevant when investigating health behaviours such as physical activity (185) or dietary patterns (186) and may be particularly pertinent when exploring the motivations behind paternal health behaviours to better enable effective care strategies, including the formulation of a reproductive life plan (187). Exploration of paternal beliefs, attitudes, and intentions to engage in preconception care and pregnancy planning is required to address important evidence gaps and overcome potential barriers in the effective support of paternal preconception health behaviours and subsequent behaviour change. Further research must also be conducted investigating paternal beliefs, attitudes, and intentions to engage in preconception care to advance knowledge of the mechanisms which underlie male preconception health behaviours. Understanding the beliefs, attitudes and intentions of males will also support the development of preconception health policy, support public health promotions, and enable health services to formulate effective paternal preconception care services and interventions to initiate and sustain behaviour change. In response, the aim of this review was to identify the health beliefs, attitudes, and intentions of males toward pregnancy planning and preconception health and care. The belief-behaviour relationship, as defined in the theory of planned behaviour (184), proposes that beliefs towards a behaviour (behavioural beliefs) collate to interact attitudes toward the behaviour and in turn contribute toward the willingness to conduct the consequent behaviour (intention) (184). The belief-behaviour relationship is considered relevant when investigating health behaviours such as physical activity (185) or dietary patterns (186) and may be particularly pertinent when exploring the motivations behind paternal health behaviours to better enable effective care strategies, including the formulation of a reproductive life plan (187). Exploration of paternal beliefs, attitudes, and intentions to engage in preconception care and pregnancy planning is required to address important evidence gaps and overcome potential barriers in the effective support of paternal preconception health behaviours and subsequent behaviour change. Further research must also be conducted investigating paternal beliefs, attitudes, and intentions to engage in preconception care to advance knowledge of the mechanisms which underlie male preconception health behaviours. Understanding the beliefs, attitudes and intentions of males will also support the development of preconception health policy, support public health promotions, and enable health services to formulate effective paternal preconception care services and interventions to initiate and sustain behaviour change. In response, the aim of this review was to identify the health beliefs, attitudes, and intentions of males toward pregnancy planning and preconception health and care.

2.3 METHODS

This review was prospectively registered with the International prospective register of systematic reviews - PROSPERO (Registration Number: CRD42023495478) and conducted in accordance with the PRISMA guidelines for reporting systematic reviews (188) and the AMSTAR 2 critical appraisal tool (189). This review was prospectively registered with the International prospective register of systematic reviews - PROSPERO (Registration Number: CRD42023495478) and conducted in accordance with the PRISMA guidelines for reporting systematic reviews (188) and the AMSTAR 2 critical appraisal tool (189).

2.3.1 Search Strategy

A search of the literature was completed on 3rd January 2024 (Appendix 2.1 Search Strategy) utilizing the following databases: 1) Medline, 2) Embase, 3) PubMed, 4) CINAHL, 5) PsycINFO, 6) Scopus, and 7) Web of Science. This search was updated on 11th February 2025, with a date limit set since 2024 to capture all recent studies published since the previous search. An initial exploratory search using PubMed and the controlled vocabulary of each database, when available, were used to identify and refine search terms. The final search strategy was developed with an expert health sciences librarian from the University of Technology Sydney (UTS). The Scopus database, and Google Scholar for some papers not in Scopus, were used to further identify all studies which referenced each included study and all studies in the reference list of each included study.

2.3.2 Selection Criteria

This review included original research manuscripts which report empirical results regarding pregnancy planning or preconception health beliefs, attitudes, and/or intentions specifically for generally healthy adult males. Any study designs (e.g. intervention and observational) and research methods (e.g. quantitative and qualitative) were eligible for inclusion. Papers were included if they identified males' intention to engage in preconception health behaviour and/or attitudes, beliefs or perspectives to make preconception health behaviour change or engage with preconception care programmes and services (Table 2.1 - PICO). Papers were not included if they only reported on males' intention to conceive/pregnancy intention (i.e. 'Do you intend to conceive in the future?' or 'Was this a planned pregnancy?'), if they only reported factors which influence intention, or if they only reported fertility or preconception health and care knowledge. These exclusions were applied in the review to remove studies that focused primarily on topics related to a men's intention to have a child or regarding preconception knowledge which did not provide details of preconception beliefs, attitudes, or

intentions or provide context for specific preconception health behaviours such as smoking or alcohol consumption.

Papers excluded were review articles, editorials, commentaries, and letters, which did not report original research, along with articles which did not explore pregnancy planning or preconception health but instead topics such as contraception, abortion, unplanned pregnancy, or ambivalent pregnancy. Also excluded were any papers which included males under 18 years old as the focus of this review is adult males. Males recruited as (health) professionals or medical health experts were also excluded due to their expert understanding of the subject matter and the focus of this review being on the general population. Papers which focused solely on males with a diagnosed illness (e.g. HIV, diabetes) or disability were also excluded as their beliefs and attitudes may be influenced by their conditions.

Table 2.1 PICO Inclusion Criteria

Population	Intervention or exposure	Comparator	Outcome
Adult males aged ≥ 18 years recruited from the general population.	Beliefs, attitudes, and/or intentions, towards pregnancy planning, preconception health and/or preconception care.	Not required, or as defined in individual studies	Not required

2.3.3 Data Extraction and Synthesis

All studies were imported into Covidence systematic review software (190) and any duplicates were removed automatically. All studies were imported into Covidence systematic review software (190) and any duplicates were removed automatically. TC screened all papers by title and abstract and then full-text, AS and DS were second independent reviewers for this process and also assisted to resolve conflicts. TC obtained the full-text article for each included paper and, using a data extraction template, performed data extraction on all included papers. Data extraction was also performed by either AS or DS for all papers and extracted data were cross-checked for accuracy and completeness.

The data extracted from each paper included country, study aim, study design, setting, study publication year and the year/s when the study was conducted, participant age and sample size. Details specific for each determinant (i.e. belief, attitude, intention, perspective) were also extracted including the key results and outcomes for each determinant and any relationships between determinants.

The extracted data were initially grouped by exposure as a 1) belief, 2) attitude, or 3) intention. A process of inductive reasoning enabled the research team to determine recurring overarching themes within the extracted data. The paternal preconception beliefs, attitudes, and intentions identified within this review were categorised, tabulated, and reported within three main themes 1) *Importance of Preconception Health and Care*, 2) *Paternal Preconception Behaviours*, and 3) *Inequalities in Preconception Health and Preconception Care*

2.3.4 Quality Assessment

Methodological rigour for studies undertaking quantitative analysis was assessed using the Newcastle Ottawa Scale (NOS) adapted for cross-sectional studies (191).(191). The NOS for cross-sectional studies comprises three domains 1) selection of participants, 2) comparability of study groups, and 3) outcome of interest. A maximum of five stars are allocated for the selection domain [representativeness of the sample, sample size, non-response rate, ascertainment of exposure], a maximum of two stars for the comparability domain [potential confounders], and a maximum of three stars for the outcome domain [assessment of the outcomes and the statistical tests performed]. A total score was allocated out of ten for each study and was then categorized as good (7-10 stars), fair (4-6 stars) or poor quality (0-3 stars) (111).

The Critical Appraisal Skills Programme (CASP) Qualitative Studies checklist was utilized to assess the quality of qualitative studies (192). The CASP checklist is comprised of three sections: Section A- Result validity (Questions 1-6), Section B – What are the results (Questions 7-9), and Section C – Will the results help (Question 10). Each question is scored on a three-point scale (yes, can't tell, no) except for question 10 which is an open-ended question (how valuable is the research?). Each qualitative study assessed using the CASP reported an affirmative, undecided or negative response for each question which contributed toward the researcher's final subjective research value by consolidating all the previous questions. For this review, a paper was deemed high value when at least 8 of 10 appraisal criteria were fulfilled and this must include consideration of ethical issues, and a clear statement of the research aims. A paper deemed moderate value affirmed at least six appraisal criteria and included consideration of ethical issues, and a clear statement of the research aims. A paper which was low value did not meet at least six critical appraisal criteria or had at least three "can't tell" appraisal criteria or did not provide a clear statement of research aims or consider ethical issues. The Critical Appraisal Skills Programme (CASP)

Qualitative Studies checklist was utilized to assess the quality of qualitative studies (192). The CASP checklist is comprised of three sections: Section A- Result validity (Questions 1-6), Section B – What are the results (Questions 7-9), and Section C – Will the results help (Question 10). Each question is scored on a three-point scale (yes, can't tell, no) except for question 10 which is an open-ended question (how valuable is the research?). Each qualitative study assessed using the CASP reported an affirmative, undecided or negative response for each question which contributed toward the researcher's final subjective research value by consolidating all the previous questions. For this review, a paper was deemed high value when at least 8 of 10 appraisal criteria were fulfilled and this must include consideration of ethical issues, and a clear statement of the research aims. A paper deemed moderate value affirmed at least six appraisal criteria and included consideration of ethical issues, and a clear statement of the research aims. A paper which was low value did not meet at least six critical appraisal criteria or had at least three "can't tell" appraisal criteria or did not provide a clear statement of research aims or consider ethical issues.
The quality assessment of each included study was assessed by two independent reviewers and where any conflicts arose, consensus was reached among the reviewers with the assistance of a third reviewer to mediate.

2.4 RESULTS

The search identified 7,762 papers for which titles and abstracts were screened, followed by screening of 172 full-text articles; nine studies were finally included in this review (Figure 2.1 PRISMA). The majority of the papers (n=6) utilised cross sectional surveys (21, 193-197).(21, 193-197). One study utilised a survey that concurrently captured both quantitative and qualitative survey responses (163), one study was a qualitative exploratory case study design which utilised semi-structured interviews (198), and one study incorporated a mixed methods design comprising a survey and semi-structured interviews (199) (Table 2.2 Study characteristics).(163), one study was a qualitative exploratory case study design which utilised semi-structured interviews (198), and one study incorporated a mixed methods design comprising a survey and semi-structured interviews (199) (Table 2.2 Study characteristics). The included studies were conducted in the United States (n=4), United Kingdom (n=1), Canada (n=1), Belgium (n=1), The Netherlands (n=1), and Malaysia (n=1). Males from each study were recruited as a member of a survey panel (n=2), or from the student health clinic of a large public university (n=1) or from a public health clinic (n=1). Recruitment of males also occurred through various other settings including community health centres and public centres for social welfare (n=1), through female partners who participated in the APROPOS-II study (n=1), online via social media (n=2), or from the

general public through in person enlistment and recruitment advertisements (n=1). Sample sizes ranged between 15 and 300 participants.

Figure 2.1 PRISMA Flow chart

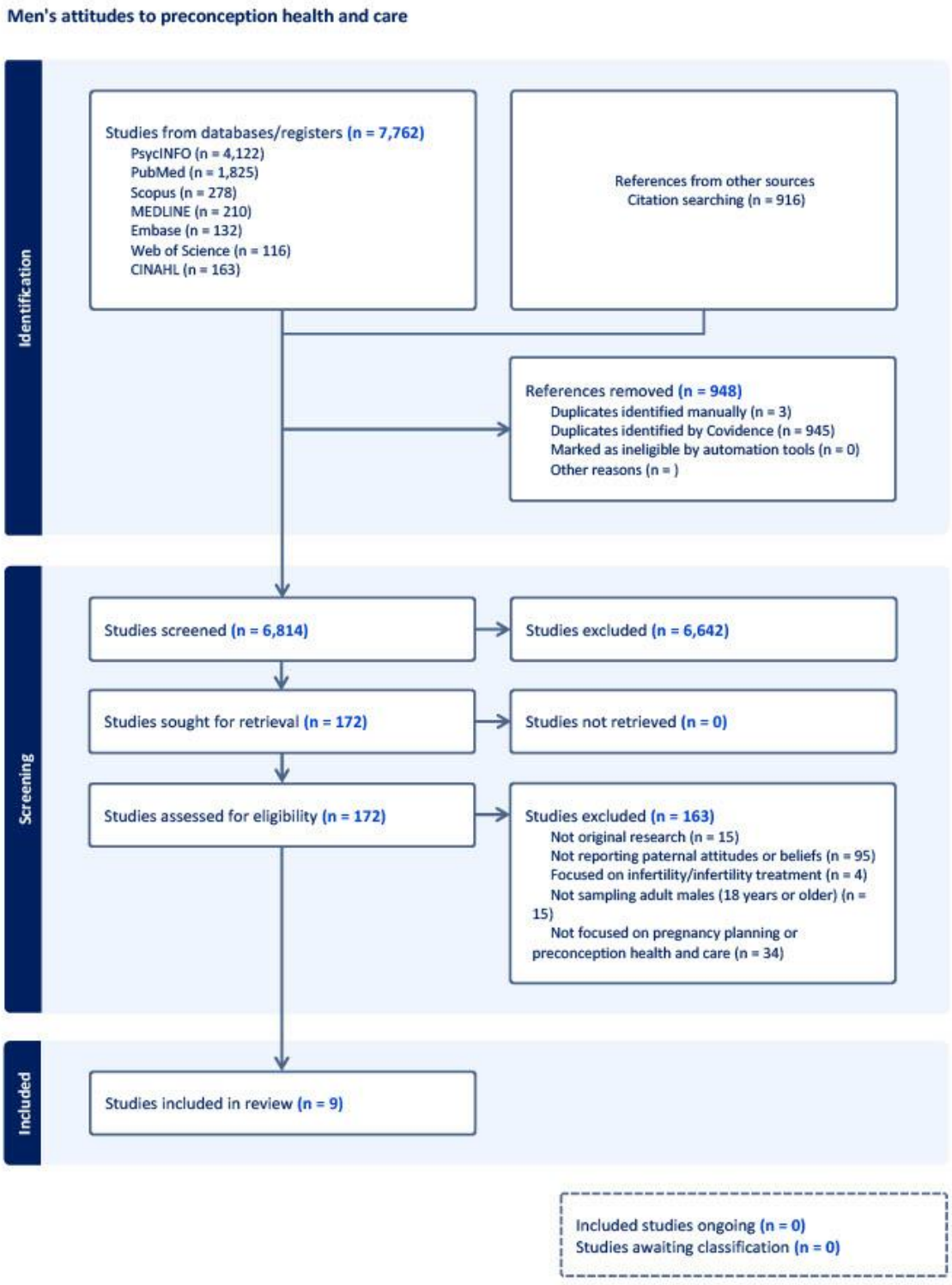


Table 2.2 Characteristics of included studies

First Author & Year of publication	*Country*	*Study Aim*	*Study design, data collection method & setting*	*Population Characteristics (Male study participants)*	*Determinant/s reported* *I = Belief* *II = Attitude* *III = Intention*		
Mello et al, 2019	United States of America (USA)	To address preconception health (PCH) knowledge gaps by assessing prescriptive gender stereotypes and assessing the intention to engage in pre-conception health related behaviours, and beliefs regarding preconception	Quantitative study, cross-sectional online questionnaire conducted in 2017 to members of a survey panel.	*Inclusion Criteria:* -heterosexual -of childbearing age (18-44 years) - report being physically able to have children in the next 2 years -interested in having children in the next 2 years. *Exclusions* -Survey incomplete and/or incoherent (as determined by the predefined cut off for completion time).	I ☒	II	III ☒
Kransdorf et al, 2016	United States of America (USA)	To determine existing awareness of reproductive life plans (RLPs) and to evaluate knowledge level and beliefs about reproductive life planning	Quantitative study, cross-sectional Student health centre of a large public university in USA conducted in 2013 to patients.	*Inclusion Criteria:* -aged 18 to 40 years - sought care at a student health center or – sought care at satellite health centers located across Phoenix, Arizona. *Exclusions* None	I ☒	II	III
			Mixed-methods study,	*Inclusion Criteria:*	I	II	III

Maas et al, 2022	The Netherlands	To explore male perceptions, beliefs, attitudes, and perspectives regarding the need to engage in preconception care.	questionnaire and semi-structured interviews conducted between 2019 and 2021 to prospective fathers, recruited through female partners, who participated in the APROPOS-II study.	-Reproductive males -Recruited through female partners who consult with one of ten community midwifery practices -Aged above 18 years - Can adequately communicate in Dutch, English, Polish, or Turkish *Exclusions* None	☒	☒	
Mello et al, 2020	United States of America (USA)	To elicit the beliefs about gendered responsibility for preconception health (PCH). .	Qualitative surveys conducted in 2017 to members of a survey panel	*Inclusion Criteria:* -heterosexual cis-gender men and women of childbearing age. -aged 18 to 44 years old -reported being able to have a child in the next 2 years -reported being interested in having a child in the next 2 years. *Exclusions* -Survey incomplete and/or incoherent (as determined by the predefined cut off for completion time).	I ☒	II	III
Cassinelli et al., 2023	Ireland	To explore the health behaviours, attitudes, and beliefs regarding preconception health and care.	Quantitative study, Combination of data from two cross-sectional studies conducted online in 2010 & 2018 to the public.	*Inclusion Criteria:* -Adults of childbearing age across the United Kingdom -Aged between 18 and 60 years *Exclusions* None	I ☒	II ☒	III
	Belgium	To determine which socio-	Quantitative study,	*Inclusion Criteria:*	I	II	III

Goossens et al., 2019		demographic and psychosocial factors are associated with the intention for preconception behavioural changes and the attitude toward these behaviours.	Cross-sectional multicentre study conducted over 2015-2016 to the public.	-Males aged between 15 and 45 years -who wish to have (more) children -able to read Dutch or English *Exclusions* None		☒	☒
Bassett-Gunter et al., 2013	Canada	To examine eating behaviour motives across 12 months, compare these across groups of new parents, non-parents, and established parents	Quantitative study, Cross-sectional survey and three-day food record [ND] issued to couples from the public.	*Inclusion Criteria:* -Men in a couple from British Columbia Canada - who are non-parents - who are new parents -who are established parents *Exclusions* -Couples that signed consent then chose not to participate -Couple that became pregnant while in the study (and did not transfer groups).	I 	II ☒	III ☒
Jackson, 2023	United States of America	To explore African American male attitudes and behaviours towards preconception counselling.	Qualitative study, exploratory multiple case study using semi-structured interviews using Zoom over a three-month period.	*Inclusion Criteria:* -African American males. -Aged between 18-39 years -Sexually active - Living in the Western United States Region *Exclusions* None	I 	II ☒	III
Mazlan, et al 2024	Malaysia	To determine men's intention to implement preconception lifestyle changes and any factors that influence their intentions.	Quantitative study, Cross-sectional survey conducted at a public health clinic between February and April 2023	*Inclusion Criteria* -Married men -Aged 18-45 years old -With wives of reproductive age (18-49 years) not on permanent contraception and planning to have more children *Exclusions*	I 	II 	III ☒

				-Foreigners -Individuals who could not understand Bahasa Melayu or English.			

2.4.1 Quality Assessment

Seven studies were assessed for quality using the NOS (21, 193-197, 199) (Appendix 2.2 NOS Quality Assessment) and most (n=6) were determined `fair' quality (21, 193-197, 199), while one was `poor' quality (195) and none were 'good' quality. All studies described and used an appropriate statistical test to measure associations and included confidence levels and p-values. None of the studies compared the characteristics between respondents and non-respondents.

The CASP Qualitative Studies checklist was applied to the qualitative conduct and analysis of three studies (163, 198, 199) (Appendix 2.3 CASP Quality Assessment). Two studies were classified as high value as they covered at least eight appraisal criteria and had a clear aim, considered ethical issues, justified a research design, and provided adequate data collection and analysis methods (199). The third study was deemed moderate value as it covered only 6 appraisal criteria and did not clearly articulate the research design or the qualitative methodology or provide a clear statement of the findings (163). The CASP Qualitative Studies checklist was applied to the qualitative conduct and analysis of three studies (163, 198, 199) (Appendix 2.3 CASP Quality Assessment). Two studies were classified as high value as they covered at least eight appraisal criteria and had a clear aim, considered ethical issues, justified a research design, and provided adequate data collection and analysis methods (199). The third study was deemed moderate value as it covered only 6 appraisal criteria and did not clearly articulate the research design or the qualitative methodology or provide a clear statement of the findings (163).

Statistically significant and consistently reported results pertaining to the preconception beliefs, attitudes, and intentions identified in this review were categorised into themes and summarised below. All results, including non-significant findings, are presented in Table 2.3.

2.4.2 Importance of Preconception Health and Care

Four studies in this review reported the importance of preconception health and preconception care, as perceived by males aged 18 - 60 (See Table 2.3) (21, 194, 198, 199).

2.4.2.1 Preconception health

One cross-sectional study determined the existing awareness and beliefs of reproductive age adult males about reproductive life planning who were recruited from a student health centre of a large public university in the US (194). Results from this study report at least 50% of participants across different age groups believed it was important to understand the influence of family history when developing a reproductive life plan ; <20 years (n=12;75%), 20-29 years (n=38;86%), for ≥ 30 years (n=4;57%) (p=0.03) (194). A high proportion of males from the aforementioned cross-sectional study (>85%), and another study which investigated prospective fathers perceptions regarding the requirement to engage in preconception care (199), agreed they made a contribution toward a healthy pregnancy and child. Although, for males considering a reproductive life plan, taking steps to optimise health before pregnancy was most often reported for males greater than 30 years old (85.7%) (194). The majority of prospective fathers (95%) agreed they can contribute to a healthy pregnancy, feel involved, and can influence the chances for the future of their child by living a healthy lifestyle (199). One cross-sectional study determined the existing awareness and beliefs of reproductive age adult males about reproductive life planning who were recruited from a student health centre of a large public university in the US (194). Results from this study report at least 50% of participants across different age groups believed it was important to understand the influence of family history when developing a reproductive life plan ; <20 years (n=12;75%), 20-29 years (n=38;86%), for ≥ 30 years (n=4;57%) (p=0.03) (194). A high proportion of males from the aforementioned cross-sectional study (>85%), and another study which investigated prospective fathers perceptions regarding the requirement to engage in preconception care (199), agreed they made a contribution toward a healthy pregnancy and child. Although, for males considering a reproductive life plan, taking steps to optimise health before pregnancy was most often reported for males greater than 30 years old (85.7%) (194). The majority of prospective fathers (95%) agreed they can contribute to a healthy pregnancy, feel involved, and can influence the chances for the future of their child by living a healthy lifestyle (199).

2.4.2.2 Preconception care

The study conducted by Maas et al (2022) conducted in the Netherlands (199) revealed that from the prospective fathers who did not attend a preconception care consultation and were aware of the possibility for a preconception care consult (n=84), 65.5% did not opt for a preconception consultation with a health care provider as they believed it was not needed. A similar proportion of prospective fathers in the same circumstances did not attend a preconception consult but were aware; 63.1% did not opt for a preconception consultation as

they agreed with the belief that they already knew enough about a healthy pregnancy. Further, based on qualitative findings from the same study, several men stated that available preconception care information was mainly communicated in a feminine tone of voice and narrative, suggesting a female cantered approach (199). From a study conducted in Ireland and the UK of adults of reproductive age and their beliefs and attitudes towards preconception care generally, one in two males (50%) agreed a dedicated clinic for preconception care is something they would use (21). The majority of participants in Ireland and the UK study agreed with the statement "My general practitioner [GP] is an appropriate person to offer preconception advice" (80%). The study conducted by Maas et al (2022) conducted in the Netherlands (199) revealed that from the prospective fathers who did not attend a preconception care consultation and were aware of the possibility for a preconception care consult (n=84), 65.5% did not opt for a preconception consultation with a health care provider as they believed it was not needed. A similar proportion of prospective fathers in the same circumstances did not attend a preconception consult but were aware; 63.1% did not opt for a preconception consultation as they agreed with the belief that they already knew enough about a healthy pregnancy.

Qualitative evidence from a study conducted in the US (198) explored the attitudes of African American males toward preconception counselling. Qualitative evidence from a study conducted in the US (198) explored the attitudes of African American males toward preconception counselling. One participant from this study stated *"I just don't feel comfortable, you know, talking about your feelings in and opening up to someone else"* while another participant revealed *"….Finding a professional that knows and is interested in helping and is also a good fit" "….. I need to know and trust people before I can ask for help and information".* Another participant states "*No, I haven't thought of going to a counsellor"….. but "It [preconception counselling] can help individuals to make an informed decision about their health, and the health of their future children which can lead to healthy pregnancy and outcomes and reduce risk of complications".* These attitudes suggest a disconnect that males can experience when seeking support for matters related to preconception.

2.4.3 Paternal Preconception Behaviours

Another key theme identified from the data was preconception health behaviours with relevant findings reported in six studies (See Table 2.3) (21, 193, 195-197, 199).

A Belgian study (195) reported intention (self-efficacy) of males to make preconception lifestyle changes was associated with higher odds of adopting a healthy lifestyle, eat healthy,

reduce alcohol consumption, or lose weight, however, confidence intervals were too wide to draw meaningful conclusions. Mixed-methods research from the Netherlands (199) surveyed prospective fathers exploring their preconception beliefs regarding preconception consultations. Contrary to other results in this review, which suggest that one in two males would use a dedicated preconception care clinic if made available, the mixed methods research from the Netherlands identified that many prospective fathers expressed they did not need a conversation with a health care provider as they already knew enough about a healthy pregnancy. One participant stated *"It [a GP proving PCC-information] is meant well, but I would think - I believe the doctor has better things to do than spending time on me to give me more information".* Another participant declared *"Not drinking alcohol is part of the deal, I also don't smoke so I didn't have to quit, and I neither do drugs. I didn't have to change much in that regard. I'm also not overweight, as far as I know. So I don't have to adjust a lot, I thought it all will be fine."*

A second study examined the preconception attitudes of Canadian couples toward the intention to eat healthy (196). This study reported longitudinal data for both affective attitudes (emotional based judgements about behaviour) and instrumental attitudes (perceived benefits and costs of the behaviour) to predict change regarding fruit and vegetable consumption and fat consumption from baseline (recruitment), 6 months from baseline, and 12 months from baseline. This study found affective attitudes were significant predictors for healthy eating among males ($\beta = 0.55$; $p<0.01$). The affective attitudes ($\beta = -0.21$; $p=0.05$) and instrumental attitudes ($\beta = 0.25$; $p<0.05$) of males were significant predictors of their fruit and vegetable consumption from baseline to twelve months only. Intention was a predictor of fruit and vegetable consumption 12 months from baseline ($\beta = 0.09$; $p=0.05$).

Research conducted in the US provided descriptive statistics to report the behavioural intentions of males before conception to avoid smoking cigarettes and avoid consuming excessive quantities of alcohol (193). Items were scored on a 5 point scale (1= strongly disagree to 5= strongly agree) and revealed that males place an emphasis on smoking avoidance (Mean 4.54:SD0.93) and to a lesser extent on too much alcohol (Mean 4.13:SD1.07) during preconception (193). This research also revealed current 'every day' male smokers were least likely to intend to engage in preconception health behaviours ($\beta = -0.331$; $p<0.001$;95% CI -0.551, – 0.111) followed by current 'some days' smokers ($\beta = 0.165$ $p>0.05$;95% CI -0.407, – 0.128) and former smokers ($\beta = 0.049$ $p>0.05$;95% CI -0.233, – 0.163), when compared with non-smokers (193).

A survey conducted in the Netherlands (199) among prospective fathers exploring their preconception beliefs regarding the cumulative effect of smoking and alcohol consumption on sperm quality found most study participants (88%) agreed these behaviours can affect the quality of their sperm. Quantitative research conducted in the UK found that more than half of males in the study (65%) agreed “It is important for men to consume a healthy preconception diet”. Approximately half (55%) of the males in the study agreed “It is important to for men to achieve a healthy weight during preconception” and “It is important for men to be physically active during preconception” (21).

A survey of married men conducted at a public health clinic in Malaysia reported their intention to make preconception lifestyle changes before their partner becomes pregnant (197). The majority of survey respondents (90%) intended to “adopt a healthy lifestyle before their partner becomes pregnant” and 75% of participants intended to “eat healthily before their partner becomes pregnant”. More than half of survey respondents (64%) intended to “discuss medications or herb use with a health care provider” and 61% intended to “reduce bodyweight before their partner becomes pregnant”. Only 35% of married men in this study intended to “attend a preconception consult with a healthcare provider before their partner becomes pregnant” or intended to “reduce drinking alcohol before their partner becomes pregnant”.

2.4.4 Inequalities in Preconception Health and Preconception Care

Preconception health and care gender differences and ethnic disparities was the third key theme identified. Five studies in this review reported gender differences or ethnic disparities in preconception health and care (See Table 2.3) (21, 163, 193, 198, 199).

A study conducted in Ireland reported only 40% of males agreed that preconception care is a high priority for themselves, yet 85% of participants agreed with the statement that “preconception care is an important health issue for women of childbearing age” (21). An US study investigated same gender stereotypes regarding a male’s roles and expectations of preconception health behaviours by asking participants “….to think about whether [men/women] are responsible for engaging in certain activities in the year before pregnancy” (193). Approximately 30% of male survey panel members from this study agreed with an equal responsibility of preconception health to both genders (193).

Beliefs about gendered responsibility were also reported in a qualitative study conducted in the US (163). This study identified main themes based upon the examined personal and collective gender group responsibilities for preconception health of female and male

respondents. The theme of `Body and health' was the most common theme mentioned for males regarding the responsibility for optimal preconception health (50%); compared with other themes which included shared responsibility (29%), choice and moral obligation (10%), gender stereotypes (23%), and doubt and uncertainty (6%). The notion of reproductive masculinity was referred to in this study by male and female participants as a reason why males can play a secondary and distant role in preconception health and care and why they can often consider, as the prospective father of the child, *"It's her duty as a prospective mother"* and *"It's not quite the same for [men] because the fetus/life isn't dependent on the actions of the father of the child".*

At least one prospective father in the study conducted by Maas et al, 2002 (199) in the Netherlands believed beneficial pregnancy outcomes were almost solely influenced by the female and therefore mostly outside their control*. " I think it's [contribution of one's heath to that of the future child] for 80%-90% influenced by the women. So in the period that you try to conceive, you also try to live a little healthier. But after that, I think it mostly depends on the women."*

The attitudes of African American males regarding preconception counselling (198) reveal *"African Americans are marginalised. So, they are given less attention during the preconception counselling period*". Another participant reflects *"Our medical people may not be able to access the same information as compared to other races. Because we know that there is some level of discrimination in accessing that information".*

Table 2.3 Summary of findings from included studies, by theme

Topic: Importance of Preconception Health and Preconception Care					
Study	**Question, scale or measure, where appropriate)**	**Statement, theme, or answer option**	**Results**		
Kransdorf et al, 2016	At the current stage of my life, I must plan on: (seven-point scale from strongly disagree (1) to strongly agree (7); disagree = 1-3/neutral = 4/agree = 5-7)	"It is important to develop a reproductive life plan"	Age <20 years: (n=33) Strongly agree or somewhat agree (n=16;48%)	Age 20-29 years: (n=80) Strongly agree or somewhat agree (n=45;56%)	Age >30 years (n=13) Strongly agree or somewhat agree (n=7;53%)
		"Understanding implication of family history"	Age <20 years: (n=33) Agree (n=12;75.0%) Neutral (n=2;12.5%) Disagree (n=2;12.5%) P=0.03	Age 20-29 years: (n=80) Agree (n=38;86.4%) Neutral (n=0;0.0%) Disagree (n=6;13.6%) P=0.03	Age >30 years (n=13) Agree (n=4;57.1%) Neutral (n=2;28.6%) Disagree (n=1;14.3%) P=0.03
		"Taking steps to optimize my health before my or my partner's pregnancy"	Age <20 years: (n=33) Agree (n=10;62.5%) Neutral (n=2;12.5%) Disagree (n=4;25.0%) P=0.72	Age 20-29 years: (n=80) Agree (n=29;65.9%) Neutral (n=6;13.6%) Disagree (n=9;20.5%) P=0.72	Age >30 years (n=13) Agree (n=6;85.7%) Neutral (n=1;14.3%) Disagree (n=0;0.0%) P=0.72
		"Improving my understanding of risks associated with pregnancy at different stages"	Age <20 years: (n=33) Agree (n=9;56.3%) Neutral (n=2;12.5%) Disagree (n=5;31.3%) P=0.28	Age 20-29 years: (n=80) Agree (n=35;77.8%) Neutral (n=2;4.4%) Disagree (n=8;17.8%) P=0.28	Age >30 years (n=13) Agree (n=6;85.7%) Neutral (n=1;14.3%) Disagree (n=0;0.0%) P=0.28
Maas et al., 2022	What are the preconceptional health beliefs amongst men. *Pregnancy planning* (five-point scale from strongly disagree (1) to strongly agree (5). Disagree = 1-3/Agree = 4-5.) (n=229)	"I think this pregnancy is taking place at the right time in our lives"	Agree (n=194; 85%) Disagree (n=35;15%)		
		"When we started trying to conceive, we thought "we'll see what happens"	Agree (n=183;80%) Disagree (n=46;20%)		
		"I felt comfortable discussing our wish to conceive with family and friends"	Agree (n=194; 85%) Disagree (n=35;15%)		
		"I thought it was important to keep our wish to conceive	Agree (n=137; 60%) Disagree (n=92;40%)		

		private between me and my partner"	
		"The current pregnancy was planned"	Agree (n=201;88%) Disagree (n=28;12%)
		"A pregnancy is not something that you can plan, it is something that happens spontaneously"	Agree (n=103;45%) Disagree (n=125;55%)
		"It is up to the woman to initiate talking about having children"	Agree (n=12;5%) Disagree (n=217:95%)
	Pregnancy preparation for men Reasons for not opting for a preconception consultation (n=84)	"I didn't need a conversation with a health care provider"	Agree (n=55;65%) Disagree (n=29;35%)
		"I already knew enough about a healthy pregnancy"	Agree (n=53;63%) Disagree (n=31;37%)
		"My partner was pregnant faster than expected"	Agree (n=16;19%) Disagree (n=68;81%)
		"My wish to conceive was private".	Agree (n=4;4%) Disagree (n=80;96%)
		"I was not willing to pay for it	Agree (n=2;3%) Disagree (n=82;97%)
		"I did not know which health care provider I could go to"	Agree (n=1;2%) Disagree (n=83;98%)
		"I didn't have time"	Agree (n=1;1%) Disagree (n=83;99%)
		"Other"	Agree (n=5;6%) Disagree (n=79;94%)

	What are the preconceptional health beliefs amongst men. *Paternal contribution* (n=229)	"I feel that the health of my partner before pregnancy affects the future health our of child"	Agree (n=210;92%) Disagree (n=19;8%)
		"I feel that as a man I can influence the chances for the future of my child by living a healthy lifestyle"	Agree (n=217;95%) Disagree (n=12;5%)
		"I feel that as a man I can contribute to a healthy pregnancy. "	Agree (n=217;95%) Disagree (n=12;5%)
		"I was well prepared for this pregnancy"	Agree (n=171;75%) Disagree (n=58;25%)
		"I feel involved in this pregnancy"	Agree (n=217; 95%) Disagree (n=12;5%)
		"I was involved in the preparations for this pregnancy"	Agree (n=194; 85%) Disagree (n=35;15%)
Maas et al., 2022	Main reason for retrieving PCC-information (n=94)	"I wanted to be well prepared for the pregnancy"	Agree (n=55;58%) Disagree (n=39;42%)
		"We did not get pregnant as quickly as hoped"	Agree (n=11;11%) Disagree (n=83;89%)
		"My partner recommended it to me"	Agree (n=5;5%) Disagree (n=89;95%)
	Perspectives of wishing to conceive: pregnancy preparation health and lifestyle involvement	Interview topics – 1) pregnancy intentions, 2) pregnancy preparation, 3) health & lifestyle and 4) involvement.	Several men struggled with the fact that the available PCC-information was mainly communicated in a feminine tone of voice.
Cassinelli et al, 2023	Attitudes towards preconception care. (5-point Likert scale ranging from strongly disagree (1) to strongly agree (5) (n=89)	"Preconception care does not have any effects on pregnancy outcome"	Agree or strongly agree (n=10; 12%) Neither, Disagree, or strongly disagree (n=79; 88%)
		"Preconception care is an important health issue for women of childbearing age"	Agree or strongly agree (n=75; 85%) Neither, Disagree, or strongly disagree (n=14; 15%)

		"Preconception care is an important health issue for men of childbearing age"	Agree or strongly agree (n=53; 60%) Neither, Disagree, or strongly disagree (n=36; 40%)
		"A dedicated clinic for preconception care is something that I would make use of, if available"	Agree or strongly agree (n=44; 50%) Neither, Disagree, or strongly disagree (n=45; 50%)
		"My friends/family do not plan for pregnancy"	Agree or strongly agree (n=17; 20%) Neither, Disagree, or strongly disagree (n=82) 80%
		"Preconception care is a high priority for me "	Agree or strongly agree (n=35; 40%) Neither, Disagree, or strongly disagree (54; 60%)
		"There is little evidence base for preconception care"	Agree or strongly agree (n=16; 18%) Neither, Disagree, or strongly disagree (73; 82%)
		"My GP is an appropriate person to offer preconception advice"	Agree or strongly agree (n=82; 80%) Neither, Disagree, or strongly disagree (n=7; 20%)
		"My practice nurse or community midwife is an appropriate person to offer preconception advice"	Agree or strongly agree (n=64; 72%) Neither, Disagree, or strongly disagree (n=25; 28%)
		"Friends and family are appropriate people to offer preconception advice"	Agree or strongly agree (n=11; 13%) Neither, Disagree, or strongly disagree (n=78; 87%).
		"The internet is an appropriate place to get preconception advice"	Agree or strongly agree (n=22; 25%) Neither, Disagree, or strongly disagree (n=67; 75%)
Jackson, 2023	Attitudes on Preconception Counselling (n=15).	How do African American males perceive preconception counselling in clinical settings?	One participant's attitude toward preconception counselling reveals "I just don't feel comfortable, you know, talking about your feelings in and opening up to someone else." Another participant perceived preconception counselling as "… getting all the facts regarding what you are getting into"…. Yet another participant reflects," No, I haven't thought of going to a counsellor"….. but "It [preconception counselling] can help individuals to make an informed decision about their health, and the health of their future children which can lead to healthy pregnancy and outcomes and reduce risk of complications…. It's also helping preparation for the family with how to adjust with a new baby."
		What factors influence preconception counselling acceptance among African American males?	Participant responses reveal "We do not have many counsellors in this field, so I think it's a challenge to find a good professional. It takes time, too. Finding a professional that knows and is interested in helping and is also a good fit" "….. I need to know and trust people before I can ask for help and information. I know I would use the internet too". Further reflection suggests "Yeah, that is all that is, the places I trust mostly. That is why you can meet preconception counselling from only a reliable source."

Topic: Paternal Preconception Behaviours				
Study	**Category of topic (scale or measure, where appropriate)**	**Description**	**Results**	
Mello et al, 2019	What are men's prescriptive same gender stereotypes regarding the behavioural intentions to conduct preconception health behaviours. `in the year before a pregnancy'. (5 point scale: 1 = strongly agree to 5 = strongly disagree)	Males should avoid smoking	Mean 4.54;SD 0.93	
		Males should avoid second hand smoke	Mean 4.33;SD 1.0	
		Males should avoid too much alcohol	Mean 4.13;SD 1.07	
	Intention to engage in preconception health related behaviours	-Avoid smoking -Avoid second-hand smoke -Avoid drinking too much alcohol	On a scale from 1 (strongly disagree) to 5 (strongly agree), males reported a significant agreeance for the behavioural intention to engage in preconception behaviours (Mean = 4.47;SD=0.69) p=0.006. Male current everyday smokers were least likely to intend to engage in preconception health behaviours (β = -0.331; p<0.001;95% CI -0.551, – 0.111) compared with current someday smokers (β = 0.165 p>0.05;95% CI -0.407, – 0.128) , former smokers (β = 0.049 p>0.05;95% CI -0.233, – 0.163) , and non-smokers (REF). Other characteristics predicting the intention to engage in preconception health behaviours for males were not statistically significant.	
Bassett-Gunter et al., 2013	Affective and instrumental attitudes towards the intentions to eat healthy, toward fruit and vegetable consumption, and toward fat consumption. (n=145)	Predictors for the intention to eat healthy	Affective Attitudes	Instrumental Attitudes
			β= 0.55; p<0.01 Affective attitudes were significant predictors of the intention to eat healthy among males.	β= 0.09; p>0.05 Instrumental attitudes were not significant predictors of the intention to eat healthy among males.

	Predictors of change in fruit and vegetable consumption from baseline to six months and to twelve months.	Fruit and vegetable consumption	Affective Attitudes (6-months)	Affective Attitudes (12-months)	Instrumental Attitudes (6-months)	Instrumental Attitudes (12-months)
			(n=119) β= - 0.01; p=0.06 Affective attitudes were not significant predictors of the intention to eat fruit and vegetables in the 6 months following baseline.	(n=101) β= - 0.21; p=<0.1 Affective attitudes were not significant predictors of the intention to eat fruit and vegetables in the 12 months following baseline.	(n=119) β= 0.25; p=0.06 Instrumental attitudes were not significant predictors of the intention to eat fruit and vegetables in the 6 months following baseline.	(n=101) β= 0.25; p<0.05 Instrumental attitudes were significant predictors of the intention to eat fruit and vegetables in the 6 months following baseline.
	Predictors of change in fat consumption from baseline to six months and to twelve months.	Fat consumption	Affective Attitudes (6-months)	Affective Attitudes (12-months)	Instrumental Attitudes (6-months)	Instrumental Attitudes (12-months)
			(n=119) β=- 0.13; p=0.74 Affective attitudes were not significant predictors of fat consumption in the 6 months following baseline.	n=101) β= -0.08; p=0.66 Affective attitudes were not significant predictors of fat consumption in the 12 months following baseline.	(n=119) β= 0.02; p=0.74 Instrumental attitudes were not significant predictors of fat consumption in the 6 months following baseline.	(n=101) β= 0.07; p=0.66 Instrumental attitudes were not significant predictors of fat consumption in the 12 months following baseline.
	The intentions to eat healthy and predict fruit and vegetable consumption from baseline to six months and to twelve months.	Fruit and vegetable consumption	6 months		12 months	
			(n=119) β= 0.15; p=0.06 The intentions to eat healthy were not significant predictors of fruit and vegetable consumption in the 6 months following baseline.		(n=101) β = 0.09; p=0.05 The intentions to eat healthy were significant predictors of fruit and vegetable consumption in the 12 months following baseline.	
	The intentions to eat healthy and predict fat consumption from baseline to six months and to twelve months.	Fat consumption	6 months		12 months	

			(n=119) β= 0.05; p=0.74 The intentions to eat healthy were not significant predictors of fat consumption in the 6 months following baseline.	(n=101) β = 0.12; p=0.66 The intentions to eat healthy were not significant predictors of fat consumption in the 12 months following baseline.
Maas et al., 2022	Perspectives of wishing to conceive pregnancy preparation health and lifestyle involvement	Interview topics – 1) pregnancy intentions, 2) pregnancy preparation, 3) health & lifestyle and 4) involvement. (n=14)	Most males expressed that they felt already healthy enough, therefore no lifestyle behaviour change was needed. *"Not drinking alcohol is part of the deal, I also don't smoke so I didn't have to quit, and I neither do drugs. I didn't have to change much in that regard. I'm also not overweight, as far as I know. So I don't have to adjust a lot, I thought it all will be fine."* *"It [a GP proving PCC-information] is meant well, but I would think "I believe the doctor has better things to do than spending time on me to give me more information".* Many males validated their inability to abstain from alcohol use during preconception by comparing themselves to unhealthier friends and instead opting to reduce alcohol use rather than abstain entirely.	
	Paternal contribution	When a prospective father smokes or drinks alcohol in the period before the pregnancy, this can affect the quality of the sperm	Agree (n=201;88%) Disagree (n=28;12%)	
Goossens et al., 2019	Intention to make preconception lifestyle changes (self-efficacy)	Adopt a healthy lifestyle	OR=5.67;p=0.03;95%CI (1.15 -27.99) A high self-efficacy to adopt a healthy lifestyle was associated with higher odds of intending to adopt a healthy lifestyle.	
		Search for information or advice on how to become pregnant in a healthy way	OR=16.55;p<0.001; 95%CI (4.75 -57.73) The search for information or advice on how to become pregnant in a healthy way was associated with the self-efficacy to search for information or advice.	
		To eat healthy	OR=28.64;p=0.003; 95%CI (3.18 -258.01) A high self-efficacy to eat healthy was associated with higher odds of intending to adopt healthy eating habits.	
		To avoid testicular hyperthermia	OR=28.29;p<0.001; 95%CI (6.63 -120.63) To avoid testicular hyperthermia is positively associated with the intention to avoid testicular hyperthermia.	
		To attend a preconception consult with a healthcare provider	OR=137.45;p<0.001; 95%CI (12.43 -1519.95) A high self-efficacy to attend a preconception consult with a healthcare provider was associated with higher odds of intending to consult with a healthcare provider.	
		To stop smoking	OR=3.74;0.23; 95%CI (0.44 -31.58)	

			The self-efficacy to stop smoking was not associated with the intention to stop smoking
		To reduce alcohol consumption	OR=43.32;p<0.001; 95%CI (10.0 -187.84) A high self-efficacy to reduce alcohol consumption was associated with higher odds of intending to reduce alcohol consumption.
		To lose weight	OR=32.40;p=0.008 95%CI (2.53 -415.45) A high self-efficacy to lose weight was associated with higher odds of intending to lose weight.
Cassinelli et al, 2023	*Same sex preconception health beliefs* (n=89) (5-point Likert scale ranging from strongly disagree (1) to strongly agree (5)	"It is important for men to consume a healthy preconception diet"	Agree or strongly agree (n=57 65%) Neither, Disagree, or strongly disagree (n=32; 35%)
		"It is important for men to take vitamins such as vitamin D during preconception"	Agree or strongly agree (n=31: 35%) Neither, Disagree, or strongly disagree (n=58; 65%)
		"It is important for men to achieve a healthy weight during preconception"	Agree or strongly agree (n=48; 55%) Neither, Disagree, or strongly disagree (n=41; 45%)
		"It is important for men to be physically active during preconception"	Agree or strongly agree (n=48; 55%) Neither, Disagree, or strongly disagree (n=41; 45%)
Mazlan et al, 2024	Intention to make preconception lifestyle changes (n=284)	"Adopt a healthy lifestyle before your partner becomes pregnant"	Agree (n=256;90.1%) Disagree (n=28;9.9%)
		"Search for information or advice on how to become pregnant in a healthy way before your partner becomes pregnant"	Agree (n=220;77.5%) Disagree (n=64;22.5%)
		"Eat healthily before your partner becomes pregnant"	Agree (n=213;75.0%) Disagree (n=71;25.0%)
		"Avoid testicular hyperthermia before your partner becomes pregnant"	Agree (n=162;57.0%) Disagree (n=122;43.0%)
		"Attend a preconception consult with a healthcare provider before your partners becomes pregnant"	Agree (n=100;35.2%) Disagree (n=184;64.8%)
		"Support your partner to perform a preconception	Agree (n=272;95.8%) Disagree (n=12;4.2%)

		lifestyle before they become pregnant"	
		"Reduce drinking alcohol before your partner becomes pregnant" (n=20)	Agree (n=7;35.0%) Disagree (n=13;65.0%)
		"Stop smoking before your partner becomes pregnant" (n=97)	Agree (n=43;44.3%) Disagree(n=54;55.7%)
		"Reduce weight before your partner becomes pregnant" (n=230)	Agree (n=140;60.9%) Disagree (n=90;39.1%)
		"Discuss medications or herb use with a healthcare provider before your partner becomes pregnant" (n=140)	Agree (n=67;64.4%) Disagree (n=37;36.6%)

Topic: Inequalities in Preconception Health and Preconception Care			
Study	**Category of topic (scale or measure, where appropriate)**	**Description**	**Results**
Mello et al, 2019	Prescriptive gender stereotypes (same gender) regarding a male's role and expectations of specific preconception behaviours `in the year before a pregnancy'. (5 point scale: 1 = strongly agree to 5 = strongly disagree)	- smoking - second-hand smoke - excessive alcohol (n=267)	Equal responsibility of preconception health to both genders: Agree: 30% A greater responsibility of preconception health to the female: Agree 52% A greater responsibility of preconception health to the male: Agree 18%
Cassinelli et al, 2023	Attitudes towards preconception care. (5-point Likert scale ranging from strongly disagree (1) to strongly agree (5)	"Preconception care does not have any effects on pregnancy outcome" (n=89)	Agree or strongly agree (n=10; 12%) Neither, Disagree, or strongly disagree (n=79; 88%)
		"Preconception care is an important health issue for women of childbearing age"	Agree or strongly agree (n=75; 85%) Neither, Disagree, or strongly disagree (n=14; 15%)
		"Preconception care is an important health issue for men of childbearing age"	Agree or strongly agree (n=53; 60%) Neither, Disagree, or strongly disagree (n=36; 40%)
		"A dedicated clinic for preconception care is	Agree or strongly agree (n=44; 50%) Neither, Disagree, or strongly disagree:(n=45; 50%)

		something that I would make use of, if available"	
		"My friends/family do not plan for pregnancy"	Agree or strongly agree (n=17; 20%) Neither, Disagree, or strongly disagree (n=82) 80%
		"Preconception care is a high priority for me"	Agree or strongly agree (n=35; 40%) Neither, Disagree, or strongly disagree (54; 60%)
		"There is little evidence base for preconception care. "	Agree or strongly agree (n=16; 18%) Neither, Disagree, or strongly disagree (73; 82%)
		"My GP is an appropriate person to offer preconception advice"	Agree or strongly agree (n=82; 80%) Neither, Disagree, or strongly disagree (n=7; 20%)
		"My practice nurse or community midwife is an appropriate person to offer preconception advice"	Agree or strongly agree (n=64; 72%) Neither, Disagree, or strongly disagree (n=25; 28%)
		"Friends and family are appropriate people to offer preconception advice."	Agree or strongly agree (n=11; 13%) Neither, Disagree, or strongly disagree (n=78; 87%).
		"The internet is an appropriate place to get preconception advice."	Agree or strongly agree (n=22; 25%) Neither, Disagree, or strongly disagree (n=67; 75%)
Mello et al, 2020	Perspectives about gendered responsibility regarding -body and health -shared responsibility -choice and moral obligation -gender stereotypes -doubt and uncertainty	Gendered roles in preconception health -Body and health -Shared responsibility -Choice and moral obligation -Gender stereotype -Doubt and uncertainty (n=251)	The theme of `Body and health' was the most common theme mentioned for males collectively (50%;n=125) regarding the responsibility of preconception health care (PCH); compared with other themes including shared responsibility (29%;n=72), choice and moral obligation (10%;n=25), gender stereotypes (23%;n=57), and doubt and uncertainty (6%;n=15). Reproductive masculinity as a concept was described by participants as the reason why males can play a secondary and distant role in PCH and why males can often consider, as the father of the child, the fetus/life they produce isn't dependent upon their actions. Regarding the gendered responsibility of preconception health by males *"It's her duty as a prospective mother"* and *"It's not quite the same for [men] because the fetus/life isn't dependent on the actions of the father of the child".* Gender stereotypes described females as more capable and cautious than males, and the male's role being to support and encourage the female and to provide and protect a healthy environment for the child to be born. Doubt and uncertainty in PCH was expressed less often among males than among females, however, a small proportion of males were still doubtful.

Maas et al., 2022	Perspectives of wishing to conceive pregnancy preparation health and lifestyle involvement	Interview topics – 1) pregnancy intentions, 2) pregnancy preparation, 3) health & lifestyle and 4) involvement.	Some men believed that beneficial pregnancy outcomes were almost solely influenced by the woman and therefore outside their control.
Jackson, 2023	Attitudes on Preconception Counselling	How do African American males perceive preconception counselling in clinical settings?	The perception of preconception counselling in a clinical setting is described by one participant – "African Americans are marginalised. So, they are given less attention during the preconception counselling period". Another participant reflects "Our medical people may not be able to access the same information as compared to other races. Because we know that there is some level of discrimination in accessing that information".

2.5 DISCUSSION

This review describes the beliefs, attitudes and intentions of males regarding preconception health and care and pregnancy planning a reported in peer-reviewed literature. Nine relevant studies were identified, with only two deemed as high quality demonstrating the currently limited evidence base on this topic. The findings of this review can be summarised with reference to three overarching themes: 1) the importance of preconception health and preconception care; 2) paternal preconception behaviours; and 3) Inequalities in Preconception Health and Preconception Care.

A key finding of this review confirms males may not always consider their responsibilities during preconception or the ramifications of their preconception health (40) or feel comfortable consulting with a health professional about preconception. For males from certain ethnic groups, such as African Americans, they may even feel marginalised in contributing to pregnancy planning and preparation. As identified in some of the studies of this review, there appears to be a tendency for males to direct a greater level of responsibility to the female than to themselves regarding preconception health (for example – a male may place greater emphasis on their female partner avoiding smoking or eating healthy during preconception than for themselves). A tendency for males not to share the preconception responsibility with the female and in some cases feel marginalised during preconception care due to their race highlights preconception challenges that currently exist for paternal preconception care. Evidence supporting male preconception beliefs, attitudes, and intentions remains emergent yet is foundational to understanding male preconception behaviours and so is urgently required to understand males' attitudes to adopt behaviour change.

Further findings highlight that males do not always opt for a preconception consultation, and some hold the belief that they already know enough about a healthy pregnancy and therefore do not need a conversation with a health care provider. Preconception research outside this review which addresses paternal preconception knowledge reports similar findings; even when males believe preconception care is important, they are not always aware of their roles and responsibilities before pregnancy and therefore do not intend to consult with healthcare practitioners to optimise their health in preparation for pregnancy (40).

A male's attitudes and intentions toward preconception consultations can be influenced by masculine stereotypes (163) which may consign undue strain and further challenge a male's engagement with preconception health and care leading to disinterest or detachment when

planning a pregnancy (163). In addition, practitioners often lack confidence to discuss preconception issues with their male patients (25). Many males may feel distant and secondary to the pregnancy planning process (200). This this appears to align with the fact they are often not included in preconception and pregnancy planning conversations in clinics (34, 35). Many males may feel distant and secondary to the pregnancy planning process (200). This this appears to align with the fact they are often not included in preconception and pregnancy planning conversations in clinics (34, 35) nor often the focus of much preconception research (33).

Males' belief that they already know enough about a healthy pregnancy and therefore do not need a conversation with a health care provider highlights the urgency of developing preconception health promotion specifically to males (87). Preconception policy and guidelines that directly help increase awareness among men are also required to address knowledge gaps and identify important areas of health behaviour change to support males in effectively contributing to reproductive health beyond fertility (179).

Another notable finding of this review is the understanding amongst males that smoking or drinking excessive amounts of alcohol in the period before pregnancy can adversely affect their sperm quality. This finding aligns with relevant research; alcohol abuse (201) and smoking (202) are associated with poor semen quality, and can influence adverse pregnancy and offspring outcomes This finding aligns with relevant research; alcohol abuse (201) and smoking (193) are associated with poor semen quality, and can influence adverse pregnancy and offspring outcomes (114). The negative health effects of smoking and excessive alcohol are serious public health issues (40, 203, 204) which threaten reproductive health and yet may be effectively addressed by practitioners during preconception consultations. Interestingly, despite the identified understanding of males regarding smoking and alcohol consumption in this review, male current everyday smokers were least likely to intend to engage in preconception health behaviours (193). Smoking and excessive alcohol consumption which can be harmful to reproductive health are still identified behaviours undertaken during preconception by a substantial number of males preparing for fatherhood (205), this may be, in part at least, due to gaps in knowledge regarding preconception health amongst this subgroup of males (40) . Our ability to target these males who continue smoking and/or excessive alcohol consumption during preconception requires further research to explore the experience and perspectives of this subgroup in more depth.

The influence of smoking and excessive alcohol consumption on male health during preconception is comprehensive and can have broader implications which extend beyond

sperm quality and alter various aspects of preconception health, such as the consumption of a healthy diet or the maintenance of a healthy bodyweight, which in turn influence mental health (206, 207), and more broadly social and behavioural determinants of health such as social inclusion, employment, housing, sexual practices, or physical activity (206, 207), and more broadly social and behavioural determinants of health such as social inclusion, employment, housing, sexual practices, or physical activity (2). This review identifies males' attitudes regarding the adverse health effects of behaviours such as smoking and excessive alcohol during preconception, which is the first step to investigating the complexities of preconception behavioural intentions among males. Public health research initiatives aimed at reproductive health must consider further exploration and evaluation of paternal preconception beliefs and attitudes to help strengthen the current evidence base and effectively support the preconception behavioural intentions of males. Such research initiatives will help all providers better understand and support males' participation in health behaviours before conception.

2.5.1 Strengths and Limitations

This review is the first to summarise the current literature pertaining to the preconception behavioural beliefs, attitudes, and intentions specifically for males, it adheres to the PRISMA reporting guidelines and the review registration process and is reinforced by a robust search strategy. However, such strengths must also be considered alongside limitations. Firstly, the review only included studies among generally healthy adult males and did not include males with a diagnosed illness, or disability, or males as health professionals or experts. Further, the studies included in the review were not often deemed good or high quality and some results identified in this review could not be utilised to draw any meaningful conclusions, despite being statistically significant ($\alpha>0.05$), due to extremely wide confidence intervals. Only nine studies were included in this review so consequently the results reported are somewhat unvaried being narrowly focused, mostly sourced within cross-sectional data utilising small samples that report descriptive statistics from North America and Europe.

2.6 CONCLUSION

This systematic review suggests the engagement and approach of many males with regards to their important role in preconception health is far from optimal. Public health promotion, education, policy, guidelines and health services relating to preconception health that explicitly and specifically target males could improve understanding and awareness across all relevant providers and others in positions to better support males to engage in pregnancy planning and preconception health. Further research on the motivations behind paternal

health beliefs and behaviours is needed to inform effective preconception health policy and interventions.

2.7 CHAPTER SUMMARY

This chapter presents a systematic synthesis of evidence, consolidating current research literature on the beliefs and intentions of males regarding pregnancy planning and preconception health and care. The relationship between beliefs and behaviours underscore the role of beliefs and intentions as foundational determinants of health-related actions. Thus, the direct association between paternal preconception health beliefs, intentions, and engagement in preconception behaviours is particularly noteworthy. A total of nine articles were included in this review.

The health beliefs, attitudes, and intentions of males within this review chapter were categorised into three main themes which address the i) importance of preconception health and care, ii) paternal preconception behaviours, and iii) Inequalities in preconception health and preconception care. Although males often acknowledge the significance of preconception health, they may not always recognize or fully embrace their roles and responsibilities in preconception health and pregnancy planning. Consequently, they may assign greater responsibility for preconception health to their female partners rather than themselves. Additionally, males may not consistently reflect on how their health behaviours influence pregnancy outcomes and offspring well-being. These gaps in awareness and engagement have implications for their decision-making processes during preconception, shaping both the health behaviours they adopt—or neglect—and the extent to which they seek preconception health information, if at all.

This review serves a dual purpose: it both informs the structural foundation of this thesis and provides an evidence base for investigating Australian males' engagement in preconception health. As a rigorous systematic review, this chapter contributes to the emerging research landscape on male preconception and pregnancy planning beliefs and intentions, underscoring their potential role as predictors of preconception health behaviours.

3 METHODOLOGY

3.1 OVERVIEW

Presented herein is an innovative project to address the primary research objectives which encompass the preconception health beliefs, behavioural intentions, and the beneficial and risky preconception health behaviours of Australian males. The objectives of this project also extend to examining the preconception health services Australian males utilise and the preconception information they seek. As an exploration of Australian male preconception research conducted within a four-phase design this project utilises three separate data sets to explore proposed public health opportunities as identified within the preconception literature relevant to public health domains i) health policy, ii) health promotion, and iii) health services delivery. The conceptual framework of this project was formulated to address the preconception issues raised in Australian public health policy relevant to male health. The project conceptual framework is supported by the preconception framework reported by Steel et al., (2025) (67) which describes parental motivation, health behaviours change/risk reduction, and improved health outcomes as key underlying factors for the three domains of public health. In addition to the preconception framework reported, this project conceptual framework has refined parental motivation to include pregnancy planning and preconception beliefs and intentions. A rationale and justification for the project methodology are outlined within this chapter below.

3.2 CONCEPTUAL FRAMEWORK

The conceptual framework serves as a foundation for the research undertaken in this thesis, and has been utilised to examine the relationship between paternal preconception health beliefs and behaviours, in the context of preconception health policy, health promotion, and health services use (Figure 3.1). This body of work aims to partly mitigate the complexities and challenges that can present when addressing preconception health research by incorporating the health perspectives and behaviours of Australian males at different stages of preconception.

Figure 3.11 Thesis Conceptual Framework

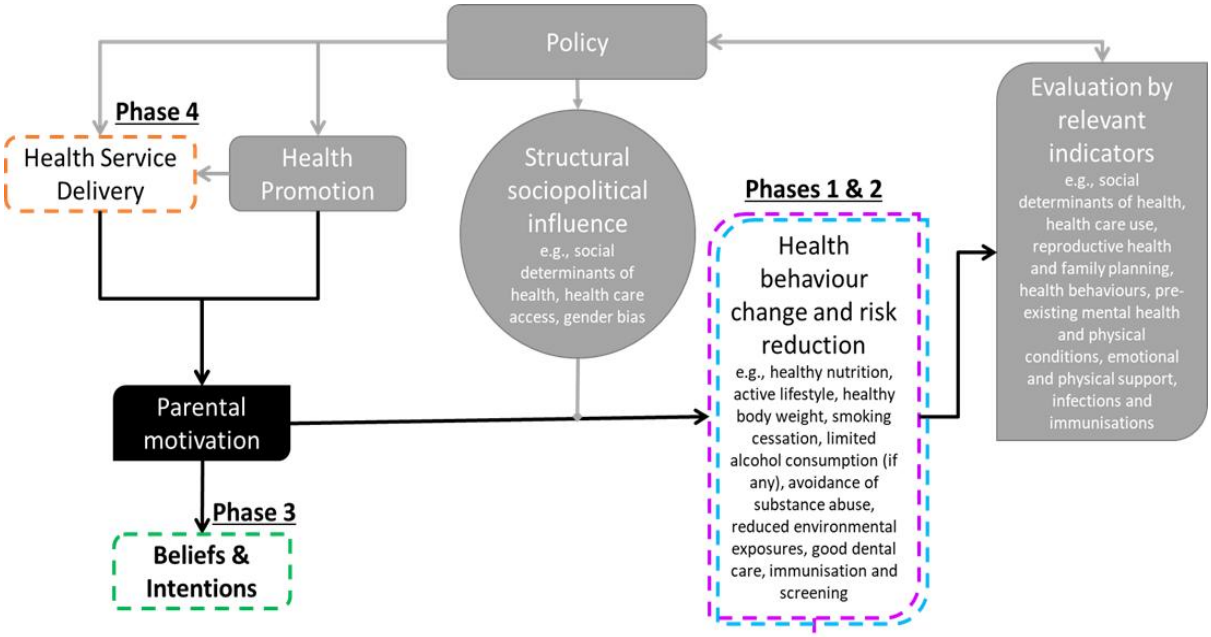


Figure adapted from Steel A, Strommer S, Adams J, Schoenaker D. Preconception health policy, health promotion, and health services to achieve health in current and future generations: a narrative review. BMC Pregnancy and Childbirth. 2025;25(1):188.

The position of preconception health and care in Australian health services delivery and with regards to public health is only emergent as is not yet governed by specific preconception policy or guidelines. Two public health policies relevant to preconception health include i) The National Men's Health Strategy [2020-2030] (37) and ii) the National Preventive Health Strategy [2021-2030] (36). These strategies identify parenthood as an important life stage event, emphasize the significance of improving the prevention of preconception risk factors, and declare preconception health promotion and male reproductive issues across primary care warrant further attention (36, 37). This thesis was modelled upon a preconception health as an overlay of three public health domains i) health policy, ii) health promotion, and iii) health services delivery (67) which overarch underlying factors contained within the framework i) parental motivation (beliefs and intentions) and ii) health behaviour change and risk reduction. To address the project aims and objectives, and to explore the breadth of public health and preconception health opportunities relevant to Australian males, each project phase was formulated based upon the underlying factors aforementioned.

Each of the three public health domains - health promotion, health service delivery, and health policy - are explored in detail throughout the thesis. Health promotion is addressed through male's engagement with preconception health information, and their interactions with health professionals. Similarly, health services delivery is addressed through treatment access, and health services utilisation. As preconception health policy remains

underdeveloped in Australia, it presents both a challenge for policymakers and a promising direction for future research.

3.3 METHODOLOGICAL APPROACH

3.3.1 Data triangulation

Data triangulation is the use of multiple data sources to identify and critically analyse information to establish comprehensive research findings (208). The triangulation of data provides the author with greater insights into the research question (208) and somewhat mitigates project bias by providing findings which are confirmed by more than once source so can be trusted and made generalizable (208). Data triangulation therefore enhances the project's validity and provides credibility to the project findings (209).

Data sources of this project triangulate and connect to represent males within three preconception perspectives i) from the general population, before becoming a father - with or without pregnancy intention, ii) Australian males when planning a pregnancy in the next 12 months, or when currently attempting pregnancy, and iii) Australian males as the reproductive partner of a pregnant female, shortly following preconception. Data triangulation in this project offsets the methodological weaknesses or data inconsistencies in any one of surveys with the strengths of the other surveys (208). By identifying and analysing males from three separate surveys, within three distinct preconception perspectives, the findings of this project can be considered rigorous whereby conflicting findings between surveys can also be identified, interpreted, and explained.

3.3.2 Survey research design

Incorporating survey design into the methodology was utilised to gather readily accessible data regarding paternal health behaviours which provided a fast, easy, and cost-effective method of analysing exposures and outcomes of adult males as the target population. The survey structure enabled data to be obtained across three preconception perspectives from a large sample over a wide geographical distribution in a relatively short period of time (210). Survey instruments could also be administered and completed online by the participants in their own time when they could think about answers and consult records or specific information.

Ethical issues were manageable when using surveys, and researcher bias was limited as participants were exposed to the same questions in the same manner (210). Administering surveys provided participants anonymity which encouraged candid and honest responses

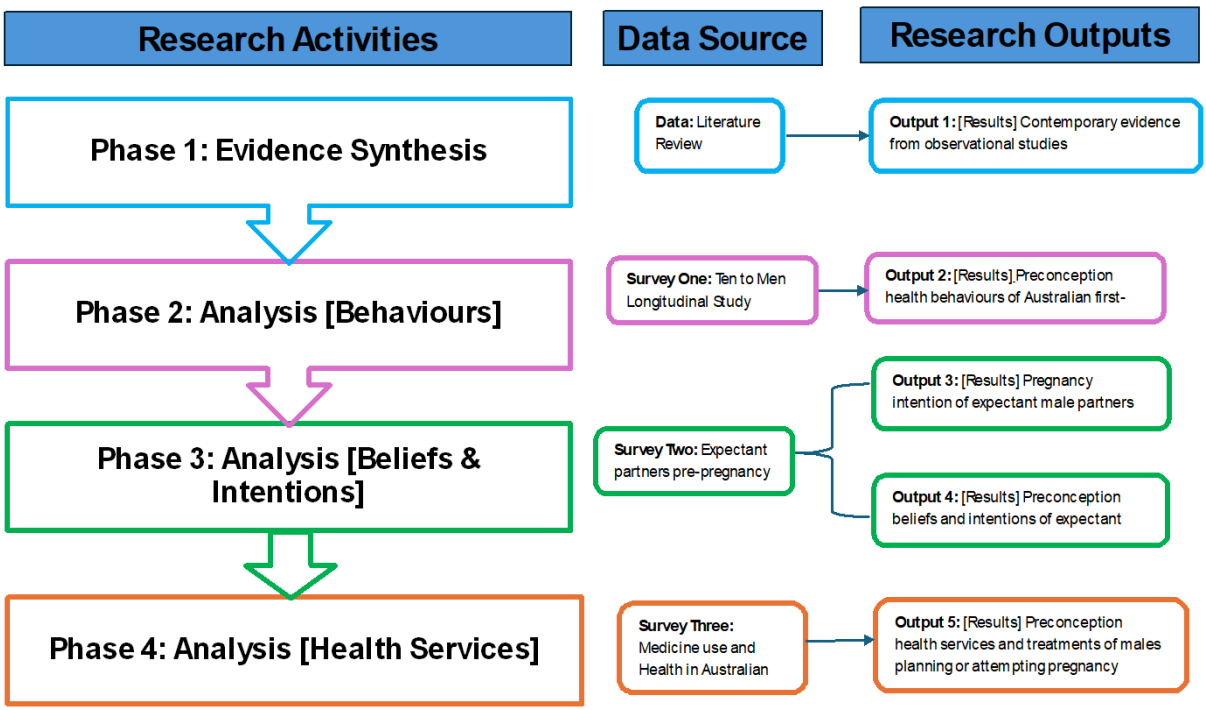
from participants. Further, surveys can be particularly useful for examining characteristics assessed through self-exploration such as attitudes or values (210). A cross-sectional study is considered particularly appropriate for addressing the prevalence of health behaviours in a population (211) which can include men who have future pregnancy intentions or who's partner is currently pregnant. However, design limitations arise with use of a cross-sectional survey, which gathers information at only one point in time and survey designs which obtain data retrospectively so are subject to reporting errors (212).

Cross sectional surveys may require large population based samples sizes to obtain meaningful results, and can be subject to various forms of bias including response bias (213). These limitations were partly offset by the triangulation of all three data sets.

3.4 FOUR PHASE DESIGN

The four phases of this study involved a mix of study designs and sample populations to address the research objectives (see Figure 3.2) (67). Phase 1 synthesised published research evidence to identify modifiable paternal preconception behaviours warranting closer examination in the subsequent phases. Phases 2 to 4 applied secondary analysis of existing survey data to then explore paternal preconception health behaviours, beliefs and intentions, and health service use from the perspective of male's at different stages of preconception planning or experience.

Figure 3.22 Thesis overview flowchart



Three national surveys were identified as pertinent to address the research project aims and objectives as each survey reported a diverse yet relevant array of preconception data from which to explore the health behaviours, beliefs and intentions of Australian males, i.e. each survey collects health and behaviour data from Australian male adults before pregnancy or regarding preconception and pregnancy planning.

i) Ten to Men: The Australian longitudinal study on male health
ii) Expectant partner's pre-pregnancy health information and health behaviours.
iii) National survey of health services utilisation in the Australian population

3.4.1 Phase 1 [Evidence synthesis]

The first phase of this project aims to synthesise paternal preconception literature relevant to health behaviours and modifiable risk factors for adverse pregnancy and offspring outcomes. Exploring factors associated with Australian males engaging in beneficial and risky preconception health behaviours, and how they influence pregnancy and offspring outcomes, provides a foundation from which to broadly scope and begin to investigate their preconception health behaviours.

Results from this analysis will address project objective 2.

3.4.1.1 Literature Review

The first phase of this project incorporated a literature review (chapter 4) to provide further rationale to support paternal preconception health behaviours and to broaden the important foundation of knowledge already presented in chapter two.

An initial review addressing paternal preconception health behaviours and risk factors associated with adverse pregnancy and offspring outcomes is demonstrated as a convincing supporting overview and cohesive collation of literature which builds upon the health beliefs, attitudes, and intentions of males toward pregnancy planning and preconception health care. A literature review design embedded in Phase 1 is sustained by the ability of the research to clearly articulate the research aim and goals and provide evidence of a comprehensive literature overview (214) which communicates relevant results.

3.4.1.1.1 Review – Paternal preconception modifiable risk factors for adverse pregnancy and offspring outcomes: a review of contemporary evidence from observational studies.

3.4.1.1.2 Overview

A systematic review of contemporary evidence from observational studies was conducted to provide a foundation from which to comprehend paternal preconception health behaviours

and their influence on the pregnancy and offspring outcomes. The review aimed to overview the paternal preconception health behaviours and modifiable risk factors that can influence adverse pregnancy and offspring outcomes and was prospectively registered with PROSPERO (CRD42021209994) and followed reporting guidelines set by PRISMA and AMSTAR 2 (REF).

3.4.1.1.3 Search Strategy and Selection

Seven databases were searched; controlled vocabulary and subject headings were utilised when available for each database. Studies were included if they were original observational research which incorporated males in the preconception period and examined an association or correlation of a modifiable risk factor or health behaviour to pregnancy or offspring health outcomes. The male participants located in this review had to identify as the partner of a pregnant women or be the biological father of the child for which the outcomes are being reported.

3.4.1.1.4 Quality Assessment

The Newcastle Ottawa Scale (NOS) was utilised to assess the quality of the studies within this review depending on their classification as a cohort or case-control study. The NOS was developed to allocate a total of nine stars across three domains i) selection of participants, ii) comparability of study groups, and iii) outcome of interest (cohort studies) or exposure (case-control) (215).

3.4.2 Phase 2 [Health behaviours – first time fathers]

Phase 2 is informed by Phase 1 of the project and explores the prevalence of paternal preconception behaviours, and the associated risks such as being overweight, along with the paternal preconception information seeking behaviours of Australian males as preconception relates to i) males in general before becoming a father, and ii) males as reproductive partners of pregnant females. Phase 2 explores the preconception health behaviours of Australian males utilizing one data set, i) Ten to Men, a national longitudinal data set.

Results from this analysis will address project objectives 2, 3, and 4.

Each national survey is outlined in detail below.

3.4.2.1 Survey one– Ten to Men: The Australian Longitudinal Study on Male Health

3.4.2.1.1 Overview

Ten to Men (TTM) is Australia's largest longitudinal study of Australian males which was commissioned by the Australian Government and initiated to build and expand the evidence

base for improving the health of boys and men across the life course. TTM, a longitudinal study involving a cohort of participants aged between 10 and 55 years (216), was conducted over eight years and in four waves, [Wave 1: October 2013 to July 2014, Wave 2: November 2015 to May 2016, Wave 3: July 2020 to February 2021, and Wave 4: 2022-2023] (216), with a capacity to address key preconception health issues and an emphasis on the social determinants of health (217). Ten to Men (TTM) is Australia's largest longitudinal study of Australian males which was commissioned by the Australian Government and initiated to build and expand the evidence base for improving the health of boys and men across the life course. TTM, a longitudinal study involving a cohort of participants aged between 10 and 55 years (216), was conducted over eight years and in four waves, [Wave 1: October 2013 to July 2014, Wave 2: November 2015 to May 2016, Wave 3: July 2020 to February 2021, and Wave 4: 2022-2023] (216), with a capacity to address key preconception health issues and an emphasis on the social determinants of health (217).

This study proposes to explore paternal preconception health and care for Australian males and in doing so it complements the National Men's Health Strategy 2020-2030, which calls for increased attention on both preconception health and fatherhood (37). Key objectives of the strategy include the empowerment of all males over all stages of life, to bolster the capacity of the health system to provide quality care for boys and men, and to generate the evidence base for improving the health of boys and men.

Ten to Men data access was sought and approved by the Ten to Men data manager using the 'Ten to Men Data Access Request Form' which required a detailed project outline, analysis plan, data storage plan, and timeline. Ethical approval to conduct secondary analysis of the Ten to Men data was sanctioned by the University of Technology Sydney (UTS) Human Research Ethics Committee (HREC) ETH24-10077.

3.4.2.1.2 Setting and participants

A stratified multi-stage cluster random sample design was employed to recruit male participants from clusters of geographical locations across Australia (216), approximately 24,000 boys and men were recruited. A stratified multi-stage cluster random sample design was employed to recruit male participants from clusters of geographical locations across Australia (216), approximately 24,000 boys and men were recruited. Participants were chosen by fieldworkers at random who approached households to determine study eligibility. Males aged from 10 years old were eligible for recruitment, but only adult males aged at least 18 years old who reported becoming a father for the first-time in the previous 12 months, in any wave, were considered for analysis.

Participants who completed the survey for wave one were invited to complete the survey for each of the subsequent waves. A separate yet similar questionnaire was provided for each wave.

3.4.2.1.3 Data analysis and management

The proposed analysis of the TTM data set is based upon several TTM survey responses relating to health behaviours and health services utilization of Australian first-time fathers.

The data set for each wave was merged, based upon the unique identifier for each participant, to create a final data set which included the variables from all four waves. Binary variables were created from categorical variables to identify males who had reported being a first-time father (yes,no). Frequencies and proportions for variables of interest were reported according to being a first-time father. Mean and standard deviation was reported for continuous variables with t-tests applied to test for statistical differences. The statistical differences for categorical variables were reported using a chi-square test with α-value set ≤ 0.05.

Backwards stepwise logistic regression was used to identify the most parsimonious model for predicting the characteristics of Australian first-time fathers.

The age variables from each wave were continuous and also reported as categorical which clustered participants as 18 to 24 years, 25 to 34 years, 35 to 44 years, 45 to 55 years, and greater than 55 years. The region of birth variable was collapsed to be consistent with world regions; ‘North-West Europe’, ‘Southern’ and ‘Eastern Europe’ into a EUROPE category; ‘South-East Asia’, ‘North East Asia’, ‘Southern and Central Asia’ into ASIA category; ‘North Africa’ and the ‘Middle East’ and ‘Sub-Saharan Africa’ into AFRICA & MID EAST category. The Employment status variable was collapsed with the ‘Full-Time’, ‘Part-Time’, Self-Employed’, and ‘Employed -unpaid worker’ options combined into an ‘Employed’ category. The highest qualification variables were collapsed to combine the responses ‘trade certificate’, ‘non-trade certificate’, ‘Associate diploma’, ‘undergraduate diploma’ into a ‘vocational education’ category and the ‘Bachelor degree’, ‘masters degree’, and ‘Doctorate’ into a ‘University degree or higher’ category. The Aboriginal variable combined responses to analyse both Aboriginals and Torres Strait Islanders in a single category. Home ownership variables combined all responses into three categories which differentiated individuals as owners, renters, or others. Household income was collapsed into the three main income thresholds based upon the low (bottom 18%), medium, and high-income levels (top 20%) as outlined by the Australian Bureau of Statistics when reporting household income and wealth (218). Household income was collapsed into the three main income thresholds based upon

the low (bottom 18%), medium, and high-income levels (top 20%) as outlined by the Australian Bureau of Statistics when reporting household income and wealth (218).

Alcohol consumption is reported based upon the guidelines recommended by the Australian Government of no more than 4 standard drinks on any one day (219). Sleep is reported based upon the recommendations from the Australian Institute of Health and Welfare being between 7 to 9 hours per night (220). Fruit and vegetable serves were reported based upon meeting the recommended daily intakes as determined by the Australian Dietary Guidelines (221), being 2 serves of fruit and 5 serves of vegetables per day. Sitting or sedentary time was reported based upon the recommendations by Safe Work Australia of no more than 7 hours per day (222). The physical activity and exercise guidelines for all Australians was the point of reference for moderate activity of at least 2.5 hours per week and/or vigorous physical activity of at least 1.25 hours per week (223). Alcohol consumption is reported based upon the guidelines recommended by the Australian Government of no more than 4 standard drinks on any one day (219). Sleep is reported based upon the recommendations from the Australian Institute of Health and Welfare being between 7 to 9 hours per night (220). Fruit and vegetable serves were reported based upon meeting the recommended daily intakes as determined by the Australian Dietary Guidelines (221), being 2 serves of fruit and 5 serves of vegetables per day. Sitting or sedentary time was reported based upon the recommendations by Safe Work Australia of no more than 7 hours per day (222). The physical activity and exercise guidelines for all Australians was the point of reference for moderate activity of at least 2.5 hours per week and/or vigorous physical activity of at least 1.25 hours per week (223).

Some variables with five or more responses were collapsed to (a) compare daily or regular health behaviours with other less frequent behaviours and to (b) simplify understanding - for example degree of difficulty e.g. combine ‘quite easy’ & ‘very easy’ into an ‘easy’ category. The variable alcohol frequency in the previous 12 months was collapsed from an eight-point scale to a three-point scale to identify consumption 1) everyday, 2) at least once a week, and 3) once a month or less frequently. Responses for the variables relating to health literacy were also reported from five categories into three categories 1) Cannot do, 2) Difficult, and 3) Easy. Responses related to medications were abridged from a from a 6-point scale to a 3-point scale; 1) daily or almost daily, 2) weekly or monthly, 3) Never.

3.4.2.1.4 Survey instrument

A separate survey instrument was administered for each Ten to Men wave, four in total. Each wave included a survey with some variation to the previous survey. Variables from the Ten to Men surveys that were identified as relevant to paternal preconception and were

consistently reported across at least two waves were considered into the analysis. Variables of interest extracted from survey and finally included in the analysis are tabulated below.

Description of Variables	***Wave 1***	***Wave 2***	***Wave 3***
Use of health services			
Consultation with health care professionals	**YES**	**YES**	**YES**
GP checkups (Frequency)	**YES**	**YES**	**YES**
Private health insurance	**YES**	**YES**	**YES**
Reasons for not getting healthcare	**YES**	**YES**	**YES**
Health literacy	--	**YES**	**YES**
Item 36 – Can make healthcare providers understand my problems	--	**YES**	**YES**
Item 38 – Can discuss health concerns with a healthcare provider	--	**YES**	**YES**
Item 41 – Have a good discussion about your health with doctors	--	**YES**	**YES**
Item 49- Can discuss things until you understand all that you need to	--	**YES**	**YES**
Item 54 - Can ask questions to get the health info that you need.	--	**YES**	**YES**
Item 48 - Ease of getting health info you understand	--	**YES**	**YES**
Home and work life			
Employment status	**YES**	**YES**	**YES**
Home ownership	**YES**	**YES**	--
Combined household income	**YES**	**YES**	**YES**
Highest qualification completed	**YES**	**YES**	**YES**
Your lifestyle			
Moderate physical activity (time spent – minutes)	**YES**	**YES**	**YES**
Vigorous physical activity (time spent – minutes)	**YES**	**YES**	**YES**
Sitting time on usual workday/non workday	**YES**	**YES**	**YES**
Fruit serves (per day)	**YES**	**YES**	**YES**
Vegetables serve (per day)	**YES**	**YES**	**YES**
Current smoker (Yes-No)	**YES**	**YES**	**YES**
Cigarette/day	**YES**	**YES**	**YES**
Smoking (past 4 weeks)	**YES**	**YES**	**YES**
Alcohol - frequency (past 12 months)	**YES**	**YES**	**YES**
Alcohol – stand drinks (per day)	**YES**	**YES**	**YES**
Sleep (hrs/night in last week)	--	**YES**	**YES**
Marijuana use	**YES**	**YES**	**YES**
Health and Wellbeing			
Health conditions	**YES**	**YES**	**YES**
Height [Body Mass Index (BMI)]	**YES**	**YES**	**YES**
Weight [Body Mass Index (BMI)]	**YES**	**YES**	**YES**
Serious injury, illness or surgery (in the past 12 months)	**YES**	**YES**	**YES**
Limited by the effects of an injury	**YES**	**YES**	--

3.4.3 Phase 3 [Health behaviours, beliefs & intentions – Expectant partners]

The first two project phases identify three core preconception health behaviours of Australian males which have influence on their body composition/weight and on their pregnancy and offspring health outcomes, and are relevant to pregnancy intention i) Regular exercise, ii) Alcohol excessiveness/avoidance, and iii) Nutrition or consuming a healthy diet.

Phase 3 of this project explores parental motivators as an overarching concept to address the pregnancy planning and preconception beliefs and intentions of Australian males. The third project phase explores preconception beliefs and intentions as an underlying factor to the health behaviours of males who are the reproductive partners of a pregnant female. Phase 3 utilizes the Theory of Planned Behaviour to explore the interconnection between Australian males' beliefs, subjective norms, and behavioural control and how they converge to inform their behavioural intentions to undertake the three core preconception health behaviours identified from Phases 1 and 2.

Results from this analysis will address project objectives 1,2, 3, and 5.

3.4.3.1 Survey Two- The expectant partner's pre-pregnancy health information and health behaviours survey.

3.4.3.1.1 Overview

The 'expectant partner's pre-pregnancy health information and health behaviours' survey was designed to explore the preconception beliefs, attitudes, and behaviours of the reproductive male partners of pregnant women (expectant partners). The expectant partners survey was completed online with an approximate duration of 30 minutes. An incentive was provided to participate, a random prize draw of $100. All participation was voluntary. Understanding was that English was well understood by all participants.

Ethics approval was obtained from the University of Technology Sydney (UTS) Human Research Ethics Committee (HREC) (ETH20-4726) to conduct secondary analysis of the Expectant partners survey.

3.4.3.1.2 Setting and participants

Participant recruitment was conducted using targeted advertising on social media platforms (i.e. Instagram, Facebook, Twitter) between December 2020 and September 2021. Any individual who met the study eligibility criteria and consented to participate was able to complete the survey via an online survey platform Qualtrics™.

Participants provided an email address to access the survey whereby being initially screened to ensure they met the eligibility criteria and to provide informed consent to participate in the survey. Consent to participate was obtained once the participant read, understood, and agreed to the eligibility criteria and preliminary survey information. Preliminary survey information included the research team and contact details for any questions, concerns, or complaints, an explanation of the research topic and research process, a summary of the time and effort involved for the participant if they participate, an explanation of any risks, and clarification as to the confidentiality and anonymity of the survey. Once consent was obtained, and a valid email address, a survey hyperlink was sent. Survey completion took approximately 30 minutes. Participants had up to 14 days to complete the survey. Participants were also recruited through their female reproductive partners and targeted using advertising on social media platforms whereby the pregnant women was sent an email with a separate hyperlink to be passed onto her partner.

Survey participants included a convenience sample of male expectant partners who were aged 18 to 49 years old, where their female partner is at any stage of pregnancy and living in Australia (n=146).

3.4.3.1.3 Survey instrument

A 92-item survey was initially developed in paper-based format and tested by three individuals who matched the eligibility criteria of the target population. Following minor edits based upon feedback, the survey was uploaded into Qualtrics™ and retested for functionality and usability prior to finalisation (168). This final survey entitled *The Expectant Partner's Pre-pregnancy Health Information and Health Behaviours survey* was developed concurrently alongside a survey instrument designed for pregnant women to retrospectively explore expectant partners preconception health, health behaviours, beliefs, attitudes, and intentions (Appendix 3.1). A 92-item survey was initially developed in paper-based format and tested by three individuals who matched the eligibility criteria of the target population. Following minor edits based upon feedback, the survey was uploaded into Qualtrics™ and retested for functionality and usability prior to finalisation (168).

Five sections and 80 items comprise the survey which is detailed in sections below.

The survey includes preliminary and closing questions (4-items) to confirm consent (yes, no), provide the date, and address any post survey comments.

Section 1 - "About you" [sociodemographic information] (15-items);

Section 2 - "Your current pregnancy" [retrospective assessment of pregnancy planning incorporating the London Measure of Unplanned Pregnancy] (172) (12-items); Section 2 -

“Your current pregnancy” [retrospective assessment of pregnancy planning incorporating the London Measure of Unplanned Pregnancy] (172) (12-items);

Section 3 - “Your health behaviours” [preconception health behaviours and history] (31-items),

Section 4 - “Pregnancy health information and care” [knowledge on the importance of preconception health, the content of preconception care, and the sources of this information (10-items);

Section 5- “Your health history” [health and pregnancy history] (8-items)

3.4.3.1.4 Data Analysis and Management

3.4.3.1.5 Health Behaviours

Pregnancy intention was evaluated utilizing the London Measure of Unplanned Pregnancy (LMUP) for women’s partners (172). The LMUP scoring guide was followed for analysis (224). Technical complications with the online survey hindered the last question of the LMUP which did not allow the selection of multiple items but only one item. As a result, the maximum score awarded for this question is 1 instead of the standard maximum of 2. Two participants had a single missing value in one LMUP variable and were excluded from the analysis; imputation was not considered. Based upon the LMUP scoring, new categorical variables were generated as ‘Planned’ (10 or 11), ‘Ambivalent’ (between 4 and 9), or `Unplanned’ (3 or less) (172).

Chi-square tests were used to examine differences between males with planned pregnancy and those with ambivalent or unplanned pregnancy based upon sociodemographic and health-related characteristics; $\alpha < 0.05$ was statistically significant. Binary variables were generated from categorical variables to identify LMUP scoring as planned (1) or ambivalent/unplanned (0). Binary variables (yes,no) were created from categorical variables for the preconception health behaviours, 1) following a weight loss diet, 2) getting tested for sexually transmitted infection, 3) visiting a dentist, 4) checking immunization status, 5) undergoing surgery to help lose weight, and for 6) preconception supplements used before pregnancy.

Effect size was measured using Cramer’s V. Results for Cramer’s V range between 0 and 1 with greater values indicative of stronger associations between variables; > 0.25 equals a very strong association, > 0.15 equals a strong association, > 0.10 equals a moderate association, > 0.05 equals a weak association and > 0 equals a very weak association (225).

3.4.3.1.6 Beliefs and intentions

Descriptive statistics were used to report preconception beliefs and intentions towards preconception care.

The constructs within the Theory of Planned Behaviour (TPB) were utilized to determine participant behaviours, beliefs, attitudes, and intentions, which were controlled by norms and subjective norms, and reported on a seven-point scale with 0 being the least favourable outcome.

Structural Equation Modelling (SEM) was utilized to analyse the survey items according to the TPB. There was initial difficulty in achieving convergence and sub-optimal model fit, which was overcome by utilizing an item parcelling strategy for SEM, combining items into 'parcels' for estimating the latent variables (226). Issues with model fit remained for the healthy diet variables and was overcome by using observed data and a path model rather than a latent variable, as was expressed for regular exercise and alcohol avoidance

A path model for the healthy diet variables incorporated two constructs of the TPB with a single response. For the remaining constructs, a single item was identified for the path model to be finalised. For the belief construct, arguably, rating the importance, pleasantness, or morality (being good/bad) did not provide a true representation of healthy eating beliefs. Participant beliefs regarding eating healthy were best portrayed by their understanding of the link between their own health and the health of their children i.e. the likelihood (extremely likely/unlikely) that eating a healthy diet 6 months before their partner's pregnancy will sustain a healthy child. For the intentions construct, stating intention explicitly may not result in the most accurate determination of the intention to eat healthy. To report intention accurately, a subtle approach was required whereby participant reluctance to report intentions was reduced while maintaining the connections made by participants to their own efforts to eat healthy. For the control construct, rating the confidence that a participant must eat healthy provided a greater significance for a control mechanism than the participant simply affirming that to eat healthy is their prerogative. For the subjective norms construct, both the reproductive partner and the health care provider were selected as the most influential individuals regarding the diets of males during preconception.

Specific demographic survey items with numerous responses (for example - education, employment, relationship, and financial manageability) were re-coded whereby responses to categorical variables were collapsed for ease of reporting. The variable `Highest qualification' was collapsed from a seven-point scale to a four-point scale ultimately identifying participants completing 1) up to year 10, 2) year 12 or equivalent, 3) vocational education (trade/apprenticeship/certificate/diploma), or 4) university degree or higher. The

variable employment status was collapsed to combine the 'looking for work' and 'not in the paid workforce' options into a single 'not currently working' option. The categorical variable `relationship status' was collapsed from a five-point scale to a four-point scale ultimately identifying if participants were 1) married, 2) de facto 3) not currently in a relationship or 4) other. Also, the categorical variable financial manageability combined the responses `It is impossible' and `It is difficult all the time' to a single response category.

BMI was calculated in STATA utilizing participant weight and height and classified according to the BMI classification percentile and cut-off points (227). BMI was calculated in STATA utilizing participant weight and height and classified according to the BMI classification percentile and cut-off points (227).

3.4.4 Phase 4 [Health services – Males planning or attempting pregnancy]

The fourth and final phase of the project addresses health services delivery as one possible setting to provide care and support for future parents. The fourth project phase addressed paternal preconception health services utilisation and treatments of Australian males when planning a pregnancy in the next 12 months, or when currently attempting pregnancy.

Results from this analysis will address project objectives 3, 4, and 5.

3.4.4.1 Survey Three – National survey of health services utilisation in the Australian Population

3.4.4.1.1 Overview

An online cross-sectional survey administered to Australian adults representative of the Australian population in respects to gender, age, and state of residence (N=2,569) (228) (Appendix 3.2). In addition, this survey also identifies individuals who are currently attempting pregnancy (QID16) or plan for their partner to become pregnant in the next 12 months (QID17). The survey was voluntary and administered online in approximately 30 minutes with a small financial incentive offered for participation.

Ethics approval was obtained from the University of Technology Sydney (UTS) Human Research Ethics Committee (HREC) (ETH22-7632) to conduct secondary analysis of the survey data.

3.4.4.1.2 Setting and participants

Survey participants were recruited through purposive convenience sampling from the Qualtrics™ database where they had registered to participate in research. Informed consent, recruitment, and data collection occurred online through Qualtrics™ between 4 February and

18 February 2022. Informed consent was obtained following the survey participant having read, understood, and agreed to the eligibility criteria and preliminary survey information (Appendix 3.2).

The survey sampled Australian adults (n=2,564) which was refined to survey participants who completed the questions regarding gender and age (92%;n=2,354). The final sample of participants were those who identified as male and were aged at least 18 years old but not greater than 55 years old (n=507) who were currently attempting pregnancy (n=36) or planning a pregnancy in the next 12 months (n=66). All consenting individuals who met the criteria were able to complete the survey.

3.4.4.1.3 Survey instrument

The survey consists of 63 questions spanning 5 domains including demographics (n=11), health and wellbeing status (n=20), health service utilization (n=16), patient experiences of care (n=10) and disclosure of medicines (n=6). A survey reporting various aspects of health and health behaviours including any diagnosed health conditions, use of health products or services and patient experiences (103).

The survey covers health and health conditions – i) Diabetes [type 1 diabetes mellitus (1), non-insulin dependent diabetes (2), insulin-dependent diabetes (3)], Cancer [cancer (benign) (4), cancer (malignant)] (5)], Cardiovascular [heart disease (6), hypertension (high blood pressure) (7), dislipidaemia (high cholesterol/triglycerides) (8)], COVID-19 (9), chronic fatigue syndrome/myalgic encephalomyelitis (19), fibromyalgia (20), migraine (59), an autoimmune condition (21), Arthritis and musculoskeletal [osteoarthritis (34), other musculoskeletal condition (35)], asthma (36), Respiratory conditions [bronchitis (37), other respiratory condition (38)], Male reproductive conditions [benign prostatic hyperplasia (enlarged prostate), other male reproductive health condition (43)], Gastrointestinal conditions [irritable bowel syndrome (IBS) (44), inflammatory bowel disease (Chron's, ulcerative colitis) (45), coeliac disease (46), gastrooesophageal reflux disease (GERD/GORD) (47), chronic constipation (48), other gastrointestinal condition (49)], Nervous disorders [mood disorder (e.g. depression) (50), anxiety disorder (51), sleep disorder (52)], Mental Health [substance use disorder (53), schizophrenia of other psychotic disorder (54), other mental health condition (55)], other long-term health condition (please specify) (56).

Variables also covered in the survey include treatments used in the previous 12 months [prescription-only pharmaceuticals (1), over-the-counter pharmaceuticals (2), Chinese herbal medicines (3), Western herbal medicines (4), vitamin/mineral supplements (5), yoga practice (6), tai chi or qi gong practice (7), relaxation techniques/meditation/mindfulness practice (8).

Frequency of visits to a health professional in the previous 12 months [general practitioner (1), specialist doctor (2), hospital doctor (3), pharmacist (4), counsellor or other mental health worker (5), community nurse/nurse practitioner (6), physiotherapist (7), chiropractor (8), dietician (9), osteopath (10), massage therapist (11), acupuncturist (12), naturopath (12), Western herbalist (13), traditional Chinese medicine practitioner (14), homeopath (15), yoga teacher (16), Other – please specific (17).

3.4.4.1.4 Data Analysis and Management

Survey data was imported into STATA17 statistical analysis software (229), prepared, and cleaned by the research team in preparation for analysis.

Binary variables were generated from categorical variables to report males from the data set who were in the preconception period either i) currently attempting pregnancy (yes, no) or ii) planning pregnancy in the next 12 months (yes, no).

Descriptive analysis was used to identify frequencies and proportions for all variables of interest including preconception health conditions, preconception treatments, and preconception health services utilised. Statistical differences between males currently attempting or planning pregnancy in the next 12 months were explored using chi-square tests with α-value <0.05 deemed to be statistically significant. Cramer's V was utilised to determine the effect size of any statistically significant results. Results for Cramer's V range between 0 and 1, greater values indicate stronger associations between variables; > 0.25 equals a very strong association, > 0.15 equals a strong association, > 0.10 equals a moderate association, > 0.05 equals a weak association and > 0 equals a very weak association (225). Results for Cramer's V range between 0 and 1, greater values indicate stronger associations between variables; > 0.25 equals a very strong association, > 0.15 equals a strong association, > 0.10 equals a moderate association, > 0.05 equals a weak association and > 0 equals a very weak association (225).

3.5 CHAPTER SUMMARY

The conceptual and methodological foundation of this thesis has been implemented to ensure alignment with its aims and objectives, thereby facilitating a coherent research narrative and the presentation of valid and credible findings. Methodological rigor is upheld through the analysis of three distinct data sets, reinforcing the study's integrity via data triangulation.

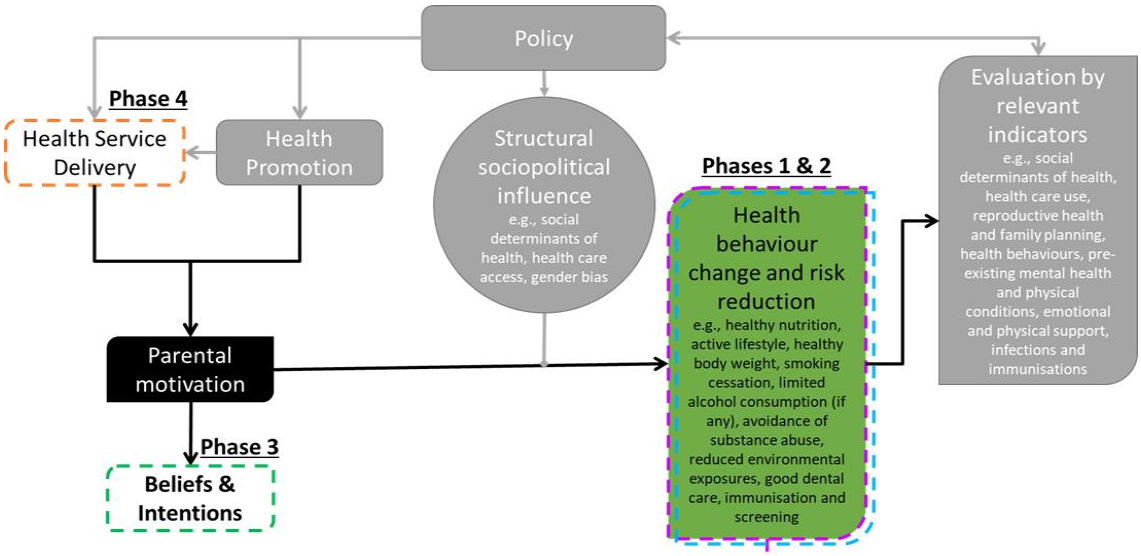
This research follows a four-phase approach within a preconception conceptual framework, which proposes that health improvements occur at the intersection of (i) health policy, (ii) health promotion, and (iii) health service delivery. Within this framework, the health service delivery domain has been designated as a focal point for the thesis, serving as a reference for preconception research within this project. Each phase of the study represents a fundamental aspect of health service delivery, embedded within the broader framework and further supported by overarching considerations of preconception health promotion and policy.

4 PATERNAL PRECONCEPTION MODIFIABLE RISK FACTORS FOR ADVERSE PREGNANCY AND OFFSPRING OUTCOMES

4.1 RATIONALE FOR THIS ANALYSIS

The rationale for the analysis conducted within this chapter aligns with the second research objective which is to identify the prevalence of clinically relevant preconception health behaviours of Australian males. The determination to incorporate a review of literature as the first phase of this project was to provide an evidence-based rationale to support exploring paternal preconception health behaviours and to broaden the important foundation of knowledge already presented in chapter two.

The content of this chapter and its relevance to the project conceptual framework is highlighted in green below.



The results presented in this chapter are published in works as detailed below:

Carter T, Schoenaker D, Adams J, Steel A. Paternal preconception modifiable risk factors for adverse pregnancy and offspring outcomes: a review of contemporary evidence from observational studies. *BMC Public Health*. 2023;23(1):509.

A copy of the full published article can be viewed in Appendix 4.1.

4.2 INTRODUCTION

Preconception care is defined as the provision of health interventions (behavioural, social, and/or biomedical) to women and couples prior to conception (181). It addresses the transgenerational opportunity of enabling and optimizing health while limiting risk factors associated with both short- and long-term adverse health outcomes for women, men, and their children. There is global consensus on the key aspects of preconception care (136), yet a consistent definition and clear attributes of the preconception population remain elusive (182). Preconception research predominately focuses on maternal modifiable risks or health behaviours associated with offspring outcomes (26) as demonstrated by a scoping review of preconception health behaviours which found only 11% of all studies included paternal modifiable risks or health behaviours (33). Nonetheless, the research community recognizes the father or male partner's contribution to child health and development before birth (87, 230) and the need to balance our gaze on men in preconception care (41). This is further supported by the increasing number and diversity of publications about paternal preconception health (231) and formulation of the Paternal Origins of Health and Disease (POHaD) model (18). As such, the preconception population may include all reproductively aged individuals in a period from their birth to the conception of their (or their partner's) pregnancy. The care provided during this period must respond to a clear set of identified risk factors and exposures as relevant to each individual.

Indeed, when planning parenthood, males find themselves within a contentious grey zone; concurrently involved while also considered an outsider (179). A recent survey in the UK found that men are interested in engaging in positive preconception health behaviours (87). Of the over 500 men surveyed, 19% had visited a primary health provider for preconception health advice, and those who had received advice were more likely to adopt positive health behaviours before their partner's pregnancy. On the other hand, general practitioners (GPs) report low confidence in their knowledge about paternal preconception health care and modifiable factors affecting male fertility (132, 232). They describe feeling apprehensive or even sensitive to the subject matter and/or challenged by navigating the stereotypical masculine predispositions toward fertility and preconception care (25). In general, preconception risks are not raised by GPs with male patients unless subfertility is involved and preconception discussions are often encumbered by numerous impediments including the limited time, financial constraints, and knowledge of GPs, plus in some cases, a lack of GP motivation and perceived need for health care (132). A systematic review of preconception care guidelines found that six of the 11 guidelines included provided preconception care guidance for men (34). Only one guideline, a position paper from the American Academy of Family Physicians, contained a dedicated section outlining

recommendations on preconception interventions for men (233). Evidently, there is an unmet need for health professionals, and men, to readily access current relevant information regarding paternal preconception health exposures and outcomes, informing clinical practice and directing health decisions. (233).

Evidence supporting paternal preconception care considers males contribution to child health and development before conception via direct (genetic and epigenetic contributions – health and lifestyle behaviours, exposure to environmental toxins, life stressors, and neuroendocrinology) and indirect pathways (the couple's relationship, and the influence of men on their partner's health and health behaviours) (234). Yet, there is a stark contrast between the magnitude of research investigating maternal preconception health risks - including body composition, lifestyle behaviours, and diet/nutrition – and the relative scarcity of research attention directed towards understanding paternal health exposures and outcomes. In direct response, this systematic review aims to advance paternal preconception research by synthesising the current evidence on associations of modifiable paternal preconception health behaviours and risk factors with pregnancy and/or offspring outcomes. (234).

4.3 METHODS

This review was prospectively registered in PROSPERO (Registration Number: CRD42021209994), and reported in line with PRISMA 2020 guidance (188) and the AMSTAR 2 critical appraisal tool (189).

4.3.1 Search Strategy

A search was conducted on January 5th 2023, (Appendix 4.2 Search Strategy), through the following databases: 1) Medline (OVID) 2) Embase (OVID), 3) Maternity and Infant care [MIDIRS] (OVID) 4) CINAHL (EBSCO), 5) PsycINFO (EBSCO), 6) Scopus, & 7) ISI Proceedings. For each database, a date limit of 2012-2023 was set. When available, subject headings identified from the controlled vocabulary of each database were also included in the search. On January 11th 2023, a Google Scholar search was conducted for the search term 'Paternal preconception', applying the filter to limit articles published since 2022 and searching through to page seven, identifying any other recently published relevant papers. Google Scholar was also used to identify relevant studies citing each included paper. Reference lists of each included paper were then checked for additional relevant studies.

4.3.2 Selection criteria

Papers were included if they were original contemporary observational research (cross-sectional, cohort or case-control study designs) involving males in the preconception period, examining an association or correlation of a modifiable risk factor or health behaviour to pregnancy and/or offspring health and developmental outcomes. The male participants must identify as being the partner of the pregnant women and/or the biological father of the child for which pregnancy and offspring outcomes were reported (Table 4.1 – PICO).

Table 4.1 PICO Inclusion Criteria

Population	Intervention/Exposure	Comparison	Outcome
Males who identified as being the partner of the pregnant women and/or the biological father of the child for which outcomes were reported.	Exposure to modifiable risk factor(s) in the preconception period.	No exposure to modifiable risk factor(s) in the preconception period (or comparison group as defined by individual studies).	Adverse pregnancy and offspring outcomes.

Observational study designs are generally utilized to identify correlations and establish findings at the population level hence are solely considered in this review.

Papers were excluded if they were: reviews, did not report new empirical findings from original studies (i.e. commentaries, opinion-pieces and editorials), not studying humans, not examining male parent exposures, did not differentiate between maternal and paternal preconception exposures, or if the exposure examined specific illness populations. Papers were also excluded when the exposure was not assessed or retrospectively recalled during the preconception period, the outcome was not related to pregnancy or offspring health or development, or the risk factor or health behaviour was not modifiable. Google Translate was used to decipher any studies located in languages other than English.

4.3.3 Data extraction

Papers were imported into Covidence systematic review software (190), and duplicates removed by automation. Titles and abstracts were screened by TC, AS and DS. Full-text articles were obtained for relevant studies and reviewed based on inclusion criteria by TC who then extracted data from each included paper. AS or DS randomly reviewed the extracted data of ten included studies for accuracy and completeness. Any conflicts were resolved by consensus.

Data extracted from each paper included: the authors and year, study design and duration, location, the preconception population, total number of participants, the paternal exposures (and exposure measures), paternal outcomes (and outcome measures), any covariates considered and the main results from each association reported.

4.3.4 Quality assessment

The quality of each paper was assessed by TC using the Newcastle-Ottawa Scale (NOS). The NOS comprises three domains 1) selection of participants, 2) comparability of study groups, and 3) outcome of interest (cohort studies) or ascertainment of exposure (case-control studies), assigning stars in each domain to a maximum of nine stars (215).(215). Papers were then categorized as good quality (7-9 stars), fair quality (4-6 stars) or poor quality (0-3 stars) using groupings employed in previous research (111).

A meta-analysis was considered, but not possible due to exposure and outcome heterogeneity.

4.4 RESULTS

A total of 65 papers were included in this review (Figure 4.1 – PRISMA) (188), comprising cohort (n=56) and case control studies (n=9) (Table 4.2 – Summary Table) & (Table 4.3 – Summary Table Findings). The majority of papers were conducted in the USA (n=18), Europe and the UK (n=19), and China (n=17), several papers were from Australia (235-241) or included an Australian health centre (242-246). Approximately half of all papers (n=29) included a sample size between 370 and 2,900, while others included > 20,000 (n=11) or ≤ 200 participants (n=13).

Study participants were diverse consisting of couples either intending pregnancy or pregnant (n=25), sub-fertile and seeking fertility treatment undergoing IVF/ICSI (n=11), or mothers and fathers of infants (n=26). Two studies included adolescents followed into parenthood as adults (247, 248), and one study included individual respondents of a national family growth survey, actively attempting pregnancy (249).

Modifiable preconception risk factors and/or health behaviour exposures examined include paternal body composition (n=25), alcohol intake (n=6), cannabis use (n=5), physical activity (n=2), smoking (n=20), stress (n=3), and nutrition (n=13) (including dietary folate intake and consumption of foods and dietary patterns). Two papers investigated multiple exposures (247, 250).

Outcomes examined include fecundability (n=6) (249, 251-259), (time to) pregnancy (n=4) (260-268), IVF/ICSI ongoing pregnancy (n=1) (247, 250, 269-277) or live birth (n=7) (235, 236, 242, 278, 279), offspring birthweight or adiposity (n=10) (237, 243-246, 280), including small for gestational age [SGA] (238-241, 281, 282), neonatal (n=1) (235, 283, 284) and offspring body composition (n=4) (236, 242, 278, 279).(236, 242, 278, 279). Other outcomes examined include offspring asthma (n=4) (237, 243, 245, 280) and lung function (n=2) (244, 246), childhood leukemia (n=4) (238, 241, 281, 282), childhood brain tumours (n=2) (239, 240), and offspring behavioural issues (n=2) (283, 284). (237, 243, 245, 280).

There was an increasing number of papers identified for inclusion in this review with the least number of papers published in 2012 and the greatest number of papers published in 2022 (see Figure 4.2).

Figure 4.1 PRISMA flow chart

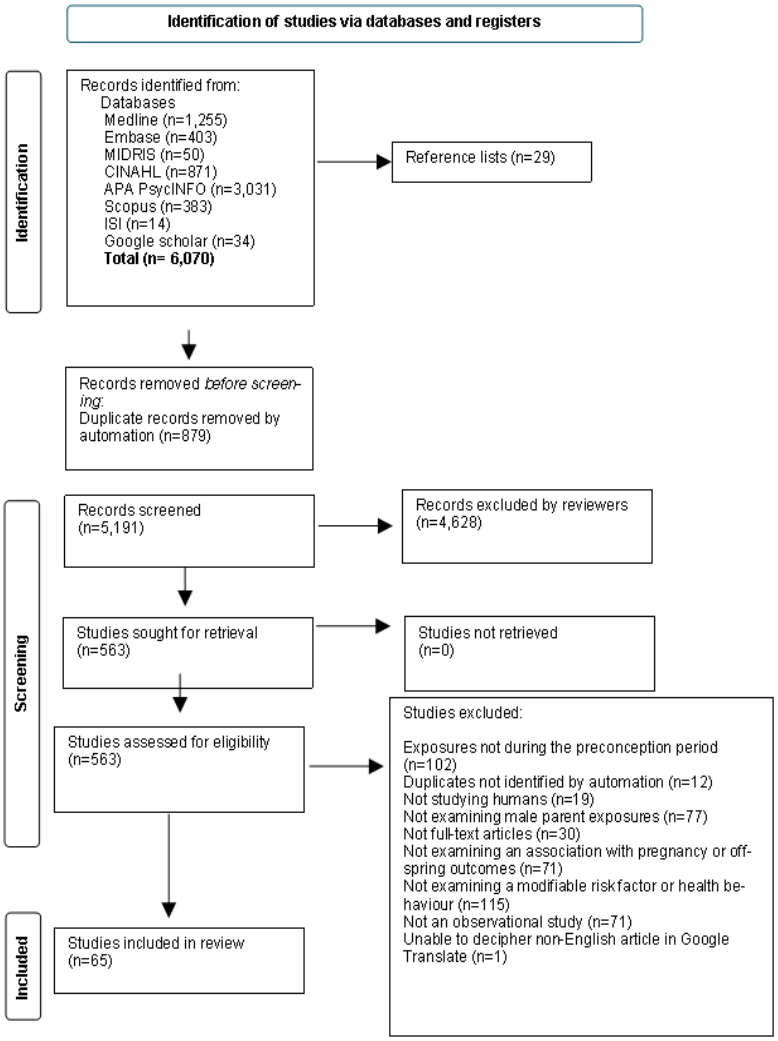
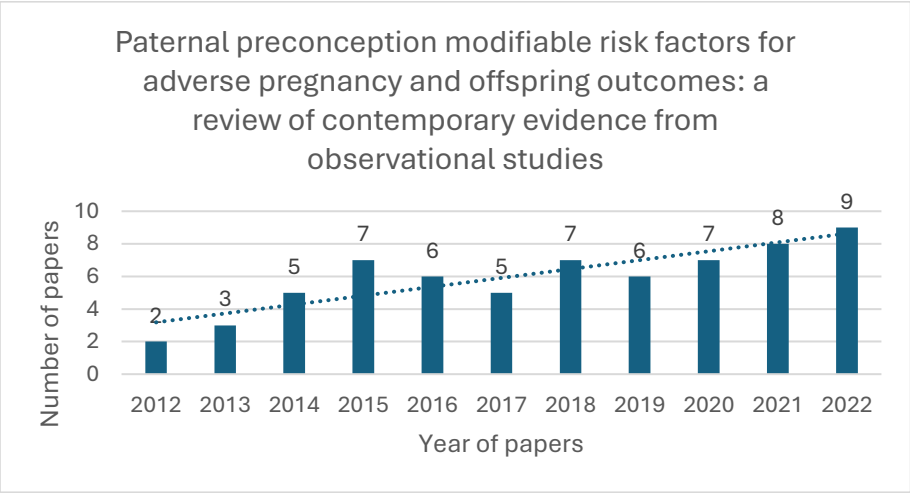


Figure 4.2 Papers included in this review



Results below are described for papers assessed as good quality with approximately half (n=30) rated good quality and two receiving a maximum nine-star rating (258, 285) (Table 4.4 - Newcastle Ottawa Scale [NOS] quality assessment (Cohorts)) & (Table 4.5 - Newcastle Ottawa Scale [NOS] quality assessment (Case controls)). Results for the fair and poor-quality papers are not further described.

4.4.1 Body Composition

Twenty-five papers investigated associations between paternal BMI and various offspring outcomes. These papers were derived from studies (n=21) conducted in the US, Europe, China, Australia, and Turkey and less than half (n=11) rated as good quality.

Less than half of the papers (n=10) used anthropometric assessment by the research team to determine BMI (247, 254, 257, 258, 261, 268, 269, 272, 277, 286); heights and weights utilized to formulate BMI were determined in the preconception period, generally from males in couples undergoing IVF/ICSI (261, 268) or males in couples currently attempting pregnancy/pregnant (257, 258, 269, 272).(257, 258, 269, 272). Of the papers validating the BMI utilizing anthropometric assessments, most were good quality and generally affirmed significant results. The remaining papers utilize retrospective reports of preconception paternal weight and height or collect paternal height and weight from medical records. Maternal reporting (n=7) occurred at approximately 10 to 18 weeks gestation; or up to four months postpartum (283, 287). Paternal self-reporting of their own weight and height (n=8) occurred at approximately week 17 of gestation (250, 270, 275, 276, 278) or up to 6 months postpartum (250). In two papers, overweight paternal status, when a child of 8 years, was reported years later through a validated drawing of silhouettes (245, 246).

Table 4.2 Summary Table

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Body Composition									
Bowatte et al 2022	Australia	Cohort [Prospective] Tasmanian Longitudinal Health Study (TAHS) 1968 - 2021	Mothers & **Fathers (N=836)** of offspring (n=1,938)	Paternal height and weight obtained from school medical records.	*BMI* – BMI trajectory from early childhood (4-6 years) to late childhood (9-10 years) and adolescence (14-15 years)	1)Maternal report of asthma at 14 years 2) Paternal report of asthma at 14 years 3) Grandfather or Grandmother ever asthma 4) Smoking status of Grandfather or Grandmother during paternal childhood 5) Grandfather's occupation	1) 'Ever' Allergic asthma 2) Asthma onset before 10 years old 3) Asthma onset after 10 years old	Offspring asthma	5
Broadney et al 2017	USA	Cohort [Retrospective] Upstate KIDS Study (Population-based) 2008-2010	Mothers & **Fathers (N=2,974)** of infants (n=3,555)	Maternal report of paternal weight & height on baseline questionnaire at 4 months postpartum	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Maternal age, 2) Race/ethnicity, 3) Education, 4) Private insurance, 5) Maternal smoking during pregnancy, 6) Alcohol use during pregnancy, 7) Parity, 8) Infant plurality, 9) Maternal pre-pregnancy BMI	Inflammatory biomarker [CRP] and Ig levels	Inflammation & immune response of neonates	6

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Casas et al 2017	Spain	Cohort [Prospective] INfancia y Medio Ambiente-Environment and Childhood [INMA] (Population-based) 2003-2008	Pregnant couples & their expectant children **(N=1,827)**	Maternal report of paternal weight & height at first prenatal visit approximately 14 weeks of gestation	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parental age, 2) Sex of the child, 3) Parental education, 4) Parental social class, 5) Parity, 6) Maternal IQ, 7) Maternal employment status during pregnancy and at 5 years, 8) Breastfeeding duration, 9) Daycare attendance, 10) Child physical activity, 11) Maternal BMI	**1)** McCarthy Scales of Children's Abilities (MSCA) [contexualized to Spanish], & **2)** The attention deficit hyoperactivity disorder [ADHD] Criteria of Diagnostic and Statistical Manual of Mental Health Disorders - 4th Edition (ADHD-DSM-IV)	Neuropsychological development of preschool children around 5 years old	9
Chen et al 2021	China	Cohort [Retrospective] Women's Hospital, School of Medicine, Zhejiang University (Hospital-based) 2013 - 2016	Subfertile couples (**Males [N=2,318])** undergoing IVF/ICSI fresh embryo transfer cycles resulting in singletons (n=1,366) and twins (n=952)	Third Party - Measurement of paternal weight and height by trained nurse	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Parental age, 2) type of infertility, 3) duration of infertility, 4) ovulatory dysfunction, 5) endometriosis, 6) maternal prepregnancy BMI	International classification of Diseases, 10th Revision (ICD-10) into 9 subcategories	Birth defect	5
Fang et al 2020	China	Cohort [Retrospective] National Free Preconception Health Examination Project (NFPHEP) (Population-based) 2012-2016	Couples planning to conceive **[Males [N=50,927])**	Third Party - Measurement of paternal weight and height by physician	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Age, 2) type of household, 3) education, 4) smoking, 5) alcohol consumption, 6) psychosocial pressure and ready for pregnancy 7) cycle regularity, 8) age of menarche, 9) gravidity, 10)	Time to pregnancy (TTP) = interval between the date of enrolment and last menstrual period (LMP)	Fecundability	5

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
						spontaneous abortion, 11) induced abortion			
Fleten et al 2012	Norway	Cohort [Prospective] Norwegian Mother and Child cohort study (MoBa) (Population-based) 1999-2009	Pregnant couples & their expectant children **(N=29,216)**	Paternal self-report of weight and height (20%) OR maternal report of paternal weight and height (80%) at approximately 17 weeks of gestation.	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parental educational level (years), 2) Paternal and maternal prenatal smoking, 3) Maternal coffee consumption during pregnancy, 4) Parental BMI	Body mass index (BMI) at 3 years old	Offspring adiposity	6
Guo et al 2022	China	Cohort [Retrospective] National Free Pre-conception Check-up Projects (NFPCP) 2013-2017	Nulliparous couples attempting pregnancy **(Males [N = 4,719,813])**	Third Party - Physician measurement of paternal weight and height.	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared) during participation in the NFPCP	1)Maternal and paternal age at last menstrual period, 2) Maternal and paternal height 3) Education level, 4) Parity, 5) Ethnicity, 6) Area of residence 7) Maternal Diabetes, 8) Maternal Hypertension, 9) Smoking 10) Alcohol use 11) Passive smoking 12) History of adverse pregnancy incl preterm birth, stillbirth, or spontaneous abortion in previous pregnancies	**1)** Large-for-gestational-age (LGA) = birthweight above 90th percentile according to birthweight centiles for a Chinese population, & **2)** Small-for-gestational-age (SGA) = birthweight below the tenth percentile on birthweight centiles for a Chinese population	Offspring birthweight	6

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Hoek et al 2022	The Netherlands	Cohort [Prospective] Rotterdam Periconception Cohort (PREDICT Study) (Hospital-based) 2017-2019	Subfertile couples (**Males [N=221])** undergoing IVF/ICSI with cultured embryos (n=757)	Third party - Anthropometric assessment completed by a trained nurse at baseline	*BMI* - "Preconceptional" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Total motile sperm count [TMSC], 2) Age, 3) Ethnicity, 4) Smoking, 5) Alcohol use, 6) Education	**1)** Fertilization rate, **2)** TMSC **3)** Embryo developmental morphokinetics, **4)** Embryo quality assessed by a time-lapse prediction algorithm (KIDScore), & **5)** Live birth rate.	IVF/ICSI induced live birth	8
Johannessen et al 2020	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013-2016	Mothers & **Fathers (N=2044),** of adult offspring (n=2,822)	Paternal self-report based upon validated figural drawing scale of 9 sex-specific silhouettes	*BMI* - "Overweight status" To identify subjects at risk for overweight body size (BMI, 25-30 kg/m²) at 8 years old, at puberty, and at age 30 years before offspring conception.	1)Paternal asthma status, 2) Education level 3) Maternal overweight status 4) Maternal asthma status 5) Offspring sex 6) Offspring age	Parent report in the RHINESSA questionnaire	Adult offspring asthma with or without nasal allergies.	6
Lonnebotn et al 2022	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013-2016	Mothers & **Fathers (N=308)** of adult offspring (n=420)	Paternal self-report based upon validated figural drawing scale of 9 sex-specific silhouettes	*BMI* - "Overweight status" To identify subjects at risk for overweight body size (BMI, 25-30 kg/m²) at 8 years old and at puberty.	1)Maternal education 2) Paternal education 3) Offspring age 4) Smoking history	Pre/post bronchodilator forced expiratory volume in one second (FEV1) & forced vital capacity (FVC).	Adult offspring lung function	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Moss et al 2015**	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994-2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants **(N = 372**)	Third party - Anthropometric assessment completed by a trained professional at baseline	*BMI* - "Preconception" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al 2014**	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006-2007	Pregnant couples & their expectant children **(N = 2,264**)	Paternal self-report of weight and height on baseline questionnaire during third trimester or within 6 months postpartum	*BMI* - "Prepregnancy" Body mass index [BMI] at conception	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist.	Spontaneous preterm birth & Small for gestational age (SGA)	3
Noor et al 2019	USA	Longitudinal cohort [Prospective] Project Viva birth cohort study of mothers and children 1999-2019	Pregnant couples & their expectant children **(N=429**)	Maternal report of paternal weight & height at first prenatal visit approximately 10 weeks gestation.	*BMI* - "Periconception" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Maternal prepregnancy BMI, 2) Maternal Age, 3) Gestational weight gain, 4) Household income, 5) Maternal education, 6) Maternal smoking, 7) Maternal alcohol use, 8) Marital status, 9) Infant's sex, 10) Race/ethnicity, 11) Gestational age at	Blood samples collected at birth, age 3 years & 7 years	Genome-wide DNA methylation patterns and birthweight in offspring.	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
						delivery, 12) Mode of delivery, 13) Birth weight, 14) Batch effects, 15) Estimated nucleated cell types from cord blood 16) WBC's			
Pomeroy et al 2015	Australia	Cohort [Prospective] Mater-University of Queensland Study of Pregnancy (MUSP) 1982-1983	Mothers and **Fathers** of infants **(N= 1,041)**	Maternal report of paternal weight and height at first prenatal visit approximately 18 weeks of gestation	*BMI* - "Pre-pregnancy" height & body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parity, 2) Maternal education, 3) Maternal smoking in the last trimester, 4) Maternal age at birth	**1)** Birthweight, **2)** Neck-rump length 3) Head circumference, **3)** Absolute and proportional limb segment and trunk lengths & **4)** Subcutaneous fat	Neonatal body measurements	6
Retnakaran et al 2021	China	Cohort [Prospective] Liuyang Preconception cohort 2009 -	Newly married couples attempting pregnancy and their expectant children **(N=1,292)**	Third party - Anthropometric assessment completed by trained staff at baseline	*BMI* - "Pregravid" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Age, 2) Years of education, 3) Smoking status, 4) BMI, 5) Household income 6) Length of gestation, 7) Total gestational weight gain, 8) Gestational diabetes, 9) Preeclampsia, & 10) Infant sex	**1)** Large-for-gestational-age (LGA) = birthweight above 90th percentile according to birthweight centiles for a Chinese population, & **2)** Small-for-gestational-age (SGA) = birthweight below the tenth percentile on birthweight centiles for a Chinese population	Offspring birthweight	8

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Robinson et al 2020	USA	Cohort [Prospective] Upstate KIDS study (Population-based) 2008-2010	Mothers and **Fathers** of children **(N= 1,915)**	Maternal report of paternal weight & height on baseline questionnaire at 4 months postpartum.	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Maternal & paternal age, 2) Insurance status, 3) Child sex, 4) Maternal race/ethnicity, 5) Education, 6) Marital status, 7) History of polycystic ovary syndrome (PCOS) and/or diagnosis, 8) Smoking, 9) Alcohol intake, 10) Maternal & paternal history of affective disorders, 11) BMI, 12) Maternal prepregnancy BMI	**1)** Positive history of attention deficit hyperactivity disorder (ADHD) or anxiety disorder **2)** Positive screening for ADHD and the inattentive or hyperactive/impulse sub scales OR report of clinical ADHD diagnosis **3)** Parental report of child borderline behavioural problems at 7 or 8 years of age.	Offspring behavioural problems and psychiatric symptoms at 7-8 years.	7
Sun et al 2022	China	Cohort [Prospective] Hunan Maternal and Child Health Hospital (Hospital-based) 2013-2019	Couples receiving antenatal care **(Males [N=34,104)**	Third party – Paternal height and weight measured at 14-16 weeks gestation	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Paternal age, 2) maternal age, 3) maternal BMI, 4) residence location, 5) education level, 6) nationality, 7) history of smoking, 8) history of drinking, 9) history of betel nut consumption, 10) history of drug use, 11) history of preterm birth, 12) per capita monthly household income	Delivery before 37 weeks gestation & Birth weight < 2,500g	Preterm birth & Low birth weight	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Sundaram et al 2017	USA	Cohort [Prospective] Longitudinal Investigation of Fertility and the Environment [LIFE]) 2005-2009	Couples attempting pregnancy **(Males [N = 501])**	Third party - Anthropometric assessment completed by a trained nurse at baseline	*BMI* - Body mass index [BMI] (Weight in kilograms over height in meters squared) and waist/hip measurements	1) Female partner's age, 2) Difference between the male and female age, 3) Both partner's smoking status, 4) Both partner's number of days of vigorous physical activity per week, 5) Both partner's free cholesterol level 6) Both partner's race 7) Both partner's education 8) Average acts of intercourse per menstrual cycle 9) Menstrual cycle regularity	Time to pregnancy (TTP) in menstrual cycles	Pregnancy	8
Umul et al 2015	Turkey	Cohort [Retrospective]	Couples **(Males [N = 155])** undergoing intracytoplasmic sperm injection (ICSI) cycles (n=177)	Third party - Anthropometric measurements	*BMI* - *B*ody mass index [BMI] (Weight in kilograms over height in meters squared) during fertility treatment.	Nil	**1)** Fertilization rate, **2)** Implantation rate, **3)** Clinical pregnancy rate, & **4)** Live birth rate	ICSI induced live birth	2
Wei et al 2022	China	Cohort [Prospective] Hunan Provincial Maternal and Children Health Care Hospital (Hospital-based) 2013-2019	Pregnant couples **(Males [N=40,650])**	Paternal self-report of weight and height on baseline antenatal questionnaire between 8- and 14-weeks' gestation	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Maternal and paternal age 2) ethnicity, 3) educational level, 4) parity, 5) family income per month, 6) active smoking before pregnancy, 7) passive smoking before pregnancy, 8) alcohol consumption before pregnancy 9) folic acid	Low birth weight = <2,500g Very low birthweight = <1,500g Extremely low birthweight <1,000g	Offspring birthweight	6

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality‡
						consumption before or during pregnancy, 10) history of adverse pregnancy outcomes, 11) history of pregnancy complications, 12) gestational weight gain recommendation range, 13) pregnancy complications in this pregnancy, 14) smoking status before pregnancy, 15) alcohol consumption before pregnancy			
Wei et al 2021	China	Cohort [Retrospective] Guangxi Zhuang Birth Cohort (GZBC) (Hospital-based) 2015-2018	Parents with singleton birth **(Males [N=1,082])**	Paternal self-report of weight and height at first antenatal interview	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Parental age at delivery, 2) offspring sex, 3) gestational age, 4) offspring birth weight), 5) maternal residential place, 6) gravidity, 7) parity, 8) drinking before pregnancy, 9) maternal passive smoking during pregnancy, 10) pregnancy comorbidities or complications, 11) caesarean section	Real-time polymerase chain reaction (qPCR)	Newborn telomere length (TL)	6
Xu et al 2021	China	Cohort [Prospective] Shanghai Jiao Tong University 2015	Pregnant couples and their expectant children **(N = 1,810)**.	Paternal self-report of weight and height at first prenatal visit approximately	*BMI* - "Preconception" body mass index [BMI] (Weight in kilograms over height in meters	1) Delivery gestational week, 2) Maternal age, 3) Gestational weight gain (GWG), 4) Education, 5) Parity, 6) Family history of	Assessed within 1 hour of birth using digital scales	Offspring birthweight	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
				16 weeks of gestation.	squared) during fertility treatment.	metabolic diseases, 7) Haemoglobin, 8) Systolic blood pressure, 9) Diastolic blood pressure, 10) Dyslipidemia, 11) Fasting plasma glucose at the first prenatal check-up 12) Offspring sex 13) Preconception BMI			
Yang et al 2015	China	Case-control [Retrospective] (Population-based) 2011-2013	Mothers & **Fathers** of cases **(N=870)** and controls **(N=5,471)**	Paternal self-report of weight and height at postpartum baseline interview.	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Infant's gender, 2) Gestational age, 3) Parental age, 4) Family income, 5) Parental education level, 6) Gravidity, 7) Parity, 8) Paternal smoking status during pregnancy, 9) Parental prepregnancy weight,10) Parental height, 11) Parental BMI, 12) Maternal alcohol consumption during pregnancy, 13) Maternal weight gain during pregnancy, 14) Maternal BMI gain during pregnancy	Live macrosomic birth (>4,000g)	Macrosomia	6
Zalbahar et al 2017	Australia	Cohort [Prospective] Mater-University of Queensland Study of Pregnancy	Mothers and **Fathers** of infants **(N= 1,494)**	Maternal report of paternal weight and height at first prenatal visit at approximately	*BMI* - "Pre-pregnancy" weight and body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parental education, 2) Family annual income, 3) Maternal gestational weight gained, 4) Maternal smoking habit, 5) Offspring birth weight, 6) Offspring gender, 7)	Physical assessment using measuring tape and digital scales at 5, 14 and 21 year follow-ups	Offspring weight & BMI changes from childhood (5 years) into adulthood (21 years).	5

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
		(MUSP) 1981-1983		18 weeks of gestation		Gestational age, 8) Breastfeeding duration, 9) Offspring's lifestyle at 14 years, 10) Maternal or paternal BMI, 11) Maternal age at birth, 12) Offspring birth weight, 13) Offspring gender			
Zhang et al 2020	China	Cohort [Retrospective] National Free Pre-conception Check-up Projects (NFPCP) 2015-2017	Nulliparous couples attempting pregnancy **(Males [N = 2,301,782])**	Third Party - Physician measurement of paternal weight and height.	*BMI* - "Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared) during participation in the NFPCP	1) Age, 2) Ethnic background, 3) Educational level, 4) Occupation, 5) Household registration and region, 6) Alcohol intake, 7) Tobacco exposure, 8) Hypertension, 9) HBsAg positive status based on male individual model A	Time to pregnancy (TTP) = [Date of the last menstruation (pregnant couples) or Date of the most recent follow-up (nonpregnant couples) - Date of baseline questionnaire completion)]/Average menstrual cycle length] + 1.	Pregnancy	9
Alcohol									
Luan et al 2022	China	Cohort [Prospective] Shanghai-Minhang Birth Cohort Study 2012 -	Mothers and Fathers of infants **(N=796)**	Maternal report of paternal preconception alcohol consumption at 12-16 weeks gestation	*Alcohol* – 3 months before conception.	1)Paternal age 2) Paternal BMI 3) Paternal education 4) Paternal smoking 5) Maternal age 6) Parity 7) Maternal depressive symptoms during pregnancy 8) Maternal preconception folic acid supplements, 9) Multivitamin supplements during pregnancy 10)	Child Behaviour Checklist (CBCL) at offspring ages 2, 4, & 6 years old.	Offspring behavioural problems	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
						Gestational weeks 11) Sex			
Milne et al 2013	Australia	Case-control [Retrospective] Aus-ALL 2003-2006 Aus-CBT 2005-2010	Mothers and **Fathers** of children with ALL (Cases [n=281] Controls [n=672) & CBTs (Cases [n=221]) and Controls [n=717]	Paternal self-report on baseline questionnaire	*Alcohol* – Any alcohol 12 months before pregnancy	1)Year of birth group 2) Maternal age, 3) Ethnicity 4) Household income 5) Birth order 6) Maternal smoking 7) Child's age 8) Child's sex 9) State of residence 10) Paternal smoking 11) Paternal age group 12) Household income	Diagnosis from one of 10 paediatric oncology centres in Australia.	Childhood acute lymphoblastic leukemia (ALL) & Childhood brain tumours (CBTs)	6
Moss et al 2015**	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994-2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants **(N = 372**)	Paternal self-report of health behaviours at wave III interview	*Alcohol* - preconception intake greater than once a month	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al 2014**	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity	Pregnant couples & their expectant children **(N = 2,264**)	Paternal self-report on baseline questionnaire during third trimester or	Alcohol intake (units/week) 6 months prior to conception and up to delivery	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist.	Spontaneous preterm birth & Small for gestational age (SGA)	3

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality‡
		[GECKO] Drenthe cohort (Population-based) 2006-2007		within 6 months following delivery					
Xia et al 2018	China	Cohort [Prospective] Shanghai-Minhang Birth Cohort Study 2012	Mothers and F**athers** of infants **(N = 980)**	Paternal self-report at baseline interview between 12 to 16 weeks of gestation.	*Alcohol* - intake at least once a week 3 months before conception	1) Parental age, 2) Parental BMI before conception, 3) Gestational age, 4) Gravidity, 5) Birth weight of offspring, 6) Paternal education, 7) Maternal passive smoking before conception (yes/no), 8) Paternal smoking (yes/no), 9) Days between birth and 12-month measurement.	**Males -** AGD-AP (centre of anus to penis) AGD-AS (centre of anus to scrotum) **Females -** AGD-AC (centre of anus to clitrous) AGD-AF (centre of anus to fourchette)	Offspring anogenital distance (AGD)	8
Zuccolo et al 2016	Norway	Cohort [Prospective] The Norwegian Mother and Child Cohort Study (MoBa) (Population based) 1999-2009	Mothers & F**athers** of children **(N= 68,244)**	Paternal self-report on baseline questionnaire at approximately 17 weeks of gestation	*Alcohol* - intake in the 6 months prior to pregnancy and up to week 18 of gestation	1) Year of birth, 2) Folic acid use around conception, 3) Whether the pregnancy was planned, 4) Maternal diabetes, 5) Parity, 6) Ethnicity, 7) Financial strain, 8) Parental age, 9) Height, 10) BMI, 11) Gross income, 12) Education, 13) Smoking/drug use in pregnancy, 14) Other parent's exposure	Sex-standardised head circumference (expressed as standard deviation [SD] scores), based on the distribution of all MoBa newborns by sex.	Offspring head circumference	4
Cannabis									

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Har-Gil et al 2021	Canada	Cohort [Retrospective] (Clinic-based) 2016-2019	Female (n=15) & **male (N=53)** cannabis users & non-users **(N=654)** undergoing IVF	Paternal self-report on baseline questionnaire	*Cannabis* - use prior to fertility treatment	Nil	1) Sperm volume 2) Sperm quality, 3) Fertilization rate 4) Implantation rate (IR) 5) Ongoing pregnancy rate (OPR)	IVF/ICSI induced live birth	2
Kasman et al 2018	USA	Cross sectional cohort [Retrospective] National Survey of Family Growth (NSFG) (Population-based) 2002-2015	Female (n=1,076) **& male (N=758)** respondents of the National Survery of Family Growth (NSFG)	Paternal self-report at baseline interview	*Cannabis* - use over the previous 12 months	1) Age, 2) Marital status, 3) Previous children, 4) Partner age (for men), 5) Previous fertility evaluation/treatment, 6) Year of survey, 7) Income, 8) Race, 9) Education	Estimated time to pregnancy (TTP) using the current-duration appaorach	Pregnancy	6
Moss et al 2015**	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994-2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants **(N = 372**)	Paternal self-report of health behaviours at wave III interview	*Cannabis* - use in the last 12 months	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Nassan et al 2019	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2005-2017	Subfertile couples (**Males [N=200])** undergoing IVF cycles (n=368)	Paternal self-report on baseline questionnaire	*Cannabis* - use ever	1) Age, 2) Race, 3) BMI, 4) Tobacco smoking, 5) Coffee and alcohol consumption, 6) Cocaine use	**1)** Implantation, **2)** Clinical pregnancy, **3)** Live birth per assisted reproductive technology (ART) cycle, & **4)** Pregnancy loss	IVF/ICSI induced live birth	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Wise et al 2018	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013-2017	Couples attempting pregnancy **(Males N = 1,125)**	Paternal self-report on baseline questionnaire	*Cannabis* - use in the previous 2 months	1) Age, 2) Race/ethnicity, 3) Education, 4) Annual household income, 5) Cigarette smoking history, 6) Alcohol intake, 7) Caffeine intake, 8) Intercourse frequency, 9) Doing something to improve chances of conception, 10) PSS-10 score, 11) MDI score, 12) Sugar-sweetened soda intake, 13) Average sleep duration 14) Employment status	Time to pregnancy (TTP) = (Menstrual cycles of attempt at study entry) + [(Last menstrual period [LMP] date from the most recent followup questionnaire − date of baseline questionnaire completion)/usual menstrual cycle length] + 1	Fecundability	6
Physical activity									
Moss et al 2015**	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994-2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants **(N = 372**)	Paternal self-report of health behaviours at wave III interview	*Physical activity* - sessions in the last week.	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al 2014**	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with	Pregnant couples & their expectant children **(N = 2,264**)	Paternal self-report on baseline questionnaire during third	*Physical activity* - moderate intensity for 30 minutes per day ≥ once a week 6 months prior to	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist.	Spontaneous preterm birth & Small for gestational age (SGA)	3

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
		Obesity [GECKO] Drenthe cohort (Population-based) 2006-2007		trimester or within 6 months following delivery	conception and up to delivery				
Smoking									
Accordini et al 2021	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013-2016	Mothers & **Fathers (N=274),** investigated in the European Community Respiratory Health Survey (ECRHS), of adult offspring (n=383)	Paternal self-report at baseline interview and ECRHS examinations.	*Smoking* – Prepubertal smoking [smoking < 15 years old] & smoking ≥ 15 years old.	1)Grand parents education level 2) Paternal age 3) Paternal education level 4) Paternal occupational class 5) Maternal smoking before or after offspring birth 6) Offspring age 7) Offspring sex 8) Offspring education level 9) Offspring smoking	Pre/post bronchodilator forced expiratory volume in one second (FEV1) & forced vital capacity (FVC)	Adult offspring lung function	8
Accordini et al 2018	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] European Community Respiratory Health Survey (ECRHS) (Population-based) 1998-2013	Mothers and **Fathers (N=1,964)** of adult offspring (n=4,192).	Paternal self-report at baseline interview and ECRHS examinations	*Smoking* – Prepubertal smoking [smoking < 15 years old] & smoking ≥ 15 years old.	1)Grandmother smoking 2) Father's ever asthma 3) Education level 4) Smoking initiation 5) Offspring gender 6) Age	Parent report in the ECRHS questionnaire	Adult offspring asthma with or without nasal allergies	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Carslake et al 2016	Norway	Combined cohort [Prospective] HUNT Study [Adult ≥ 20 years] (1984 – 2008)/ YoungHUNT Study [Child 13-19 years] (1995 – 2007)	Mothers and **Fathers (**[HUNT] of offspring [YoungHUNT] **(N=221).**	Paternal self-report at baseline interview.	*Smoking* – Prepubertal smoking [smoking < 11 years old]	1)Offspring birth order 2) Maternal education 3) Paternal employment 4) Maternal and Paternal smoking status at time of offspring conception 5) Offspring sex	Body Mass Index (BMI)	Offspring adiposity	6
Deng et al 2013	China	Case-control [Retrospective] Gene-environmental interaction study on CHD occurrence (Hospital-based) 2010-2011	Pregnant couples & their expectant children as CHD cases **(N=267)** & controls **(N=386)**	Maternal report at baseline interview during pregnancy but after prenatal diagnosis of CHD	*Smoking* - "Periconceptional" being 3 months before conception through to the first trimester of pregnancy	1) Maternal residence, 2) Age, 3) Education, 4) Prepregnancy BMI, 5) Parental alcohol use during the 3 months before and 3 months after conception, 6) Folic acid intake during the 3 months before and 3 months after conception, 7) Family history of CHD, 8) Parity	Diagnosed via prenatal echocardiography	Congenital heart defects (CHD) in offspring	8
Frederiksen et al 2020	Costa Rica	Case-control [Retrospective] Costa Rican Childhood Leukemia Study (CRCLS) (Population-based) 2001-2003.	Mothers and Fathers (**N=198)** of offspring suffering leukemia (N=292) [Cases] & cancer free age matched offspring (N=578) [controls]	Paternal self-report at baseline interview	*Smoking* – Tobacco smoking 12 months before conception	1)Child sex 2) Birth year 3) Parental education 4) Paternal age 5) Maternal smoking	Diagnosis, between 1995-2000 in Costa Rica while aged < 15 years, of Acute Lymphoblastic Leukemia (ALL) (N=252) or Acute Myeloid Leukemia (AML) (N=40).	Childhood leukemia	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Knudsen et al 2020	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013-2016	Mothers & **Fathers (N=2,111)** of adult offspring (n=2,939)	Paternal self-report at baseline interview and examinations.	*Smoking* – Prepubertal smoking [smoking before 15 years old] & smoking ≥ 15 years old. Preconception smoking [≥ 2 years before offspring birth year]	1)Parental education 2) offspring sex	**1)** BMI [weight (kg)/height (m)^2] **2)** Bioelectrical impedance analysis **3)** Fat mass index (FMI) [fat mass (kg)/height (m)^2	Adult offspring BMI index and FMI index	5
Ko et al 2014	Taiwan	Longitudinal cohort [Prospective] Taiwan Birth Cohort Study (National) 2005-2006	Mothers & **Fathers** of infants **(N= 21,248)**	Maternal report at baseline interview 6 months postpartum	*Smoking* - Preconception tobacco being before pregnancy and up to four months postpartum	1) Maternal age, 2) Nationality, 3) Education, 4) Parity, 5) Total weight gain during pregnancy, 6) Infant gender, 7) Multifetus, 8) Paternal smoking in the same period	**1)** Low Birth weight (LBW) < 2,500g, **2)** Small for gestational age (SGA) - Birth below the 10th percentile of gender-specific birth weight for gestational age based on the 1998-2002 nationwide percentiles & **3)** Preterm birth < 37 weeks	Offspring birthweight & incidence of preterm delivery	5
Milne et al 2013	Australia	Case-control [Retrospective] The Australian Study of Childhood Brain Tumors (Aus-CBT) (Population-based) 2005-2010	Mothers and Fathers (N=1048) of children with childhood malignancy and brain tumors (CBT) (n=247) & controls (n=801)	Paternal self-report on mailed questionnaire	*Smoking* - Average number of cigarettes smoked per day in each calendar year from age 15 until year after child's birth	1)Child's ethnicity, 2) year of birth group, 3) Mother's age group, 4) Father's age group, 5) alcohol consumption during pregnancy, 6) household income	Diagnosis at one of 10 Australian paediatric oncology centres	Childhood brain tumors (CBT)	5

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Moss et al 2015**	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994-2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants **(N = 372**)	Paternal self-report of health behaviours at wave III interview	*Smoking* - At least one cigarette per day over the last 30 days	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al 2014**	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006-2007	Pregnant couples & their expectant children **(N = 2,264**)	Paternal self-report on baseline questionnaire during third trimester or within 6 months following delivery	*Smoking*- cigarettes per day in the 6 months prior to conception and up to delivery	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist.	Spontaneous preterm birth & Small for gestational age (SGA)	3
Northstone et al 2014	UK	Cohort [Prospective] The Avon Longitudinal Study of Parents and Children (ALSPAC) 1991-1992	Pregnant couples where **fathers** identified as smoking regularly (n=5,376) including before 11 years old **(N=166)**	Paternal self-report on baseline questionnaire completed during pregnancy	*Smoking* - Prepubertal tobacco before 11 years of age	1) Parity of the mother at the time of birth of the offspring (primiparae vs multiparae), 2) Highest maternal education level 3) Housing tenure 4) Maternal smoking during pregnancy 5) Paternal smoking at conception	**1)** BMI, **2)** Waist circumference, **3)** Total-body fat mass, & **4)** Lean mass	Offspring adiposity	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Orsi et al 2015	France	Case-Control [Retrospective] ESTELLE study (Population-based) 2010 - 2011	Mothers and fathers **(N=247)** of offspring suffering childhood acute leukemia (CL) (N=69) [Cases] & cancer free age matched offspring (N=178) [Controls]	Paternal self-report on baseline questionnaire	*Smoking* – Tobacco smoking during the 3-month period preceding conception; the "pre-conception period"	1)Offspring Age 2) Offspring Sex 3) Mother's age at child's birth 4) Mother's education 5) Birth order	Diagnosed with CL <15 years old as per the National Registry of Childhood Hematopoietic Malignancies (NRCH) criteria.	Childhood acute leukemia (CL)	7
Sapra et al 2016	USA	Cohort [Prospective] Longitudinal Investigation of Fertility and the Environment [LIFE]) 2005-2009	Couples attempting pregnancy **(Males [N = 501])**	Paternal self-report at baseline interview	*Smoking* - Lifetime exposure to tobacco products (including cigarettes, electronic cigarettes, cigars, pipes, waterpipes, chewing tobacco, snuff and dip)	1) Race/ethnicity, 2) Education, 3) Income, 4) Age, 5) Alcohol use, 6) Caffeine use, 7) BMI, 8) Blood cadmium in each partner, 9) Couple's mean age, 10) Difference in partners' ages	Time to pregnancy (TTP) in menstrual cycles	Pregnancy	7
Svanes et al 2017	**Northern Europe** Norway, Sweden, Iceland, Denmark, Estonia.	Combined Cohort [Prospective] European Community Respiratory Health Survey (ECRHS) (1989-1992) & Respiratory Heath in Northern Europe (RHINE) (Population-based)	Mothers and **Fathers (N=3,777)** of offspring aged 2-51 years (n=24,168)	Paternal self-report on RHINE III questionnaire.	*Smoking* – Tobacco smoking prior to conception including period around birth.	1)Age 2) Study centre 3) Parental age 4) Parental asthma before age 10, 5) Parental education	Diagnosis via parental report	Offspring asthma before/after 10 years	6

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
		1991 - 2012							
Wang et al 2022	China	Cohort [Retrospective] National Free Pre-Pregnancy Checkups Project (NFPCP) (Population-based) 2010-2016	Non-smoking women and their smoking husbands **(N= 190,529)**	Paternal self-report at preconception health examination	*Smoking* - Tobacco while attempting conception in the following 6 months.	1) Maternal and paternal age at last menstrual period, 2) Higher education, 3) Han ethnicity, 4) Preconception body mass index (BMI), 5) Alcohol drinking, 6) Parental passive smoking, 7) History of adverse pregnancy outcomes, 8) Region of the service station	Delivery before 37 completed gestational weeks	Preterm birth (PTB)	5
Wang et al 2018	China	Cohort [Retrospective] National Free Pre-Pregnancy Checkups Project (NFPCP) (Population-based) 2010-2016	Non-smoking women and their **husbands (N= 5,770, 691)**	Paternal self-report at preconception health examination	*Smoking* - Tobacco while attempting conception in the following 6 months.	1) Maternal and paternal age at last menstrual period, 2) Higher education, 3) Han ethnicity, 4) Preconception body mass index (BMI), 5) Alcohol drinking, 6) Parental passive smoking, 7) History of adverse pregnancy outcomes, 8) Region of the service station	Fetal death before week 28 of gestation	Spontaneous abortion (SA)	6

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Wesselink et al 2019	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013-2018	Couples attempting pregnancy **(Males N = 1,411)**	Paternal self-report on baseline questionnaire	*Smoking* - Tobacco while attempting conception for ≤ 6 menstrual cycles	1) Age, 2) Race/ethnicity, 3) Education, 4) Annual household income, 5) BMI, 6) Sugar sweetened beverage intake, 7) Healthy eating index score, 8) Multivitamin or folic acid supplement use, 9) Sleep duration, 10) PSS-10 score, 11) MDI score, 12) Parity, 13) Intercourse frequency, 14) Doing something to improve chances of conception	Pregnancy attempt time = (Menstrual cycles of attempt time at baseline)+[(Last menstrual period [LMP] date from most recent followup questionnaire—date of baseline questionnaire)/Cycle length]+1.	Fecundability	5
You et al 2022	China	Cohort [Prospective] Children lifeway Cohort 2018 -	Mothers and **Fathers (N=1,037)** of first grade students (7-8 years old)	Paternal self-report at baseline interview	*Smoking* - Tobacco smoking before conception	1)Sex 2) Actual age 3) Father overweight, 4) Mother overweight 5) Percentage of food expenditure 6) Educational level of parents 7) Caesarean section 8) Birthweight 9) Breastfeeding 10) Other household smoking 11) Mother exposed to SHS during pregnancy 12) Picky eaters 13) TV watching time 14) physical exercise 15) Frequency of eating fried/baked food 16) Late-night dinners 17) Vegetable and fruit	Age and sex specific BMI cut-off points according to the growth standard of China "Screening for overweight and obesity among school-age children and adolescents"	Offspring overweight/obesity	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality‡
						18) Snack consumption			
Zhou et al 2020	China	Cohort [Prospective] National Preconception Health Care Project (NPHCP) (Population-based) 2010-2012 * with matched case control	Couples attempting pregnancy **(Males [N= 566,439])**	Paternal self-report at baseline interview.	*Smoking* - Tobacco smoking before conception	1) Maternal age, 2) Education, 3) Occupation, 4) Residence status, 5) Self-reported medical history, 6) Smoking, 7) Second hand smoking, 8) Alcohol consumption, 9) Folic acid supplement, 10) Paternal alcohol consumption	[*Primary] Birth defects = diagnosis on hospital records of first 42 days after delivery [*Secondary] Birth defect types = congenital heart disease, limb anomalies, clefts, digestive tract anomalies, gastroschisis and neural tube defects.	Offspring birth defects	7
Zwink et al 2016	Germany	Case-control [Retrospective] (Population based) 2009-Ongoing	Mothers **& Fathers** of cases **(N = 158**) and controls **(N = 474)**	Maternal report on baseline interview at approximately 8 years postpartum.	*Smoking* - "Periconceptional" tobacco being 3 months before conception until the fourth month of pregnancy.	1) Gender, 2) Birth year of the child, 3) Maternal age, 4) BMI, 5) Maternal body weight	Diagnosis of **1)** Esophageal atresia with or without tracheoesophageal fistula (EA/TEF) or **2)** Anorectal malformations (ARM) ARM's	Offspring malformations	4
Stress									

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Bae et al 2017	USA	Cohort [Prospective] Longitudinal Investigation of Fertility and the Environment [LIFE]) (Population-based) 2005-2009	Couples attempting pregnancy and their expectant children **(N=235)**.	Paternal self-report at baseline interview assessed by Cohen's Perceived Stress Scale [PSS-4]	*Stress* - & lifetime history of physician-diagnosed anxiety and/or mood disorders	1) Age, 2) Serum cotinine, 3) Annual income, 4) Maternal parity	Secondary sex ratio (SSR) [Males:Females at birth]	Offspring sex	6
Mutsaerts et al 2014**	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006-2007	Pregnant couples & their expectant children **(N = 2,264**)	Paternal self-report on baseline questionnaire during third trimester or within 6 months following delivery	*Stress* - Paid working hours < 16 hours per week.	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist.	Spontaneous preterm birth & Small for gestational age (SGA)	3
Wesselink et al 2018	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013-2018	Couples attempting pregnancy **(Males N = 1,272)**	Paternal self-report on baseline questionnaire assessed by the Perceived stress scale [PSS]	*Stress* - Perceived stress in the last month	1) Age, 2) BMI, 3) Race/ethnicity, 4) Education, 5) Household income, 6) Employment status, 7) Work duration, 8) Physical activity	Pregnancy attempt time = (Menstrual cycles of attempt time at baseline)+[(Last menstrual period [LMP] date from most recent followup questionnaire—date of baseline questionnaire)/Cycle length]+1.	Fecundability	7
Nutrition									

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Bailey et al 2014	Australia	Case-control [Prospective] The Australian Study of Causes of acute lymphoblastic leukemia (ALL) in children (Aus-ALL). (Population-based) 2003-2007	Mothers and Fathers of children with ALL (n=285) and controls (n=595)	Paternal self-report on food frequency questionnaire (FFQ)	*Folate & Vitamins B6/B12* - during the 6 months before conception	1)Birth order 2) best parental education, 3) paternal age, 4) paternal smoking in the conception year, 5) year of agreement and FFQ version, 6) supplement use (folate, B6, or B12), 7) control state, 8) control sex, 9) control age	Diagnosis at one of 10 Australian paediatric oncology centres	Childhood acute lymphoblastic leukemia (ALL)	5
Greenop et al 2015	Australia	Case-control [Retrospective] The Australian Study of Childhood Brain Tumors (Aus-CBT) (Population-based) 2005-2010	Mothers and Fathers (N=866) of children with childhood malignancy and brain tumors (CBT) (n=237) & controls (n=629)	Paternal self-report on food frequency questionnaire (FFQ)	*Folate & Vitamins B6/B12* - during the 6 months before conception	1)Control age, 2) control sex, 3) control state of residence, 4) child's year of diagnosis/recruitment, 5) paternal age, 6) best parental education, 7) child's ethnicity, 8) paternal preconceptional high alcohol consumption.	Diagnosis at one of 10 Australian paediatric oncology centres	Childhood brain tumors (CBT)	5
Hatch et al 2018	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013-2017	Couples attempting pregnancy **(Males N = 1,045)**	Paternal self-report on food frequency questionnaire (FFQ) at baseline	*Sugar sweetened beverage intake* – Servings per week in the past month	1)Male and female age, 2) male and female BMI, 3) age, 4) race/ethnicity, 5) education, 6) annual household income, 7) smoking history, 8) BMI, 9) physical activity, 10) caffeine intake, 11) alcohol intake, 12) sleep duration, 13) perceived stress scale	Time to pregnancy (TTP) [(menstrual cycles of attempt time at baseline) + [(LMP date from most recent follow-up questionnaire - date of baseline questionnaire)/cycle length] + 1]	Fecundability	6

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
						score, 14) intercourse frequency			
Hoek et al 2019	The Netherlands	Cohort [Prospective] Rotterdam Periconception Cohort (PREDICT Study) (Hospital-based) 2010-2015	Pregnant couples **(N=511)** producing spontaneous pregnancy (n=303) or IVF/ICSI pregnancy (n=208).	Paternal self-report on baseline questionnaire	*Folate* - "Periconceptional" status being 14 weeks before pregnancy and up to 10 weeks of gestation	1) Gestational age at the time of ultrasound, 2) Paternal age, 3) Paternal smoking and alcohol, 4) Geographic origin, 5) Maternal age, 6) Maternal BMI, 7) Maternal smoking and alcohol, 8) Parity, 9) RBC folate levels, 10) Education level, 11) Geographic origin, 12) Fetal gender	**1)** Crown-rump length (CRL) & **2)** Embryonic volume (EV) at 7, 9 and 11 weeks of gestation	Embryonic growth trajectories	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Lippevelde et al 2021	Norway	Combined cohort [Prospective] Young-Health Study in Nord-Trondelag (Young-HUNT 1 1995-1997 & Young-HUNT 3 2006-2008)	Adolescents (13-19 years old) followed into adulthood becoming Mothers & Fathers of infants. Young-HUNT 1 **Father**-offspring dyads (**N = 2,140**). Young-HUNT 3 **Father**-offspring dyads **(N= 391**)	Adolescent self-report on baseline questionnaire	*Diet* - Dietary exposures during adolescence	**1)** Adolescents age, **2)** BMI z-score **3)** Education plans **4)** Chewing tobacco use **5)** Smoking **6)** Alcohol use	**1)** Birthweight (g) **2)** Length (cm) **3)** Head circumference (cm) **4)** Placenta weight (g), **5)** Gestational length (weeks) & **6)** Ponderal index - Adiposity ([Birthweight (g) /Birth length^3 (cm)]*100)	Neonatal health of offspring	8
Martin-Calvo et al 2019	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007-2017	Subfertile couples undergoing fertility treatment **(Males N=108)** producing singletons [n=85), twins (n=54) & triplets [n=3])	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Folate* - Preconception intake prior to or up to 12 weeks after the day of peak oestradiol concentration during a fertility treatment cycle (IVF/ICSI/IUI)	1) Age, 2) Choline, betaine, methionine, vitamin B6, vitamin B12, 3) Total energy intake, 4) Diet quality, 5) Maternal BMI, 6) Maternal smoking status, 7) Infertility diagnosis, 8) Type of fertility treatment	**1)** Gestational age at delivery (days), **2)** Live birth of a neonate ≥ 24 weeks of gestation, & **3)** Gestational age-adjusted birthweight.	IVF/ICSI/IUI induced live birth	7
Mitsunami et al 2021	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007-2018	Subfertile couples (**Males [N=231])** undergoing IVF cycles (n=407)	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Diet* - patterns 1 (processed foods) & 2 (whole/unprocessed foods) over the previous 12 months	1) Men's age, 2) Total caloric intake, 3) BMI, 4) Race, 5) Smoking status, 6) Education level, 7) Physical activity, 8) Women's age + BMI, 9) Couple's primary infertility diagnosis, 10) Treatment protocol, 11) Women's adherence to the two dietary patterns, 12)	**1)** Fertilization rate, **2)** Probability of implantation, **3)** Clinical pregnancy, & **4)** Probability of live birth per initiated treatment cycle.	IVF/ICSI induced live birth	7

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
						Women's race, 13) Women's smoking status			
Moss et al 2015**	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994-2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants **(N = 372**)	Paternal self-report of health behaviours at wave III interview	*Diet* - Fast food consumption	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Oostingh et al 2019	The Netherlands	Cohort [Prospective] Rotterdam Periconception Cohort (PREDICT Study) (Hospital-based) 2010-2016	Pregnant couples **(Males [N= 638])**	Paternal self-report on baseline food frequency questionnaire (FFQ) before 8 weeks of gestation.	*Diet* - Habitual food intake and dietary patterns in a four week period during periconception being 14 weeks before and up to 10 weeks following conception.	1) Gestational age, 2) Maternal and paternal total energy intake, 3) Maternal and paternal BMI, 4) Maternal age, 5) Maternal and paternal smoking, 6) Nulliparous, 7) Fetal gender	**1)** Longitudinal crown-rump length (CRL), & **2)** Embryonic volume (EV), via transvaginal ultrasound, at 7, 9 and 11 weeks of gestation	First trimester embryonic growth	6
Twigt et al 2012	The Netherlands	Cohort [Prospective] 'Achieving a Healthy Pregnancy' (AHP) (Hospital-based) 2007-2010	Subfertile couples **(Males [N=199])** with IVF treatment and embryo transfer within 6 months after AHP.	Paternal self-report on baseline questionnaire	*Diet* – Main food groups 1)Whole wheat 2) Unsaturated oils 3) Vegetables 4) Fruits 5) Meat 6) Fish	1)Maternal age 2) Maternal smoking 3)Preconception Dietary Risk Score [PDR] of the partner 4) Maternal and Paternal BMI	A pregnancy with positive fetal heart action at around 10 weeks after embryo transfer confirmed by ultrasonography.	IVF/ICSI induced ongoing pregnancy	5

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Wesselink et al 2016	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013-2017	Couples attempting pregnancy **(Males N = 662)**	Paternal self-report on food frequency questionnaire (FFQ) at baseline	*Diet* – Caffeinated beverages; approximate servings per week	1) Age, 2) race/ethnicity, 3) education, 4) BMI, 5) smoking history, 6) alcohol intake, 7) intercourse frequency, 8) sleep duration, 9) work time	Time to pregnancy (TTP) [(menstrual cycles of attempt time at baseline) + [(LMP date from most recent follow-up questionnaire - date of baseline questionnaire)/cycle length] + 1]	Fecundability	6
Xia et al 2016	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007-2014	Subfertile couples (**Males [N=142])** undergoing IVF/ICSI cycles (n=248)	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Diet* - Dairy intake in the previous 12 months	1) Age, 2) BMI, 3) Smoking status, 4) Total exercise time, 5) Dietary patterns, 6) Alcohol, 7) Caffeine, 8) Total energy intake, 9) Female dairy intake, 10) Female age, 11) Prudent dietary pattern, 12) Western dietary pattern	**1)** Fertilization rate , **2)** Implantation rate, **3)** Clinical pregnancy rate & **4)** Live birth rate per initiated cycle.	IVF/ICSI induced live birth	7
Xia et al 2015	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007-2014	Subfertile couples (**Males [N=141])** undergoing IVF/ICSI cycles (n=246)	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Diet* - Meat intake in the previous 12 months	1) Age, 2) Total energy intake, 3) BMI, 4) Alcohol, 5) Caffeine, 6) Prudent dietary pattern, 7) Western dietary pattern, 8) Infertility diagnoses, 9) Mode of insemination, 10) Female meat intake	**1)** Fertilization rate , **2)** Implantation rate, **3)** Clinical pregnancy rate & **4)** Live birth rate per initiated cycle.	IVF/ICSI induced live birth	7

Table 4.3 Summary table of findings from included studies

First Author & Year	Results from paternal exposure	Quality score±
	Body composition	
Bowatte et al 2022	Both ever asthma risk in offspring and asthma before age 10 years old were associated with father's high BMI trajectory (relative risk ratio [RRR] = 1.72 [95% CI: 1.00, 2.97] and RRR = 1.70 [95% CI: 0.98, 2.93], respectively). In the sex-stratified analysis, only the high BMI trajectory of fathers was associated with offspring ever allergic asthma (RRR = 2.04 [95% CI: 1.12, 3.72]; P = 0.02).	5
Broadney et al 2017	Paternal pre-pregnancy body mass index [BMI] categories overweight [25.0 - 29.9 kg/m²], obese class I [30.0 - 34.9 kg/m²], and obese class II/III [> 35 kg/m²] are associated with reduced neonatal IgM levels (β = -0.08, [95% CI: -0.13, -0.03], P = 0.001); (β = -0.07, [95% CI: -0.13, -0.01], P = 0.029]); (β = -0.11, [95% CI: -0.19, -0.04], P = 0.003). Paternal overweight or obesity (class I or II/III) is not associated with the neonatal inflammation score (β = 0.003, [95% CI: -0.10, 0.11]); (β = 0.05, [95% CI: -0.07, 0.17]); (β = 0.07, [95% CI: -0.09, 0.23]) or CRP level (β = 0.02, [95% CI: -0.04, 0.09]); (β = 0.01, [95% CI: -0.07, 0.09]); (β = 0.004, [95% CI: -0.10, 0.10]).	6
Casas et al 2017	Zero association identified between paternal pre-pregnancy underweight [< 18.5 kg/m²] or obese fathers [≥30 kg/m²] and cognitive and psychomotor scores; Global cognitive index (β = 2.78, [95% CI: -8.40, 13.97]), (β = 0.51, [95% CI: -1.68, 2.69]); Memory (β = 4.63, [95% CI: -7.04, 16.31]), (β = 1.67, [95% CI: -0.62, 3.95]); Motor (β = -5.42, [95% CI: -17.51, 6.67]), (β = -0.96, [95% CI: -3.35, 1.42]). There is also no association between behavioural outcomes at pre-school age and underweight or obese fathers; ADHD Inattention (IRR = 3.46, [95% CI: 0.77, 15.49]), (IRR = 2.12, (95% CI: 0.73, 6.17); Hyperactivity (IRR = 1.38, [95% CI: 0.39, 4.76]), (IRR = 1.38, [95% CI: 0.96, 1.99]); Childhood Asperger Syndrome Test [CAST] (IRR = 0.85, [95% CI: 0.50, 1.46]), (IRR = 1.01, [95% CI: 0.91, 1.13]).	9
Chen et al 2021	The birth defect rate was significantly higher when paternal prepregnancy BMI ≥25 kg/m2 in IVF cycles (aOR 1.82, 95% CI: 1.06,3.10). Couples with paternal prepregnancy BMI ≥25 kg/m2 had a four-fold increased risk of congenital malformations of the musculoskeletal system (aOR 4.38, 95% CI: 1.31,14.65) P = 0.017 compared to couples with paternal prepregnancy BMI < 25 kg/m2. This association still remained after adjustment for confounding factors (aOR 4.55, 95% CI 1.32–15.71). No association was seen between paternal prepregnancy BMI and risk of other subcategories of birth defects.	5
Fang et al 2020	Pre-pregnancy BMI was roughly associated with TTP among men with BMI ≥24 (FOR 0.97 95%CI: 0.95,0.99); however, this association for men disappeared after adjusting for demographic characteristics (aFOR 1.01 95%CI: 0.98,1.02). Following logistic regression, no association was observed between male pre-pregnancy BMI ≥24 and subfecundity (aOR 0.97 95%CI: 0.92 – 1.03).	5
Fleten et al 2012	Using absolute BMI values, paternal pre-pregnancy BMI and offspring BMI at age 3 years are associated (β = 0.038, [95% CI: 0.033, 0.044], P = 0.018). Using BMI as z-score [standard deviation] (β = 0.125, [95% CI: 0.107, 0.143], P = 0.805), there is no longer an association.	6
Guo et al 2022	Following multivariate adjustment, husbands who were underweight had significantly higher risk (OR = 1·17 [95% CI: (1·15, 1·19)] of SGA compared with the husband with normal BMI. In addition, a significant and increased risk of LGA was observed for overweight and obese men (OR = 1·08 [95% CI: 1·06,1·09]); (OR = 1·19 (95% CI: 1·17, 1·20)] respectively. Reduced paternal BMI was associated with an increased risk of SGA when paternal BMI was less than 22·64 (P non-linear< 0·001). Meanwhile, increasing paternal BMI were associated with an increased risk of LGA when paternal BMI was more than 22·92 (P non-linear< 0·001).	6

First Author & Year	Results from paternal exposure	Quality score±
Hoek et al 2022	Paternal periconceptional BMI is negatively associated with the fertilization rate (β = −0.01, [SE = 0.004], P = 0.002]); for every increase in paternal BMI point the fertilization rate decreased 1%. Paternal BMI is not associated with the TMSC (β = −2.48, [SE = 1.53], P = 0.11]), the KIDScore (β = −0.01, [SE = 0.02], P = 0.62]), the embryo usage rate (β = −0.001, [SE = 0.004], P = 0.84]), a positive pregnancy (β = 0.03, OR = 1.03, P = 0.49), fetal heartbeat (β = 0.03, OR = 1.03, P = 0.51) or live birth (β = 0.01, OR = 1.01, P = 0.82).	8
Johannessen et al 2020	Among offspring with ECRHS/RHINE fathers who had become overweight during puberty, there was an increased risk of adult offspring's asthma without nasal allergies (RRR = 2.36 [95% CI: 1.27, 4.38]), compared with fathers who had never been overweight. Offspring's overweight status at age 8 years was positively associated with adult offspring's asthma without nasal allergies (RRR = 1.50 [95% CI: 1.05, 2.16]. The risk of offspring's overweight status at age 8 years was greater if the father was overweight at the same period [OR = 2.23 [95% CI: 1.45, 3.42] compared with the offspring having fathers who had never been overweight.	6
Lonnebotn et al 2022	Fathers' overweight before puberty had a negative indirect effect, mediated through sons' height, on sons' forced expiratory volume in one second (FEV_1) (beta (95% CI): −144 (−272, −23) mL) and forced vital capacity (FVC) (beta (95% CI): −210 (−380, −34) mL), and a negative direct effect on sons' FVC (beta (95% CI): −262 (−501, −9) mL); statistically significant effects on FEV_1/FVC were not observed.	7
Moss et al 2015**	Paternal preconception overweight [25.0 - 29.9 kg/m²] and obesity [> 30 kg/m²] is not associated with gestational age (-0.19, [95% CI: -1.30, 0.91], P = 0.37); (-0.39, [95% CI: -1.71, 0.94], P = 0.28), or offspring birthweight (35.6, [95% CI: -1.40, 211.3], P = 0.34); (76.8, [95% CI: -74.6, 228.1], P = 0.16).	7
Mutsaerts et al 2014**	No association identified between paternal pre-pregnancy BMI and spontaneous preterm birth (OR = 0.99, [95% CI: 0.93, 1.06]) or SGA (0.96, [95% CI: 0.91, 1.01]).	3
Noor et al 2019	Cord blood DNA methylation at 9 CpG sites is associated with paternal BMI independent of maternal BMI (P = < 0.05). Methylation at cg04763273, between TFAP2C and BMP7, decreased by 5% in cord blood with every 1-unit increase in paternal BMI (P = 3.13×10^{-9}), decreases persist at ages 3 (P =0.002) and 7 (P = 0.004). Paternal BMI is associated with methylation at cg01029450 in the promoter region of the ARFGAP3 gene; methylation at this site is also associated with lower infant birthweight (β = −0.0003; SD = 0.0001; P = 0.03).	7
Pomeroy et al 2015	Paternal pre-pregnancy BMI is positively associated with neonatal neck-rump length (β = 0.12, P = 0.008) and the distal limb segments [lower arm/lower leg length] (β = 0.09, P =0.006);(β = 0.09, P = 0.003). Neonatal birthweight (β = 0.08, P = 0.003), proximal limb segments [upper arm/thigh length] (β = 0.10, P = 0.001);(β = 0.08, P = 0.008), relative upper limb length (β = 0.10, P = 0.002) and relative lower limb length (β = 0.09, P = 0.004) are associated with paternal height only. Neonatal head circumference and adiposity are only associated with maternal pre-pregnancy height and BMI.	6
Retnakaran et al 2021	Offspring birthweight increases by 10.7 g per unit increase in paternal pregravid BMI ([95% CI: 0.5, 20.9], P = 0.04), yet paternal pregravid BMI is not an independent predictor for LGA (aOR = 1.15, [95% CI: 0.92, 1.44]) or SGA (aOR = 0.88, [95% CI: 0.67, 1.17]). When modelled separately, paternal pregravid weight (P = 0.04), not height (P = 0.43), is associated with offspring birthweight.	8
Robinson et al 2020	No association identified between paternal BMI overweight [≥ 25 kg/m²- <30 kg/m²], obese class I [≥ 30 kg/m²- <35 kg/m²] and obese class II [≥ 35 kg/m²] and offspring behavioural issues or psychiatric symptoms at 7-8 years; P trend for behavioural outcomes range from 0.13 [Maternal reported ADHD diagnosis] to 0.79 [Prosocial behaviours].	7
Sun et al 2022	Compared with normal weight men, paternal pre-pregnancy overweight was associated with a significantly increased risk of preterm birth (aOR 1.34 95% CI: 1.25,1.45) and low birth weight (aOR 1.60 95% CI: 1.46-1.74) in offspring. There was also an increased risk of preterm birth (aOR 1.26 95% CI: 1.14,1.40) and low birth weight (aOR 1.40 95% CI: 1.25,1.58) in offspring of paternal pre-pregnancy obesity.	7

First Author & Year	Results from paternal exposure	Quality score±
Sundaram et al 2017	Male BMI [25 - < 35 kg m²] and [≥ 35 kg m²] is not associated with TTP, when modelled individually; (aFOR = 0.92, [95% CI: 0.70, 1.22]), (aFOR = 0.83, [95% CI: 0.53,1.28]). Obese class II couples (BMI.> 35.0 kg/m2) associate with fecundability (aFOR = 0.41, [95% CI: 0.17, 0.98]) having a longer TTP in comparison to couples with normal BMI (<25 kg/m2) (aFOR = 0.91, [95% CI: 0.25, 3.37]).	8
Umul et al 2015	Increasing paternal BMI is inversely associated with sperm concentration (P = 0.02), sperm motility (P = 0.04), the clinical pregnancy rate (P = 0.04), and the live birth rate (P = 0.03). Zero association identified between paternal BMI and the fertilization rate (P = 0.89) or the implantation rate (P = 0.62).	2
Wei et al 2022	Paternal pre-pregnancy overweight and obesity are associated with a higher risk of low birth weight (LBW) (overweight: OR = 1.637, 95% CI: 1.501 ,1.784); (obesity: OR = 1.454, 95% CI: 1.289, 1.641) and very low birth weight (VLBW) (overweight: OR = 1.310, 95% CI: 1.097,1.564); (obesity: OR = 1.320, 95% CI: 1.037, 1.681). Paternal pre-pregnancy underweight is associated with a lower risk of LBW (OR = 0.660, 95% CI: 0.519, 0.839). Parents who were both excessive-weights in pre-pregnancy BMI, as well as overweight mothers and normal-weight fathers before pre- pregnancy, were more likely to have o□spring with LBW, VLBW, and extremely low birth weight (ELBW).	6
Wei et al 2021	Paternal pre-pregnancy BMI overweight (OW) did not present associations with newborn relative telomere length (TL) in cord blood, even following adjustments (percentage change 0.93 (95% CI: -5.59,8.14));P=0.772 or stratification by newborn sex (percentage change 2.09 (95% CI: -7.53,12.72));P=0.686. Analysis of the combined effects of parental weight status on newborn TL showed that TL was significantly shortened among newborns whose mothers were overweight and fathers were of healthy weight when compared with those whose mothers and fathers were both of normal weight (percentage change − 8.38 (95% CI: − 15.47,− 0.92)); P = 0.028.	6
Xu et al 2021	Each standard deviation (SD) increment of paternal BMI (approx 3.27 kg/m²) is associated with an additional 29.6g increase of birth weight ([95% CI: 5.7, 53.5], P = 0.02). As a continuous variable, one-unit increase in paternal BMI (1.0 kg/m²) is associated with a 9.6g increase of offspring birth weight ([95% CI: 2.3, 17.0], P = 0.01). The association between paternal preconception body weight and offspring's birth weight is pronounced in male neonates and neonates with overweight mothers or mothers with excessive gestational weight gain [GWG] (P = <0.05).	7
Yang et al 2015	Fathers overweight [BMI 24.0 - 27.9 kg/m²] or obese [BMI ≥ 28.0kg/m²] before pregnancy have an elevated risk of giving birth to a macrosomic infant, compared with their normal weight counterparts (aOR = 1.33, [95% CI: 1.11, 1.59]);(aOR =1.99 [95% CI: 1.49,2.65]). Paternal pre-pregnancy weight only [≥75.0 kgs], not height, is associated with increased risk of macrosomia (aOR = 1.49, [95% CI: 1.16, 1.92]).	6
Zalbahar et al 2017	Overweight or obese [OW/OB] fathers [> 25 kg/m²] and normal weight mothers [< 25 kg/m²] have an increased risk of offspring OW/OB at both the 5 to 14 year plus the 14 to 21 year follow-up (aOR = 2.34, [95% CI: 1.50, 3.65]);(aOR = 2.27, [95% CI: 1.60, 3.24]). This risk increases further when both parents are OW/OB (aOR = 9.95, [95% CI: 5.60, 17.69]); (aOR = 12.47, [95% CI: 7.40, 21.03]); for every unit increase in paternal and maternal BMI z-score, offspring BMI z-score increased, on average, by between 0.15% (kg m²) and 0.24% (kg m²) throughout the 5, 14 and 21 year follow-up.	5
Zhang et al 2020	Underweight [< 18.5 kg/ m²] male partners prolong a couples' TTP (aFOR = 0.95, [95% CI: 0.94, 0.96]) compared to male partners with normal BMI [18.5 - 23.9 kg/m²]. A combination of normal BMI women and overweight men [24.0 - 28.9 kg/m²] have the greatest opportunity for pregnancy (aFOR = 1.03, [95% CI: 1.02, 1.03]), a combination of obese women and underweight men have the least opportunity for pregnancy (aFOR = 0.70, [95% CI: 0.65, 0.76]).	9
Alcohol		
Luan et al 2022	The risks of rating scores on anxious/depressed were increased by 33% (RR = 1.33 [95% CI: 1.09, 1.61]) and 37% (RR = 1.37 [95% CI: 1.02,1.84]) among girls in the exposed group at ages 4 and 6, respectively. Risks of somatic complaints were increased by 18% (RR = 1.18 [95% CI: 1.00, 1.40]) and 65% (RR 1.65,[95% CI: 1.14, 2.38]) among boys in the exposed group at ages 4 and 6. Also, there was the increased risks of sleep problems (RR	7

First Author & Year	Results from paternal exposure	Quality score±
	= 1.25[95% C:I 1.00,1.55]) in girls at age 4, thought problems (RR = 1.32 [95% CI: 1.01, 1.73]) in girls at age 6, and rule-breaking behaviours (RR = 1.35 [95% CI: 1.09, 1.67]) in boys at age 6.	
Milne et al 2013	For both ALL and CBT case/control, there was some evidence of a U-shaped relationship between the amount of alcohol fathers consumed in the 12 months before the pregnancy and risk of both cancers. The odds ratios (ORs) fell with increasing consumption, to a minimum at 14–21 standard drinks a week, ALL (OR=0.51 [95% CI: 0.32, 0.81]);CBT (OR=0.58 [95% CI: 0.35,0.96]), and rose to a maximum at 28 drinks a week; ALL (OR=1.20 [95% CI: 0.79,1.83); CBT (OR =1.53 [95% CI:0.95, 2.44]). The p values for the quadratic terms in the ALL and CBT models were 0.005 and 0.02, respectively.	6
Moss et al 2015**	Paternal preconception alcohol intake > once a month is not associated with offspring birthweight (−85.9, [95% CI: -336.2, 164.3], P = 0.50) or offspring gestational age (−0.10, [95% CI: -0.96, 0.77], P = 0.83).	7
Mutsaerts et al 2014**	Paternal preconception alcohol intake > 7 units/week is not associated with spontaneous preterm birth (OR = 1.08, [95% CI: 0.64, 1.83]) or SGA (OR = 1.07, [95% CI: 0.73, 1.56]).	3
Xia et al 2018	In the paternal alcohol-exposed group [> 81 g/wk], male offspring have shorter mean AGDs; for AGD-AP at birth (β = - 1.73, P = 0.04) and 12 months (β = -7.29, P = 0.05), and shorter mean AGD-AS at 6 months (β = - 4.91, P = 0.02). Female offspring have shorter mean AGD-AF (β = -0.72, P = 0.02) at birth yet longer mean AGD AC (β = 2.81, P = 0.04) and AGD-AF (B = 1.91, P = 0.04) at 12 months.	8
Zuccolo et al 2016	Increased odds of microcephaly at birth with alcohol dose per occasion at 5+ units/sitting; [1 - 2 units] (OR = 1.48, [95% CI: 0.77, 2.84], P = 0.238), [3-4 units] (OR = 1.64, [95% CI: 0.85, 3.16], P = 0.140), [5+ units] (OR = 1.93, [95% CI: 1.01, 3.70], P = 0.048). The average paternal preconception alcohol dose per occasion and general head circumference at birth is not associated [1 - 2 units] (β = -0.00, [95% CI: -0.05, 0.04], P = 0.831), [3-4 units] (β = -0.00, [95% CI: -0.05, 0.04], P = 0.915), [5+ units] (β = -0.02, [95% CI: -0.07, 0.02], P = 0.293).	4
Cannabis		
Har-Gil et al 2021	Sperm quality is associated with cannabis use (6 [1.4], P = 0.022), compared with non-use (6[2.2], P = 0.50). Sperm volume (2.69/2.5 [1.6]), IVF fertilization (53/53 [37]), the IR (P = 0.46) and OPR (P = 0.508) are not associated with male cannabis use.	2
Kasman et al 2018	Zero association identified between male cannabis use and TTP, regardless of frequency; [< 1/month] (aTR = 0.9, [95% CI: 0.7, 1.2], P = 0.43), [Monthly] (aTR = 0.9, [95% CI: 0.5, 1.8], P = 0.73), [Weekly] (aTR = 1.0, [95% CI: 0.3, 2.9], P = 1.00), [Daily] (aTR = 1.1, [95% CI: 0.79, 1.5], P = 0.65).	6
Moss et al 2015**	Paternal preconception cannabis use is not associated with gestational age (0.41, [95% CI: -0.43, 1.25], P = 0.34) or offspring birthweight (201.9, [95% CI: -97.6, 501.3], P = 0.19).	7
Nassan et al 2019	Compared to males who are past or never cannabis users, couples where the male partner is a cannabis user at enrolment (n = 23) have increased probability of implantation (77.9, [95% CI: 53.5, 91.5], P = < 0.05) and live birth (47.6, [95% CI: 32.4, 63.3], P = < 0.05), independent of women's cannabis use. Clinical pregnancy is not associated with male cannabis use; (60.1, [95% CI: 42.6, 75.4])	7
Wise et al 2018	Male current cannabis users (n=100) present no association between cannabis use and fecundability (aFR = 1.01, [95% CI: 0.81, 1.27]) even following stratification by intercourse frequency (aFR = 1.35, [95% CI: 0.72, 2.53]) and timing of sexual intercourse (aFR = 1.05, [95% CI: 0.76, 1.45]). Paternal cannabis use [< 1 time/week] has slightly decreased fecundability (FR = 0.87, [95% CI: 0.66, 1.15]), compared with non-current users.	6
Physical activity		

First Author & Year	Results from paternal exposure	Quality score±
Moss et al 2015**	Zero association identified between paternal preconception bouts of physical activity per week and gestational age (0.02, [95% CI: -0.04, 0.07], P = 0.53) or offspring birthweight (1.7, [95% CI: -13.0, 16.4], P = 0.82).	7
Mutsaerts et al 2014**	Paternal preconception physical activity of moderate intensity < 1 time/week is not associated with spontaneous preterm birth (OR = 0.76, [95% CI: 0.45, 1.27]) or SGA (OR = 1.33, [95% CI: 0.95, 1.87]).	3
Smoking		
Accordini et al 2021	Fathers' smoking initiation in prepuberty (generation G1) had a negative direct effect on their own FEV1/FVC (Δz-score −0.36, 95% CI: −0.68, -0.04) compared with fathers' never smoking. This exposure had a negative direct effect on both offspring's FEV1 (−0.36, 95% CI: −0.63, −0.10) and FVC (−0.50, 95% CI: −0.80, −0.20) (generation G2). Fathers' smoking initiation at later ages also had a negative direct effect on their own FEV1 (−0.27, 95% CI: −0.51,−0.02) and FEV1/FVC (−0.20, 95% CI: −0.37,−0.04), but no effect found on offspring's lung function.	8
Accordini et al 2018	Fathers' smoking before they were 15 years old were associated with asthma without nasal allergies in their offspring [relative risk ratio ((RRR) =1.43 95% CI: 1.01, 2.01]. The risk of fathers' asthma (generation F1) was higher if their parents (generation F0) had ever had asthma (grandmothers' asthma: (OR = 3.08 [95% CI: 1.96,4.85]); grandfathers' asthma: (OR = 2.38 [95% CI: 1.51, 3.75]). The risk of asthma with or without nasal allergies in offspring (generation F2) was higher if the offspring's father had ever had asthma (RRR = 2.37 and 1.70), respectively.	7
Carslake et al 2016	Paternal smoking during pre-adolescence (<age 11) is not reliably or strongly associated with BMI among sons, with an estimated association close to zero (mean difference in kg m-2 (95% CI) was -0.18 (-1.75, 1.39) for sons aged 12±19 and 0.22 (-0.53, 0.97) for all ages). Among daughters, early-onset paternal smoking was imprecisely associated with an elevated BMI (mean difference was 1.50 (0.00, 3.00) for daughters aged 12±19 and 0.97 (0.06, 1.87) for all ages).	6
Deng et al 2013	During the periconceptional period, light paternal smoking [1-9 cigarettes/day] increases the risk of isolated conotruncal heart defects (aOR = 2.23, [95% CI: 1.05, 4.73]). Medium paternal smoking [10-19 cigarettes/day] increases the risk of septal defects (aOR = 2.04, [95% CI: 1.05, 3.98]) and left ventricular outflow tract obstructions (aOR = 2.48, [95% CI: 1.04, 5.95]). Heavy paternal smoking (≥ 20 cigarettes/day) provides even greater risk of isolated conotruncal heart defects (aOR = 8.16, [95% CI: 1.13, 58.84]) and left ventricular outflow tract obstructions (aOR = 13.12, [95% CI: 2.55, 67.39]). No association identified between paternal smoking and right ventricular outflow tract obstructions; light smoking (AOR = 1.84, [95% CI 0.88, 3.85]); medium smoking (aOR = 2.04, [95% CI: 0.71, 5.89]); heavy smoking (aOR = 6.02, [95% CI: 0.98, 36.77]).	8
Frederiksen et al 2020	Nil associations identified between paternal smoking before conception and childhood ALL (OR = 1.00, 95% CI: 0.73, 1.38). Paternal smoking before conception was associated with an increased risk of childhood AML in both the crude (OR = 2.55, 95% CI: 1.25, 5.21) and adjusted models (OR = 2.51, 95% CI: 1.21, 5.17).	7
Knudsen et al 2020	In the unadjusted analysis, father's preconception smoking, both starting before or from age 15 years, was associated with increased offspring BMI. Following adjustments, father's smoking onset ≥ 15 years was significantly associated with increased BMI in their adult offspring (0.551, [95% CI: 0.174, 0.929]) P=0.004. Father's preconception smoking onset ≥ 15 years was also associated with increased offspring FMI (2.590 [95% CI: 0.544, 4.63]) P=0.014. Further, sons of fathers' who started to smoke ≥ 15 years of age (interaction p = 0.014) had significantly higher FMI compared to sons of never smoking fathers.	5
Milne et al 2013	Paternal preconception smoking showed no association with childhood brain tumor (CBT) risk (OR = 0.99 (95% CI: 0.71, 1.38); P =0.54. There was also no association evident when paternal smoking was stratified by child's age.	5

First Author & Year	Results from paternal exposure	Quality score±
Ko et al 2014	Paternal preconception smoking [11-20 cigarettes/day] has a negative effect on overall infant birthweight (β = -19.17 [7.74], P = 0.013) but is not associated with gestational age (β = -0.05 [0.028], P = 0.108). Paternal preconception smoking [> 20 cigarettes/day] is not associated with preterm delivery (1.07, [95% CI: 0.84, 1.35]), low birth weight (1.14, [95% CI: 0.87, 1.27]), or small for gestational age [SGA] (1.12, [95% CI: 0.90, 1.40]).	5
Moss et al 2015**	Paternal preconception smoking at least one cigarette/day for one month is not associated with gestational age (−0.31, [95% CI:−1.20, 0.59], P = 0.50) or offspring birthweight (−219.6, [95% CI: −537.0, 97.8], P = 0.18).	7
Mutsaerts et al 2014**	Paternal smoking [1-10 cigarettes/day] or [< 10 cigarettes/day] 6 months prior to conception, is associated with an increased risk of SGA (OR = 1.69; [95% CI: 1.10, 2.59]); (OR = 2.25, [95% CI: 1.51, 3.37]) but not spontaneous preterm birth (OR = 1.34, [95% CI: 0.74, 2.41]); (OR = 1.13, 95% CI: 0.59, 2.14).	3
Northstone et al 2014	In sons whose fathers started smoking <11 years, mean differences in BMI, waist circumference, and fat mass all show increases in measures at ages 13 , 15 and 17; at 13 years BMI (2.83, [95% CI: 1.20, 4.25]), waist circumference and fat mass (4.83, [95% CI: 0.98, 8.68], P = 0.014);(5.79, [95% CI: 2.67, 8.91] P = <0.0001), and at 15 years BMI (2.03 [95% CI: 0.45, 3.6]), waist circumference and fat mass (4.84, [95% CI: 0.99, 8.66], P = 0.006); (5.50, [95% CI: 1.88, 9.30], P = 0.004). At 17 years there is an association with BMI (3.25 [95% CI: 1.15, 5.35]) and fat mass (10.6 [95% CI: 5.40, 15.9], P = <0.0001); waist not recorded. Daughters' measurements vary with associations at ages 9 (all measurements), 11 (lean mass P = 0.023), 13 (waist circumference P = 0.004 & lean mass P = 0.028) and 17 (fat mass P = 0.012).	7
Orsi et al 2015	Pre-conception paternal smoking was significantly associated with ALL (OR = 1.2 [95% CI: 1.1,1.5)] and AML (OR = 1.5 [95% CI: 1.0–2.3]). For ALL, the ORs were higher for smoking\10 cigarettes daily than for the highest consumption; no significant trend was evidenced. For AML, significant trends were evidenced for both periods (p trend = 0.03 and 0.02, respectively), with ORs of close to 2.0 for smoking more than 15 cigarettes daily. No joint effect of paternal and maternal smoking was detected.	7
Sapra et al 2016	Paternal cigarette smoking is associated with a longer TTP compared with never users (aFOR = 0.41, [95% CI: 0.24, 0.68]); attenuated slightly after adjusting for cadmium (aFOR = 0.44, 95% CI: 0.24, 0.79). When modelling partners together, paternal cigarette smoking remains associated with a longer TTP (aFOR = 0.46, [95% CI: 0.27, 0.79]), also attenuated after adjustment for cadmium (aFOR = 0.50, [95% CI 0.27 - 0.91]). Zero association identified between TTP and exposure to any other tobacco products including cigars (FOR = 0.70, [95% CI: 0.45, 1.08]) or snuff and chew tobacco (FOR = 1.17, [95% CI: 0.70, 1.95].	7
Svanes et al 2017	Non-allergic early-onset asthma (asthma without hay fever) was more common in the offspring with fathers who smoked before conception (OR = 1.68 [95% CI: 1.18,2.41]). The risk was highest if father started smoking before age 15 years (OR = 3.24 [95% CI: 1.67,6.27]), even if he stopped more than 5 years before conception (OR = 2.68 [95% CI: 1.17, 6.13]).Both a father's early smoking debut (P=0.001) and a father's longer smoking duration (P=0.01) before conception increased non-allergic early-onset asthma in offspring, even with mutual adjustment and adjusting for number of cigarettes and years since quitting smoking. A father's smoking debut before age 11 years (102 fathers) showed the greatest increased risk (OR = 3.95, [95% CI: 1.07,14.60]), followed by smoking debut ages 11–14 (OR =1.75, [95% CI: 1.07,1.86]) and smoking debut after age 15 (OR=1.37, [95% CI: 1.00,1.86]). Longer duration of smoking was also associated with an increased risk, up to 1.8-fold for those smoking for more than 10 years (OR = 1.76, [95% CI: 0.96,3.25]).	6
Wang et al 2022	Hazard ratio (HR) of preterm birth (PTB) was 1.07 (95% CI, 1.06–1.09), compared with women without preconception paternal smoking. Compared with participants without preconception paternal smoking, the fully adjusted HRs of PTB were (1.04 [95% CI: 0.99,1.08]), (1.05 [95% CI: 1.01, 1.08]), (1.06 [95% CI: 1.03, 1.09]), (1.14 [95% CI: 1.07, 1.21]) and (1.15 [95% CI: 1.11, 1.19]) for participants whose husband smoked 1–4, 5–9, 10–14, 15–19, and ≥ 20 cigarettes/day respectively (***P*** linear < 0.05).	5

First Author & Year	Results from paternal exposure	Quality score±
Wang et al 2018	Women with exposure to paternal preconception smoking have increased odds of SA (aOR = 1.11, [95% CI: 1.08, 1.14], P = <0.01). This association is evident when smoking > 10 cigarettes/day, P = <0.01; [10-14 cigarettes/day] (aOR = 1.11, [95% CI: 1.06, 1.16]), [15-19 cigarettes/day] (aOR = 1.21, [95% CI: 1.09, 1.33]) and ≥ 20 cigarettes/day (aOR = 1.23, [95% CI: 1.17, 1.30).	6
Wesselink et al 2019	Male current regular smoking, current occasional smoking, and former smoking is not associated with fecundability (FR = 0.96, [95% CI: 0.70, 1.34]), (FR = 0.83, [95% CI: 0.61, 1.13]), (FR = 1.14, [95% CI: 0.97, 1.35]).	5
You et al 2022	For those with only preconception exposure, compared with children without paternal smoking, the risk of childhood overweight and obesity was increased (OR = 1.41 [95% CI: 1.17, 1.85]). Following further adjustments, for lifestyle and dietary factors, this effect remained statistically significant (OR = 1.54 [95% CI: 1.14, 2.08]). When stratified by sex, the effects of only preconception exposure on childhood overweight and obesity was statistically significant for only boys (p<0.05).	7
Zhou et al 2020	There is an increased risk of birth defects in the continued-smoking (OR = 1.87, [95% CI: 1.36, 2.56], P < 0.001) and decreased-smoking groups (OR = 1.41, [95% CI: 1.10, 1.82], P = 0.007). Continued paternal smoking is associated with an elevated risk of congenital heart diseases (OR = 2.51, [95% CI: 1.04, 6.05], P = 0.040), limb abnormalities (OR = 20.64, [95% CI: 6.26, 68.02], P < 0.001), digestive tract anomalies (OR = 3.67, [95% CI: 1.44, 9.37], P = 0.007) and neural tube defects (OR = 4.87, [95% CI: 1.66, 14.28], P = 0.004). There is no association between continued paternal smoking and clefts (OR 1.44, [95% CI: 0.34, 5.90], P = 0.625) or gastroschisis (OR = 2.63, [95% CI: 0.82, 8.40] P = 0.103).	7
Zwink et al 2016	Paternal periconceptional tobacco consumption is lower in the fathers of EA/TEF patients [Any smoking] n= 20 (20%) P = 0.003, compared with fathers of isolated ARM patients [Any smoking] n= 49 (40%) P = 0.003.	4
Stress		
Bae et al 2017	There is a 76% increase in risk of fathering a male infant (RR = 1.76, [95% CI: 1.17, 2.65]) in men diagnosed with anxiety disorders compared with those not diagnosed. This association is strengthened (RR = 2.03, [95% CI: 1.46, 2.84]) when modelled jointly for the couple.	6
Mutsaerts et al 2014**	Paternal paid working hours < 16 hours/week is not associated with spontaneous preterm birth (OR = 2.21, [95% CI: 0.78, 6.26]) or SGA (OR = 0.76, [95% CI: 0.23, 2.45]).	3
Wesselink et al 2018	Men's baseline PSS scores are not associated with fecundability; [PSS score 10 - 14] (FR = 0.95 [95% CI: 0.79, 1.15]), [PSS Score 15-19] (FR = 1.07 [95% CI: 0.86, 1.33]), [PSS Score 20-24] (FR = 1.02 [0.76, 1.36]), [PSS Score ≥ 25] (FR = 1.03 [0.69, 1.54]).	7
Nutrition		
Bailey et al 2014	No significant associations identified with paternal dietary intake of folate or vitamin B6 or vitamin B12 and risk of ALL; (OR = 1.37 95% CI: 0.78, 2.40).	5
Greenop et al 2015	No significant associations identified between risk of childhood brain tumors (CBT) and energy adjusted dietary folate >509.5 (mcg) (OR = 0.85 95% CI: 0.56,1.28) or energy adjusted B6 > 1.71 (mg) (OR=0.98 95% CI: 0.66,1.47). A high B12 intake (>5.91(mcg)) was not significantly associated with an increased risk of CBT (OR = 1.74 95% CI: 1.14, 2.66).	5
Hatch et al 2018	Male intake of sugar-sweetened beverages is associated with reduced fecundability (aFR= 0.78 95% CI: 0.63, 0.95) for ≥ 7 sugar-sweetened beverages per week compared with none. Fecundability was further reduced among those who drank ≥7 servings per week of sugar-sweetened sodas (aFR= 0.67 95% CI: 0.51, 0.89). The largest reduction in fecundability was seen in men who consumed seven or more energy drinks per week	6

First Author & Year	Results from paternal exposure	Quality score±
	(FR=0.42; 95% CI: 0.20, 0.90). Diet sodas did not have significant association with fecundability at ≥7 servings per week (aFR= 0.93 95% CI: 0.71, 1.2).	
Hoek et al 2019	In spontaneously conceived pregnancies, there is a negative association between paternal RBC folate status and CRL trajectories, in Q2 [875–1,018 nmol/L;] (β = -0.14; [95% CI: - 0.28, -0.006], P = 0.04) and Q4 [1,196–4,343 nmol/L] (β = - 0.19, [95% CI: - 0.33, -0.04], P = 0.012). A negative association also exists for EV trajectories in Q4 (β= - 0.12, [95% CI: -0.20, -0.05], P = 0.001). No association identified between paternal RBC folate status and CRL or EV trajectories in IVF-ICSI pregnancies [Q4] (β = 0.03, [95% CI: -0.07, 0.13], P = 0.55), (β = 0.03, [95% CI: -0.03, 0.08], P = 0.32).	7
Lippevelde et al 2021	In Young-HUNT1, an extra serving of fruit per week in the paternal diet, during adolescence, is associated with a 2.35g increase in offspring placenta weight [95% CI: 0.284, 4.42], P = 0.03. A slightly shorter birth length is associated with increased paternal vegetable intake during adolescence (β = -0.048, [95% CI: -0.080, -0.016], P = 0.003) and a lower ponderal index is associated with paternal whole grain bread consumption (β = -0.003, [95% CI: -0.005, -0.001], P = 0.01). Paternal lunching regularly in adolescence is associated with an increase in offspring head circumference (β = 0.160, [95% CI: 0.001, 0.320], P = 0.05). Birthweight is not associated with any paternal dietary exposures; [Fruit] (β = 5.84 [95% CI: -0.983, 12.7], P = 0.1). These associations are not observed in Young-HUNT3.	8
Martin-Calvo et al 2019	A 400 µg/day increase in preconception paternal folate intake is associated with a 2.6-day longer gestation [95% CI: 0.8, 4.3], P = 0.004. This association is strongest in multifetal pregnancies (β = 10.7, [95% CI: 4.6, 16.8]). Zero association identified between paternal folate intake and gestational age-specific birthweight (β = -11.4, [95% CI: -28.2, 5.4]).	7
Mitsunami et al 2021	Paternal adherence to either dietary patterns 1 or 2 is not associated with the fertilization rate during IVF or ICSI ([Pattern 1] P = 0.59, [Pattern 2] P = 0.06), ([Pattern 1] P = 0.72, [Pattern 2] P = 0.94). Zero association identified between male dietary patterns and probabilities of implantation, clinical pregnancy, or live birth; ([Pattern 1] P = 0.68, [Pattern 2] P = 0.43), ([Pattern 1] P = 0.35, [Pattern 2] P = 0.68), ([Pattern 1] P = 0.53, [Pattern 2] P = 0.10).	7
Moss et al 2015**	Males eating fast food more frequently have infants born earlier than men who eat fast-food less frequently (-0.16, [95% CI: -0.32, 0.00], P = 0.04). There is no association between paternal fast-food consumption and birthweight (-36.0, [95% CI: -89.8, 17.8], P = 0.19).	7
Oostingh et al 2019	Zero association identified between paternal dietary patterns and CRL or EV in spontaneous pregnancies; [Whole wheat grains and vegetables] (β = -0.006 [95% CI: -0.069, 0.058]), (β = 0.001 [95% CI: -0.022, 0.021]), and in IVF/ICSI pregnancies, (β = -0.015 [95% CI: -0.061, 0.031]), (β = -0.006 [95% CI: -0.025, 0.013]), independent of maternal dietary patterns.	6
Twigt et al 2012	Paternal Preconception Dietary Risk Score [PDR] did not affect the chance of pregnancy after IVF/ICSI treatment (OR =0.95 [95% CI: 0.48,1.86]) P=0.88.	5
Wesselink et al 2016	Total caffeine intake among males was associated with fecundability for ≥ 300mg vs. <100 mg/day (OR = 0.72, 95% CI: 0.54, 0.96).	6
Xia et al 2016	Men's total dairy intake is not associated with the fertilization rate [Conventional IVF] (0.75, [95% CI: 0.60, 0.86], P = 0.29), [ICSI] (0.72, [95% CI: 0.58, 0.82], P = 0.18], the implantation rate (0.58, [95% CI: 0.40, 0.74], P = 0.87), the clinical pregnancy rate (0.51, [95% CI: 0.34, 0.68], P = 0.54), or the live birth rate (0.46, [95% CI: 0.28, 0.65], P = 0.65).	7
Xia et al 2015	A positive association identified between paternal poultry intake and the fertilization rate, [Model 1] P = 0.05, [Model 2] P = 0.03, [Model 3] P = 0.03, [Model 4] P = 0.04, with a 13% higher fertilization rate among men in the highest quartile of poultry intake compared with those in the lowest quartile (78% vs. 65%) [Model 4]. Men's total meat intake is not associated with the implantation rate (0.52, [95% CI: 0.37, 0.67], P = 0.67), clinical pregnancy rate (0.45, [95% CI: 0.32, 0.59], P = 0.56), or live-birth rate (0.35, [95% CI: 0.22, 0.50], P = 0.82).	7

The outcomes and outcome measures varied, however, ten studies assessed the association of paternal BMI with offspring BMI/bodyweight (235, 247, 269, 270, 272, 275-278), and one paper assesses offspring weight and BMI changes from childhood (5 years) into adulthood (21 years) (236).

Results of associations between body composition and offspring outcomes were inconsistent. In some studies paternal preconception overweight (25.0 - 29.9 kg/m²) and obesity (> 30 kg/m²) were not associated with offspring birthweight (247) and paternal pregravid BMI was not an independent predictor for large for gestational age (LGA) or small for gestational age (SGA) (269). However, other studies found that offspring birthweight increased by 10.7 g per unit increase in paternal pregravid BMI (95% CI: 0.5, 20.9, P = 0.04) (269), and each standard deviation (SD) increment of paternal BMI (approximately 3.27 kg/m²) was associated with an additional 29.6g increase of birth weight (95% CI: 5.7, 53.5, P = 0.02) (270). Further, compared with normal weight men, paternal pre-pregnancy overweight was associated with a significantly increased risk of preterm birth (aOR 1.34 95% CI: 1.25,1.45) and low birth weight (aOR 1.60 95% CI: 1.46-1.74) in offspring (277).

Paternal pregravid weight (P = 0.04), not height (P = 0.43), was associated with infant birth weight (269) and with increased risk of macrosomia (aOR = 1.49, [95% CI: 1.16, 1.92]) (275), while neonatal birth weight was associated with paternal height only (β = 0.08, P = 0.003) (235). In another study, paternal pre-pregnancy BMI was only associated with offspring BMI when using absolute BMI values not BMI as a z-score (278).

Fathers' overweight before puberty had a negative indirect effect, mediated through sons' height, on sons' forced expiratory volume in one second (FEV_1) (beta (95% CI): −144 (−272, −23) mL) and forced vital capacity (FVC) (beta (95% CI): −210 (−380, −34) mL), and a negative direct effect on sons' FVC (beta (95% CI): −262 (−501, −9) mL) (246). (246).

Male BMI ≥25 kg m² was not associated with time to pregnancy (TTP)(257), yet underweight (< 18.5 kg/ m²) was associated with a longer TTP (adjusted fecundability odds ratio [aFOR] = 0.95, [95% CI: 0.94, 0.96]) compared to normal BMI (18.5 - 23.9 kg/m²) (258).

In couples undergoing IVF/ICSI, paternal periconceptional BMI was negatively associated with fertilization rate (β = −0.01 [SE = 0.004], P = 0.002]), while paternal BMI was not associated with the total motile sperm count (TMSC), the KIDScore, the embryo usage rate, a positive pregnancy, fetal heartbeat, or live birth (261). (261).

Offspring methylation was associated with paternal BMI independent of maternal BMI (P = < 0.05)(288).(288). Methylation decreased by 5% in cord blood with every 1-unit increase in paternal BMI (P = 3.13 × 10 $^{-9}$), decreases persist at 3 years old (P =0.002) and 7 years old (P = 0.004) (288).(288). Paternal BMI was associated with methylation at cg01029450 in the promoter region of the ARFGAP3 gene; methylation at this site was also associated with lower infant birthweight (β = −0.0003; SD = 0.0001; P = 0.03) (288). (288).

No association was found between behavioural outcomes at pre-school age and underweight (< 18.5 kg/m²) or obesity (≥30 kg/m²) in fathers (285).(285). Equally, no associations were found between paternal BMI overweight (≥ 25 kg/m²- <30 kg/m²), obese class I (≥ 30 kg/m²- <35 kg/m²) and obese class II (≥ 35 kg/m²) and offspring behavioural issues or psychiatric symptoms at 7-8 years (283). (283).

4.4.2 Alcohol

Six papers examined alcohol as an exposure (238, 247, 250, 284, 289, 290); three rated as good quality (247, 284, 289). Excluding one, each paper used paternal self-reports of alcohol consumption with varying definitions; one article specified units/per week (250), the others assessed consumption more broadly either as intake ≥ 1/week (289), ≥ 1/month (247) or general intake (290). A single study presented a maternal report of paternal preconception alcohol consumption, 3 months before conception, at 12-16 weeks gestation (284).

When examining an outcome of offspring anogenital distance (AGD), in the paternal alcohol-exposed group (> 81 g/wk), male offspring had shorter mean AGDs (289); for AGD-AP [the centre of the anus to the cephalad insertion of the penis] at birth (β = - 1.73, P = 0.04) and 12 months (β = -7.29, P = 0.05), and shorter mean AGD-AS [the centre of the anus to the posterior base of the scrotum] at 6 months (β = - 4.91, P = 0.02) (289). Female offspring had shorter mean AGD-AF [the centre of the anus to the posterior convergence of the fourchette) (β = -0.72, P = 0.02) at birth yet longer mean AGD AC [the centre of the anus to the clitoris] (β = 2.81, P = 0.04) and AGD-AF (B = 1.91, P = 0.04) at 12 months (289). Further, the relative risks of anxiety or depression were increased by 33% (RR = 1.33 [95% CI: 1.09, 1.61]) and 37% (RR = 1.37 [95% CI: 1.02,1.84]) among girls in the exposed group at ages 4 and 6, respectively (284). Paternal alcohol consumption greater than once per month was not associated with offspring birthweight or gestational age (247).

4.4.3 Cannabis

Paternal cannabis exposure was assessed in five papers (247, 249, 251, 262, 263), two rate as good quality (247, 263). Each paper has a sample size < 1,200 and each utilized paternal self-reporting of cannabis use broadly assessing general use, rather than specific amounts, over a pre-determined period (i.e., last 2 months or 12 months).

In sub-fertile couples undergoing IVF/ICSI, compared to males who were past or never cannabis users, couples where the male partner used cannabis at enrolment had increased probability of implantation (77.9, [95% CI: 53.5, 91.5], P = < 0.05) and live birth (47.6, [95% CI: 32.4, 63.3], P = < 0.05), independent of women's cannabis use (263). Clinical pregnancy was not associated with male cannabis use (263), nor was gestational age or offspring birthweight (247).

4.4.4 Physical Activity

The associations of paternal physical activity with offspring outcomes were assessed in two papers (247, 250), one rated as good quality (247). This study found no association between paternal preconception bouts of physical activity per week and gestational age or offspring birthweight (247).

4.4.5 Smoking

The association of tobacco smoking with offspring outcomes was examined in 20 papers (239, 242-244, 247, 252, 259, 271, 273, 274, 279-282, 291-296); half (n=10) were rated as good quality (243, 244, 247, 259, 271, 273, 274, 279, 281, 282, 291, 293, 294) and nine papers adjusted for maternal smoking and/or paternal passive smoking in their analysis (244, 271, 273, 274, 279, 281, 293, 294).

Paternal cigarette smoking was associated with a longer TTP compared with never users (aFOR = 0.41, [95% CI: 0.24, 0.68]), while no associations were found for other tobacco products including cigars or snuff and chew tobacco (259).

Outcomes involving smoking and birth defects report that during the periconceptional period, light paternal smoking [1-9 cigarettes/day] increased the risk of isolated conotruncal heart defects (aOR = 2.23, [95% CI: 1.05, 4.73]) (291). Medium paternal smoking [10-19 cigarettes/day] increased the risk of septal defects (aOR = 2.04, [95% CI: 1.05, 3.98]) and left ventricular outflow tract obstructions (aOR = 2.48, [95% CI: 1.04, 5.95]) (291). Heavy paternal smoking (≥ 20 cigarettes/day) increased the risk of isolated conotruncal heart

defects (aOR = 8.16, [95% CI: 1.13, 58.84]) and left ventricular outflow tract obstructions (aOR = 13.12, [95% CI: 2.55, 67.39]) (291).(291). Likewise, an increased risk of birth defects was found for continued-smoking (OR = 1.87, [95% CI: 1.36, 2.56], P < 0.001) and decreased-smoking groups (OR = 1.41, [95% CI: 1.10, 1.82], P = 0.007) compared with those fathers that quit smoking during early pregnancy and those who did not smoke at all during preconception (294).

Paternal preconception smoking at least one cigarette/day for one month was not associated with gestational age or offspring birthweight (247).(247) In contrast, a second study found sons whose fathers started smoking <11 years, the adjusted mean differences in BMI, waist circumference, and fat mass all showed higher values at ages 13, 15, and 17 (274). Further, the risk of childhood overweight and obesity was increased among children exposed to paternal preconception smoking compared to children without paternal smoking exposure (OR = 1.41 [95% CI: 1.17, 1.85]) (279).(279)

Paternal preconception smoking 12 months prior to conception was associated with an increased risk of childhood acute myeloid leukemia (AML) (OR = 2.51, 95% CI: 1.21, 5.17) (281) and paternal smoking just 3 months prior to conception provided significant associations with acute lymphoblastic leukemia (ALL) (OR = 1.2 [95% CI: 1.1,1.5)] and acute myeloblastic leukemia (AML) (OR = 1.5 [95% CI: 1.0–2.3]) (282).

Paternal preconception smoking also provided significant associations with offspring lung function and asthma; fathers' smoking initiation in prepuberty (generation G1) had a negative direct effect on their own FEV1/FVC (difference in offspring's expected score −0.36, 95% CI: −0.68, -0.04) compared with fathers' never smoking. This exposure had a negative direct effect on both offspring's FEV1 (−0.36, 95% CI: −0.63, −0.10) and FVC (−0.50, 95% CI: −0.80, −0.20) (generation G2) (244). Fathers' smoking before age 15 years was associated with higher risk of asthma without nasal allergies in their offspring [relative risk ratio ((RRR) =1.43 95% CI: 1.01, 2.01] (243).

4.4.6 Stress

Paternal stress exposure was examined in three papers (250, 253, 297); including one rated as good quality (253). This study found men's baseline perceived stress scale [PSS] scores were not associated with fecundability (253).

4.4.7 Nutrition

Papers examining paternal nutrition (n=13) evaluated the associations of a range of nutritional exposures including paternal preconception folate, vitamins B6 and B12, and general dietary patterns with numerous offspring outcomes. These papers utilized data from several studies (n=8) originating in the US, Norway, The Netherlands, and Australia. Approximately half of these papers (n=7) rated as good quality.

Paternal nutritional factors explored included dietary patterns (265, 298) or specific foods groups including dairy (266), and meat (267). IVF/ICSI-induced live birth was an outcome examined in three papers (265-267). A positive association was found between paternal poultry intake and fertilization rate, with a higher fertilization rate among men in the highest quartile of poultry intake [78%] compared with those in the lowest quartile [65%] (267). Men's total dairy intake was not associated with fertilization rate, implantation rate, clinical pregnancy rate, or live birth rate (266). Also, paternal adherence to specific dietary patterns [pattern 1 = greater intake of processed foods/meats/high fat/dairy/sugar; pattern 2 = greater intake of fruit/vegetables/legumes/whole grains/nuts/fish] was not associated with fertilization rate (265) when undergoing IVF cycles.

One paper investigated dietary exposures during adolescence and subsequent neonatal health (248). In a sample of adolescents followed into adulthood becoming fathers (n=2,140), an extra serving of fruit per week was associated with a 2.35g increase in offspring placenta weight [95% CI: 0.284, 4.42], P = 0.03 (248). Further, paternal lunching regularly in adolescence was associated with an increase in offspring head circumference (β = 0.160, [95% CI: 0.001, 0.320], P = 0.05) and whole grain bread consumption was associated with a lower ponderal index (β = -0.003, [95% CI: -0.005, -0.001], P = 0.01) (248). Birthweight was not associated with any paternal dietary exposures (248).

Generally, paternal preconception dietary patterns were collected through paternal self-reports on standardised food frequency questionnaires (FFQ) at baseline and include fast foods (247); males eating fast food more frequently had infants born earlier than men who eat fast food less frequently (-0.16, [95% CI: −0.32, 0.00], P = 0.04) (247).

Table 4.4 Newcastle Ottawa Scale [NOS] quality assessment (Cohorts)

First author & Year	Newcastle Ottawa Scale - Criteria									
	SELECTION				COMPARABILITY		OUTCOME			TOTAL
	Exposed cohort (representativeness)	Non-exposed cohort	Ascertainment of exposure	Outcome of interest not present at start of study	Based on design or analysis (AGE)	Based on design or analysis (OTHER FACTORS)	Assessment of outcome	Appropriate length of follow-up	Adequacy of follow-up of cohorts	
Accordini et al 2021	✶	✶	✶		✶	✶	✶	✶	✶	8
Accordini et al 2018	✶	✶	✶		✶	✶		✶	✶	7
Bae et al 2017		✶	✶	✶	✶	✶		✶		6
Bowatte et al 2022		✶	✶			✶		✶	✶	5
Broadney et al 2017	✶	✶			✶	✶	✶		✶	6
Carslake et al 2016	✶	✶				✶	✶	✶	✶	6
Casas et al 2017	✶	✶	✶	✶	✶	✶	✶	✶	✶	9
Chen et al 2021		✶	✶		✶	✶	✶			5
Fang et al 2020	✶	✶	✶		✶	✶				5
Fleten et al 2012	✶	✶		✶		✶		✶	✶	6
Guo et al 2022	✶	✶	✶	✶	✶	✶				6
Har-Gil 2021		✶					✶			2
Hatch et al 2018		✶		✶	✶	✶		✶	✶	6
Hoek et al 2022		✶	✶	✶	✶	✶	✶	✶	✶	8
Hoek et al 2019		✶	✶		✶	✶	✶	✶	✶	7

Johannessen et al 2020	✶	✶			✶	✶		✶	✶	6
Kasman et al 2018	✶	✶	✶	✶	✶	✶				6
Knudsen et al 2020	✶	✶				✶		✶	✶	5
Ko et al 2014	✶	✶	✶		✶	✶				5
Lippevelde et al 2021	✶	✶		✶	✶	✶	✶	✶	✶	8
Lonnebotn et al 2022	✶	✶			✶	✶	✶	✶	✶	7
Luan et al 2022		✶	✶	✶	✶	✶		✶	✶	7
Martin-Calvo et al 2019		✶	✶	✶	✶	✶		✶	✶	7
Mitsunami et al 2021		✶	✶	✶	✶	✶		✶	✶	7
Moss et al 2015	✶	✶		✶	✶	✶		✶	✶	7
Mutsaerts et al 2014	✶	✶							✶	3
Nassan et al 2019		✶	✶	✶	✶	✶		✶	✶	7
Noor et al 2019		✶		✶	✶	✶	✶	✶	✶	7
Northstone et al 2014	✶	✶		✶		✶	✶	✶	✶	7
Oostingh et al 2019		✶		✶	✶	✶	✶		✶	6
Pomeroy et al 2015		✶			✶	✶	✶	✶	✶	6
Retnakaran et al 2021		✶	✶	✶	✶	✶	✶	✶	✶	8
Robinson et al 2020	✶	✶		✶	✶	✶		✶	✶	7
Sapra et al 2016		✶	✶	✶	✶	✶	✶	✶		7
Sun et al 2022		✶	✶	✶	✶	✶		✶	✶	7

Sundaram et al 2017		✶	✶	✶	✶	✶	✶	✶	✶	8
Svanes et al 2017	✶	✶			✶	✶		✶	✶	6
Twigt et al 2012		✶		✶	✶	✶			✶	5
Umul et al 2015		✶					✶			2
Wang et al 2022	✶	✶	✶		✶	✶				5
Wang et al 2018	✶	✶	✶	✶	✶	✶				6
Wei et al 2022		✶		✶	✶	✶	✶	✶		6
Wei et al 2021	✶	✶	✶		✶	✶	✶			6
Wesselink et al 2019		✶		✶	✶	✶		✶		5
Wesselink et al 2018		✶	✶	✶	✶	✶		✶	✶	7
Wesselink et al 2016		✶		✶	✶	✶		✶	✶	6
Wise et al 2018		✶		✶	✶	✶		✶	✶	6
Xia et al 2018		✶	✶	✶	✶	✶	✶	✶	✶	8
Xia et al 2016		✶		✶	✶	✶	✶	✶	✶	7
Xia et al 2015		✶		✶	✶	✶	✶	✶	✶	7
Xu et al 2021		✶	✶	✶	✶	✶		✶	✶	7
You et al 2022		✶	✶		✶	✶	✶	✶	✶	7
Zalbahar et al 2017		✶			✶	✶	✶	✶		5
Zhang et al 2020	✶	✶	✶	✶	✶	✶	✶	✶	✶	9
Zhou et al 2020		✶	✶	✶	✶	✶		✶	✶	7

Zuccolo et al 2016	✶	✶			✶	✶				4

Table 4.5 Newcastle Ottawa Scale [NOS] quality assessment (Case controls)

Newcastle-Ottawa Critical Analysis (Case controls) - Criteria										
First author & Year	**SELECTION**				**COMPARABILITY**		**EXPOSURE**			**TOTAL**
	Adequacy of case definition	**Representativeness of the cases**	**Selection of controls**	**Definition of controls**	**Comparability of cases and controls (AGE)**	**Comparability of cases and controls (OTHER FACTORS)**	**Ascertainment of exposure**	**Same method of ascertainment for cases and controls**	**Non-Response rate**	
Bailey et al 2014	✶		✶		✶	✶	✶			5
Deng et al 2013	✶	✶		✶	✶	✶	✶	✶	✶	8
Frederiksen et al 2020	✶	✶	✶	✶	✶	✶		✶		7
Greenop et al 2015	✶		✶		✶	✶	✶			5
Milne et al 2013	✶	✶	✶		✶	✶		✶		6
Milne et al 2013	✶		✶		✶	✶	✶			5
Orsi et al 2015	✶	✶	✶	✶	✶	✶		✶		7
Yang et al 2015		✶	✶	✶	✶	✶		✶		6
Zwink et al 2016	✶			✶	✶	✶				4

Two papers specifically investigated paternal folate (264, 299). In males undergoing fertility treatment, a 400 μg/day higher preconception folate intake was associated with a 2.6-day longer gestation [95% CI: 0.8, 4.3], P = 0.004 (264). In spontaneously conceived pregnancies, a significant negative association was found between paternal red blood cell [RBC] folate status and crown-rump length (CRL) trajectories, in Quartile 2 [875–1,018 nmol/L;] (β = -0.14; [95% CI: - 0.28, -0.006], P = 0.04) and Quartile 4 [1,196–4,343 nmol/L] (β = - 0.19, [95% CI: - 0.33, -0.04], P = 0.012) compared with the reference values in Quartile 3 (299). A negative association was also found for embryonic volume (EV) trajectories in Quartile 4 (β= - 0.12, [95% CI: -0.20, -0.05], P = 0.001) (299).

4.5 DISCUSSION

This paper reports the first review collating literature assessing modifiable paternal health behaviours and risk factors in the preconception period and highlights clear disparity between the preconception research for women as compared to that for men. While single papers identified in our review do demonstrate adverse pregnancy and offspring outcomes associated with paternal risk factors in the preconception period, current research of paternal health behaviours and risk factors provides an emerging rather than mature evidence-base. Nevertheless, our review did identify a number of important findings.

One consistent finding of this review was the association between paternal preconception smoking and increased risk of adverse infant outcomes, including birth defects and childhood leukemia especially acute myeloid leukemia/acute myeloblastic leukemia (AML). Adverse outcomes such as birth defects are mirrored in maternal preconception smoking literature (115, 300-303), yet the impact of maternal smoking on the risk of AML remains contentious (304). Smoking in the preconception period may be as perilous for males as for females, as smoking can potentially affect semen quality (52). Many male smokers (and even more so in smoking couples) consider smoking an indispensable characteristic of their domestic, social and working lives (53) and many report a lack of motivation, willpower, and/or strength to successfully quit (305), in turn influencing female smoking patterns and family environments (53). Paternal preconception smoking may well be contributing to the estimated 240,000 newborns dying worldwide annually due to birth defects (306). The finding of paternal preconception smoking and the increased risk of adverse infant outcomes is altogether disconcerting considering the widespread use of tobacco, and that males are more likely than females to engage in risk-taking behaviours, including smoking (305); the estimated global prevalence of male adolescent smokers in 133 countries is 23.29% .

The papers in this review which focus upon body composition with birthweight outcomes generally affirm positive associations between increasing paternal BMI and offspring birthweight. Indeed, this finding aligns with the literature outside this review which acknowledges that mothers and fathers with overweight or obesity are more likely to have children with overweight or obesity (55, 307-309), compared with those with a normal weight. The positive associations between increasing paternal BMI and offspring bodyweight may, in part, result from unhealthy preconception environments and relationships with food. Food-based parenting strategies (55) and spending too much time sedentary (57) may also contribute to influencing offspring weight status. One paper in this review did chart offspring weight and BMI changes from childhood into adulthood (236), however, this reported research did not control for the offspring's diet and physical exercise.

Nonetheless, an individual's birthweight can influence both their body weight in childhood (310) and their body weight as they transition into adulthood (311); external literature positively associates both a higher birthweight and childhood obesity with overweight/obesity at 15-20 years of age (312). Frameworks to maintain healthy bodyweight, in turn promoting healthy birthweights, endure in the Global action plan on physical activity 2018-2030 (66) and in national overweight/obesity guidelines in countries such as Australia (64) and the Unites States (65).

It is important to note that most papers included in this review utilize retrospective reports (paternal self-reports or maternal reports) of anthropometric data collected at baseline. Such retrospective self-reporting is also evident in the maternal preconception literature (313, 314) and is often considered unreliable and subject to inaccuracies due to self-reporting bias or recall bias (315). Inaccuracies and reporting bias may be present in particular in papers that utilize maternal reports of paternal preconception height and body weight at minimum 10 weeks of gestation in some papers up to 4 months postpartum. Consequently, retrospective reports of data at baseline may undermine the validity, accuracy, and therefore the reliability of BMI data used in these papers. It is important to note that most papers included in this review utilize retrospective reports (paternal self-reports or maternal reports) of anthropometric data collected at baseline. Such retrospective self-reporting is also evident in the maternal preconception literature (313, 314) and is often considered unreliable and subject to inaccuracies due to self-reporting bias or recall bias (315). Inaccuracies and reporting bias may be present in particular in papers that utilize maternal reports of paternal preconception height and body weight at minimum 10 weeks of gestation in some papers up to 4 months postpartum. Consequently, retrospective reports of data at baseline may undermine the validity, accuracy, and therefore the reliability of BMI data used in these papers.

The majority of papers in our review report research undertaken in distinct geographical regions with the USA, Europe and the UK, and China heavily represented. As such, the implications for reduced geographical spread of the available research examining paternal preconception health exposures and outcomes must also be considered. It may be that existing region-specific idiosyncrasies of paternal health behaviours, and associated adverse health outcomes for their children, are yet to be described due to the absence of research conducted in other countries and cultures. These gaps limit the opportunities for tailored preconception care policies and interventions and constrain the broader understanding of the potential importance of paternal preconception care. Notwithstanding, such issues foster opportunities for other countries and cultures to identify, learn from and support paternal health.

While almost all papers in this review adjust for some confounders, less than half (n=23) adjusted for the same maternal exposure (i.e., paternal BMI studies adjusting for maternal BMI). Many papers in this review did not adjust for maternal exposures and thus may present biased results and conclusions. Further, many maternal studies do not control for paternal exposures which is a limitation in the field that requires urgent research attention and refocus.

The date parameters set during the search may also represent a limitation as it may have resulted in manuscripts published before the 2012 being overlooked. However, up until recently the preconception research field has primarily focused on the effects of maternal exposures and as such it is unlikely that significant research was overlooked by this date restriction.

Further limitations of the review include the potential for missed citations due to issues with article indexing. Our search protocol did not employ search term truncations or singular synonyms in the final search string which may have resulted in some citations being missed. However, the search protocol was informed by an experienced health librarian, and additional methods – such as reference list and citation checking - were used to identify relevant manuscripts not identified through the primary search. Furthermore, previous search strings trialed for this review that used different synonyms, truncations and search term categories did not result in any additional relevant manuscripts being identified beyond those included in the final search. As such, the literature review is the most comprehensive review of the topic conducted to date.

This review is innovative in that it provides the first examination of paternal preconception risk factors and their association with adverse pregnancy and offspring outcomes. The rigour

of the review is also bolstered through adhering to established systematic review reporting guidelines (PRISMA and AMSTAR).

4.6 CONCLUSION

Overall, this review shows that paternal preconception modifiable risk factors are largely underexplored; smoking and body composition appear to be important areas for consideration in paternal preconception care. While the current literature identifies an emerging evidence-base around paternal preconception modifiable risk factors, there is a need for further investigation to help better inform paternal preconception care and national and international preconception care guidelines. In particular, further research is necessary to identify and better understand the modifiable risk factors affecting males in the preconception period, and how these risk factors influence offspring outcomes, to inform clinical recommendations and health decisions. The future of paternal preconception care and the integration of such care into frontline health practice and policy rests with informed collaboration between clinicians, researchers and policymakers (41).

4.7 CHAPTER SUMMARY

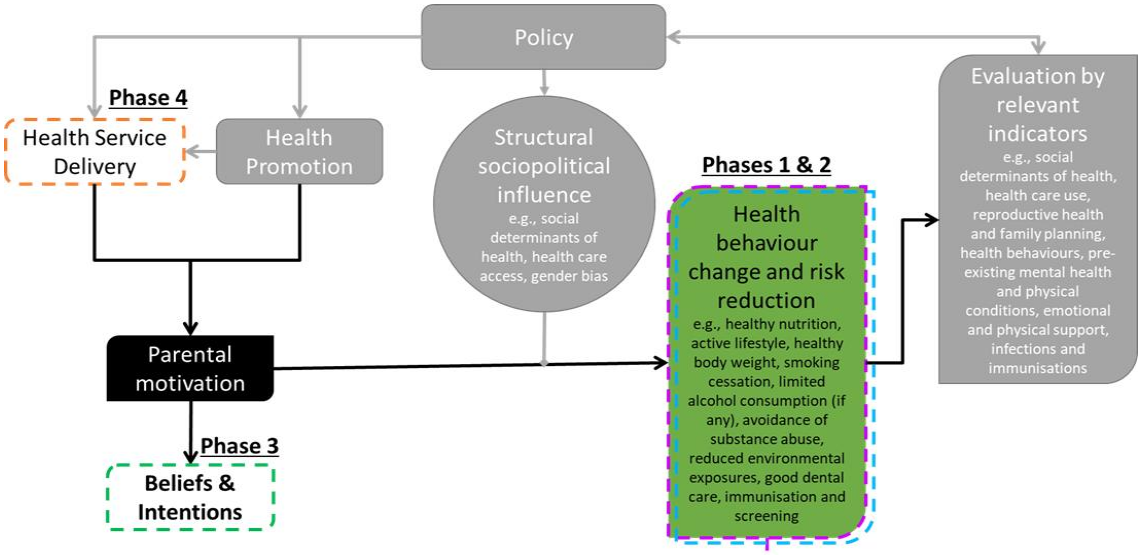
This chapter initiates the four-phase research design by presenting an evidence synthesis that builds upon the foundation established in the systematic review presented in Chapter Two. It comprises a literature review of contemporary evidence examining the paternal preconception health behaviours and modifiable risk factors associated with adverse pregnancy and offspring outcomes. The review identified a wide range of adverse pregnancy and offspring outcomes, which were linked to seven key preconception health behaviours and risk factors: (i) body composition, (ii) alcohol consumption, (iii) cannabis use, (iv) physical activity, (v) smoking, (vi) stress, and (vii) nutrition. Overall, smoking and body composition—specifically variations in body mass index beyond a healthy range—emerged as the most frequently reported preconception risk factors among males, consistently associated with negative pregnancy and offspring outcomes. In contrast, evidence regarding the impact of stress and, to a lesser extent, nutrition on pregnancy and offspring outcomes was limited. Similarly, the influence of alcohol consumption, physical activity, and cannabis use on pregnancy and offspring outcomes was sparsely documented in the literature. This chapter examines the behavioural component of the beliefs-behaviours relationship, providing a research foundation for understanding paternal preconception health beliefs and behaviours in Australia.

5 THE PRECONCEPTION HEALTH AND HEALTH BEHAVIOURS OF AUSTRALIAN FIRST-TIME FATHERS

5.1 RATIONALE FOR THIS ANALYSIS

The rationale for the analysis undertaken in this chapter aligns with research objectives two three, and four. These research objectives aim to identify the prevalence of clinically relevant preconception health behaviours of Australian males, explore the social determinants associated with Australian males engaging in preconception health behaviours, and to identify the health service utilisation and preferences of Australian males during the preconception period. The preconception health behaviours and risk factors of males relevant to this analysis are an exploration of those behaviours identified from the review of literature completed in chapter four. Utilising data from the largest all male study in Australia, the results of this chapter can identify the preconception health characteristics and relevant health behaviours and risk factors from a broad scope of Australian adult males who have reported becoming a father in the previous 12 months.

The content of this chapter and its relevance to the project conceptual framework is highlighted in green below.



5.2 INTRODUCTION

During the months to years prior to conception, known as the *preconception period*, care and support can be initiated or provided as part of biomedical, behavioural, and social health interventions for women and couples to optimise pregnancy and offspring outcomes (136). Preconception care is considered an effective catalyst for behaviour change prior to parenthood, and a strategy to manage any potential barriers to health to ensure optimal outcomes (150). Research suggests modifying and sustaining behaviour change up to 12 months but at least three months prior to conception to optimise preconception health status (131, 316). However, the importance of preconception health extends beyond the 12 months prior to conception and is therefore also relevant to males during early childhood and adolescence who, as potential future fathers, can be engaged by other males to promote positive health behaviours which translate into adulthood (317).

Preconception health can be optimised through effective preconception care strategies to systematically address exposures and behaviours known to have epigenetic influences on health, such as smoking, excessive alcohol consumption, a nutritionally balanced diet (318), and regular physical activity (319). Addressing these behaviours are key considerations due to their known influence on adverse pregnancy and offspring outcomes such as risk of preterm birth or low birthweight (114). Health conditions such as depression or asthma are also key considerations to be addressed during the preconception period due to their known influences on pregnancy and offspring outcomes such as infertility (320) or spontaneous abortion (321).

In addition to health behaviours and health conditions, social determinants of health (2), alongside characteristics such as gender (199) and age (322), may influence an individual's engagement and responsiveness to preconception care strategies and their ability to optimise health behaviours. Social determinants include characteristics such as being married or being in a committed relationship, being employed and able to sustain financial comfortability, or having stable housing (67), all of which will influence an individual's health behaviour's and access to health services. However, preconception care that supports males to optimise medical, behavioural and social risk factors is currently an underutilised approach (26, 33, 135).

A male's roles, responsibilities, and contributions before conception are contingent on their awareness and motivation toward planning and preparing for pregnancy and parenthood (87). This may be influenced by the engagement in pregnancy preparation of their female partner (26, 38), and the knowledge and expertise of health practitioners and health services accessed (or not) by males (25, 132). By acknowledging that a male's responsibilities and

influence commences in the preconception period (179), there is a need to actively include male partners in parenthood preparation (180), integrate males into preconception care, and advocate for coordinated paternal preconception care delivery. The integration of males into preconception-based discussions is rarely considered within clinical encounters regarding pregnancy or family planning (25, 323) or within preconception care policies, guidelines, and recommendations (34, 135).

Males wanting to become a parent can feel uncomfortable sharing their experiences and emotions in discussions and in groups (27). For males who may wish to be proactively involved in planning to start a family may find themselves feeling like the 'optional' member of preconception health discussions (179) only referred to by health professionals during matters of infertility. Ultimately, paternal preconception care has the potential to significantly benefit the health of males and, subsequently, of future generations.

In light of the current gaps in research, the study reported here draws upon the largest national all male-cohort study, Ten to Men (TTM) (216) to ascertain the preconception health status and preconception health behaviours of Australian males before they become first-time fathers. In addition, the study explored the associations between preconception health characteristics and becoming a first-time father among Australian adult males.

5.3 MATERIALS AND METHODS

5.3.1 Study design

This study utilised longitudinal data from the Australian Longitudinal Study on Male Health (TTM) (216).(216). TTM was conducted in four waves; Wave1 [2012-2014]; Wave 2 [2015-2016]; Wave 3 [2020-2021]; Wave 4 [2022-2023] (Figure 1). Access and use of TTM data (Version 4.0.1) was approved by the TTM Data Manager in accordance with the terms set forth in the *Ten to Men: The Australian Longitudinal Study on Male Health Data User Agreement and Deed of Confidentiality.*

Study ethics approval was obtained from the University of Technology Sydney [UTS] Human Research Ethics Committee [HREC] (ETH24-10077). This study complies with the Reporting of Observational studies in Epidemiology [STROBE] guidelines (324).

5.3.2 Setting and participants

TTM was conducted to further knowledge of male health and the factors that influence male health and has the capacity to address key preconception health issues and emphasize the social determinants of health (217). TTM data provides a focal point for the enablement of

the National Men's Health Strategy 2020-2030 (325) which calls for addressing increased attention to both preconception health and fatherhood. TTM was conducted over eight years in four waves commencing in 2013 (216) and recruited approximately 24,000 boys and men aged from 10 to 55 years old, at wave 1, from across Australia (216). Study recruitment used a stratified, multi-stage cluster random sample design which identified Australian males based upon clusters of geographical units (216). Fieldworkers approached households to determine if residents were eligible for study inclusion. Study participants were chosen at random to ensure diversity in representation across all Australian States and Territories. All participants who completed Wave 1 were invited to participate in the subsequent waves. A separate questionnaire was administered for each wave which elicited details regarding participant sociodemographic characteristics, their health and wellbeing, lifestyle, views and feelings, relationships and sex, home and work life, and use of health services. The males considered for the current study were adult participants aged at least 18 years old who became a first-time father in the 12 months prior to any of the waves.

5.3.3 Survey instrument

The questionnaires administered for each wave generally reported the same variables although nuances were reported at each timepoint. In each questionnaire, survey respondents answered, '*in the past 12 months, have you become a father for the first time?'.* Respondents who answered 'yes' to this question were identified as 'first-time fathers'.

The analysis undertaken for the study reported in this paper draws upon the following sociodemographic variables: age, region of birth, marital status, private health insurance status, employment status, main industry of employment, highest qualification completed following high school, identification as an Aboriginal or Torres Strait Islander, home ownership status, and combined household income.

Variables also included were health and health behaviours such as smoking [current smoker and cigarettes per day], alcohol consumption [standard drinks per day and frequency in the last 12 months], sleep [hours/minutes per night during week/on weekend], body mass index [BMI], number of new female sexual partners in the previous 12 months, fruit and vegetable servings per day, usual sitting time on a workday/weekend [minutes], and physical activity in the previous week [number of times and times spent in minutes].

Variables relevant to health conditions and health literacy were also analysed including serious personal injury, illness or surgery in the last 12 months, incapacity due to injury, specific heath conditions in the past 12 months [Eczema, Asthma, COPD, Chronic Bronchitis, Arthritis, Cataracts, Diabetes mellitus, Depression, Post-traumatic stress, other

anxiety disorders, schizophrenia, high cholesterol, high blood pressure, heart attack, heart failure, angina, stroke, cancer, sleep apnoea], and variables relating to health literacy [understanding and discussing information from a healthcare provider].

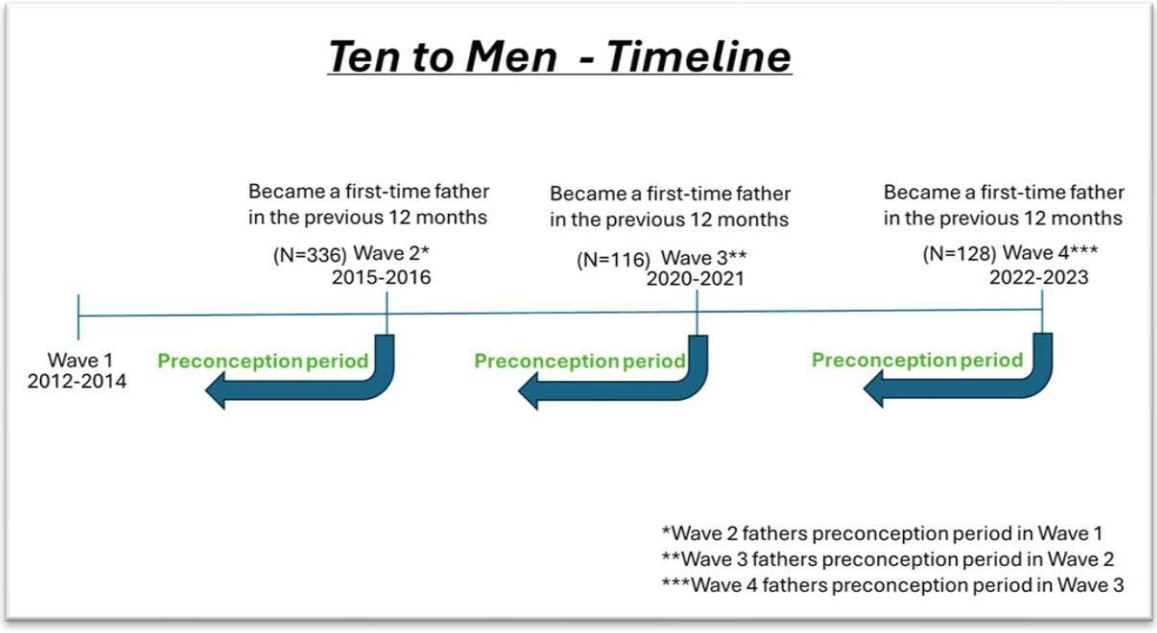
Other variables analysed related to health consultations [professionals in the last 12 months and frequency of checkups with a GP], reasons why healthcare cannot be accessed, and drug use in the past 4 weeks and 12 months [Marijuana].

5.3.4 Data Analysis

TTM data version 4.0.1 incorporated four separate data files (one for each wave). The data files for each wave were imported into the STATA18 statistical software *(StataCorp LLC)* and merged using the unique identifier for each study participant.

From the merged data set, variables of interest were identified across all waves and binary variables were generated from categorical variables to determine participants at each wave who identified as a first-time father in the past 12 months (yes,no). First-time fathers identified in each wave had their health behaviours analysed from the previous waves i.e. any first-time fathers identified in waves 2, 3, and 4 had their health behaviours analysed from waves 1, 2, and 3, respectively (Figure 5.1).

Figure 5.1 Ten to Men Timeline



Frequencies and proportions for all categorical variables of interest were reported according to being a first-time father. Statistical differences in variables were explored using chi-square tests with α-value set of 0.05. The mean and standard deviation was reported for all continuous variables and t-tests applied to test for statistically significant differences. Any

missing variables or responses identified in the questionnaire such as i) Not asked, ii) Don't know, iii) Refused to answer, and iv) Invalid response were not included in the analysis.

Backwards stepwise logistic regression was used to identify the most parsimonious model for characteristics of males predicting who became first-time fathers. All differences in variables measured by chi-square tests or t-tests, with a p value $p<0.20$, were included in the regression model. The variable with the highest p-value was removed from the model then the model was tested and re-tested until the final p-value for the model was ≤ 0.05. Any variables which were only answered by a subset of the population were not included in the logistic regression analysis for example – the number of cigarettes smoked per day (smokers only).

5.4 RESULTS

Across the four waves, a total of 11,811 adult males responded to the question regarding becoming a first-time father in the past 12 months (referred to as all respondents). A total of 572 adult males had become a father for the first time (first-time fathers) and therefore had health behaviours in previous waves which were reported prior to them becoming a father, during preconception. A total of 11,239 did not become a first-time father during the study period (others).

5.4.1 Sociodemographic characteristics

For all respondents, about half were aged 45-55 years (32.0%) or >55 years (16.6%) (Table 5. 1). Most respondents were born in Oceania (83.1%), married (70.0%), employed (79.1%), and/or reported an income over $99,000 per year (n=63.3%).

When comparing the sociodemographic characteristics of first-time fathers during the preconception period with others, first-time fathers mean age was lower (mean 35.9; SD 8.2 vs 42.3;SD 12.3, $p<0.001$). Age reported by category revealed a high proportion of first-time fathers aged between 25 to 34 years old (40.3%) or 35 to 44 years old (39.5%) compared with others from the same age ranges; 25 to 34 years (15,1%) or 35 to 44 years (22.2%) ($p<0.001$). A greater proportion of first-time fathers were born in Asia (9.5%) compared to others (6.0%) while a smaller proportion of first-time fathers were born in Europe (4.6%) than others (7.1%) ($p=0.01$). Also, first-time fathers were more often married (73.8%) and/or employed (82.8%) than others (69.8% and 78.9%) respectively, ($p=0.002$). First-time fathers were also more likely to hold private health insurance (68.0%) compared with others (62.1%).

Table 5.1 Sociodemographic characteristics of Australian adult first-time fathers

Characteristics	All (n =11,811)	Became first time father in the previous 12 months (n= 572)	Did not become a first-time father in the previous 12 months (n=11,239)	P value
	Mean; SD	**Mean; SD**	**Mean; SD**	
Age (years)	42.0; (12.2)	35.9 (8.2)	42.3 (12.3)	<0.001
	n (%)	**n (%)**	**n (%)**	
18 to 24 years	1,398 (11.8)	37 (6.4)	1,361 (12.1)	<0.001
25 to 34 years	1,931 (16.3)	231 (40.3)	1,700 (15.1)	
35 to 44 years	2,723 (23.0)	226 (39.5)	2,497 (22.2)	
45 to 55 years	3,789 (32.0)	61 (10.6)	3,728 (33.1)	
Aged greater than 55 years	1,970 (16.6)	17 (2.9)	1,953 (17.3)	
Region of birth		**(n=7,755)**		
Oceania and Antarctica	6,449 (83.1)	340 (82.9)	6,109 (83.1)	0.01
Europe	545 (7.0)	19 (4.6)	526 (7.1)	
Africa and Mid East	197 (2.5)	9 (2.2)	188 (2.5)	
Asia	481 (6.2)	39 (9.5)	442 (6.0)	
Americas	83 (1.0)	3 (0.7)	80 (1.0)	
Marital status		**(n=10,445)**		
Married/de facto	7,318 (70.0)	393 (73.8)	6,925 (69.8)	0.001
Separated but not divorced	306 (2.9)	7 (1.3)	299 (3.0)	
Divorced/Widowed	415 (3.9)	7 (1.3)	408 (4.1)	
Never married	2,406 (23.0)	125 (23.5)	2,281 (23.0)	
Private health insurance		**(n=11,655)**		
	7,275 (62.4)	388 (68.0)	6,887 (62.1)	0.004
Employment status		**(n=11,735)**		
Employed	9,291 (79.1)	473 (82.8)	8,181 (78.9)	0.002
Unemployed	1,240 (10.5)	64 (11.2)	1,176 (10.5)	
Neither working or looking for work	1,204 (10.2)	34 (5.9)	1,170 (10.4)	
Education–highest qualification completed following high school		**(n=10,957)**		
Have not completed any qualification	1,274 (11.6)	37 (6.5)	1,237 (11.9)	<0.001
Begun but did not complete any qualification	1,023 (9.3)	55 (9.7)	968 (9.3)	
Vocational Education - Trade/Certificate/Diploma	5,165 (47.1)	235 (41.7)	4,930 (47.4)	
University degree or higher	3,095 (28.2)	214 (38.0)	2,881 (27.7)	
Other	400 (3.6)	22 (3.9)	378 (3.6)	
Identify as Aboriginal or Torres Strait Islander		**(n=11,770)**		
	261 (2.2)	16 (2.8)	245 (2.1)	0.334
Home ownership status		**(n=11,405)**		
Owned outright, or with a mortgage, or being purchased under a rent/buy scheme	5,690 (48.8)	283 (50.3)	5,407 (49.8)	0.01
Renting or pay board	4,769 (41.8)	252 (44.8)	4,517 (41.6)	
Being occupied rent-free	653 (5.7)	17 (3.0)	636 (5.8)	
Other	293 (2.5)	10 (1.7)	283 (2.6)	
Combined household income		**(n=10,971)**		
Low income (up to $37,500 per annum or up to $769 per week)	755 (6.8)	31 (5.6)	724 (6.9)	0.05
Moderate income (between $37,501 to $99,000 or between $770 and $1,919 per week)	3,273 (29.8)	144 (26.2)	3,129 (30.0)	
High income (Over $99,000 or at least $1,920 per week)	6,943 (63.3)	374 (68.1)	6,569 (63.0)	

A larger proportion of first-time fathers held a university degree or higher (38.0%) and/or generated a high income, being over $99,000 per annum, (68.1%) compared with others; university degree or higher (27.7%) (p<0.001); high income (63.0%) (p=0.05). Further, a

slightly greater proportion of first-time fathers were paying rent or board (44.8%) compared with others (41.6%) (p=0.01).

5.4.2 Health and health behaviours

All respondents who were smokers (35.6%) reported smoking an average of nine cigarettes per day (mean 8.8; SD 9.4) (Table 5.2). Close to half of all respondents reported alcohol consumption at least once a week (45.5%), but most respondents met the alcohol guidelines of no more than four standard drinks per day (80.6%). Most respondents also met the daily sleep requirements during the weekend (91.6%). The majority of all respondents met the recommended daily limits for sitting on a non-workday (94.1%). Similarly, a large proportion of all respondents met the weekly recommendations for physical activity, both moderate (60.8%) and vigorous (77.5%).

First-time fathers more often reported being overweight before conception (31.8%) compared with others (27.6%) (P=0.002) but generally smoked less cigarettes per day (mean 4.9; SD 6.6) than others (mean 11.4; SD 8.8) (p<0.001). The proportion of first-time fathers who reported daily alcohol consumption (1.4%) was less than others (2.5%) (p=0.01) and a greater proportion of first-time fathers met the alcohol guideline (n=85.7%) compared with others (80.3%) (p=0.002). The requirements for vigorous physical activity per week were also met by a greater proportion of first-time fathers (81.9%) compared to others (77.3%) (p=0.009). First-time fathers also reported a greater average number of minutes of physical activity per week (mean 383.4; SD 299.3) than others (mean 332.5; SD 301.1) (p<0.001). Fewer first-time fathers reported meeting the recommendations for moderate physical activity per week (55.9%) compared with others (61.1%) (p<0.001).

Table 5.2 Health and health behaviours of Australian adult first-time fathers

Characteristics	All (n =11,811)	Became first time father in the previous 12 months (n=572)	Did not become a first-time father in the previous 12 months (n=11,239)	P value
	n (%)	**n (%)**	**n (%)**	
	(n=7,026)			
Smoking (Current Smoker)	2,505 (35.6)	102 (31.1)	2,403 (35.8)	0.08
	(n=2,580)			
	Mean;SD	**Mean;SD**	**Mean;SD**	**P value**
Smoking (Cigarettes per day - currently)	8.8 (9.4)	4.9 (6.6)	11.4 (8.8)	<0.001
	n (%)	**n (%)**	**n (%)**	**P value**
	(n=10,806)			
Alcohol **Meet guidelines of no more than 4 drinks on any day?**	8,713 (80.6)	463 (85.7)	8,250 (80.3)	0.002
Alcohol (Frequency in the last 12 months)	**(n=11,620)**			
Every day	286 (2.4)	8 (1.4)	278 (2.5)	0.01

At least once a week	5,289 (45.5)	234 (41.2)	5,055 (45.7)	
Once a month or less frequently	6,045 (52.0)	326 (57.4)	5,719 (51.7)	
Sleep **Meet recommendations getting at least 7 hours and up to 9 hours a day?**				
	(n=11,147)			
Weekday	8,305 (74.5)	393 (72.9)	7,912 (74.6)	0.38
	(n=11,652)			
Weekend	10,683 (91.6)	513 (90.6)	10,170 (91.7)	0.35
	Mean;SD	**Mean;SD**	**Mean;SD**	**P value**
	(n=11,811)			
Body Mass Index (BMI)				
Underweight (BMI <18.5)	194 (1.6)	2 (0.3)	192 (1.7)	0.002
Normal weight (BMI 18.5 – 24.9)	1,613 (13.66)	91 (15.9)	1,522 (13.5)	
Overweight (BMI 25.0 – 29.9)	3,287 (27.8)	182 (31.8)	3,105 (27.6)	
Obesity (BMI>30)	6,717 (56.8)	297 (51.9)	6,420 (57.1)	
	(n=2,222)			
	n (%)	**n (%)**	**n (%)**	**P value**
Fruit serves per day **Meet the recommended daily intake of 2 or more serves?**	9,365 (79.2)	465 (81.3)	8,900 (79.1)	0.22
Vegetable serves per day **Meet the recommended daily intake of 5 or more serves?**	5,767 (48.8)	259 (45.2)	5,508 (49.0)	0.08
Sitting time usual workday **Meet the recommended daily limit of no more than 7HRS?**	10,452 (88.4)	494 (86.3)	9,958 (88.6)	0.10
Sitting time usual non workday **Meet the recommended daily limit of no more than 7HRS?**	11,122 (94.1)	551 (96.3)	10,571 (94.0)	0.02
Physical Activity [previous week] ***Moderate physical activity (time spent)***				
Meet the recommendations of at least 2.5 hours per week?	7,190 (60.8)	320 (55.9)	6,870 (61.1)	0.01
Physical Activity [previous week] ***Vigorous physical activity (time spent)***				
Meet the recommendations of at least 1.25 hours per week?	9,160 (77.5)	469 (81.9)	8,691 (77.3)	0.009
	(n=10,886)			
	Mean;SD	**Mean;SD**	**Mean;SD**	**P Value**
Total time of physical activity in minutes (last 7 days)	334.2 (301.3)	383.4 (299.3)	332.5 (301.1)	<0.001
Drug Use				
Marijuana in the past 4 weeks**	**(n=1,342)**			
	674 (50.2)	32 (51.6)	642 (50.1)	0.82
Marijuana in the past 12 months	**(n=11,336)**			
	2,986 (26.3)	145 (25.5)	2,841 (26.3)	0.65

* Only asked to current smokers

** Only asked if used in the past 12 months

5.4.3 Health conditions

More than one quarter of all respondents (28.4%) had reported serious personal injury, illness or surgery in the previous 12 months and more than half of all respondents reported being partly limited by this injury (55.3%) (Table 5.3). The most reported health conditions were depression (19.5%), other mental health conditions (21.0%), high blood pressure (15.8%), high cholesterol (13.9%) and asthma (12.9%). Less than one in 10 respondents reported the remainder of all other health conditions such as eczema (10.7%), high blood pressure (9.8%), and sleep apnoea (7.8%).

Table 5.3 Health conditions of Australian adult first-time fathers

Characteristics	All (n =11,811)	Became first time father in the previous 12 months (n=572)	Did not become a first-time father in the previous 12 months (n=11,239)	P value
	n (%)	n (%)	n (%)	
		(n=11,632)		
Serious personal injury, illness or surgery (last 12 months)	3,312 (28.4)	156 (27.3)	3,156 (28.5)	0.53
Limited by Injury*		**(n=2,915)**		
Yes - Fully	221 (7.6)	5 (4.0)	216 (7.7)	0.22
Yes- but only partly	1,612 (55.3)	67 (54.0)	1,545 (55.3)	
Health Conditions in the past 12 months		**(n=11,423)**		
Eczema	833 (7.2)	61 (10.7)	772 (7.1)	0.001
		(n=11,769)		
Asthma	1,523 (12.9)	79 (13.8)	1,444 (12.9)	0.52
		(n=11,048)		
COPD	89 (0.8)	3 (0.5)	86 (0.8)	0.45
		(n=11,046)		
Chronic bronchitis	188 (1.7)	9 (1.6)	179 (1.7)	0.84
		(n=11,046)		
Arthritis	1,126 (10.1)	28 (4.9)	1,098 (10.5)	<0.001
		(n=11,046)		
Cataracts	80 (0.7)	3 (0.5)	77 (0.7)	0.58
		(n=11,728)		
Diabetes mellitus	595 (5.0)	23 (4.0)	572 (5.1)	0.24
		(n=11,774)		
Depression	2,295 (19.5)	102 (17.8)	2,193 (19.6)	0.30
		(n=11,047)		
Post-traumatic stress	305 (2.7)	21 (3.7)	284 (2.7)	0.15
		(n=11,724)		
Other anxiety disorders or mental health conditions^	2,466 (21.0)	104 (18.2)	2,362 (21.1)	0.09
		(n=11,426)		
Schizophrenia	72 (0.6)	5 (0.8)	67 (0.6)	0.44
		(n=11,730)		
High Cholesterol	1,639 (13.9)	44 (7.7)	1,595 (14.3)	<0.001
		(n=11,726)		
High Blood pressure	1,860 (15.8)	56 (9.8)	1,804 (16.1)	<0.001
		(n=11,044)		
Heart attack	124 (1.1)	3 (0.5)	121 (1.1)	0.17
		(n=11,046)		
Heart failure	56 (0.5)	2 (0.3)	54 (0.5)	0.60
		(n=11,045)		

Angina	116 (1.0)	3 (0.5)	113 (1.0)	0.21
	(n=11,727)			
Stroke	76 (0.6)	2 (0.3)	74 (0.6)	0.36
	(n=11,729)			
Cancer ^^	349 (2.9)	5 (0.8)	344 (3.0)	0.002
	(n=11,725)			
Sleep apnoea	1,029 (8.7)	45 (7.8)	984 (8.8)	0.43

* Question only asked to respondents with an injury

^ Other anxiety conditions separate to post-traumatic stress disorder.

^^ Includes bowel cancer, bladder cancer, brain cancer, prostate cancer, skin cancer, testicular cancer, thyroid cancer, other or unknown types of cancer.

To compare the health conditions of first-time fathers and others , several conditions were reported less often by first-time fathers including arthritis (4.9%) vs (10.5%) ($p<0.001$); high cholesterol (7.7%) vs (14.3%) ($p<0.001$); high blood pressure (9.8%) vs (16.1%) ($p>0.001$), and cancer (0.8%) vs (3.0%) ($p<0.001$). First-time fathers more often reported Eczema (10.7%) vs (7.1%) ($p=0.001$).

5.4.4 Health consultations, health information, and health literacy

The majority of all respondents had consulted a GP in the past 12 months (91.3%) and approximately one third of all respondents have consulted a specialist doctor (37.8%) or pharmacist (32.2%) during the same period (Table 5.4). From the respondents who consulted with a GP, 44% reported the frequency of GP checkups was 'never'. When exploring the reasons why healthcare in general could not be accessed, respondents could not access healthcare due to waiting times being too long or there being no appointments (34.8%), due to cost (34.2%), or simply due to not deciding to seek care (29.7%).

Comparing the health consultations of first-time fathers with others, a slightly higher proportion of first-time fathers reported consulting with a GP (93.7%), than others did (91.2%) ($p=0.04$). In contrast, a slightly lower proportion of first-time fathers reported consulting with a social worker (0.3%) compared with others (1.6%). More than half of the first-time fathers reported never consulting with a GP for a checkup (54.2%) compared with 43% of others who reported the same ($p<0.001$). There were no statistically significant differences for variables related to heath information and health literacy.

Table 5.4 Health consultations, health information, and health literacy of Australian first-time fathers

Characteristics	All (n =11,811)	Became first time father in the previous 12 months (n=572)	Did not become a first-time father in the previous 12 months (n=11,239)	P value
	n (%)	n (%)	n (%)	
Consulted with a health care professional in the last 12 months				
		(n=11,728)		
General practitioner (GP)	10,713 (91.3)	535 (93.7)	10,178 (91.2)	0.04
		(n=11,728)		
Specialist doctor	4,441 (37.8)	197 (34.5)	4,244 (38.0)	0.08
		(n=11,728)		
Pharmacist	3,781 (32.2)	204 (35.7)	3,577 (32.0)	0.06
		(n=11,728)		
Chiropractor	2,436 (20.7)	119 (20.8)	2,317 (20.7)	0.96
		(n=11,759)		
Dentist	7,264 (61.7)	364 (63.7)	6,900 (61.6)	0.32
		(n=11,080)		
Diabetes Educator	192 (1.7)	10 (1.7)	182 (1.7)	0.94
		(n=11,728)		
Naturopath	427 (3.6)	19 (3.3)	408 (3.6)	0.68
		(n=11,080)		
Social worker	172 (1.5)	2 (0.3)	170 (1.6)	0.01
Frequency of consultations with a GP* (n=11,711)				
More than once a year	1,145 (9.7)	34 (5.9)	1,111 (9.9)	<0.001
Once a year	2,177 (18.6)	73 (12.8)	2,104 (18.8)	
Less frequently	3,212 (27.4)	154 (27.0)	3.058 (27.4)	
Never	5,177 (44.2)	309 (54.2)	4,868 (43.7)	
Reasons why healthcare cannot be accessed (n=2,861)				
No service in area	554 (19.3)	24 (15.5)	530 (19.6)	0.22
Waiting times too long/no appointments	996 (34.8)	55 (25.7)	941 (34.7)	0.80
Not taking new patients	230 (8.0)	18 (11.7)	212 (7.8)	0.08
Cost	980 (34.2)	51 (33.1)	929 (34.3)	0.76
Decided not to seek care	852 (29.7)	48 (31.1)	804 (29.7)	0.69
Too busy	571 (19.9)	36 (23.3)	535 (19.7)	0.27
Transport	152 (5.3)	4 (2.6)	148 (5.4)	0.12
Language problems	25 (0.8)	3 (1.9)	22 (0.8)	0.14
Other reasons	99 (3.4)	6 (3.9)	93 (3.4)	0.76
Health Information and literacy	**n (%)**	**n (%)**	**n (%)**	**P value**
Item 36 – Can make healthcare providers understand my problems (n=11,566)				
Cannot do	168 (1.4)	7 (1.2)	161 (1.4)	0.22
Difficult	1,276 (11.1)	50 (8.9)	1,226 (11.2)	
Easy	10,029 (87.4)	501 (89.7)	9,528 (87.3)	
Item 38 – Can discuss health concerns with a healthcare provider (n=11,475)				
Cannot do	166 (1.4)	6 (1.0)	160 (1.4)	0.40
Difficult	1,251 (10.9)	53 (9.5)	1,198 (10.9)	
Easy	10,058 (87.6)	498 (89.4)	9,560 (87.5)	
Item 41 – Have a good discussion about your health with doctors (n=11,478)				
Cannot do	143 (1.2)	4 (0.7)	139 (1.2)	0.34
Difficult	1,257 (10.9)	55 (9.8)	1,202 (11.0)	
Easy	10,078 (87.8)	499 (89.4)	9,579 (87.7)	
Item 49- Can discuss things until you understand all that you need to (n=11,471)				
Cannot do	159 (1.3)	5 (0.9)	154 (1.4)	0.50
Difficult	1,354 (11.8)	62 (11.1)	1,292 (11.8)	
Easy	9,958 (86.8)	491 (87.9)	9,467 (86.7)	
Item 54 - Can ask questions to get the health info that you need (n=11,469)				
Cannot do	152 (1.3)	5 (0.9)	147 (1.3)	0.48
Difficult	1,220 (10.6)	54 (9.6)	1,166 (10.7)	
Easy	10,097 (88.0)	499 (89.4)	9,598 (87.9)	
Item 48 - Ease of getting health info you understand (n=11,515)				
Cannot do	113 (0.9)	4 (0.7)	109 (0.9)	0.66
Difficult	1,071 (9.3)	48 (8.6)	1,023 (9.3)	
Easy	10,331 (89.7)	507 (90.7)	9,824 (89.6)	

* Only asked to respondents who consulted with a GP

5.4.5 Associations of preconception health and health behaviours with becoming a first-time father

The preconception health characteristics which were associated with becoming a first-time father in the previous 12 months are reported in Table 5.5.

Males who became fathers for the first-time were less likely to meet the recommended guidelines for moderate physical activity (aOR=0.63; CI 0.52 -0.76) or the guidelines for vigorous physical activity (aOR=0.66; CI 0.48 -0.90) than others who did not become a first-time father. Although, there was no difference in the average total physical activity time between males who became first-time fathers and others (aOR=1.00; CI 1.00 – 1.00). Men who became fathers for the first-time were also less likely to report cancer (aOR = 0.21; CI 0.08 – 0.52) compared with others.

Table 5.5 Multivariate logistic regression on associations between preconception characteristics and becoming a first time father (adjusted model)

	Become a first-time father in the previous 12 months		
	aOR	95% CI	P value
Characteristics*			
Alcohol (Standard drinks in a day) Meet guidelines of no more than 4 drinks on any day?	1.44	(1.09 – 1.91)	0.009
Moderate physical activity (last 7 days) Meet the recommendations of at least 2.5 hours per week?	0.63	(0.52 – 0.76)	<0.001
Vigorous physical activity (last 7 days) Meet the recommendations of at least 1.25 hours per week?	0.66	(0.48 – 0.90)	0.01
Average physical activity total	1.00	(1.00 – 1.00)	<0.001
Eczema	1.61	(1.20 – 2.14)	0.001
Cancer	0.21	(0.08 – 0.52)	0.001

Preconception health characteristics identified to be associated with becoming a first-time father included meeting the recommended guidelines for daily safe alcohol consumption (aOR=1.44; CI 1.09 -1.91) alongside reporting eczema (aOR=1.61; CI 1.20 - 2.14).

5.5 Discussion

This study draws on data from a longitudinal cohort to examine the preconception health, health literacy, and health behaviours of Australian males prior to becoming a first-time father. Health conditions and behaviours that may impact pregnancy and child health outcomes were reported in this study, being overweight or having eczema were

preconception health characteristics which were more likely to be reported by males who became a first-time father than others. Preconception health research exploring the pregnancy and offspring outcomes of individuals with eczema is scarce yet the paternal use of common eczema treatments, such as topical steroids to downregulate inflammation, may have adverse outcomes for the child (326, 327). In addition, a review of literature details some of the pregnancy and offspring outcomes when males are overweight (114) and acknowledges being overweight as a preconception risk factor for both the male (for conditions such as hypertension) and their offspring (for issues such as high birthweight) (292). Independent of sociodemographic and health related factors, logistic regression analysis reveals males becoming a first-time father were more likely to meet the recommendations for safe alcohol consumption and less likely to meet the recommendations for moderate or vigorous physical activity or to report cancer before conception. These findings offer valuable insights into the health of males prior to parenthood.

One key finding from this study was the high proportion of males who consulted with a GP prior to becoming a father for the first-time. GPs are widely recognised as having a key role in preconception care, both in terms of screening and management of health risks (131, 157, 328). Consulting with a GP provides greater exposure to general and multidisciplinary preconception health and care opportunities before fatherhood. Cultural factors, such as Australian masculinity (329), will influence the perceptions of the importance of paternal preconception health, so all health professionals (including GPs) can function as an interconnected network of providers (330) and, in doing so, support Australian males during the preconception period. However, Australian GPs are gatekeepers to patient access to government funding for primary care consultations and subsequent health care via referral (331). As such, GPs can not only provide preconception care but can facilitate opportunities for Australian males to reduce the costs of accessing specialist and allied health professionals which can also deliver components of preconception care. Indeed, GPs are a key health system point of contact for most Australian men in the preconception period (332) and indigenous health workers may provide cultural health context for males during preconception who identify as Aboriginal or Torres Strait Islander (330) . Yet, previous research reveals males do not always feel comfortable or have the inclination to discuss matters relating to preconception health and care with the GP (21, 198, 199). Conversely, GPs report not feeling confident or well-equipped to facilitate effective preconception care discussions with male patients (25, 132) and therefore may not prioritise screening health risks, promoting health behaviour change, or making referrals aimed at optimising pregnancy and offspring outcomes by improving paternal preconception health. Therefore, males may be engaging with GPs and other health professionals but not necessarily regarding

pregnancy preparation. With this in mind, the first steps toward effectively addressing the implementation of effective paternal preconception care requires normalising the inclusion and engagements of males when discussing preconception care and pregnancy planning.

Our analysis also reveals males who become a father for the first-time were more likely to meet the guidelines for daily safe alcohol consumption compared with others who did not become a first-time father. This finding is partly supported by the results of published literature reporting that while males may intend to avoid or limit alcohol during the preconception period, they still often consume alcohol regularly (87, 168). Romantic partner alcohol use can influence alcohol consumption of the other partner (333) so the safe alcohol consumption by males in this study could be a proactive approach to health in support of their partner who may not be consuming alcohol in preparation for pregnancy (334, 335). Many Australian males (73%) are married prior to fatherhood (336) so partner support during the pregnancy planning period should be an important consideration of males (337). However, the role of reproductive partners to support the preconception health of males is underexplored in the literature (338).

Males must concurrently consider the direct influence and impact their excessive alcohol consumption or binge drinking - five or more alcohol beverages per sitting - can have on pregnancy and offspring outcomes (114, 284, 339). Paternal preconception alcohol consumption is acknowledged as having adverse effects on offspring which may include outcomes such as the increased odds of microcephaly or a shorter mean anogenital distance (114). However, evidence reveals that many males are not fully aware of their roles and responsibilities before conception (39, 87, 199) and therefore remain unaware of the direct influence they can have on pregnancy and offspring outcomes which can include epigenetic influences from behaviours such as alcohol consumption (340). Safe alcohol consumption (no more than four standard drinks per day) is an influential factor for males and their reproductive partners who can help males to translate their intentions to moderate alcohol into healthful behaviours. During the preconception period, safe alcohol consumption must be considered a key behaviour to address in the context of intentions for pregnancy to mitigate risks of adverse pregnancy and offspring outcomes.

Our analysis also shows males who became a first-time father were less likely than other males to meet the recommendations for moderate physical activity and less likely to meet the recommendations for vigorous physical activity in the previous seven days. The importance of physical activity in improving preconception health has been acknowledged (341), however, the literature and guidelines which focus on preconception care and discuss physical activity often do not integrate males (33, 34). Therefore, research which provides a

link between male physical activity during the preconception period and the influence on pregnancy and offspring outcomes is limited (114). Research relevant specifically to physical activity suggests that aerobic or vigorous physical activity can influence mental health (342, 343), body composition (344), and possibly even influence sleep quality and sleeping patterns (345, 346), all of which are relevant to preconception health and can have the potential to influence pregnancy and offspring outcomes (114, 347, 348). Our study finding of expectant partners not meeting physical activity recommendations suggests Australian males are not taking advantage of the opportunities during the preconception period regarding the benefits of physical activity for their health with moderate and vigorous physical activity remaining inconsistent or absent. This finding also suggests males who intend to conduct physical activity to optimise their health (168) may not necessarily meet the recommendations for this kind of physical activity but may instead meet recommendations for other physical activities such as walking. Further research is needed to involve reproductive males as future fathers who can be targeted as participants to help better understand males during the preconception period and their beliefs, and intentions towards moderate and vigorous physical activity.

Another noteworthy finding of this study is the overall proportion of Australian males prior to becoming first-time fathers who did not meet the daily recommendation for vegetable consumption. More than half of the Australian males in our study not meeting the recommendations for vegetable consumption is concerning as vegetable consumption is an important aspect of a balanced healthy diet, providing vitamins, nutrients and fibre (221). Yet the proportion of Australian males not meeting the recommendations for vegetable consumption in our study is considerably greater than other Australian males generally, reported at only 3% (349). The importance of nutrition as a key health behaviour relevant to pregnancy and offspring outcomes has been highlighted in a review of paternal preconception modifiable risk factors (114). Indeed, insufficient vitamins from vegetable consumption, such as folate, may underlie some issues relating to male reproductive health and fertility (350). The finding that Australian males did not meet the daily vegetable consumption in this study is also pertinent to sperm quality and insightful to the finding that more than half of the first-time fathers in our study had obesity. Vegetable consumption can have effects on sperm quality, with a low total sperm count associated with low vegetable intake (351). Inadequate vegetable consumption has also been reported more commonly among infertile men (352). Paternal preconception vegetable consumption, body weight, and infertility may be interrelated (261, 353) (354). Our finding that many Australian males do not report daily recommended vegetable consumption may signal an important opportunity for clinicians to pursue the food habits of males and to assess the behavioural

control of males to maintain a healthy diet, and body weight, especially when planning a pregnancy, to ensure optimal pregnancy and offspring outcomes.

Some limitations constrained the study outcomes. The survey data utilised for this study was self-reported so was subject to recall bias (355). Also, due to the timing of the Ten to Men study waves, the preconception period could not be defined within a specific timeframe but rather within the varying time periods between each study wave. Further, iterations in survey responses over the four respective data waves did not allow for the research team to optimise the longitudinal nature of the data which was aggregated and analysed cross sectionally. Nevertheless, this study utilises data from the largest all-male longitudinal study in Australia to identify findings pertinent to the important but under-researched topic of male preconception health and care

5.6 CONCLUSION

Most males in our study generally reported health behaviours before parenthood which indicated some alignment to preconception care recommendations such as meeting the guidelines for safe daily alcohol consumption. However, participants also reported preconception risk factors that may impact pregnancy and child health outcomes such as not meeting the weekly recommendations for physical activity or not meeting the daily recommendations for vegetable serves. The health conditions of Australian males may also present as a risk factor that may impact pregnancy and child health outcomes. One in five soon to be fathers reported a mental health condition which also identifies the need for addressing aspects of mental health during preconception care. These findings highlight the importance of both research examining and subsequently public health initiatives addressing where necessary the preconception health behaviours of Australian males to mitigate health risks associated with pregnancy and offspring outcomes.

5.7 CHAPTER SUMMARY

This chapter commences an investigation into the preconception health behaviours of Australian males and provides the first series of results in the second phase of the thesis design. Results from this chapter have been analysed to ascertain male preconception health behaviours and preconception information and advice seeking utilising data from a national all male longitudinal study that identified males as becoming a father in the previous 12 months. Across all Ten to Men waves, a total of 572 males were identified as becoming a father in the previous 12 months.

The main findings of this chapter report that Australian males during preconception prior to fatherhood often meet safe alcohol guidelines but do not often meet the guidelines for exercise or daily vegetable consumption. The results of this chapter therefore highlight and emphasize the importance of safe alcohol consumption, regular physical activity, and consumption of healthy diet for males during the preconception period.

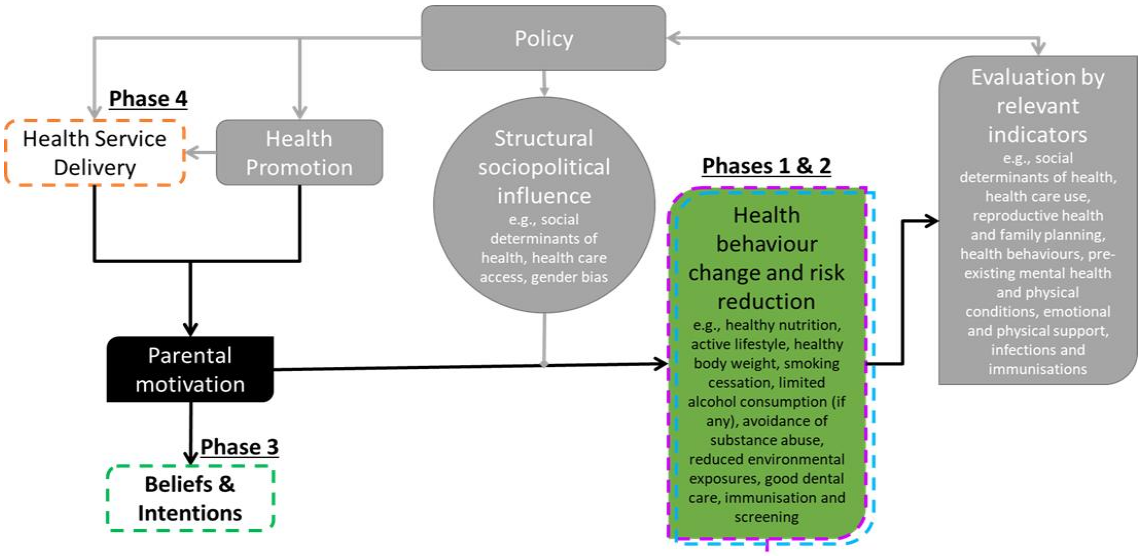
An examination of the preconception health behaviours of Australian males prior to becoming fathers which provides evidence of their preconception health and the risk factors that may influence pregnancy health and offspring outcomes. An analysis and summary of results which serves to introduce and familiarize the reader with the all-important concept of pregnancy intention, or the conscious effort for pregnancy, which can underlie health behaviours.

6 PREGNANCY INTENTION, PRECONCEPTION HEALTH, AND HEALTH BEHAVIOURS, AMONG EXPECTANT MALE PARTNERS

6.1 RATIONALE FOR THIS ANALYSIS

This chapter is an extension of chapter five and aligns with the first, second, third, and fifth project objectives as it broadens focus to the pregnancy intentions of males, as the reproductive partner of a pregnant female. Access to an invaluable preconception source of national cross-sectional data enables an analysis to explore factors associated with Australian males engaging in beneficial and risky preconception health behaviours, to identify the prevalence of clinically relevant preconception health behaviours, and to examine health messages and information received by Australian males during preconception and toward pregnancy planning and preconception health and care.

The content of this chapter and its relevance to the project methodological framework is highlighted in green below.



The results presented in this chapter are published in works as detailed below:

Carter T, Schoenaker D, Adams J, Steel A. Pregnancy intention, preconception health, health behaviours, and information and health advice seeking among expectant male partners. *BMC Primary Care*. 2025;26(1):36.

A copy of the full published article can be viewed in Appendix 6.1.

6.2 INTRODUCTION

Preconception is the period prior to conception when individuals and couples can seek or be provided with support to optimise their health status as well as reduce behaviours and environmental exposures that may contribute to adverse pregnancy and offspring outcomes (136). However, an individual's ability to capitalise on the opportunities afforded by the preconception period is affected by the degree to which becoming pregnant is a conscious decision, a complex multidimensional construct (356, 357) referred to as 'pregnancy intention'. Intending pregnancy is an important public health measure (170), and a principal preconception concept for couples and individuals alike, which may result in pregnancy planning and preparation. However, unplanned pregnancies, including pregnancies that are either mistimed (169, 358) or occur when parents are ambivalent to becoming pregnant, are also common (127, 357). Healthful preconception behaviours such as physical activity (169) or taking folate (359) and personal attributes such as relationship stability (360), and health seeking information in preparation for pregnancy (169) or taking folate (169, 359) or taking folate (359) and personal attributes such as relationship stability (360), and health seeking information in preparation for pregnancy (22) have been associated with intended pregnancies among females.

Public awareness must rebalance the gaze and consider males too provide genetic contributions toward their offspring and therefore healthy male sperm is a vital consideration before pregnancy to ensure healthy pregnancy and offspring outcomes. However, circumstances such as being overweight or obese can negatively impact sperm quality (361) and adversely influence pregnancy and offspring outcomes and fertilisation rates (261). Opportunities for males to receive or seek preconception health information, initiate discussions with health professionals, and optimise health and behaviours in preparation for a healthy pregnancy and child are also associated with pregnancy intention. Males with pregnant partners (referred to here as 'expectant partners') are role models for their future children so may have considered altering their health behaviours before pregnancy, to minimise adverse pregnancy and offspring outcomes (114), in turn providing a foundation for positive contributions toward family health, a stable family environment, and an active role in a child's life (179, 200).

Research from the United Kingdom has reported that up to 20% of expectant partners draw upon sources of preconception diet and lifestyle information from peers, family, and friends and via books and online resources to optimise their preconception health and wellbeing for the sake of their expectant children (87). A public health and health promotion agency in Australia has also developed a male preconception checklist that outlines the importance of

men managing their weight, restricting smoking, and exercising regularly as well as booking a preconception health check with a general practitioner (GP) (142). Health services can play a key role among males during preconception by assisting to source information and to provide advice on paternal preconception matters (93, 131).

Pivoting from intended to unintended pregnancies, approximately 40% of pregnancies globally are estimated to be unintended (362), which has been associated with unhealthy behaviours among women such as preconception substance use (11), smoking and alcohol consumption (363), and adverse maternal and infant outcomes (364). For males, unintended pregnancies are often reported with insecure financial circumstances, less stable relationships, and false assumptions about contraception use (365). Unintended pregnancies, alongside the problematic approach to motivate men to attend primary health-services (366) and GPs' limited knowledge about factors which affect male fertility (25), hinder progress towards paternal preconception care. Several barriers to discussing fertility and preconception health with males are reported among GP's (25) and unwavering challenges endure for primary health services generally especially due to a lack of male preconception primary health-care initiatives (367). As such, preconception care discussions are not always initiated with males who consult with health care services or who attend primary health care (25) and exposure to a range of preconception services and information, including immunization checking, dietary advice, and smoking cessation assistance is also sometimes absent. Consequently, males may not always consider the impact of their lifestyle behaviours and modifiable risk factors on either their own health or that of their offspring (87). Pivoting from intended to unintended pregnancies, approximately 40% of pregnancies globally are estimated to be unintended (362), which has been associated with unhealthy behaviours among women such as preconception substance use (11), smoking and alcohol consumption (363), and adverse maternal and infant outcomes (364). For males, unintended pregnancies are often reported with insecure financial circumstances, less stable relationships, and false assumptions about contraception use (365). Unintended pregnancies, alongside the problematic approach to motivate men to attend primary health-services (366) and GPs' limited knowledge about factors which affect male fertility (25), hinder progress towards paternal preconception care. Several barriers to discussing fertility and preconception health with males are reported among GP's (25) and unwavering challenges endure for primary health services generally especially due to a lack of male preconception primary health-care initiatives (367). As such, preconception care discussions are not always initiated with males who consult with health care services or who attend primary health care (25) and exposure to a range of preconception services and information, including immunization checking, dietary advice, and smoking cessation assistance is also

sometimes absent. Consequently, males may not always consider the impact of their lifestyle behaviours and modifiable risk factors on either their own health or that of their offspring (87).

To provide further evidence on how to guide and support males during preconception and when planning a pregnancy, this study aimed to describe the preconception health status, behaviours, information, and advice-seeking of male expectant partners, and to explore differences in these preconception factors based on pregnancy intention.

6.3 MATERIALS AND METHODS

6.3.1 Study design

An observational retrospective cross-sectional study utilizing data from an online survey was conducted between December 2020 and September 2021. The survey involved a convenience sample of pregnant women and their expectant partners. Informed written consent was obtained from all participants and the study was performed in accordance with the Declaration of Helsinki (368). Ethics approval was obtained by University of Technology Sydney (UTS) Human Research Ethics Committee (HREC) (ETH20-4726). Participants and survey administration

Eligible survey participants included those who self-identified as a female, aged 18 to 49 years, and at any stage of pregnancy living in Australia. Expectant partners of eligible participants were also eligible to participate. Targeted advertising was utilized on social media platforms (i.e. Instagram, Facebook, Twitter) to recruit participants and an incentive was provided. A screening instrument was utilized to ensure that participants met the eligibility criteria and to collect their name and email address. Any individual who met the study eligibility criteria and consented to participate was able to complete the survey via the online survey platform Qualtrics™. Eligible females received a hyperlink whereby they were instructed to complete their own survey and forward the second survey onto their partners. Eligible male expectant partners were also directly targeted for recruitment and, following consent, received a hyperlink being instructed to complete their own survey and forward the second survey onto their pregnant partners.

Analysis provided in this paper includes only the male expectant partners of eligible study participants i.e. not female partners.

6.3.2 Survey instrument and data

A paper-based survey was developed and tested by three individuals, feedback was provided which resulted in the survey being built into Qualtrics™ and retested before finalising (Appendix 3.1). This survey of partners of pregnant women was developed in tandem with the survey instrument designed for pregnant women. The *Expectant partner's pre-pregnancy health information survey* consists of 80-items across five sections including preliminary survey consent, date, and post survey comments (4-items), [1] "About you" (sociodemographic characteristics, height and weight) (15-items); [2] "Your current pregnancy" (retrospective assessment of the degree and timing of pregnancy planning incorporating the version of the London Measure of Unplanned Pregnancy [LMUP] for partners(172) (12-items); [3] "Your health behaviours" (history of and changes in preconception health and health behaviours) (31-items); [4] "Prepregnancy health information and advice" (knowledge on the importance of preconception health, the content of preconception care, and the source(s) of this information) (10-items); and [5] "Your health history" (health history, general health status, and pregnancy history) (8-items).(172) (12-items); [3] "Your health behaviours" (history of and changes in preconception health and health behaviours) (31-items);

6.3.3 Sociodemographic characteristics

The survey obtained participant gender, age, residential postcode, private health insurance cover, highest qualification completed, employment status, relationship status, financial management status, identity as Aboriginal or Torres Strait Islander, first language spoken, country of birth, and health care card access.

6.3.4 Health status and health history

Expectant partners rated their current general health status (excellent - poor), responded to questions about any longstanding illness and health conditions diagnosed (3 months before partner's pregnancy) and reported their body weight and height. The survey also asked about participant's contraception use (6 months before pregnancy) and if they had have ever smoked and/or ever consumed alcohol.

6.3.5 Health behaviours

Survey questions identified participant's actions in preparing for pregnancy overall (Stop/cut back smoking and alcohol, eat healthier, seek medical advice, use vitamin supplements). Health behaviours were then identified based upon three preconception time periods: three,

six and twelve months prior to pregnancy. Behaviours identified three months prior to pregnancy included alcohol consumption, smoking, and physical activity levels plus the consulting with health professionals for ongoing assistance. Health behaviours in the six months prior to pregnancy that were identified included following a weight loss diet, testing for sexually transmitted infections (STIs), and use of contraception methods. Health behaviours in the 12 months prior to pregnancy that were identified included any actions before partner became pregnant (visit a dentist, check immunizations) and consulting with a health professional about their partner becoming pregnant.

6.3.6 Preconception health information and advice

Questions further established if expectant partners had searched for information about becoming pregnant, and if so, asked about the source of this information and who (which partner) did this information related to. Also, questions explored whether expectant partners were provided with information about diet and lifestyle options for example eating a healthy diet, smoking, consuming alcohol, or taking vitamin C supplements before pregnancy.

6.3.7 Pregnancy Intention

Pregnancy intention was assessed using the London Measure of Unplanned Pregnancy (LMUP) for women's partners; a measure developed in the UK which identifies the degree of planning for a current/recent pregnancy (172).

6.4 DATA ANALYSIS

Survey data were imported into Stata 17.1 and prepared for analysis by the research team. Survey participants comprise those who consented to participate in the survey, reported their sex as male, and completed all the survey questions directly related to the LMUP. The LMUP was scored as per the instrument's guide; participants response to each item score a minimum 0 and maximum 2 which then combine to a total score (224). Technical issues with the online survey did not allow the last question of the LMUP to select multiple items but only one item. As a result, the maximum score awarded for this question is 1 instead of the standard maximum of 2. The LMUP scoring guide was followed for analysis. Two participants had a single missing value in one LMUP variable and were excluded from the analysis; imputation was not considered.

Based on the LMUP scoring, new categorical variables were generated as 'Planned' (LMUP score 10 or 11), 'Ambivalent' (between 4 and 9), or `Unplanned' pregnancy (3 or less)(172). A binary variable was then generated to combine the 'Ambivalent' and `Unplanned'

categories (ambivalent/unplanned) as only one participant had a score of 3 or less (369). Data was tabulated into categories describing participant demographics, health status and history, health behaviours and health information. Variables of interest were then analysed according to planned and ambivalent/unplanned pregnancies.

Binary variables were created from categorial variables to determine descriptive statistics for health status and health history, participant health behaviours, and health information and advice. Body mass index (BMI) was calculated using the participants height and weight and then categorized according to the World Health Organization classifications (370). Participants with missing data were not included in the analysis. Chi-square tests were utilized to examine differences by LMUP categories (planned or ambivalent/unplanned). ANOVA tests were employed to compare differences in medians according to LMUP category for continuous variables. An alpha value below 0.05 was considered statistically significant and effect size was determined using Cramer's V (371). Results for Cramer's V range between 0 and 1, greater values indicate stronger associations between variables; > 0.25 equals a very strong association, > 0.15 equals a strong association, > 0.10 equals a moderate association, > 0.05 equals a weak association and > 0 equals a very weak association (225).

6.5 RESULTS

A total of 156 expectant partners were eligible and provided consent to participate in the survey. The LMUP for partners includes six questions and has a maximum total score of 12 with higher scores indicating a greater degree of pregnancy planning (369) (Appendix 6.2 LMUP). Most expectant partners (n=138) completed all the LMUP questions and were included in the analysis. The majority of expectant partners had a planned pregnancy (n=90;65.2%).

Table 6.1Sociodemographic characteristics of expectant male partners

	LMUP category			
	All (n=138)	**Planned (n=90)**	**Ambivalent/ Unplanned (n=48)**	***p* value (Cramer's V)**
	n (%)	***n (%)***	***n (%)***	
Age (n=128)				
Less than 29 years^	39 (30.4)	22 (25.5)	17 (40.4)	0.06
30 - 39 years	79 (61.7)	59 (68.6)	20 (47.6)	
40 years +	10 (7.8)	5 (5.8)	5 (11.9)	
State of residence (n=138)				
New South Wales	45 (32.6)	28 (31.1)	17 (35.4)	0.11
Victoria	41 (29.7)	22 (24.4)	19 (39.5)	
Queensland	23 (16.6)	17 (18.8)	6 (12.5)	
Other*	29 (21.0)	23 (25.5)	6 (12.5)	
Private health insurance (n=138)	85 (61.5)	59 (65.5)	26 (54.1)	0.19
Highest educational qualification (n=138)				
Up to year 12 or equivalent*	15 (10.8)	9 (10.0)	6 (12.5)	0.52

Vocational education (e.g. Apprenticeship/Diploma)	45 (32.6)	27 (30.0)	18 (37.5)	
University degree or Higher	78 (56.5)	54 (60.0)	24 (50.0)	
Employment status (n=138)				
Full-time work (≥35 hours/week)	123 (89.1)	82 (91.1)	41 (85.4)	0.58
Part time or casual temp work	11 (7.9)	6 (6.6)	5 (10.4)	
Not currently working	4 (2.9)	2 (2.2)	2 (4.1)	
Relationship status (n=138)				
Married	97 (70.2)	71 (78.8)	26 (54.1)	0.006 (0.26)
De facto	38 (27.5)	18 (20.0)	20 (41.6)	
In a relationship but not living with my partner	3 (2.1)	1 (1.1)	2 (4.1)	
Financial manageability (n=138)				
It is impossible/It is difficult*	34 (24.6)	19 (21.1)	15 (31.2)	0.36
It is not too bad	73 (52.9)	51 (56.6)	22 (45.8)	
It is easy	31 (22.4)	20 (22.2)	11 (22.9)	
Identify as Aboriginal or Torres Strait Islander (n=138)	5 (3.6)	2 (2.2)	3 (6.1)	0.15
First language other than English (n=138)	16 (11.5)	7 (7.7)	9 (18.7)	0.05 (0.16)
Born outside Australia (n=138)	32 (23.1)	20 (22.2)	12 (25.0)	0.71
Health care card (n=138)	42 (30.4)	25 (27.7)	17 (35.4)	0.35

^ One participant was identified under 20 years of age
*Other includes South Australia/ACT/Tasmania/Western Australia/Northern Territory
** Includes no formal qualifications, year 10 or equivalent, and year 12 or equivalent.
*** Combined it is impossible; is difficult all the time; it is difficult some of the time

6.5.1 Demographics

Overall, the most common age range of expectant partners was 30-39 years (57.2%) and most were employed full-time (89.1%) and married (70.2%) (Table 6.1). A small percentage of expectant partners identified as Aboriginal or Torres Strait Islander (3.6%). When comparing expectant partners with planned pregnancy and expectant partners with ambivalent/unplanned pregnancy, a very strong association was identified between the LMUP categories and relationship status (V=0.26; p=0.009) indicating that expectant partners with planned pregnancy were more often married. A very strong association was also identified for financial manageability (V=0.26; p=0.01), suggesting that expectant partners with ambivalent/unplanned pregnancy more often had difficulty with managing finances. A strong association was identified for age range (V=0.24; p=0.01); expectant partners with planned pregnancy were most often in the age range of 30-39 years. A moderate association was identified for expectant partners with an ambivalent/unplanned pregnancy who more often spoke a primary language other than English (V=0.16; p=0.05).

6.5.2 Health status and health history

Most expectant partners reported their general health status as “good” (60.4%) and approximately half (49.2%) reported no contraception use in the 6 months before their partners pregnancy as they were trying to conceive (Table 6.2). According to the BMI classifications, expectant partners with planned pregnancy were most often overweight

(42.0%). A comparison of the LMUP categories provided evidence to support very strong associations; expectant partners with ambivalent/ unplanned pregnancy more often had a longstanding illness, disability, or infirmity (V=0.31 ;p=0.002) and more often did not use contraception (V=0.37; p<0.001).

Table 6.2 Health status and health history of expectant male partners

	LMUP category			
	All (n=138)	**Planned (n=90)**	**Ambivalent/ Unplanned (n=48)**	**P (Cramer's V)**
	n (%)	***n (%)***	***n (%)***	
General Health Status (n=96)				
Excellent	22 (22.9)	14 (21.5)	8 (25.8)	0.74
Good	58 (60.4)	41 (63.0)	17 (54.8)	
Fair/Poor	16 (16.6)	10 (15.3)	6 (19.3)	
Longstanding illness, disability, or infirmity (n=96)	15 (15.6)	5 (7.6)	10 (32.2)	0.005 (0.31)
Diagnosed or taking medications for any conditions [3 months before partner's pregnancy]	31 (22.4)	21 (23.3)	10 (20.8)	0.73
***Contraception use* [6 months before partner's pregnancy] (n=128)**				
Yes	43 (33.5)	30 (35.7)	13 (29.5)	<0.001 (0.37)
No – Was trying to conceive	63 (49.2)	48 (57.1)	15 (34.0)	
No – Was <u>not</u> trying to conceive	22 (17.1)	6 (7.1)	16 (36.3)	
	Median (Q1, Q3)	***Median (Q1, Q3)***	***Median (Q1, Q3)***	
***Body Mass Index [BMI]* (n=136)**	27.4 (23.6, 30.9)	27.7 (24.8, 31.0)	26.6 (23.4, 30.7)	0.56
***BMI Classification* (n=136)**	***n (%)***	***n (%)***	***n (%)***	
Normal weight [BMI 18.5 – 24.9] *	46 (33.8)	26 (39.5)	20 (41.6)	0.30
Overweight [BMI 25.0 – 29.9)	50 (36.7)	37 (42.0)	13 (27.0)	
Obesity class I [BMI 30.0 – 34.9]	26 (19.1)	17 (19.3)	9 (18.7)	
Obesity class II [BMI 35.0 – 39.9] & class III [BMI > 40]	14 (10.2)	8 (9.0)	6 (12.5)	

** Zero participants were underweight [BMI <18.5]*

6.5.3 Preconception health behaviours

Numerous expectant partners reported physical exercise in the three months before their partner's pregnancy (69.5%); generally, expectant partners reported an average number of five hours of physical activity per week (SD 3.0 - 7.5) (Table 6.3 Health behaviours). The majority of expectant partners had ever consumed alcohol (84.7%) and approximately one third of expectant partners had ever smoked (36.3%). Almost one third of expectant partners reported seeing any health professional 12 months before their partner's pregnancy (32.2%). A small number of expectant partners reported using folic acid before their partner's pregnancy (2.9%). A very strong association was observed for physical activity three months before the partner's pregnancy with LMUP category (V=0.27; p=0.001) indicating that a greater proportion of expectant partners with planned pregnancy reported physical exercise. A strong association was identified between having ever smoked and reporting an ambivalent/unplanned pregnancy (V=0.24; p=0.005), while a strong association was also identified for checking immunizations 12 months before partner's pregnancy and planned pregnancy (V=0.23; p=0.006).

Table 6.3 Health behaviours of expectant male partners

Participant health behaviours	LMUP category			
	All (n=138)	Planned (n=90)	Ambivalent/ Unplanned (n=48)	P (Cramer's V)
	n (%)	*n (%)*	*n (%)*	
Vitamins/supplements before partner's pregnancy				
Folic acid (n=80)	4 (5.0)	3 (5.6)	1 (3.7)	0.58
Ordinary multivitamin (n=86)	16 (11.5)	12 (13.3)	4 (8.3)	0.28
Vitamin C (n=82)	9 (6.5)	6 (6.6)	3 (6.2)	1.00
Zinc (n=81)	7 (5.0)	6 (6.6)	1 (2.0)	0.23
Omega 3 (n=84)	7 (5.0)	3 (3.3)	4 (8.3)	0.19
Antioxidants (n=79)	2 (1.4)	2 (2.2)	0 (0.0)	0.42
Herbal medicines (n=80)	3 (2.1)	2 (2.2)	1 (2.0)	1.0
Other (n=80)	8 (5.8)	6 (6.6)	2 (4.1)	0.71
Any folic acid ˣ	18 (13.0)	14 (15.5)	4 (8.3)	0.29
Any natural health product ˣˣ	30 (21.7)	22 (24.4)	8 (16.6)	0.29
Physical activity [3 months before partner's pregnancy] (n=134)	96 (69.5)	71 (78.8)	25 (52.0)	0.001 (0.27)
	Median (Q1, Q3)	**Median (Q1, Q3)**	**Median (Q1, Q3)**	
Number of physical activity hours per week (n=95)	5 (3, 7.5)	5 (3, 7.5)	5 (3, 6)	0.10
	n (%)	***n (%)***	***n (%)***	
Ever smoked (n=134)	50 (36.3)	25 (27.7)	25 (52.0)	0.005 (0.24)
Cigarettes	42 (84.0)	19 (76.0)	23 (92.0)	0.20
E-cigarettes	4 (8.0)	4 (16.0)	0 (0.0)	
Other	4 (8.0)	2 (8.0)	2 (8.0)	
Smoking [3 months before partner's pregnancy] (n=50)**	22 (44.0)	9 (36.0)	13 (52.0)	0.25
	Median (Q1, Q3)	**Median (Q1, Q3)**	**Median (Q1, Q3)**	
Number of cigarettes or equivalents per day (n=20)	8 (2,18.5)	8 (2, 16)	8 (3, 20)	0.61
	n (%)	***n (%)***	***n (%)***	
Ever consumed alcohol (n=132)	117 (84.7)	78 (86.6)	39 (81.2)	0.39
Alcohol consumption [3 months before partner's pregnancy]***				
	Median (Q1, Q3)	**Median (Q1, Q3)**	**Median (Q1, Q3)**	
Units during the week (Monday to Thursday) (n=113)	2 (0, 4)	2 (0, 4)	1 (0,3)	0.11
Units during the weekend (Friday to Sunday) (n=114)	4 (1, 6)	4 (1, 6)	4 (1, 8)	0.76
Any action before partner became pregnant [6 months before partner's pregnancy]				
Followed a weight loss diet	15 (19.7)	10 (18.1)	5 (23.8)	0.74
Get tested for a sexually transmitted disease	10 (13.1)	9 (16.3)	1 (4.7)	0.26
Contraception methods [6 months before partner's pregnancy] ****				
Condoms (n=39)	27 (69.2)	19 (70.3)	8 (66.6)	0.81
Other^ (n=116)	18 (15.5)	12 (16.2)	6 (14.2)	0.78
Any action before partner became pregnant [12 months before partner's pregnancy]				
Visit a dentist	59 (42.7)	42 (46.6)	17 (35.4)	0.20
Check immunizations	22 (15.9)	20 (22.2)	2 (4.1)	0.02 (0.26)
Seeing any health professional about becoming pregnant [12 months before partner's pregnancy] (n=96)	31 (32.2)	21 (32.3)	10 (32.2)	0.99

ˣ Folic acid or multivitamin

ˣˣ Use of any vitamin/supplement including folic acid, multivitamin, vitamin c, zinc, omega 3, antioxidants, herbal medicines, other,

** only asked of those participants who reported having ` ever smoked'.
*** only asked of those participants who reported having ` ever consumed alcohol'.
**** only asked of those participants who reported ` using contraception in the 6 months before pregnancy'.
^ Other includes abstinence, withdrawal, and timed intercourse.

6.5.4 Preconception health information and advice

Almost one third of all expectant partners reported looking for and finding information about becoming pregnant (31.8%) (Table 6.4).

Table 6.4 Health information and advice for expectant male partners

Participant preconception health information and advice	LMUP category			
	All (n=138)	Planned (n=90)	Ambivalent/ Unplanned (n=48)	*p* value (Cramer's V)
	n (%)	*n (%)*	*n (%)*	
Look at information about becoming pregnant [12 months prior]				
Yes – I went looking for information and found it	44 (31.8)	36 (40.0)	8 (16.6)	0.005 (0.23)
Yes- I did not go looking for information but found it anyway	6 (4.3)	4 (4.4)	2 (4.1)	1.00
No – I went looking for information but did not find any	2 (1.4)	1 (1.1)	1 (2.0)	1.00
No - I did not go looking for information and did not find any	46 (33.3)	26 (28.8)	20 (41.6)	0.12
Who did the information relate to**				
My partner only	11 (22.0)	10 (25.0)	1 (10.0)	0.42
Both me and my partner	38 (76.0)	29 (72.5)	9 (90.0)	0.24
Sources of preconception information/*****				
Books	19 (38.0)	17 (42.5)	2 (20.0)	0.27
Leaflets	14 (28.0)	11 (27.5)	3 (30.0)	1.00
Internet	46 (92.0)	37 (92.5)	9 (90.0)	0.79
Magazines	3 (6.0)	2 (5.0)	1 (10.0)	0.61
Family of friends	19 (38.0)	14 (35.0)	5 (50.0)	0.45
GP	25 (50.0)	20 (50.0)	5 (50.0)	1.00
Midwife	7 (14.0)	6 (15.0)	1 (10.0)	0.57
Obstetrician/Gynaecologist	7 (14.0)	5 (12.5)	2 (20.0)	0.61
When preparing for pregnancy, did anyone give you information about...				
Immunisation (n=88)	23 (16.6)	19 (21.1)	4 (8.3)	0.06
Smoking (n=88)	27 (19.5)	18 (20.0)	9 (18.7)	0.86
Alcohol (n=88)	25 (18.1)	18 (20.0)	7 (14.5)	0.43
Physical activity (n=88)	20 (14.4)	13 (14.4)	7 (14.5)	0.98

Stopping contraception (n=88)	20 (14.4)	14 (15.5)	6 (12.5)	0.62
Eating a healthy diet (n=88)	19 (13.7)	15 (16.6)	4 (8.3)	0.20
Folic acid (n=88)	18 (13.0)	13 (14.4)	5 (10.4)	0.60
A healthy weight (n=88)	16 (11.5)	12 (13.3)	4 (8.3)	0.57
Sexually transmitted diseases (n=88)	16 (11.5)	12 (13.3)	4 (8.3)	0.57
Ordinary multivitamin (n=87)	15 (10.8)	12 (13.3)	3 (6.2)	0.25
Omega 3 (n=84)	7 (5.0)	3 (3.3)	4 (8.3)	0.23
Zinc (n=84)	6 (4.3)	5 (5.5)	1 (2.0)	0.66
Vitamin C (n=84)	5 (3.6)	3 (3.3)	2 (4.1)	1.00
Antioxidants (n=84)	3 (2.1)	2 (2.2)	1 (2.0)	1.00
Herbal medicines (n=84)	3 (2.1)	2 (2.2)	1 (2.0)	1.00

*** only asked of those participants who reported 'looking at information about becoming pregnant' in the year before their partner became pregnant.*
**** Naturopaths, Pharmacists, and Doulas not included in final analysis due to nil results.*

A large proportion of expectant partners sourced preconception information from the internet (92.0%) and in many instances the preconception information related to both males and females (76.0%). When preparing for pregnancy, many expectant partners received information regarding immunizations (28.9%), smoking (19.5%), and alcohol (18.1%), yet fewer received information about maintaining a healthy weight (11.5%) or sexually transmitted diseases (11.5%). Upon comparing LMUP categories, a very strong association was identified between planned pregnancy and being issued pregnancy preparation information about immunization (V=0.26; p=0.02). A strong association was identified between planned pregnancy and looking for and finding information about becoming pregnant (V=0.23; p=0.005).

6.6 Discussion

This study on paternal pregnancy intention and planning identified several key findings of importance for public health and reproductive health broadly and more specifically for expectant partners preconception health and care, and their efforts to seek, source, identify, and consult for preconception information and advice. According to the LMUP for Women's Partners (172), the proportion of expectant partners with a planned pregnancy in our study (69%) was lower than in other studies exploring males' pregnancy intention (81-95%) (120, 365). Our study also reported a proportion of expectant partners with planned pregnancy less than the planned pregnancy rate generally reported for women (83%) (372) and similar to the estimated global planned pregnancy rate (60%) (362). The public health implications of this research rebalance the social gaze to consider the impact of male health during

preconception and to prompt males to take opportunities to sustain health during preconception. Noteworthy findings within our study are discussed below.

When comparing the sociodemographic characteristics of expectant partners in our study according to pregnancy intention, some findings align with existing evidence describing the target population. For example, male expectant partners with intended pregnancy were most commonly aged 30-39 age (373), were often in committed relationships (374), and generally did not report issues with financial manageability (375). Other findings in our study present potential areas for exploration and future research; a significant proportion of expectant partners who had a first language other than English or who had ever smoked reported ambivalent pregnancies.

A large proportion of expectant partners in our study with a planned pregnancy undertook physical activity in the three months prior to their partner's pregnancy (69.5%), averaging five physical activity hours per week. Regular exercise plays an important role in regulating body weight and BMI (376), and with general physical function and health related well-being; (377) a lack of exercise is considered a major cause of chronic disease (73). However, the health benefits of preconception interventions including regular exercise is only emerging for reproductive males(142). Our finding of expectant partners undertaking physical activity during preconception is promising and may even substantiate why many expectant partners in our study report their health status as good or excellent. Despite perceiving their health as good or excellent, and undertaking physical activity, numerous expectant partners who planned pregnancy in our study had overweight status with a BMI between 25.0 and 29.9 (42%). The literature exploring males having overweight or obese suggests that their offspring are more likely to also have overweight or obesity (270, 378) and asthma (237). Expectant partners having overweight and intending pregnancy should feel supported to optimise their body weight and reduce their risks, given that a sustained and increased BMI can signpost numerous ailments (60) and, along with waist and hip measurements, presents a health risk factor (54). Although, according to BMI, having overweight does not always equate to being `unhealthy' and boundaries can seem blurred between BMI and health (379) due to the limitations of BMI due to its lack of distinction between fat and muscle tissue or determining body weight distribution (380). Expectant partners having the perception of reasonable health yet living with overweight underscores the importance for males planning a pregnancy to be aware that despite undertaking physical activity, their preconception BMI may influence the health of their child later in life. Males during the preconception period and specifically the 3-month period prior to conception require further exploration to determine the influence of their regular exercise on pregnancy and offspring outcomes and to

determine the efficacy of paternal preconception health and care treatment plans incorporating regular exercise.

Expectant partners with planned pregnancy in our study actively sought information and advice and often used the internet as a source of preconception information (92.0%). More broadly, previous research has shown that how males plan and prepare for pregnancy is varied;(120) one Australian study identified that males often only seek information regarding fertility when experiencing difficulties conceiving (381) while another study from England suggests that one in two males have looked at information about their partners pregnancy before conception from a variety of sources (87). For many males, seeking information or advice about pregnancy planning may now be a process governed online and by social media whereby familiar digitized social platforms are used to support decision making when planning a pregnancy (382). Thus, online resources, social media platforms, and primary health care services all play a key role and have an onus to promote and provide accurate and reliable preconception information to reproductively aged males, especially those who are planning pregnancy.

Our study also shows that close to one quarter (22.2%) of expectant partners who planned a pregnancy completed immunization checks in the 12 months prior to their partners pregnancy and that approximately one fifth (21.1%) of expectant partners who planned a pregnancy received information or advice about immunization. The research exploring immunisation status during preconception is primarily focused on women (17, 24, 183) and checks for females before pregnancy are actively encouraged in the resources available for pregnancy planning,(140, 383) are advocated by Governments worldwide,(384, 385) and also recommend in the guidelines utilized by GPs for preventive activities in general practice (157). As messages are directed and disseminated mainly toward the birthing parent not the couple or the male (386), and even when males check immunizations during preconception, immunization information will not always translate to immunisation currency or even immunization acceptance. Our results regarding immunisation may underscore the emphasis placed on immunization information, advice, and messages during the times of COVID-19 for both women and men (387). Post COVID-19, preconception equality advocates that males should also reduce the risks of various infectious diseases to promote health (388) and thus preconception immunization status screening and information should be incorporated into consultations for all reproductive males intending pregnancy, including males who report any longstanding illness, disability, or infirmity.

Another key finding in this study is that expectant partners who report any longstanding illness, disability, or infirmity (15%) more often have an ambivalent or unplanned pregnancy

than a planned pregnancy. Evidence suggests that approximately one in three adults live with multiple chronic conditions (389). Males with longstanding chronic illness, including preconception paternal comorbidity such as metabolic syndrome, threaten the health of their gametes and have been associated with higher odds of pre-term birth or low birth weight than males without comorbidities (390). Previous research also identifies that the partners of disabled fathers are at higher risk of unintended pregnancy compared with the partners non-disabled fathers (391). Hence, for expectant partners with health-related issues which may manifest as a longstanding chronic illness, disability, or infirmity, their partner's pregnancy may not always be intended or may even result in adverse pregnancy outcomes (392). Therefore, tailoring a reproductive life plan specifically to males with longstanding chronic illness or disability may help promote pregnancy intention and paternal preconception health amongst this sub-population. All reproductive males, including those with longstanding chronic illness or a disability, are likely to benefit from preconception care and require targeted information regarding the importance of pregnancy planning and preparation.

6.7 Conclusion

The majority of expectant partners in our study had a planned pregnancy, yet close to one third of the expectant partners in our study remain ambivalent about their current pregnancy. Key differences, including undertaking physical activity and checking immunisations, were evident in the health behaviours of expectant partners with a planned pregnancy compared with ambivalent/unplanned pregnancy. Our study establishes a foundation for further large-scale research to be conducted to build a knowledge base for clinicians to better understand preconception health for males and their information and advice seeking behaviours and enable policy makers to formulate health policies and initiatives aimed at improving male preconception health and awareness.

6.8 Chapter Summary

This chapter builds upon the analysis presented in Chapter five by examining the preconception health behaviours of Australian males, as expectant partners, based upon their pregnancy intention. In addition, the chapter also introduces results for their preconception health information and advice seeking. The results from this chapter provide the first series of results for the third phase of the thesis design. Results from this chapter have been analysed to ascertain the preconception health behaviours and preconception information and advice seeking of Australian males using data from a national survey exploring preconception health for male reproductive partners of pregnant women (expectant partners). Intention was considered for males retrospectively, after their preconception

experiences, to ensure expectant partners were not swayed by referring to any current preconception experiences.

Findings of this chapter reveal that the sources of preconception information sought by Australian males do not always appear to be influenced by their pregnancy intention. Further, expectant partners with any longstanding illness, disability, or infirmity more often had an ambivalent or unplanned pregnancy than a planned pregnancy. Notably, the proportion of Australian males who intended pregnancy was lower in the results of this chapter compared with other studies and when compared with global estimates. Australian males who intended pregnancy often undertook health behaviours such as regular physical activity and immunisation checks and often used the internet as a source of preconception information. This chapter provides a summary of key findings and establishes a conceptual link to the beliefs–behaviours relationship. It sets the stage for the subsequent exploration of Australian males' preconception beliefs and intentions, which aim to predict the health behaviours identified in Phases One and Two of the research.

7 PRECONCEPTION HEALTH BELIEFS AND INTENTIONS PREDICT BEHAVIOURS AMONG EXPECTANT MALE PARTNERS

7.1 RATIONALE FOR THIS ANALYSIS

The rationale for this analysis aligns with the first, second, and third research objectives which are to explore Australian males' attitudes and intentions toward pregnancy planning and preconception health and care. Analysis of a national data set which focuses on the preconception health beliefs and intentions of three key preconception health behaviours identified from chapters five and six i) regular exercise, ii) alcohol avoidance, and iii) healthy diet.

The content of this chapter and its relevance to the project methodological framework is highlighted in green below.

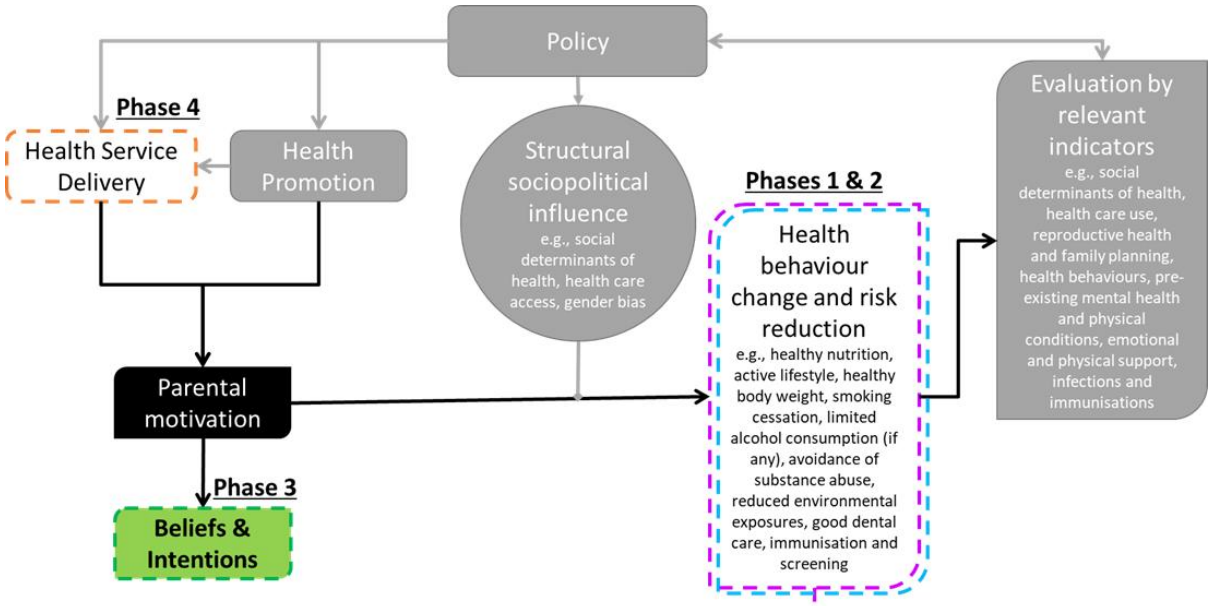


Figure adapted from Steel A, Strommer S, Adams J, Schoenaker D. Preconception health policy, health promotion, and health services to achieve health in current and future generations: a narrative review. BMC Pregnancy and Childbirth. 2025;25(1):188.

The results presented in this chapter are published in works as detailed below:

Carter T, Schoenaker D, Rogers K, Adams J, Steel A. Preconception health beliefs and intentions predict behaviours among expectant male partners: a cross-sectional study. *Archives of Public Health*. 2025;83(1):182.

A copy of the full published article can be viewed in Appendix 7.1.

7.2 INTRODUCTION

Health prior to a pregnancy - preconception health - is synonymous with preventive health and is considered a public health priority for reproductively aged populations across the globe (15). A conscious decision to attempt pregnancy, referred to as 'pregnancy intention', allows couples to plan and prepare for pregnancy by initiating healthful behaviours such as undertaking regular exercise, adopting a healthy diet, and avoiding alcohol to improve their chance of a healthy pregnancy and child. Preconception health and health behaviours, as well as pregnancy spacing and timing, are important considerations for both females and males with research suggesting preconception health behaviours and modifiable risk factors can have both short and long-term health implications for parents and their children (26, 33, 114). Males are duly recognised as having a direct and indirect influence on pregnancy and offspring outcomes whereby they can indirectly support maternal behaviours during preconception (198, 200) while their own preconception behaviours can have direct genetic (393) and epigenetic consequences (319). Yet, evidence describing reproductive males' preconception health and health behaviours is only newly emerging, partly because capturing and reporting the preconception health behaviours of males can be difficult (394). From the available evidence, a recent review of paternal preconception modifiable risk factors identifies several health behaviours of males which report adverse pregnancy and offspring outcomes such as alcohol, smoking, and nutritional exposures (114). This review also highlighted many gaps in understanding male preconception for behaviours such as physical activity, a healthy diet, and alcohol consumption that needed to be addressed through further research.

Males have been identified as often not aware of the concept of preconception health, nor its importance and they may appear reluctant during discussions (39). Moreover, males less frequently seek health care support than females (394) and health care professionals, including general practitioners, often do not feel comfortable with their knowledge regarding male preconception health and fertility issues (25). Often males consider such integral public health topics to be a female domain (120) despite often agreeing with the importance placed on paternal preconception health and care (395) and possessing a general willingness to use preconception care services (396). A Swedish longitudinal study investigating males' pregnancy planning behaviour, for example, examined males' preparations for pregnancy and found only a small portion of men (17%) adjusted their preconception behaviours to improve their health (120). Often males consider such integral public health topics to be a female domain (120) despite often agreeing with the importance placed on paternal preconception health and care (395) and possessing a general willingness to use preconception care services (396). A Swedish longitudinal study investigating males'

pregnancy planning behaviour, for example, examined males' preparations for pregnancy and found only a small portion of men (17%) adjusted their preconception behaviours to improve their health (120).

It is important for researchers, practitioners, policy makers and all stakeholders of preconception health to understand the relationships between paternal preconception behaviours and paternal preconception beliefs, and intentions to better support behaviour change for males before conception, and effectively target appropriate preconception messages and interventions (83). Exploring the belief-behaviour relationship that drives the motivational factors of male's behavioural intentions can assist to better understand subsequent paternal preconception behaviours. Therefore, the aim of this study was to examine pathway associations of preconception and pregnancy planning health beliefs with intentions and behaviours among expectant male reproductive partners (expectant partners) of pregnant women.

7.3 METHODS

7.3.1 Study design

We conducted an observational study utilizing data from an online cross-sectional survey conducted between December 2020 and September 2021. The survey included a convenience sample of expectant partners.

7.3.2 Participants and survey administration

Expectant partners were eligible to participate if they were male, aged 18 to 49 years, and the reproductive partner of a pregnant female. Targeted advertising was utilized on social media platforms (i.e. Instagram, Facebook, Twitter) for participants to be recruited from the general public; a small financial incentive was provided for participation. A screening instrument was used at the start of the survey to ensure participants met the eligibility criteria [an Australian male, aged 18 to 49 years, and the reproductive partner of a pregnant female] and to collect their name and email address. Any individual meeting the study eligibility criteria and who consented to participate then completed the survey via the online survey platform Qualtrics™. The recruitment strategy was also initiated by the pregnant female who received a hyperlink instructing them to complete the survey and to also forward a survey link onto their male reproductive partners.

7.3.3 Survey instrument and data

A paper-based survey was initially developed and tested by three individuals, feedback was provided which resulted in the survey being built into Qualtrics™ and retested (Appendix 3.1). The final survey consisted of 80-items across five sections including [1] “About you” (sociodemographic characteristics); [2] “Your current pregnancy” (retrospective assessment of the degree and timing of pregnancy planning using the partners version of the London Measure of Unplanned Pregnancy (LMUP) (172); [3] “Your health behaviours” (changes in preconception health and health behaviours); [4] “Pre-pregnancy health information and advice” (knowledge on the importance of preconception health, the content of preconception care, and the source(s) of this information); and [5] “Your health history” (health and pregnancy history).

7.3.4 Participant demographics

The survey sought expectant partners’ gender, age, private health insurance cover, highest qualification completed, employment status, relationship status, financial manageability status, identity as Aboriginal or Torres Strait Islander, first language spoken, country of birth, and health care card access.

7.3.5 Participant health history, health status, and pregnancy planning

Expectant partners rated their current general health [excellent-poor] and reported any longstanding illness, disability or infirmity; as well as body weight and height which were used to calculate and classify body mass index (BMI). The survey examined how the pregnancy was identified, their pregnancy intention, if the pregnancy resulted from fertility treatment, and contraception use 6 months before pregnancy.

7.3.6 Participant health behaviours

Survey questions identified expectant partners’ health behaviours before pregnancy including alcohol consumption, smoking, physical activity, healthy diet, and supplements used. Alcohol consumption, a healthy diet, smoking, and physical activity were identified based on any history of use and use three months and six months prior to pregnancy. In addition, proximal preconception outcomes were reported related to physical activity, alcohol, and a healthy diet (i.e. I exercised regularly, ate a healthy diet, and avoided alcohol) for at least 6 months before their partners’ pregnancy. Other potential preconception health behaviours such as following a weight loss diet, getting tested for a sexually transmitted

disease (STI), visiting a dentist, checking immunization status, or undergoing surgery to help lose weight were also reported.

7.3.7 Participant preconception beliefs, and intentions

Survey items regarding beliefs and intentions were formulated using the Theory of Planned Behaviour (TPB), a framework best suited to the research question and widely utilized. The TPB examines the belief-behaviour relationship and aims to provide an explanation for the influences of behaviour, thereby understanding and even predicting behaviour (397). The TPB model suggests that belief-based measures drive intentions, which are controlled by norms, subjective norms, and perceived behavioural control to determine behaviour (184). This study reported the beliefs, intentions, subjective norms, and perceived behavioural control for three outcomes which have been identified as research gaps in the preconception literature for males (114, 168) 1) regular exercise, 2) healthy diet, and 3) alcohol avoidance. Each outcome was measured on a seven-point scale; expectant partners' beliefs were measured in the survey ranging from important to not important, being pleasant to unpleasant, being good to bad, or from being extremely likely to extremely unlikely (i.e. My doing regular exercise during the 6 months prior to partners pregnancy is… important/not important). Intentions were measured in the survey by questions reporting from extremely likely to extremely unlikely for participants (i.e. I intend to exercise regularly for at least 6 months before my partner becomes pregnant… extremely likely/unlikely). Expectant partners' behaviours in the survey were measured in one question which ranged from definitely true to definitely false (i.e. I exercised regularly for at least 6 months before my partner became pregnant…true/false).

7.3.8 Data Analysis

Survey data were imported into STATA statistical software – version 17, cleaned, and prepared for analysis by the research team. Descriptive statistics detailed participant demographic characteristics, preconception health history, health status and pregnancy intention, as well as preconception health behaviours, beliefs, and intentions. BMI was calculated using participant weight and height and classified according to the World Health Organization (WHO) BMI classification (227). Pregnancy intention was evaluated using the LMUP for women's partners; a validated and widely used measure to identify the degree of planning/intention for a current/recent pregnancy (172). The LMUP score ranges from 0-12, with a higher score indicating greater pregnancy planning/intention (369). The LMUP score was categorised as 'Planned' (10 or 11), 'Ambivalent' (between 4 and 9), or `Unplanned' (3 or less) (172).

Structural Equation Modelling (SEM) was used to estimate associations between TPB concepts, using survey items to construct latent variables. Parcelling (16) was applied to items used to estimate the latent constructs if convergence or an acceptable model fit was unable to be achieved, and then if this was unsuccessful the concepts were represented by single items in a path model. The indicators used in the path model were rationalized by two members of the research team and comprised a single variable for each construct (See Supplementary Table 1). Regression paths were included to estimate the level of association between beliefs, subjective norms, perceived behavioural control, and intention, and between intention and behaviour. Model fit was established through the Comparative Fit Index (CFI), Tucker Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA) and Standardised Root Mean Square Residual (SRMR). Item non-response was dealt with by using full information maximum likelihood when estimating the model. Standardised path coefficients were estimated. The analysis was conducted with the Lavaan package (398) in R (version 4.3.1). A power analysis was not conducted on the sample. A formal sample size calculation for a specific effect size prior to the analysis as was not conducted as this research was based upon a secondary analysis question. The proposed model was not like models used in simulations for sample size requirements (399) so the 'sample size lower bound' (400) was checked for an anticipated effect size of regression paths of 0.4, and with up to 5 latent variables. The lower bound was 100, which was considered close enough to the study sample (n=94) that analysis would proceed.

7.4 RESULTS

The study sample comprised 156 expectant partners and most identified as reproductive males (n=146) who were included in this study. The proportion of planned pregnancies in this study (65.2%) is higher than the proportion of intended pregnancies for Australian couples (60%) (401).

7.4.1 Participant demographics

The mean age of expectant partners was 31 years (Table 7.1). A large proportion of expectant partners were employed full-time [≥35 hours/week] (87.6%) and married (69.1%) while over half held private health insurance (59.9%) and/or a university qualification (53.4%) and/or reported that 'It is not too bad' to manage financially (52.7%). A small proportion of expectant partners identified as Aboriginal and Torres Strait Islander (4.1%).

Table 7.1 Sociodemographic characteristics of expectant male partners

Characteristics	*Mean (SD; min, max)*
Age (n=136)	31.0 (4.6; 19, 44)
Highest level of education (n=146)	**N (%)**
Year 10 or less	7 (4.7)
Year 12 of equivalent	10 (6.8)
Vocational education [Apprenticeship/Diploma/Certificate]	51 (34.9)
University qualification	78 (53.4)
Private health insurance (n=146)	87 (59.9)
Employment status (n=146)	
Full-time work (≥35 hours/week)	128 (87.6)
Part-time work (<35 hours/week)	10 (6.8)
Casual/temp work (irregular hours)	3 (2.0)
Not currently working	5 (3.4)
Relationship status (n=146)	
Married	101 (69.1)
De facto	41 (28.0)
Other	4 (2.7)
Financial manageability (n=146)	
It is impossible/It is difficult all the time	12 (8.2)
It is difficult some of the time	26 (17.8)
It is not too bad	77 (52.7)
It is easy	31 (21.2)
Identify as Aboriginal or Torres Strait Islander (n=146)	6 (4.1)
First language other than English (n=145)	16 (11.0)
Born outside Australia (n=146)	32 (21.9)
Health care card (n=146)	45 (30.8)

7.4.2 Participant health history, status, and pregnancy planning

Expectant partners generally rated their health status as good (60.8%) with some reporting a longstanding illness, disability, or infirmity (15.4%) (see Table 7.2 Health history, health status, and pregnancy planning). About one third of expectant partners had a normal weight (33.3%), overweight (35.4%), or obesity (31.2%). According to the LMUP categories, most pregnancies were planned (65.2%), while a very small minority were unplanned (0.7%). Further, many expectant partners confirmed the pregnancy using a home pregnancy test (71.9%) and one in 10 pregnancies were conceived via fertility treatment (9.5%). Half of the expectant partners reported that they did not use contraception prior to their most recent pregnancy as they were trying to conceive (50.0%).

Table 7.2 Health history, health status, and pregnancy planning of expectant male partners

Characteristics	**N (%)**
General health status (n=97)	
Excellent	22 (22.6)
Good	59 (60.8)
Fair	15 (15.4)
Poor	1 (1.0)
Longstanding illness, disability, or infirmity (n=97)	15 (15.4)
BMI classification (n=144)	
Underweight	0 (0.0)
Normal weight	48 (33.3)
Pre-obesity	51 (35.4)

Obese class I	30 (20.8)
Obese class II/III	15 (10.4)
LMUP Category (n=139)	
Planned	90 (65.2)
Ambivalent	48 (34.7)
Unplanned	1 (0.7)
Confirmation of pregnancy (n=146)	
Home pregnancy test	105 (71.9)
From a health professional	8 (5.4)
My partner told me	33 (22.6)
Pregnancy resulting from fertility treatment (n=146)	14 (9.5)
Contraception use [6 months before partner's pregnancy] (n=130)	
Yes	43 (33.0)
No – I was trying to conceive	65 (50.0)
No – I was not trying to conceive	22 (16.9)

7.4.3 Participant preconception health behaviours

The majority of expectant partners reported history of any alcohol consumption (88.8%) (Table 7.3 Health behaviours). Many expectant partners who reported a history of alcohol consumption also reported alcohol consumption in the three months before pregnancy (62.0%). Less than half of all expectant partners had a history of ever smoking (37.5%) and of those with a history of ever smoking, less than half were smoking in the three months prior to conception (45.1%).

Table 7.3 Health behaviours of expectant male partners

Characteristics	**N (%)**
Alcohol behaviours (n=134)	
History of alcohol consumption ever	119 (88.8)
Consumption in the three months before conception (n=116)	72 (62.0)
	Mean (SD; min, max)
Total average units consumed per week in the 3 months before conception *During the week	2.6 (3.5; 0 ,20)
Total average units consumed per week in the 3 months before conception *On the weekend	4.9 (5.3; 0, 30)
I avoided alcohol for at least 6 months before my partners pregnancy ^ (n=95)	4.4 (2.6; 0,7)
Smoking behaviours (n=136)	**N (%)**
History of ever smoking	51 (37.5)
Smoking in the three months prior to conception (n=51)	23 (45.1)
Exercise behaviours (n=136)	
Any exercise in the 3 months before conception	97 (71.3)
	Mean (SD: min, max)
Hours of exercise per week in the 3 months before conception (n=97)	6.3 (5.3: 1, 35)
I exercised regularly for at least 6 months before my partners pregnancy (n=95)	3.1 (2.4; 0,7)
Preconception health behaviours (n=78)	**N (%)**
Follow a weight loss diet	15 (19.2)
Get tested for a sexually transmitted infection	11 (14.1)
Visit the dentist	60 (76.9)
Check immunisation status	22 (28.2)
Undergo surgery to help lose weight	-

I ate a healthy diet for at least 6 months before my partners pregnancy (n=93)	2.7 (1.5;0,7)
Supplements used before pregnancy	
Folic acid (n=82)	3 (3.6)
Ordinary multivitamin (n=80)	8 (10.0)
Vitamin C (n=82)	2 (2.4)
Zinc (n=79)	3 (3.8)
Omega 3 (n=79)	5 (6.3)
Antioxidants (n=80)	1 (1.2)
Herbal medicines (n=80)	1 (1.2)
Other (n=80)	6 (7.5)

^All items scored on a 7-point scale (0-7).

The majority of expectant partners reported any exercise in the three months before conception (71.3%) with a mean number of hours per week at approximately six (mean 6.3; SD 5.3). The most common health behaviours before pregnancy were visiting a dentist (76.9%) or checking immunization status (28.2%), while the most common supplements used before pregnancy were an ordinary multivitamin (10.0%) or omega 3 (6.3%).

7.4.4 The associations between preconception beliefs, subjective norms, perceived behavioural control, and intentions and behaviours

Median scores, and the interquartile range (IQR, 25% and 75% percentiles), for preconception beliefs, norms, perceived behavioural control, and intentions and behaviours were measured on a seven-point scale from extremely likely to extremely unlikely (Table 7.4 Health beliefs and intentions). SEM model fit for the outcomes exercise and alcohol was adequate (Appendix 7.3), and a path model was used for diet due to issues with convergence and model fit. The models for each concept are presented in Figure 1, Figure 2, and Figure 3.

For the exercise outcomes, results indicated that the beliefs of expectant partners toward regular exercise and their perceived behavioural control to exercise regularly were associated with a greater intention to exercise regularly (Standardised estimate $\beta=0.54$; $p=0.0087$ and $\beta=0.43$; $p=0.02$, respectively). The subjective norms of expectant partners were not associated with an intention to exercise regularly $\beta=0.11$; $p>0.05$). Similarly for alcohol, the beliefs of expectant partners toward alcohol avoidance and their perceived behavioural control toward alcohol avoidance were associated with a greater intention to avoid alcohol ($\beta=0.43$; $p<0.001$ and $\beta=0.36$; $p<0.001$, respectively). For the healthy diet outcome, subjective norms regarding a healthy diet as expressed by an expectant partner and perceived behavioural control to adopt a healthy diet were associated with an intention to adopt a healthy diet ($\beta=0.23$; $p=0.04$ and $\beta=0.47$; $p<0.001$, respectively). The beliefs of expectant partners toward a healthy diet and the subjective norms of their health care providers towards a healthy diet were not associated with the intention for a healthy diet

(β=0.07; p>0.05 and β=0.13; p>0.05, respectively). Intention was in turn associated with behaviour for all three outcomes.

Table 7.4 Health beliefs and intentions of expectant male partners

**All items scored on a 7-point scale (0-7).*

CONSTRUCT		Behaviour		
		Regular Exercise (n=95)	**Healthy Diet (n=93)**	**Alcohol Avoidance (n=95)**
		Median (IQR)	**Median (IQR)**	**Median (IQR)**
Past behaviour	I …… regularly for at least 6 months before becoming pregnant [definitely true/definitely false]	3 (1,5)	3 (2,4)	5 (2,7)
Beliefs	My ……. during the 6 months prior to becoming pregnant is			
	[important/not important]	3 (2,4.5)	2 (1,4)	4 (2,6)
	[pleasant/unpleasant]	2 (1,4)	2 (1,3)	3 (1,5)
	[good/bad]	1 (0,3)	1 (1,3)	2 (1,4)
	If I …… for 6 months before becoming pregnant my child will be healthy [extremely likely/extremely unlikely]	3 (2,4)	3 (2,4)	3 (2,4)
Intentions	I intend to……. for at least 6 months before becoming pregnant [extremely likely/extremely unlikely]	3 (1,4)	2 (1,4)	3 (1,6)
	I will make an effort to …… for at least 6 months before becoming pregnant [extremely likely/extremely unlikely]	3 (1,4)	2 (1,4)	3 (1,6)
Control	I am confident I can ……. for at least 6 months before becoming pregnant [extremely likely/extremely unlikely]	3 (1,4)	2 (1,3)	3 (1,5)
	…….for 6 months before becoming pregnant is up to me [extremely likely/extremely unlikely]	1 (0,2)	1 (1,2)	1 (0,3)
Norms	Most people like me …… for 6 months before becoming pregnant [extremely likely/extremely unlikely]	4 (2,5)	4 (3,5)	4 (3,6)
Subjective Norms	My reproductive partner thinks it's important for me to …… for 6 months before becoming pregnant [strongly agree/strongly disagree]	3 (2,4)	2 (1,4)	3.5 (2,5)
	My older female relatives (e.g., mother, grandmother, aunt) thinks it's important for me ……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	3 (2,5)	3 (2,5)	3 (2,5)
	My older male relatives (e.g., father, grandfather, uncle) thinks it's important for me to……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	4 (3,5)	4 (2,5)	4 (3,6)
	My male friends and family of similar age thinks it's important for me to ……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	4 (2,5)	4 (2,5)	4 (2,6)
	My female friends and family of similar age thinks it's important for me to …… for 6 months before becoming pregnant [strongly agree/strongly disagree]	3 (2,5)	3 (2,4)	3 (2,5)
	My health care provider thinks it's important for me to ……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	2 (1,3)	2 (1,3)	2 (1,4)

Figure 7.1 [Regular Exercise] Theory of Planned Behaviour (TPB) - Path Model

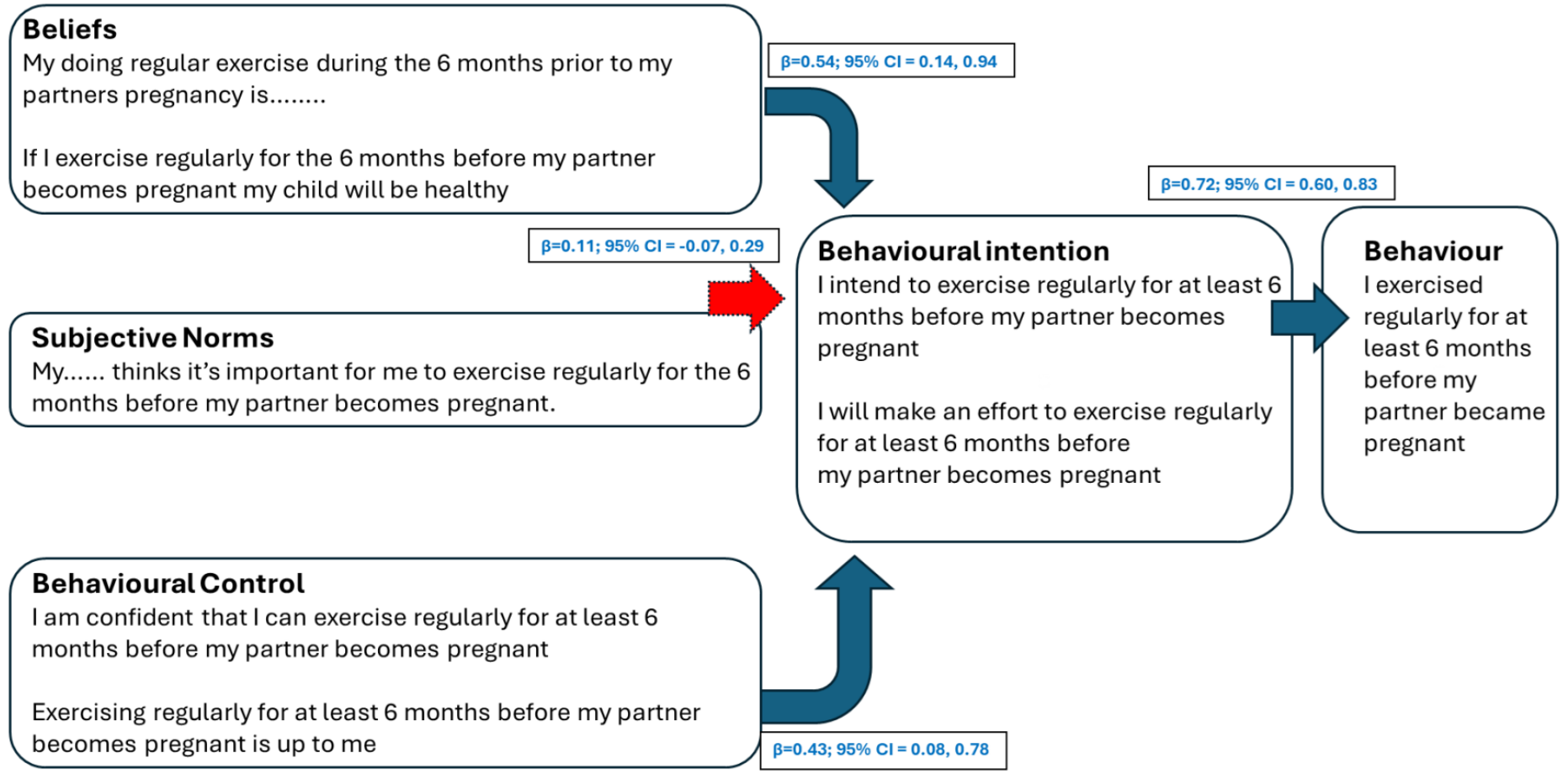


Figure 7.2 [Healthy Diet] Theory of Planned Behaviour (TPB) - Path Model

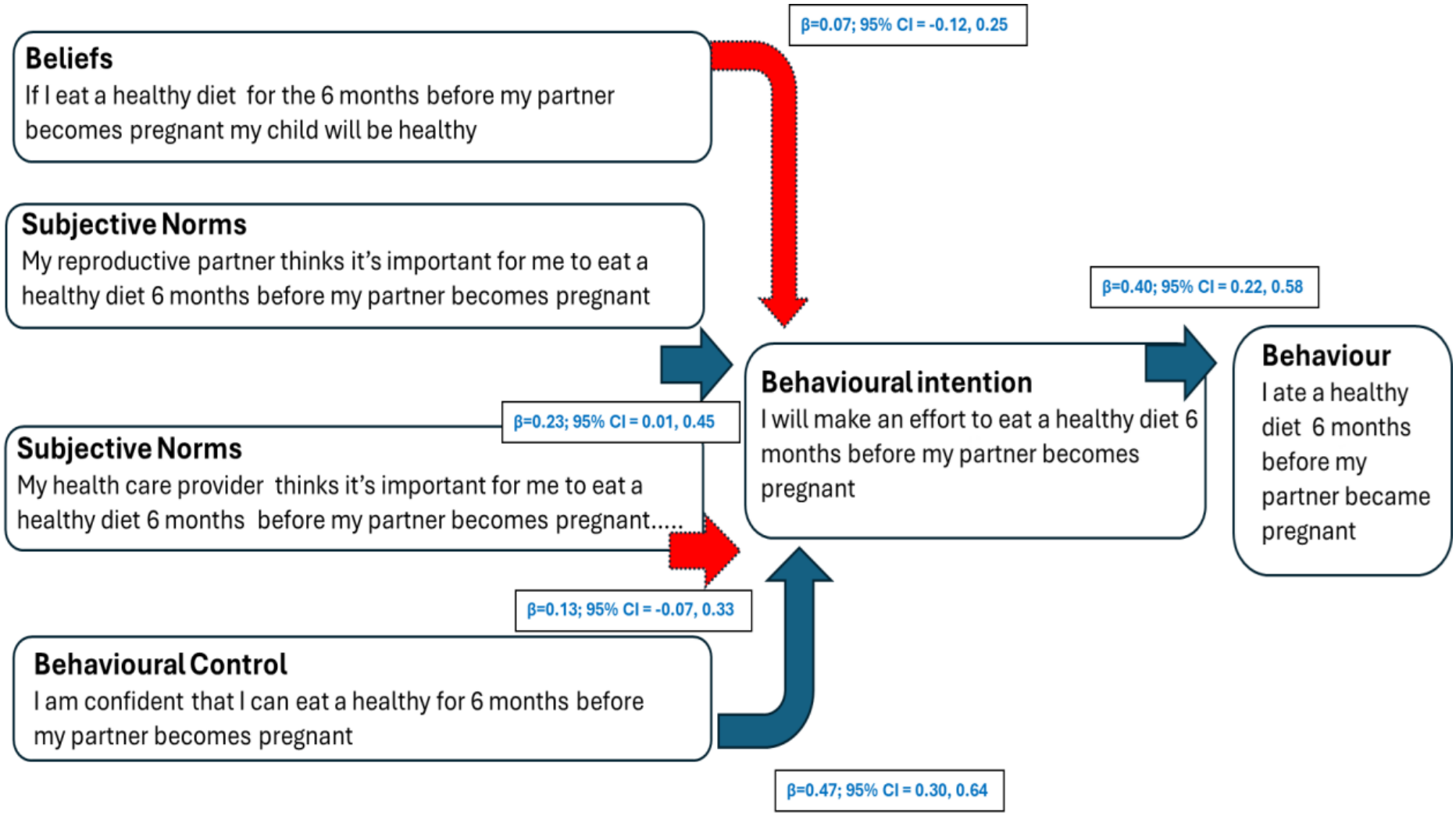
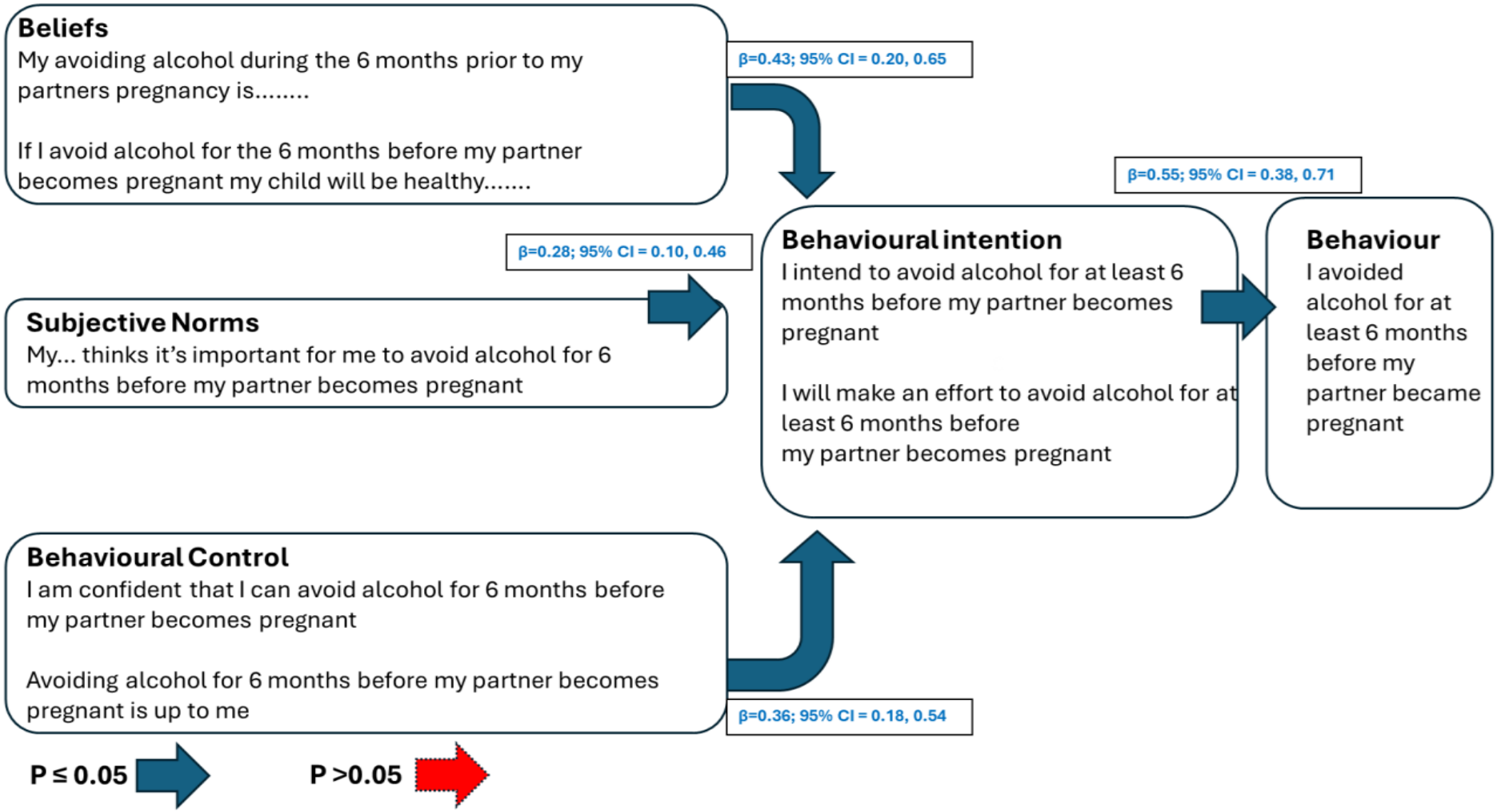


Figure 7.3 [Alcohol Avoidance] Theory of Planned Behaviour (TPB) - Path Model



7.5 DISCUSSION

Our study advances the understanding of paternal preconception health by examining the relationships and pathways between expectant partner's health beliefs, and intentions and behaviours around dietary practices, alcohol avoidance, and regular exercise before pregnancy. Considering the majority of pregnancies in our study were planned (65.2%), key findings suggest that preconception beliefs about exercise and alcohol predict intention to exercise regularly and to avoid alcohol. Further, the confidence/control about being able to exercise regularly, eat a healthy diet and avoid alcohol all predict intention for these behaviours amongst expectant partners. Partner opinion on the importance of eating a healthy diet was an important predictor for intention to eat a healthy diet. Also, expectant partners' intentions for all three behaviours predicted behaviour, most strongly for exercise.

Most expectant partners in our study undertook regular exercise in the three months before conception. Previous research investigating behavioural intention to exercise has explored mixed gender populations, such as university students (402, 403). This work provides varied results and suggests that intention to exercise does not always translate into practice (404). Evidence exploring physical activity specifically among males during preconception is lacking (114). However, evidence does suggest that the health behaviours of males can have a direct and indirect influence on pregnancy and offspring outcomes. Nuances in sociodemographic characteristics such as being educated may justify the intent for physical activity among expectant partners in our study given approximately one in two held a university qualification. In our study, when comparing regular exercise with a healthy diet or avoiding alcohol, the behavioural intention to regularly exercise was not influenced by the subjective expectations of others. Specifically, our study found expectant partners' intention to exercise may be less often influenced by other individuals in their lives, such as their reproductive partners or male or female family and friends. The reason for this finding, however, is unclear. It is possible that men are instead relying on their own personal beliefs and responding to their personal health needs, and the subsequent individualised health benefits resulting from a regular exercise regime, rather than relying on external factors as motivations to exercise regularly. Considering the inherent risks of sedentary lifestyles and the rising global prevalence of overweight and obesity (405, 406), our finding that intention to exercise regularly is related to exercise behaviour is promising for paternal preconception intervention development. However, our finding relating to expectant partners preconception exercise must also consider the influence of their beliefs, subjective norms, and their perceived control of their behaviour on their intention to exercise. These three factors underpinning intention must be targeted in future research to develop a clear understanding

of exercise for males during preconception. The health impacts of regular exercise have been investigated for males during preconception in a limited number of studies; a review exploring paternal preconception modifiable risk factors identified only two papers relevant to exercise and both papers reported no associations between paternal preconception physical activity and adverse pregnancy or offspring outcomes (114). Hence, further studies are needed to explore opportunities for promoting physical activity among males who plan to become a parent during the preconception period to motivate and facilitate a behaviour change to support their own life-long health and possibly that of their family.

The beliefs of expectant partners in our study toward alcohol avoidance during preconception were associated with a greater intention to avoid alcohol. However, most expectant partners consumed alcohol in the three months before conception. The disconnect between expectant partners' beliefs about alcohol (avoiding alcohol is important) and their behaviours regarding alcohol (avoiding alcohol) before pregnancy may be due to alcohol, as an addictive drug, being culturally encouraged in Australia (407) despite public health campaigns highlighting the general health risks and adverse effects of alcohol use (408). Considering the normalization of alcohol consumption in Australian society, due to social acceptability and regular availability, a 'culture of intoxication' (407) exists, especially for younger males (409). It may be that the cultural context and addictive properties of alcohol both play their part in challenging the beliefs of males to abstain from drinking alcohol during preconception, as is demonstrated in our study. Health behaviours such as alcohol consumption and tobacco smoking can interrelate and often co-exist (410) within a complex environment of social and cultural norms (411) and this link may also explain why close to half of the expectant partners in our study who had ever smoked chose to smoke in the three months prior to their partners pregnancy. Expectant partners in our study who hold the belief to avoid alcohol during preconception yet report alcohol consumption or smoking in the three months before conception is concerning due to the potential for adverse pregnancy and offspring outcomes such as foetal birth defects (412) and child behavioural problems (284). Associations between alcohol consumption or smoking and adverse and pregnancy outcomes have also been identified in a recent review of paternal preconception modifiable risk factors (114). Understanding future fathers' resistance to changing alcohol consumption and smoking patterns during preconception requires further research which can guide Governments to consider instituting overarching preconception guidelines focusing on males as well as females, and couples. To better support the disparity between males' preconception beliefs and their behaviours towards alcohol, and their behaviours while consuming alcohol such as smoking, industry collaborations must be strengthened to

facilitate the effective translation of alcohol related information between researchers, practitioners, health and community organisations, and the general public.

Many expectant partners in our study did not report consuming a healthy diet in the six months before conception. However, our analysis did reveal that the healthy diet of some expectant partners was most often influenced by their reproductive partners, more so than their health care provider. The dietary beliefs of males, for example beliefs regarding healthy eating or binge drinking, are only marginally investigated, among male consumers (413), and are often based on outdated evidence (414, 415). More recent literature highlights the importance of initiating healthful dietary regimes for males during preconception, validating the effects of poor paternal dietary patterns and paternal nutrition on pregnancy and offspring outcomes (114, 416). Most expectant partners in our study were married and, indeed, being in a committed relationship can have an influence on an individual's behaviours which impact their health (417) including their diet. Many expectant partners in our study worked full-time and, due to the convenience, cost and availability of certain foods, may have resorted to foods often deemed nutritionally imbalanced or even 'unhealthy' such as packaged, preprepared or 'fast food' (418). The diets of expectant partners in our study must also be understood within the context of wider cultural stereotypes such as masculine eating and drinking beliefs often associated with a low concern for unhealthy eating/drinking (413) and the consumption of disproportionate amounts of macronutrients (419). Our study identifies an expectant partner's healthy diet as influenced by their reproductive partner. As such, the influence of the couple or the family on a male's diet is noteworthy and signals an important challenge for public health policy makers and researchers to pursue the food habits of males and to assess the perceived behavioural control of males to maintain a healthy diet during preconception and when planning a pregnancy.

Our study provides new insights, being the first to examine the influence of males, as expectant partners, and their beliefs, norms, and perceived behavioural control on intentions and subsequent preconception health behaviours. This sample also displays a number of other health conditions which may further affect the behavioural decisions of expectant partners. Future research should examine some of the potential influence of health status and other factors on intentions for expectant partners. A key strength of our study is the data collection directly from male expectant partners rather than being reported by their female partners and while their partner was still pregnant – addressing an important gap in paternal preconception research to date (114). Although, our study is not without limitations. Firstly, when conducting analysis, issues were identified with using the SEM model to fit the healthy diet outcome which could only be resolved by utilizing a path model which was selected by two members of the research team. As such, the determination of each healthy diet variable

may attract researcher-bias toward the final SEM model and regression results. Also, participants were recruited via social media; hence, sampling bias may influence the findings of this study. Despite the global use and acceptance of social media, recruitment via this medium is unlikely to provide a true representation of the target population during preconception. As such, the absence of national data describing demographic characteristics of expectant fathers in Australia limits the ability to determine the representativeness of the study sample. Therefore, the study recruitment strategy and small sample size of this study may not report an entirely accurate representation of Australian male ethnicities or males as reproductive partners of pregnant Australian women (420, 421). In addition, the SEM model did not account for characteristics such as BMI or smoking due to the complexity of the model and the need for extra paths to different latent variables. Furthermore, this study uses past behaviours to predict future intention and therefore had to be supported by a proxy measure of preconception behaviour. Finally, self-reporting on a survey may also present the potential for self-reporting bias.

7.6 CONCLUSION

Our study highlights the importance of engaging males as expectant partners during preconception to characterize their beliefs and intentions which are exacted through their personal values (norms), the values of others (subjective norms) and their perceived behavioural control. Overall, our study demonstrated that expectant partners' preconception beliefs about exercise and alcohol predict their intention to exercise regularly and avoid alcohol. Further, the confidence/ perceived behavioural control about being able to exercise regularly, eat a healthy diet and avoid alcohol all predict intention for these behaviours. Partner opinion on the importance of eating a healthy diet was an important predictor for expectant partners' intention to eat a healthy diet. Importantly, expectant partners' intentions for all three behaviours predicted behaviour, most strongly for exercise. Further studies examining paternal preconception health beliefs, and intentions and the motivations behind health behaviours for males are needed to help develop targeted preconception health promotion messages and interventions that support males to optimise their preconception health.

7.7 CHAPTER SUMMARY

This chapter examines the health beliefs, attitudes, and intentions of Australian males through the belief-behaviour interrelationship and the Theory of Planned Behaviour, a framework from which to scope project objective one. The belief-behaviour connection has been utilised in this chapter as a grounded and trusted theoretical paradigm to provide a

logical sequence and explanation for the influences of three key behaviours of Australian males. This chapter covers the preconception beliefs and the behavioural intentions to predict preconception health behaviours to i) avoid alcohol, ii) undertake regular physical activity, and iii) consume a healthy diet.

Chapter findings reveal the beliefs of Australian males regarding health behaviours such as regular exercise and alcohol avoidance have an association and can influence their behavioural intentions to undertake such behaviours. Findings also highlight the importance of partner opinion when addressing the behavioural intention for healthful eating during preconception.

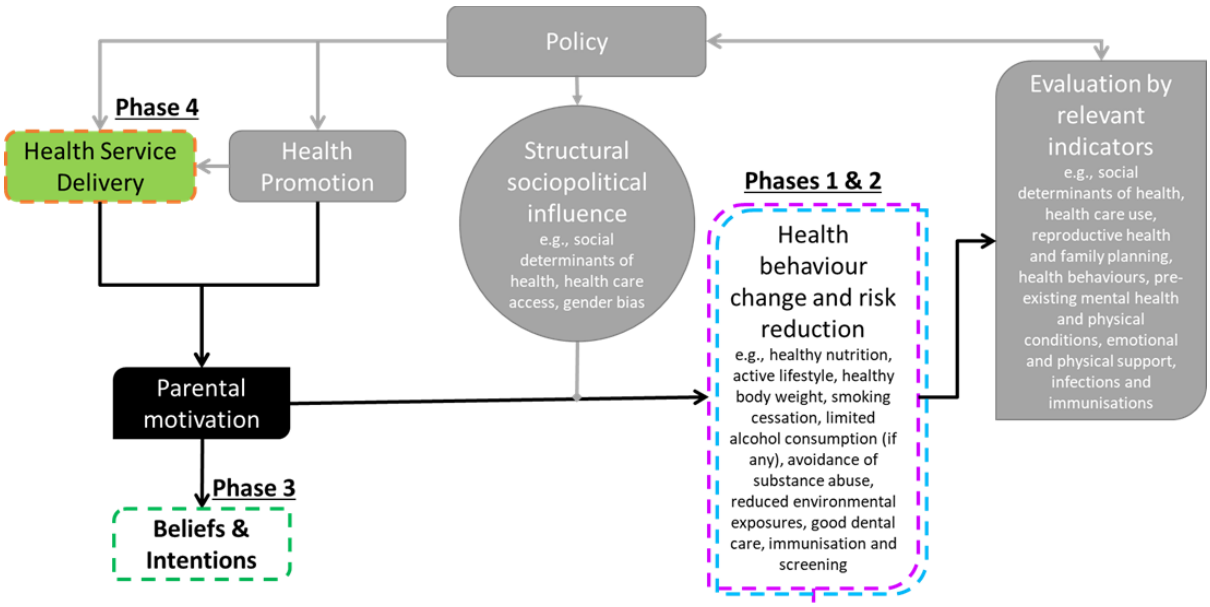
An investigation into the beliefs and intentions of Australian males to predict key preconception behaviours. The beliefs and intentions which underly the health behaviours of Australian males should also be considered within preconception treatments for males and discussed with males during their preconception health service use.

8 PATERNAL PRECONCEPTION HEALTH, TREATMENTS, AND HEALTH SERVICES UTILIZATION AMONG AUSTRALIAN MALES ATTEMPTING OR PLANNING PREGNANCY

8.1 RATIONALE FOR THIS ANALYSIS

The rationale for this analysis aligns with the third, fourth, and fifth project objectives which are to address and the social determinants of health, and to identify the health service utilisation, and health information seeking attributes of Australian males either planning pregnancy or attempting pregnancy. Analysis of a national dataset can be utilised to determine males' sociodemographic characteristics, their diagnosed health conditions, the health services they utilise, and the treatments they are administered.

The content of this chapter and its relevance to the project methodological framework is highlighted in green below.



8.2 INTRODUCTION

Preconception care is the provision of biomedical, behavioural, and social health intervention to women and couples before conception, aiming to improve health status, in the short and long term, by limiting behaviours and modifiable risk factors which contribute to adverse health outcomes (136). While health during the preconception period is an essential consideration for both females and males (35), preconception care interventions predominantly focus on the female alone (24, 422), overlooking the contribution of paternal preconception health. The need for preconception care to include males (41) is underscored by a recent review of paternal preconception modifiable risk factors which found paternal smoking may increase the risk of birth defects and higher paternal body mass index (BMI) was associated with higher offspring birthweight (114). Further emerging evidence suggests preconception exposures influence sperm epigenetics (20, 423) and acknowledges the importance of exploring environmental influences from father to child, as addressed in the Paternal Origins of Health and Disease [POHaD] theory (18). Ideally, to optimise pregnancy and offspring outcomes, males planning or even contemplating pregnancy should be considered by health professionals as candidates for preconception care.

Population-based survey data suggests more than one third of Australian men and women who report ever being pregnant, or having a pregnant partner, experienced at least one unintended pregnancy (401). Pregnancy planning advice in Australia is promoted through an alliance of national (424) and state-based (140) sexual and reproductive health organisations. Pregnancy planning advice incorporating the male partner does occur but is not widespread (425-428), offering limited advice to assist Australian males during the preconception period. Preconception care in Australia is further hindered by the limited high-quality preconception care clinical guidelines across the range of health services (34) available in Australia. Although the Royal Australian College of General Practitioners (RACGP) provides recommendations to support general practitioner (GP) delivery of preventive activities prior to pregnancy (157) as well as guidelines for the implementation of prevention in the general practice setting (429), the Australian community also have access to medical specialists, allied health workers, midwives, nurses, and primary care complementary health practitioners (153, 430, 431), for which no preconception care guidelines are known to exist. Even with the support practice guidelines, Australian GPs have identified several barriers to discussing preconception health with male patients, including their own knowledge gaps (25). With a general lack of preconception awareness, or knowledge (132), both Australian health professionals and Australian males may feel challenged to participate in or to discuss preconception and health behaviours, attitudes, or intentions, even when a pregnancy is being planned.

Health professionals in Australia may be well-positioned to consider incorporating preconception care into daily routine practices, to involve males in preconception discussions, and ultimately facilitate paternal preconception health and care. With this in mind, identifying the health services that males consult during the crucial period of preconception is important to advance the current understanding of paternal preconception health and care. Such insights can be used to identify opportunities to optimise paternal preconception health, and the range of healthcare professionals who may have a role in this, with the overarching aim to improve relevant modifiable paternal preconception risk factors. In response, this study aims to describe the preconception health, treatments, and health service utilization of Australian males who identify as planning or attempting pregnancy.

8.3 METHODS

8.3.1 Study design

This study used data from a nationally representative online survey (103) of Australian adults, examining their health conditions diagnosed, their current treatments utilized, the health services they use and the health services that prescribe their treatments. This study adheres to the STROBE reporting guidelines (432).

8.3.2 Setting

Survey participants (participants) were identified through purposive convenience sampling from a database and included if they were Australian adults, aged 18 years over, and registered to participate in research (103). Participants were representative of the Australian population, regarding gender, age, and state of residence. Recruitment and data collection occurred between 4 February and 18 February 2022. Database members were sent a participation invitation online via email which included a hyperlink to the survey, requiring approximately 30 minutes to complete. Informed consent was obtained from each participant (n=2,569) prior to survey commencement. Participants were excluded from the analysis if informed consent was not obtained. The survey began with a disclaimer outlining who was conducting the research, how and why it was being conducted, what the survey was about, what participation involved, and any potential risks or inconveniences. A small financial incentive ($30 gift voucher) was provided for being a member of the database and taking the time to participate (103). Survey participants were questioned on any retrospective behaviour or exposure related survey responses to within the previous 12 months to minimise the potential for recall bias. As described previously by Harnett et al (2019) (228), survey validity was undertaken prior to survey dissemination.

Of the total survey participants, 92% (n=2,354) answered the question regarding gender and age. From these participants, males aged ≤55 years (n=507) were identified for analysis in the current study and recorded a 100% response rate.

8.3.3 Measures

The survey instrument has been described and utilized in a previous study (103). Briefly, the survey instrument comprised 63 items across five domains including demographics (n=11), health and wellbeing status (n=20), health service utilization (n=16), patient experiences of care (n=10) and disclosure of medicines (n=6). Male survey participants (the participants) confirmed `Are you or your partner currently attempting to become pregnant?' or `Do you or your partner plan to become pregnant in the next 12 months?'. The following categorical variables were included for analysis in this study; sociodemographic characteristics such as age, private health insurance status, highest qualification completed, current employment status, and present relationship status. Also included in the analysis were the health conditions diagnosed in the previous three years, treatments and health services utilized in the previous 12 months, and treatments recommended by each health service.

8.3.4 Data analysis

Survey data were imported into Stata 17 (StataCorp LLC) statistical analysis software. There was no formal evaluation of content or construct validity conducted, and reliability testing was not performed.

Analysis was conducted on males aged no more than 55 years to minimise data from older males less likely to report planning or attempting pregnancy. The survey identified pregnancy planning intent by asking participants `are you or your partner currently attempting to become pregnant' (yes, no, unsure) and `do you or your partner plan to become pregnant in the next 12 months' (yes, no, unsure). Binary variables were created from these categorical variables to identify and report on males from the data set who were currently attempting pregnancy (yes, no) or planning a pregnancy in the next 12 months (yes, no). Any missing responses or unsure answers were not included in the analysis (n = 32). Binary variables (yes, no) were also created to recategorize the 5-point scale (None [1]… More than 6 [5]), used to identify the frequency of visits to specific health services, reporting a visit or not.

Descriptive analysis was employed to identify frequencies and proportions for all variables of interest within the five domains. Statistical differences in the variables of interest according

to attempting pregnancy or planning pregnancy were explored using chi square tests with an α-value <0.05 considered statistically significant. The effect size of any statistically significant outcomes of the chi-square tests were determined utilizing Cramer's V. Results for Cramer's V range between 0 and 1, greater values indicate stronger associations between variables; > 0.25 equals a very strong association, > 0.15 equals a strong association, > 0.10 equals a moderate association, > 0.05 equals a weak association and > 0 equals a very weak association (225). Results for Cramer's V range between 0 and 1, greater values indicate stronger associations between variables; > 0.25 equals a very strong association, > 0.15 equals a strong association, > 0.10 equals a moderate association, > 0.05 equals a weak association and > 0 equals a very weak association (225).

8.4 RESULTS

For all participants (n=507), there was an even distribution in the age ranges of 35-44 years and 45 –55 years (n=155; 30.5%;) (see Table 1). Approximately half of all participants had private health insurance (n=229;45.1%), a similar proportion were employed full-time i.e., ≥ 35hours/week (n=284; 56.0%). Less than half of all participants were in a relationship with a member of a different sex (n=209; 41.2%), a greater proportion of participants were never married (n=236; 46.5%). Further, one in five participants received a nervous disorder diagnosis in the previous three years (n=104; 20.5%). Prescription-only pharmaceuticals (n=242; 47.7%) and over-the-counter pharmaceuticals (n=226; 44.6%) were the most utilized treatments by all participants while the GP (n=396; 78.1%) and pharmacist (n=335; 66.0%) were the most consulted health services. Approximately half of all participants had no health condition diagnosed in the previous three years (n=242; 47.7%).

Among participants identified for analysis, 7% were currently attempting pregnancy (n=36) and 13% were planning a pregnancy in the next 12 months (n=66).

8.4.1 Socio demographics

Participants currently attempting pregnancy (n=36) were mostly aged 35-44 years (n=19; 52.7%) p≤0.001 while participants planning a pregnancy in the next 12 months (n=66) were commonly 25-34 years (n=24; 36.3%) or 35-44 years (n=26; 39.3%) p≤0.001 respectively (see Table 1). As current employment status increased in permanency and time, so did the proportion of participants currently attempting pregnancy (casual/temp employment: [n=2] 5.5%; part-time: [n=5] 13.9%; full-time: [n=26] 72.2%) p=0.11 or planning a pregnancy in the next 12 months (casual/temp employment: [n=4] 6.0%; part-time: [n=8] 12.1%; full-time: [n=49] 74.2%) p≤0.001. In parallel, as the highest level of qualification increased, so too did the proportion of participants currently attempting pregnancy (Year 12: [n=9] 25.0%; vocational

education: [n=11] 30.5%; university degree: [n=15] 41.6%) p=0.32 or planning pregnancy in the next 12 months (Year 12: [n=15] 22.7%; vocational education: [n=15] 22.7%; university degree: [n=32] 48.5%) p=0.18.

Strong associations were identified between relationship status and currently attempting pregnancy (V=0.24; p≤0.001) or planning pregnancy in the next 12 months (V=0.26; p≤0.001). Similarly, strong associations were identified for age with currently attempting pregnancy (V=0.17; p≤0.001) or planning a pregnancy in the next 12 months (V=0.18; p≤0.001). A strong association was also identified for current employment status with planning pregnancy in the next 12 months (V=0.16; p≤0.001).

Table 8.1 Sociodemographic characteristics of males attempting pregnancy or planning pregnancy in the next 12 months

Participant characteristics	*All (n=507)*	*Currently attempting pregnancy*				*Planning pregnancy in the next 12 months*			
	Total	Yes (n=36)	No (n=471)	P	Cramer's V	Yes (n=66)	No (n=441)	*P*	Cramer's V
	n (%)	*n (%)*	*n (%)*			*n (%)*	*n (%)*		
Age range									
18-24 years	68 (13.4)	3 (8.3)	65 (13.8)	≤0.001 *	0.17	10 (15.1)	58 (13.1)	≤0.001 *	0.18
25-34 years	129 (25.4)	12 (33.3)	117 (24.8)			24 (36.3)	105 (23.8)		
35-44 years	155 (30.5)	19 (52.7)	136 (28.8)			26 (39.3)	129 (29.2)		
45-55 years	155 (30.5)	2 (5.5)	153 (32.4)			6 (9.0)	149 (33.8)		
Private Health Insurance									
Yes	229 (45.1)	14 (38.9)	215 (45.6)	0.43	-	33 (50.0)	196 (44.4)	0.39	-
Highest qualification completed									
≤ year 10 or equivalent	61 (12.0)	1 (2.7)	60 (12.7)	0.32	-	4 (6.0)	57 (12.9)	0.18	-
Year 12 or equivalent	129 (25.4)	9 (25.0)	120 (25.4)			15 (22.7)	114 (25.8)		
Vocational education (e.g. Apprenticeship/Diploma)	125 (24.6)	11 (30.5)	114 (24.3)			15 (22.7)	110 (24.9)		
University degree or Higher	192 (37.8)	15 (41.6)	177 (37.5)			32 (48.5)	160 (36.3)		
Current employment status									
Full-time work (≥35 hours/week)	284 (56.0)	26 (72.2)	258 (54.7)	0.11	-	49 (74.2)	235 (53.2)	≤0.001 *	0.16
Part-time work (<35 hours/week)	68 (13.4)	5 (13.9)	63 (13.3)			8 (12.1)	60 (13.6)		
Casual/temp work (irregular hours)	31 (6.1)	2 (5.5)	29 (6.1)			4 (6.0)	27 (6.1)		
Not currently working	124 (24.4)	3 (8.3)	121 (25.7)			5 (7.6)	119 (26.9)		
Present relationship status									
Never married	236 (46.5)	4 (11.1)	232 (49.2)	≤0.001 *	0.24	12 (18.1)	224 (50.8)	≤0.001 *	0.26
Different sex married/de facto relationship	209 (41.2)	26 (72.2)	183 (38.8)			44 (66.6)	165 (37.4)		
Same sex married/de facto relationship	20 (3.9)	5 (13.9)	15 (3.1)			7 (10.6)	13 (2.9)		
No longer married	42 (8.2)	1 (2.8)	41 (8.7)			3 (4.5)	39 (8.8)		

8.4.2 Health conditions diagnosed in the previous three years

Almost one third of all participants currently attempting pregnancy were diagnosed with a nervous condition in the previous three years (n=11; 30.5%) p= 0.12, and one quarter of all participants currently attempting pregnancy reported a migraine diagnosis in the previous three years (n=9; 25%) p≤0.001 (see Table 2). Several participants currently attempting pregnancy were diagnosed with a cardiovascular condition during the same period (n=7; 19.4%) p=0.13. Likewise, participants planning pregnancy in the next 12 months had a high proportion of nervous disorders (n=13; 19.7%) p=0.86 and cardiovascular conditions (n=12; 18.1%) p=0.07 diagnosed in the previous three years. Approximately equal proportions of participants reported no diagnosis in the previous three years for both currently attempting pregnancy (n=12; 33.3%) p=0.07 or planning pregnancy in the next 12 months (n=25; 37.9%) p=0.08.

A diabetes diagnosis in the previous three years was strongly associated with planning pregnancy in the next 12 months (V=0.17; p≤0.001) and moderately associated with currently attempting pregnancy (V=0.11; p=0.01). Diagnosis with migraine in the previous three years was strongly associated with currently attempting pregnancy (V=0.18; p≤0.001) yet was not associated with planning a pregnancy in the next 12 months.

Table 8.2 Health Conditions diagnosed in the previous three years

Health conditions diagnosed	*All (n=507)*	*Currently attempting pregnancy*			*Planning pregnancy in the next 12 months*		
	Total	Yes (n=36)	No (n=471)	P (Cramer's V)	Yes (n=66)	No (n=441)	P (Cramer's V)
	n (%)	n (%)	n (%)		n (%)	n (%)	
Arthritis and musculoskeletal conditions	2 (0.4)	0 (0.0)	2 (0.4)	0.69	0 (0.0)	2 (0.4)	0.58
Asthma	27 (5.3)	2 (5.5)	25 (5.3)	0.94	3 (4.5)	24 (5.4)	0.76
Autoimmune conditions	9 (1.8)	1 (2.8)	8 (1.7)	0.63	1 (1.5)	8 (1.8)	0.86
Cancer	31 (6.1)	3 (8.3)	28 (5.9)	0.56	6 (9.1)	25 (5.6)	0.27
Cardiovascular conditions	59 (11.6)	7 (19.4)	52 (11.0)	0.13	12 (18.1)	47 (10.6)	0.07
Chronic fatigue syndrome/myalgic encephalomyelitis	10 (1.9)	1 (2.8)	9 (1.9)	0.7	1 (1.5)	9 (2.0)	0.77
COVID-19	39 (7.7)	5 (13.9)	34 (7.2)	0.14	7 (10.6)	32 (7.2)	0.34
Diabetes	18 (3.5)	4 (11.1)	14 (2.9)	0.01* (0.11)	8 (12.1)	10 (2.2)	<0.001* (0.17)
Fibromyalgia	3 (0.6)	0 (0.0)	3 (0.7)	0.63	0 (0.0)	3 (0.7)	0.50
Gastrointestinal conditions	33 (6.5)	2 (5.5)	31 (6.5)	0.81	3 (4.5)	30 (6.8)	0.48
Male reproductive conditions	6 (1.1)	0 (0.0	6 (1.2)	0.49	1 (1.5)	5 (1.1)	0.78
Mental Health	53 (10.4)	2 (5.5)	51 (10.8)	0.31	3 (4.5)	50 (11.3)	0.09
Migraine	37 (7.3)	9 (25.0)	28 (5.9)	≤0.001* (0.18)	8 (12.1)	29 (6.6)	0.10
Nervous disorders	104 (20.5)	11 (30.5)	93 (19.7)	0.12	13 (19.7)	91 (20.6)	0.86
Respiratory conditions	17 (3.3)	1 (2.8)	16 (3.4)	0.84	1 (1.5)	16 (3.6)	0.37
Other long-term health condition	31 (6.1)	1 (2.8)	30 (6.3)	0.38	2 (3.0)	29 (6.6)	0.26
None of the above	242 (47.7)	12 (33.3)	230 (48.8)	0.07	25 (37.9)	217 (49.2)	0.08

8.4.3 Treatments utilized in the previous 12 months

More than half of the participants currently attempting pregnancy utilized over-the-counter pharmaceuticals in the previous 12 months (n=21; 58.3%) p=0.08 (see Table 3). Almost half of all participants currently attempting pregnancy utilized prescription-only pharmaceuticals (n=16; 44.4%) p=0.68 or vitamin/mineral supplements (n=16; 44.4%) p=0.27 during the same period. Participants planning pregnancy in the next 12 months followed a similar pattern to those participants currently attempting pregnancy; over-the-counter pharmaceuticals were the most utilized treatment (n=30; 45.4%;) p=0.87 and also prescription-only pharmaceuticals (n=26; 39.4%) p=0.14 or vitamin/mineral supplements (n=21; 31.8%) p=0.43.

The use of western herbal medicine treatments in the previous 12 months demonstrated a moderate association with currently attempting pregnancy (V=0.09; p=0.02). The use of western herbal medicine (V=0.18; p≤0.001), Chinese herbal medicine (V=0.10; p=0.01), and yoga practice (V=0.10; p=0.01) as treatments utilised in the previous 12 months showed strong associations with planning pregnancy in the next 12 months.

8.4.4 Health professionals and services consulted in the previous 12 months

Most participants currently attempting pregnancy consulted a GP in the previous 12 months (n=34; 94.4%) p=0.01 and more than three quarters of participants currently attempting pregnancy consulted a pharmacist (n=28; 77.7%) p=0.12 during the same period (see Table 3). Equally, the majority of participants planning pregnancy in the next 12 months consulted a GP in the previous 12 months (n=57; 86.3%) p=0.08 and three quarters of participants planning pregnancy in the next 12 months consulted a pharmacist (n=50; 75.7%) p=0.07 during the same period.

Currently attempting pregnancy was strongly associated with consulting a massage therapist (V=0.12; p=≤0.001), GP (V=0.10; p=0.10), or a specialist doctor (V=0.10; p=0.10); a moderate association was identified with consulting a counsellor or other mental health worker (V=0.08; p=0.05). Planning pregnancy in the next 12 months showed a strong association with consulting a massage therapist (V=0.21; p≤0.001), a counsellor or other mental health worker (V=0.14; p≤0.001), a community nurse/nurse practitioner (V=0.13; p≤0.001), or a hospital doctor (V=0.12; p≤0.001). Planning pregnancy in the next 12 months showed a moderate association with consulting a pharmacist (V=0.07; p=0.07).

Table 8.3 Treatments utilized, and health services consulted in the previous 12 months

Treatment/Health service	*All (n=507)*	*Currently attempting pregnancy*				*Planning pregnancy in the next 12 months*			
	Total	Yes (n=36)	No (n=471)	P	Cramer's V	Yes (n=66)	No (n=441)	*P*	Cramer's V
	n (%)	*n (%)*	*n (%)*			*n (%)*	*n (%)*		
Treatments									
Prescription-only pharmaceuticals	242 (47.7)	16 (44.4)	226 (47.9)	0.68	-	26 (39.4)	216 (48.9)	0.14	
Over-the-counter pharmaceuticals	226 (44.6)	21 (58.3)	205 (43.5)	0.08	-	30 (45.4)	196 (44.4)	0.87	-
Chinese herbal medicines	40 (7.9)	4 (11.1)	36 (7.6)	0.45	-	10 (15.1)	30 (6.8)	0.01	0.10
Western herbal medicines	29 (5.7)	5 (13.9)	24 (5.1)	0.02	0.09	11 (16.6)	18 (4.0)	≤0.001*	0.18
Vitamin/mineral supplements	183 (36.0)	16 (44.4)	167 (35.4)	0.27	-	21 (31.8)	162 (36.7)	0.43	-
Yoga practice	51 (10.0)	6 (16.6)	45 (9.5)	0.17	-	12 (18.1)	39 (8.8)	0.01	0.10
Relaxation techniques/meditation/mindfulness	101 (19.9)	7 (19.4)	94 (19.9)	0.94	-	9 (13.6)	92 (20.8)	0.17	-
Health service									
General practitioner	396 (78.1)	34 (94.4)	362 (76.8)	0.01	0.10	57 (86.3)	339 (76.8)	0.08	-
Specialist doctor	151 (29.7)	17 (47.2)	134 (28.4)	0.01	0.10	27 (40.9)	124 (28.1)	0.03	-
Hospital doctor	111 (21.9)	12 (33.3)	99 (21.0)	0.08	-	23 (34.8)	88 (19.9)	≤0.001*	0.12
Pharmacist	335 (66.0)	28 (77.7)	307 (65.1)	0.12	-	50 (75.7)	285 (64.6)	0.07	0.07
Counsellor or other mental health worker	94 (18.5)	11 (30.5)	83 (17.6)	0.05	0.08	22 (33.3)	72 (16.3)	≤0.001*	0.14
Community nurse/nurse practitioner	63 (12.4)	7 (19.4)	56 (11.9)	0.18	-	16 (24.2)	47 (10.6)	≤0.001*	0.13
Massage Therapist	75 (14.8)	11 (30.5)	64 (13.6)	≤0.001*	0.12	23 (34.8)	52 (11.8)	≤0.001*	0.21
Primary care complementary medicine practitioner^	15 (2.9)	2 (5.5)	13 (2.7)	0.34	-	5 (2.9)	10 (2.2)	0.01	0.10

^Naturopath, Western herbalist, traditional Chinese medicine practitioner

Table 8.4 Health services treatment recommendations made to males

Treatments prescribed or recommended by health professional category * Participants can select more than one option	*All (507)*	*Currently attempting pregnancy*				*Planning pregnancy in the next 12 months*			
	Total	**Yes (n=36)**	**No (n=471)**	**P**	**Cramer's V**	**Yes (n=66)**	**No (441)**	**P**	**Cramer's V**
	n (%)	*n (%)*	*n (%)*			*n (%)*	*n (%)*		
General Practitioner (n=396)									
Prescription-only pharmaceuticals (n=242)	211 (87.2)	15 (93.7)	196 (86.7)	0.41	-	21 (80.7)	190 (87.9)	0.30	-
Over-the-counter pharmaceuticals (n=226)	120 (53.1)	14 (66.6)	106 (51.7)	0.19	-	18 (60.0)	102 (52.0)	0.41	-
Chinese herbal medicines (n=40)	12 (30.0)	0 (0.0)	12 (33.3)	0.16	-	2 (20.0)	10 (33.3)	0.42	-
Western herbal medicines (n=29)	16 (55.1)	4 (80.0)	12 (50.0)	0.22	-	7 (63.6)	9 (50.0)	0.47	-
Vitamin/mineral supplements (n=183)	63 (34.4)	7 (43.7)	56 (33.5)	0.41	-	9 (42.8)	54 (33.3)	0.38	-
Yoga practice (n=51)	13 (25.5)	4 (66.6)	9 (20.0)	0.01	0.34	4 (33.3)	9 (23.0)	0.47	-
Relaxation /meditation/mindfulness (n=101)	36 (35.6)	3 (42.8)	33 (35.1)	0.68	-	4 (44.4)	32 (34.8)	0.56	-
Specialist doctor (n=151)									
Prescription-only pharmaceuticals (n=242)	67 (27.7)	2 (12.5)	65 (28.7)	0.16	-	6 (23.1)	61 (28.2)	0.57	-
Over-the-counter pharmaceuticals (n=226)	39 (17.2)	6 (28.5)	33 (16.1)	0.15	-	11 (36.6)	28 (14.3)	<0.001	0.20
Chinese herbal medicines (n=40)	8 (20.0)	2 (50.0)	6 (16.6)	0.11	-	4 (40.0)	4 (13.3)	0.06	-
Western herbal medicines (n=29)	8 (27.6)	2 (40.0)	6 (25.0)	0.49	-	4 (36.3)	4 (22.2)	0.40	-
Vitamin/mineral supplements (n=183)	15 (8.2)	1 (6.2)	14 (8.3)	0.76	-	1 (4.7)	14 (8.6)	0.54	-
Yoga practice (n=51)	10 (19.6)	2 (33.3)	8 (17.7)	0.36	-	4 (33.3)	16 (15.4)	0.17	-

Relaxation /meditation/mindfulness (n=101)	18 (17.8)	1 (14.3)	17 (18.0)	0.8	-	2 (22.2)	16 (17.4)	0.71	-
Hospital doctor (n=111)									
Prescription-only pharmaceuticals (n=242)	24 (9.9)	3 (18.7)	21 (9.2)	0.22	-	4 (15.4)	20 (9.2)	0.32	-
Over-the-counter pharmaceuticals (n=226)	20 (8.8)	3 (14.3)	17 (8.3)	0.35	-	6 (20.0)	14 (7.1)	0.02*	0.15
Chinese herbal medicines(n=54)	0 (0.0)	0 (0.0)	0 (0.0)	N/A	N/A	0 (0.0)	0 (0.0)	N/A	N/A
Western herbal medicines (n=29)	8 (27.6)	3 (60.0)	5 (20.8)	0.07	-	5 (45.5)	3 (16.6)	0.09	-
Vitamin/mineral supplements (n=183)	13 (7.1)	3 (18.7)	10 (6.0)	0.05	0.14	5 (23.8)	8 (4.9)	≤0.001*	0.23
Yoga practice (n=51)	5 (9.8)	2 (33.3)	3 (6.6)	0.03*	0.28	4 (33.3)	1 (2.5)	≤0.001*	0.43
Relaxation /meditation/mindfulness (n=101)	6 (5.9)	0 (0.0)	6 (6.3)	0.49	-	1 (11.1)	5 (5.4)	0.49	-
Pharmacist (n=335)									
Prescription-only pharmaceuticals (n=242)	30 (12.4)	5 (31.2)	25 (11.0)	0.01	0.15	6 (23.1)	24 (11.1)	0.08	-
Over-the-counter pharmaceuticals (n=226)	48 (21.2)	7 (33.3)	41 (20.0)	0.15	-	8 (26.6)	40 (20.4)	0.43	-
Chinese herbal medicines(n=54)	0 (0.0)	0 (0.0)	0 (0.0)	N/A	N/A	0 (0.0)	0 (0.0)	N/A	N/A
Western herbal medicines (n=29)	10 (34.5)	2 (40.0)	8 (33.3)	0.77	-	3 (27.2)	7 (38.9)	0.52	-
Vitamin/mineral supplements (n=183)	28 (15.3)	2 (12.5)	26 (15.5)	0.74	-	2 (9.5)	26 (16.0)	0.43	-
Yoga practice (n=51)	6 (11.7)	3 (50.0)	3 (6.6)	≤0.001*	0.43	3 (25.0)	3 (7.7)	0.10	-
Relaxation /meditation/mindfulness (n=101)	5 (4.9)	1 (14.3)	4 (4.2)	0.23	-	0 (0.0)	5 (5.4)	0.47	-
Complementary medicine practitioner^ (n=15)									
Prescription-only pharmaceuticals (n=242)	5 (2.0)	0 (0.0)	5 (2.2)	0.54	-	1 (3.8)	4 (1.8)	0.50	-
Over-the-counter pharmaceuticals (n=226)	3 (1.3)	1 (4.7)	2 (1.0)	0.14	-	0 (0.0)	3 (1.5)	0.49	-
Chinese herbal medicines(n=40)	8 (20.0)	1 (25.0)	7 (19.4)	0.79	-	3 (30.0)	5 (16.6)	0.36	-

Western herbal medicines (n=29)	5 (17.2)	2 (40.0)	3 (12.5)	0.13	-	3 (27.2)	2 (11.1)	0.26	-
Vitamin/mineral supplements (n=183)	8 (4.3)	1 (6.2)	7 (4.2)	0.70	-	2 (9.5)	6 (3.7)	0.22	-
Yoga practice (n=51)	6 (11.7)	2 (33.3)	4 (8.8)	0.08	-	1 (8.3)	5 (12.8)	0.67	-
Relaxation /meditation/mindfulness (n=101)	10 (9.9)	0 (0.0)	10 (10.6)	0.36	-	0 (0.0)	10 (10.8)	0.29	-

^Naturopath, Western herbalist, traditional Chinese medicine practitioner

8.4.1 Treatments recommended by healthcare professionals

Overall, a GP was reported as the most likely of all health professionals to recommend prescription-only pharmaceuticals (n=211; 87.2%) (see Table 4). More than half of all over-the-counter pharmaceuticals were recommended by a GP (n=120; 53.1%) and over half of all the western herbal medicines treatments were recommended by a GP (n=16; 55.1%). One quarter of all yoga practice treatments were recommended by a GP (n=13; 25.5%). Specialist doctors recommended prescription-only pharmaceuticals (n=67; 27.7%) and western herbal medicines (n=8; 27.6%) in approximately equal proportions. A high proportion of yoga practice treatments were also recommended by a specialist doctor (n=10; 19.6%) Further, high proportions of western herbal medicine treatments were recommended by a hospital doctor (n=8; 27.6%) or a pharmacist (n=10; 34.5%).

8.5 DISCUSSION

The common age range of study participants planning or attempting pregnancy is 35-44 years, which is similar to the median age of Australian fathers (approximately 33 years old) since 2005 (433), and aligns with evidence that advancing paternal age (≥40 years old) at time of conception is increasingly common (434). Enabling males to transition into fatherhood is a prudent preconception consideration and, when appropriate, discussions between health practitioners and male patients should highlight the potential for inherent risks and complications, including diminishing semen quality, that accompany advancing age and pregnancy (435). Australian males should feel empowered and not discouraged in their family planning decisions, therefore all adult males intending pregnancy, including those ≥ 35 years old, should be considered by health practitioners as candidates for paternal preconception health care.

The health service utilization patterns and treatments noted in this study somewhat mirror those of the general Australian population and of other populations internationally. Statistics confirm that GPs are the most common health service provider consulted in 2021-2022 (436-438), prescribing high volumes of prescription-only pharmaceuticals and recommending over the counter pharmaceuticals, as dispensed by a pharmacist (154). GPs are the most consulted health service provider and therefore likely to have a central role in delivery of paternal preconception health. However, many GPs do not feel confident in their knowledge regarding preconception healthcare for males and factors which affect male fertility (25, 132). Further, evidence reveals that GPs perceive preconception health care and fertility as sensitive topics which should be directed toward females (25, 132). Pharmacists may also play a critical role in promoting paternal preconception health (439), directing men towards

useful information regarding side effects and contraindications for prescription-only pharmaceuticals and over-the-counter pharmaceuticals. Given GPs and pharmacists are the most common health professionals consulted by males during the preconception period, their competence, confidence, and active roles in facilitating paternal preconception health must be carefully considered, and additional research should explore opportunities and barriers to their ability to effectively deliver such care.

Alongside doctors and pharmacists, our study found that participants planning a pregnancy in the next 12 months commonly consulted a massage therapist or counsellor or other mental health worker. Mental health is an important consideration when planning for a pregnancy (440, 441) and supportive therapies such as counselling can be sought during this time. When planning a pregnancy, individuals may also access services such as massage therapy. Yet, limited research explores the role of counsellors or massage therapists during the preconception period; and as such the degree to which these health professionals consider preconception care within their scope, and their level of competence and skill in providing preconception support is unknown. It is possible that participants planning a pregnancy are more likely than other males to proactively promote healthful regimes and health seeking behaviours and thus consult with practitioners, such as a massage therapist or a counsellor or other mental health worker (427), whose practices do not involve the use of medications. Consequently, prescription-only pharmaceuticals may not be recommended by these practitioners and therefore utilized less often by their patients, as reflected in this study. Ultimately, males and their partners planning a pregnancy who consult with a counsellor or other mental health worker or a massage therapist are engaging in a multidisciplinary therapeutic approach (442) whereby the workloads of health practitioners become distributed and the emphasis on consulting with a GP or allied health professional to attain prescription-only treatments may be reduced. A clear path for males planning a pregnancy requires effective collaboration and communication between all health practitioners and services in a bid to optimise interdisciplinary treatment options and support person-centred care. Future research must consider exploring the roles of supportive and complementary therapies for males during the preconception period as their health may well be managed within a collaboration of conventional and complementary health professionals.

This study also found a high proportion of western herbal medicine treatments or yoga practice are recommended to males attempting or planning pregnancy by a medical doctor or pharmacist, albeit this finding must be considered within the constraints of the small sample size. Individuals planning a pregnancy or attempting pregnancy who seek alternative forms of non-pharmacological treatment, such as western herbal medicine (443, 444), may construe such treatments as safe and effective. In some countries, including Australia,

complementary medicine manufacturing, including western herbal medicine, is reputed for quality and safety and is considered a benchmark for international consumers (445). However, manufacturing safety and quality does not guarantee the safe or effective use of western herbal medicines. Unfortunately, many western herbal medicines have the potential to harm if administered by an individual without appropriate training yet can be recommended by health practitioners with minimal consultation (446); a concern given previous research has found that less than one-third of Australian GPs feel confident advising their patients about herbal therapies and only 20% of GPs had education on this topic (447). Indeed, while this study establishes a strong association between planning a pregnancy in the next 12 months and western herbal medicine treatments, administration without appropriate training ensures that the safety and appropriateness of the prescription cannot be determined. Similarly, yoga practice has a strong health presence globally (448, 449). Despite the gender related perceptions which may influence a man to practice yoga (450), it is acknowledged that health practitioners could play an important role in promoting yoga practice among males (450, 451). Pregnancy too is noted as motivation for beginning and/or continuing yoga (452, 453). The recommending of treatments such as western herbal medicine or yoga practice in this study can be rationalized through the growing acceptance of both treatments among health professionals (454-456). Such treatment recommendations may also be explained by prudent males, and their partners, attempting or planning a pregnancy who request or even challenge practitioners to broaden their treatment options (103, 427). While the true nature of the association between these health practices and pregnancy planning requires further study, these results do highlight the need for males to have access to health practitioners with training in complementary medicine or yoga practice to ensure their safe and appropriate use during the preconception period. For males during this time, both western herbal medicine and yoga practice treatments require further exploration.

8.5.1 Study strengths and limitations

This study pioneers research in paternal preconception; however, these results must be considered within the context of the study's limitations. This study is exposed to sampling bias (457), the study sample was obtained through purposive convenience sampling, hence, individuals are more likely selected for inclusion than others based upon their willingness and/or availability. Further, the survey gathers self-reported data from 12 months and up to 3 years prior. Recounting information from up to three years ago can present as recall bias (457). Only face validity was undertaken on the survey instrument therefore the overall validity of the instrument was not determined. Also, statistical analysis was not conducted to

determine the reliability of the survey instrument (Cronbach's alpha). The survey was also administered during the COVID-19 pandemic and as such the health of Australian males and the health services they utilized in the previous 12 months may not be representative of usual circumstances and thus may limit the external reliability of the results. Finally, due to the limited sample size in the study, regression models were underpowered, and the study did not adjust for potential confounding factors. Notwithstanding, such limitations must serve to refine future paternal preconception research.

8.6 CONCLUSION

This study was based on data that was collected in the Australian Covid 19 pandemic, which may have biased our findings. Nonetheless, it highlights the potential role of allied healthcare practitioners and non-pharmaceutical options in the preconception health care of males. This study also highlights the necessity for preconception health and care to be initiated within a collaboration of GPs, pharmacists, and appropriately qualified and trained health practitioners who facilitate client centred care and support interdisciplinary treatment options. Both western herbal medicine and yoga are preconception treatments which warrant further investigation for males during the preconception period. Large scale and longitudinal studies are required to progress understanding of paternal preconception health and care behaviours and utilization, and to effectively enable the integration of male health into the delivery of preconception care.

8.7 CHAPTER SUMMARY

Chapter 8 examines the preconception health of Australian males using data from a national survey of health services utilisation. This chapter covers the types of health services Australian males' access during the preconception period, and the treatments they are recommended, based upon their pregnancy intentions, defined as either planning or attempting pregnancy in the next 12 months.

Chapter findings reveal that, regardless of planning or attempting pregnancy, Australian males most commonly consult GPs and pharmacists during the preconception period. Additional consultations reported by males include with health care professionals such as massage therapists and counsellors. In addition to pharmaceutical treatments, males attempting pregnancy were more likely to use western herbal medicine treatments while males planning pregnancy were more likely to use yoga therapy as a treatment during the preconception period. Findings also highlight the need for a collaboration of health professionals to effectively facilitate person-centred paternal preconception care in Australia. Further research is needed to deepen understanding of male health service utilization during

the preconception period, and to support the integration of paternal health into a comprehensive preconception care framework. This is the final results chapter presented prior to the thesis discussion, detailed in the following chapter.

9 DISCUSSION

9.1 CHAPTER INTRODUCTION

This discussion chapter is formulated as a summary and interpretation of the main findings of this thesis and is organised to effectively explore the research objectives and address the thesis question. Presented herein is as an integration of the findings derived from the four project phases as presented in the results chapters four, five, six, seven, and eight. In addition, this discussion chapter incorporates reference to external preconception research alongside theoretical, and practical literary knowledge, policy, and clinical information relevant to preconception health and preconception care for Australian males. A synopsis of the discussion chapter is included which highlights the key thesis findings from each of the results chapters. Finally, the chapter presents the disciplinary implications and the strengths and limitations to this research project.

9.2 THESIS SUMMARY, PURPOSE, AND MAIN FINDINGS

Table 9.1 presents a summary of the main findings from each research phase of the thesis and as they relate to the each of the research objectives.

This thesis explores the Australian preconception landscape from the perspectives of three unique adult populations, samples from different data sets. The three sample populations are i) any adult male aged from 18 years to 55 years; ii) males planning pregnancy or attempting pregnancy; or iii) or males with a reproductive partner who is currently pregnant. To effectively measure and report the preconception health of Australian males, key preconception health indicators (67) are utilised. Such indicators are identified in the preconception research and detailed in chapter 1 (see section 1.1).

The literature regarding the preconception care and pregnancy planning intentions and health behaviours of Australian males is scant, paternal preconception health and care is under-researched. Males during the preconception period are not always aware of the subsequent behavioural ramifications of undertaking preconception health behaviours and their influence on adverse pregnancy and offspring outcomes. From a public health perspective, the importance of engaging males to discuss preconception health is generally not considered within guidelines and policy or within the preconception research and not practiced by health practitioners. Therefore, paternal preconception care is not adopted within the public health landscape and so is often not explored. Although, the internet and social media have an important and influential role to play in preconception health and health seeking, including information related to preconception health and pregnancy planning matters. In the context of public health, the internet and social media are a convenient initial

frontline solution for information and common point of contact for Australian males during the preconception period.

The main thesis findings attempt to fill a gap in the emerging preconception health and preconception care evidence pertaining to males' preconception health and care, which is only emerging. Refer to Table 9.1 - findings from the first project phase (reported in chapter four) identify seven key preconception health behaviours and modifiable risk factors for Australian males within a review of contemporary evidence i) Body composition (BMI), ii) Alcohol consumption, iii) Cannabis use, iv) Physical activity, v) Smoking, vi) Stress, and vii) Nutrition. Two of these risk factors, namely smoking and body composition(258, 261, 269), consistently associated with adverse infant outcomes.

The second project phase explores Australian males, as reported in chapter five, which covers any adult Australian males aged 18 to 55 years. Findings from this phase indicate most (91.3%%) consult with a general practitioner (GP) and many (80.6%) meet the guidelines for safe alcohol consumption. However, for the same cohort, numerous males do not meet the guidelines for moderate (39.2%) or vigorous (22.5%) physical activity in a week, nor do they meet the guidelines for daily vegetable consumption (51.2%).

Phase three of the thesis (reported in chapters six and seven) includes an analysis of Australian males with a reproductive partner who is currently pregnant, and addresses preconception health behaviours and the beliefs and behavioural intentions to undertake three key preconception health behaviours. The three key health behaviours are addressed in thesis phases one and two i) physical activity, to ii) alcohol avoidance, and iii) consumption of a healthy diet. Findings from chapter 6 indicate that the source of preconception information sought by these males during the preconception period was not influenced by their pregnancy intention. However, the internet was utilised to source information by the vast majority. Also, one in five Australian males with planned pregnancy completed immunisation checks during the preconception period and one in three Australian males with any longstanding illness, disability, or infirmity had an ambivalent or unplanned pregnancy. Findings from chapter 7 indicate preconception beliefs about physical activity and alcohol predict intention to exercise regularly and to avoid alcohol. Most expectant partners undertook physical activity in the three months before conception but many consumed alcohol during the same period. In addition, the behavioural intention of Australian males to consume a healthy diet was significantly influenced by their reproductive partners.

Table 9.1 Summary of the main thesis findings which address the research objectives

Phase 1	Phase 2		Phase 3	Phase 4
Modifiable risk factors for adverse pregnancy outcomes	**Longitudinal Survey [First time fathers]**	**Cross Sectional Survey [Partners of pregnant women]**	**Cross Sectional Survey [Partners of pregnant women]**	**Cross Sectional Survey [Planning or attempting pregnancy]**
Chapter 4	**Chapter 5**	**Chapter 6**	**Chapter 7**	**Chapter 8**
Seven key preconception health behaviours and risk factors, **i)** Body mass index (BMI), ii) Alcohol consumption, iii) Cannabis use, iv) Physical activity, v) Smoking, vi) Stress, vii) Nutrition. Consistent associations identified between paternal preconception smoking and increased risk for adverse infant outcomes **[RO2]** Consistent associations identified between increasing paternal preconception BMI and offspring birthweight **[RO2]**	Australian males prior to becoming a first-time father: i) consulted with a GP but only occasionally attended GP for checkup **[RO4]** and often meet the guidelines for safe alcohol consumption **[RO2, RO3]** iii) often did not meet the guidelines for i) moderate or ii) vigorous physical activity or for vegetable consumption **[RO2]**	Most expectant partners undertook regular physical activity in the three months before conception **[RO2]** Sources of preconception information sought did not seem to be influenced by pregnancy intention, yet information is actively sought using the internet **[RO1, RO5]** One quarter of expectant partners with planned pregnancy completed immunisation checks during preconception **[RO2]** Those with any longstanding illness, disability, or infirmity more often reported ambivalent or unplanned pregnancy than a planned pregnancy **[RO1, RO3]**	Beliefs and intentions for **three** key preconception health behaviours **i)**regular exercise **ii)** alcohol avoidance **iii)** healthy diet Most expectant partners undertook regular exercise in the three months before conception. Yet, many consumed alcohol during the same period **[RO2, RO3]** Preconception beliefs about exercise and alcohol predict intention to exercise regularly and to avoid alcohol **[RO1, RO2, RO3]** The behavioural intention to consume a healthy diet was influenced by reproductive partners **[RO1, RO2, RO3]**	GPs and pharmacists are the most common health service providers consulted by Australian males planning or attempting pregnancy **[RO3, RO4]** Western herbal medicine treatments or yoga practice are recommended to males attempting or planning pregnancy by a medical doctor or pharmacist **[RO4, RO5]** Australian males planning a pregnancy commonly also consult a massage therapist or counsellor or other mental health worker **[RO4]**

Research objective 1 [RO1] Explore the beliefs and intentions of Australian males towards pregnancy planning and preconception care
Research objective 2 [RO2] Identify the prevalence of clinically relevant preconception health behaviours of Australian males
Research objective 3 [RO3] Explore the social determinants associated with Australian males engaging in preconception health behaviours
Research objective 4 [RO4] Identify the health service utilisation and preferences of Australian males during the preconception period
Research objective 5 [RO5] Examine health information received by Australian males during the preconception period and toward pregnancy planning and preconception health and care

The fourth and final project phase (chapter eight) reports GPs and pharmacists are the most common health service providers consulted by Australian males planning or attempting pregnancy. Regarding preconception treatments, western herbal medicine treatments or yoga practice are often recommended to males attempting or planning pregnancy by a medical doctor or pharmacist. Australian males planning a pregnancy commonly consult a massage therapist or counsellor or other mental health worker and therefore address their health needs with health professionals, in addition to GPs, that have roles in allied health care or other primary care areas.

9.3 INTEGRATED DISCUSSION FINDINGS

The main thesis findings from each of the four thesis phases, and any points of data overlap, are identified using a process described by Lewis et al (458). To determine the integrated discussion findings, the results from each chapter are tabulated (Chapters 4-7; see Table 9.1) and each thesis research objective is mapped against each chapter (See Table 9.2).

Table 9.2 Integrated discussion findings

	Beliefs and intentions [RO1]	*Health behaviours [RO2]*	*Social determinants of health [RO3]*	*Health service utilisation [RO4]*	*Health information [RO5]*
Chapter 4 (Phase 1) *Review*		⊗			
Chapter 5 (Phase 2) *Quantitative*		⊗	⊗	⊗	
Chapter 6 (Phase 3) *Quantitative*	⊗	⊗	⊗		⊗
Chapter 7 (Phase 3) *Quantitative*	⊗	⊗	⊗		
Chapter 8 (Phase 4) *Quantitative*			⊗	⊗	⊗

The integrated findings of this thesis align with each of the research objectives and are the primary focus for the body of work presented in this chapter.

Each of the integrated findings are detailed below:

1) The internet and social media are common point of contact for Australian males during the preconception period.
2) Australian males may consult a variety of health professionals during the preconception period, but they do not always have regular checkups with a GP.
3) Most Australian males have behavioural risk factors that may impact their health and can influence pregnancy and offspring outcomes, regardless of their pregnancy intention.

The beliefs and behavioural intentions of Australian males during the preconception period are not always aligned with their preconception health behaviours

9.3.1 The internet and social media are a common point of contact for Australian males during the preconception period

Findings reported in this thesis reveal more than 90% of Australian males use the internet as a source of preconception health information (refer to chapter 6 section 6.5.4). This finding is rational considering the surge in internet and social media uptake in the previous 15 years, and given the digital shift toward AI technologies (459, 460). Approximately 91% of the Australian population were engaged online from 2015 to 2022 (92), which aligns with the high proportion of Australian male utilising the internet reported in the chapter 6 finding.

The internet and social media use can provide males with direct access to preconception health and care information and resources. However, socioeconomic factors such as i) household income, ii) occupation iii) education, v) age, and vi) geographical location (461) may limit access to such information sources available online. Internet and social media use to obtain pregnancy and preconception information can therefore highlight class and social disparities particularly for males residing in rural areas or areas with restricted internet access and who do not have access to a device to engage with online content. In addition, gender based bias is evident regarding preconception health and care information which is tailored toward females (426). Emerging preconception research exploring online searches for preconception services (93) found only 69% of services made reference to providing services for males. Moreover, the use of internet and social media for preconception health information, in many instances, insufficiently reflects ethnic and cultural diversity with minimal information specific for Aboriginal and Torres Strait Islander males. The use of the internet and social media for pregnancy and preconception information can therefore act as both an enabler and a barrier to males engaging in positive preconception health behaviours (420).

Males can initially access preconception information online; however, the internet and social media is not the only point of contact for preconception information. Beyond digital platforms, males preparing for fatherhood may access preconception care, information, and advice by utilising health services and consulting with health professionals (refer to chapter 8 section 8.4.4). Opportunities to attend social clubs and community programs, may be particularly relevant for Australian males residing in rural and remote areas to foster emotional and mental support (462). Despite these avenues for information, few initiatives are aimed at male preconception health prior to becoming a father.

9.3.1.1 The benefits and risks for males using the internet and social media as a preconception health information source

The widespread use of internet by Australian males (92), allows their engagement across geographical boundaries (463), as demonstrated by male survey participants in this thesis (refer to chapter 6 section 6.5.4). Adult males in Australia often use digital platforms to access health information and can access digital information alongside visiting a health professional (93). However, reliance upon the internet and social media for information sources during the preconception period can pose risks. Given the findings from chapter 6 and the high rate of internet use, males must be equipped to obtain and interpret reliable sources of preconception information provided online which will be based upon many factors including their health literacy (464), the context of the preconception issue, and any health advice received, including from a health care professional (168). Further, the extensive use of internet and social media by many Australian males may result in an overreliance on health information exposure from the internet and social media sources in lieu of professional consultation. The use of the internet and social media to source health information as a replacement to health services can be highly problematic due to the propensity for misinformation (465, 466) or for information to be incorrectly interpreted.(168). Further, the extensive use of internet and social media by many Australian males may result in an overreliance on health information exposure from the internet and social media sources in lieu of professional consultation. A continuation of research is required to understand the internet and social media engagement of males and to develop strategies to mitigate the risks associated with exposure to any inaccurate or even adverse information, which has the potential to cause harm (460).

9.3.1.2 Preconception health and care information for Australian males using the internet and social media

Online preconception information and resources may serve as an initial point of contact for Australian males with internet availability seeking health related information (Refer to section 9.3.1). Research external to this thesis has also revealed one in every two males seek information and advice about pregnancy during the preconception period (87), although exposure to preconception information and advice will vary considerably. Men's limited awareness regarding preconception health (39, 40) – and particularly their role in the health of their future child - may also limit their determination to actively seek such information. Even for those men who look for preconception health information, their ability to obtain, assess, and apply preconception health information may be constrained by the availability of online preconception information that are specific to their gender (93). There is an online

preconception health checklist specifically for Australian males (142) which details many of the important preconception health behaviours highlighted in both this thesis and the National Men's Health Strategy 2020 2030 (37). Additionally, male preconception health is emphasised by initiatives such as Healthy Male (141). These platforms and websites mean many Australian males have access to targeted online preconception information. However, organisations such as Family Planning Australia also provide gender neutral pre-pregnancy planning information online covering various health related areas alongside a checklist of recommendations to optimise health (140, 467). There is an abundance of female specific preconception information online (131, 468, 469) in comparison to male specific information which is promoted by only a few online sources. Often the preconception information provided is gender neutral and will not highlight why and how the importance of preconception health and care can apply to the reproductive partner. As such, males may disregard gender neutral or female specific preconception information and resources as irrelevant to addressing their own needs. Such information and resources may fail to empower males to seek further support or guide them to address their broader roles and responsibilities during the preconception period.

Further online preconception health and care and pregnancy planning information sources are still urgently needed to better support a flow of preconception information to reproductive Australian males that motivates them to consider how a health professional can best meet their health needs. Ultimately, all males need to be educated and become aware of preconception health by being provided with resources to assist them to understand the effective use of the internet and social media for accessing preconception information. Future research is warranted to explore how males can effectively use the internet and social media to identify accurate and factual real-world information resources.

9.3.1.3 The relevance of pregnancy intention for Australian males seeking information and advice when using the internet and social media and other information sources.

Pregnancy intention is associated with the preconception information seeking behaviours of some Australian males, with 40% of those planning a pregnancy reporting they searched for and located preconception information compared with only 16.6 % of males with unplanned or ambivalent pregnancy (Refer to chapter 6 section 6.5.4). Nevertheless, few significant differences in the source or content of preconception information were observed between Australian males who plan their pregnancy and those who have ambivalent or unplanned pregnancy (Refer to chapter 6 section 6.5.4). These findings from chapter 6 reveal that pregnancy intention may be a potential motivator to seek information and advice for less than half of all Australian males. However, pregnancy intention does not significantly

influence the source or content of the information which may be accessed (Refer to chapter 6 section 6.5.4). Australian males who intend pregnancy and reside in rural and remote areas, where social isolation can be common, may depend upon information and support online and via social media as an avenue for support.

Nonetheless, pregnancy intention alone is not a strong determinant of preconception information exposure for males which suggests further research is required to explore preconception health and care information and resources which target males, and address pregnancy intention, as the use and effectiveness of such information and resources remains unclear. Future research must also consider the dynamics of pregnancy intention to ensure online paternal preconception information is portrayed and disseminated in a manner which reaches the intended audience.

9.3.2 Australian males may consult a variety of health professionals during the preconception period, but they do not always have regular checkups with a GP

Thesis findings reveal that the majority of Australian males (91%), including those males who are planning or attempting pregnancy, consult a primary care health professional prior to pregnancy (Refer to chapter 5 section 5.4.4) (Refer to chapter 8 section 8.4.4). In the Australian context, the primary care health professional is a GP. However, there are marginal differences in the GP consultation rates of males who became a first-time father in the previous 12 months compared with other males (Refer to chapter 5 section 5.4.4). These findings identified from chapters 5 and 8 align with the established patterns of health services use and consultation among adult males identified in both external literature (87) and reported in national statistics (332). In contrast, thesis findings further reveal that 44% of respondents who consult a GP during the preconception period report their frequency of GP checkups as ‘never’ (Refer to chapter 5 section 5.4.4). The findings from chapter five suggest that many males attend GP consultations but do not consider attending regular consultations with a GP or healthcare provider for any pregnancy planning or preconception matters before their partner becomes pregnant. Such a finding is confirmed in the preconception literature which identifies a lack of preconception care engagement between GPs and patients (132). Hence, for many males planning or attempting pregnancy, even in cases when they attend a general health check-up with the GP, preconception care discussions are not always initiated (25). Consequently, males often remain unaware and without access to a range of preconception services that rely on expert advice and guidance from a GP, including immunization checking, dietary advice, assistance to quit smoking, or treatment modifications (470). The preconception care engagement of the male reproductive

partner in many clinical settings remains unrecognised and insufficiently integrated into GP consultations.

9.3.2.1 Preconception health and care for males in the context of the Australian health care system

A national preconception framework and public health policy focused on preconception health and care in Australia has yet to be established. Consequently, initiatives to promote public engagement and support the effective integration of preconception health and care are not at the forefront of Australian public health discussions. In primary care settings, the preconception health focus of Australian health professionals is generally rather narrow (124) with preconception care left primarily to GPs. Yet GPs operate within a restricted framework that does not widely promote the importance of preconception health and therefore lacks specific preconception policy that incorporates males (34). Furthermore, the time constraints and competing priorities of GPs appear to hamper the initiation of preconception care discussions (471) and the ability for GPs to effectively support pregnancy planning and preconception care for males.

In the context of preconception health and care for Australian males, some may consult health professionals in addition to GPs, including those who are appropriately trained to consider the subsequent long-term effects of health behaviours (471) and prescribe non-pharmaceutical treatment options (103). Such health professionals and health services are a critical adjunct for males regarding preconception health and care as they can provide concurrent treatment options to prescription pharmaceuticals. Indeed, sharing the preconception care workload and reducing the emphasis on GP consults for preconception matters may be a progressive step forward. However, the absence of a national framework combined with a limited primary health focus regarding preconception care underscores the enduring need for a robust health care system to cater for preconception health. Such a system could support the preconception health awareness of practitioners and foster interdisciplinary collaboration with other health professionals to promote individualised care. Therefore, practitioner collaboration and clinical training in Australia is essential to effectively communicate preconception health information and preconception care to males, based upon the key health indicators which are relevant to preconception health (refer to chapter 1 section 1.1).

More broadly, the Australian healthcare system faces many challenges and is constrained by an ageing population, increasing costs, and burdens on health services (153). These pressures on the healthcare system contribute to practitioner overload and limit attention to public health priorities, such as paternal preconception care. Given the preconception

framework and policy gaps in Australia, there is an urgent need to transition the preconception health and care focus, responsibility, and workloads from GPs and specialists to multi-disciplinary teams for engagement (472).

9.3.2.2 The engagement between males and health professionals regarding preconception health and preconception care.

In addition to GP consultations, approximately one in three Australian adult males consulted a specialist doctor or pharmacist, and one in five reported consultations with a chiropractor (Refer to chapter 5 section 5.4.4). Thesis findings also reveal Australian males consult with health professionals such as massage therapists or counsellors or mental health workers (Refer to chapter 8 section 8.4.4). Consultations with a variety of health professionals demonstrates a diversification in health preferences but does not imply an active involvement in reproductive and preconception care matters (366). The preconception literature suggests disengagement between males and health professionals regarding preconception care; males do not often seek medical attention or care for their preconception health (366). Males participating in fertility research have further emphasized this trend of disengagement regarding preconception care discussions by reporting preconception care and fertility as maternal health issues that are challenging to discuss (38). Without adequate awareness or exposure to preconception care options, Australian males can then undervalue the importance of changing their health behaviours for optimal pregnancy and offspring outcomes. Future research should prioritize examining the engagement between health professionals and males during the preconception period. Such research will be critical to initiate discussions between males and their health care providers regarding preconception care, and to support preconception health behaviour changes.

There are several barriers which have been identified to engage both health professionals and male patients in preconception care discussions (25), many are pertinent to the Australian healthcare context. These barriers can include the predominance of female-directed preconception health advice and recommendations (33), the limited knowledge of GPs about factors affecting male fertility (124, 132, 471) , and the constraints of consultation time. In addition, Australian health practitioners and health services report not always possessing the competence and confidence to prioritise preconception care and to promote preconception health care information (132). Such challenges are compounded in the absence of a preconception care framework and specific preconception care policy. Practitioners can deliver engaging preconception care by utilising RACGP guidelines for preventive health activities (157), in the best interest of pregnancy intent when formulating treatments (157), alongside their clinical and empirical knowledge and foresight.

9.3.2.3 Treatments recommended to males during the preconception period.

Another thesis finding demonstrates that western herbal medicine treatments or yoga practice are recommended by GPs or pharmacists to males who are attempting or planning pregnancy (Refer to chapter 8 section 8.4.5). This finding is novel as evidence reporting males using western herbal medicine of yoga practice during preconception is limited. Further, this finding provides evidence to support the growing acceptance of preventive and natural health ideologies within mainstream health (473), coinciding with the treatment options provided by other primary health care practitioners. However, such recommendations have potential implications for professional practice out of scope and highlight the importance of ensuring that health practitioners and services are appropriately trained. Males may seek treatments in addition to pharmaceuticals to remove any adverse effects, treatments may include counselling, western herbal medicine, traditional Chinese medicine (474), manipulative therapies, and mind body therapies (452).

Treatment options may also include the limiting of prescription only-pharmaceutical administration using the process of deprescribing, or the assessment of medicines with the view of ceasing usage if the medicine may cause harm or no longer fits with the current goals of care (470). Teratogenic treatments such as isotretinoin for acne, anti-convulsant drugs for epilepsy, or corticosteroids for asthma should be cautioned in the preconception period to avoid congenital anomalies (475). Deprescribing may be the opportunity for both GPs and pharmacists to play a key role to facilitate precautious measures with teratogenic treatments and to ensure optimal health outcomes, which is best achieved through multi-modality preconception care (439).

9.3.3 Most Australian adult males have behavioural risk factors that may impact their health and can influence pregnancy and offspring outcomes, regardless of their pregnancy intention

Thesis findings reported in chapters 5 and 6 (Refer to chapter 5 section 5.4.2) (Refer to chapter 6 section 6.5.3) reveal that many Australian males undertake health behaviours during the preconception period which can be protective or risky and that may influence pregnancy and offspring outcomes. Such behaviours and risk factors include, but are not limited to, physical activity, smoking, alcohol consumption, fruit and vegetable consumption, and obesity. The findings from chapters 5 and 6 reflect the preconception health and behaviours undertaken by Australian males within two preconception perspectives, as adult males before fatherhood and when they have a planned or unplanned a pregnancy. A comprehensive understanding of the preconception health behaviours and behavioural risk factors of Australian males, and their influence on pregnancy and offspring outcomes, can

be informed by the established indicators of preconception health (67), as defined in chapter 1 (refer to section 1.1).

9.3.3.1 The social determinants of preconception health for Australian males

Thesis findings reveal that several social determinants of health are uniform for many Australian males in the preconception period who, as first-time fathers or expectant partners, are often married and employed full-time, and approximately half often hold a university degree or higher qualification (Refer to Chapter 5 section 5.4.1) (Refer to Chapter 6 section 6.5.1) (Refer to chapter 7 section 7.4.1). These social determinants of health will interact with the cultural norms and lifestyle choices of males and may reflect their commitment and social support toward family planning when, for instance, they engage in financial planning, alongside pregnancy planning, cohabitation with their reproductive partner, and marriage (476). Although the sociodemographic characteristics of Australian males, such as being married or holding a university degree, are not indicative of all males. Within this thesis, the social determinants of health relevant to Australian males report limited significance in the context of pregnancy intention. Thesis findings also provide limited evidence to support that one determinant is indicative of any other – for instance an Australian male's level of education or socioeconomic position does not correspond to their marital status or is not necessarily associated with their pregnancy intention during the preconception period. Despite their significance, the social determinants of health remain underexplored as an area of preconception research focus which should be investigated further, particularly about pregnancy and offspring outcomes.

9.3.3.2 The health conditions of Australian males

Mental health and behavioural conditions present as the most prevalent (161) health priority areas in Australia, as detailed in the National Health Priority Areas (NHPA) (50). These observations from the NHPA align with the findings presented this thesis which highlight a prevalence of mental health conditions, such as depression and anxiety – reported by one in five males (Refer to chapter 5 section 5.4.3). Emerging areas of preconception care research in mental health services and paternal perinatal mental health (441, 477) underscore the significance of these conditions for males planning a pregnancy or currently attempting a pregnancy.

The emotional and mental readiness for fatherhood can be influenced by mental challenges which manifest as depression or anxiety (478), and must not be underrated (200) due to the potential consequences for long-term mental instability and for offspring wellbeing (478). Health conditions such as depression and anxiety are prevalent and may carry substantial

impact on the preconception health of Australian males and their offspring. Depression during the preconception period can negatively impact fertility for a couple (320). A recent systematic review which investigates paternal perinatal depression and anxiety reports mental distress as a potential modifiable predictor for child development with poor health outcomes reported for social-emotional, cognitive, language, and physical development of offspring (478). Depression during the preconception period can negatively impact fertility for a couple (320). In order to mitigate the potential risks of adverse pregnancy and offspring outcomes, mental health conditions and mental health and behavioural conditions should be prioritized and at the forefront of public health research considerations moving forward.

NCDs are particularly burdensome for males during the preconception period due to their strong association with several contributing risk factors which are modifiable in nature, for instance smoking, diet, physical activity, and excessive alcohol (479). In a socioeconomic context, NCDs can have health consequences on the professional and personal lives of males during the preconception period due to the potential for reduced productivity and subsequent financial strain, and the potential for social disconnection. Type 2 Diabetes Mellitus, for instance, affects millions of Australian adults who ultimately experience diminished levels of preconception health (480) and are exposed to potential epigenetic consequences (481-483) which pose intergenerational health risks. While the RACGP put forth diabetes management guidelines that acknowledge the negative effects associated with diabetes and pregnancy (484), such guidelines primarily address the concerns of the female and overlook details related to risk factors relevant to the male. Given more than half of the Australian public experience some form of morbidity, including comorbidity and multimorbidity, there is a need to consider NCDs, such as diabetes, to mitigate the preconception health risks of males to optimise pregnancy and offspring outcomes.

9.3.3.3 Both modifiable and non-modifiable risk factors can influence the preconception health of Australian males and influence pregnancy and offspring outcomes

Australian males require greater awareness and education regarding behavioural risk factors that may influence their health outcomes during the preconception period and when planning for pregnancy or attempting pregnancy. Such factors can be categorized as modifiable or non-modifiable. However, males do not always recognise the impact of their health behaviours or consider their roles and responsibilities for pregnancy and offspring outcomes (485). Pregnancy planning ambivalence and limited motivation to make alterations to any modifiable risks contribute to suboptimal preconception care engagement. The consequences of preconception health behaviours are significant, with implications relevant to spermatogenesis (340, 353) and epigenetic influences (319), which then relate to

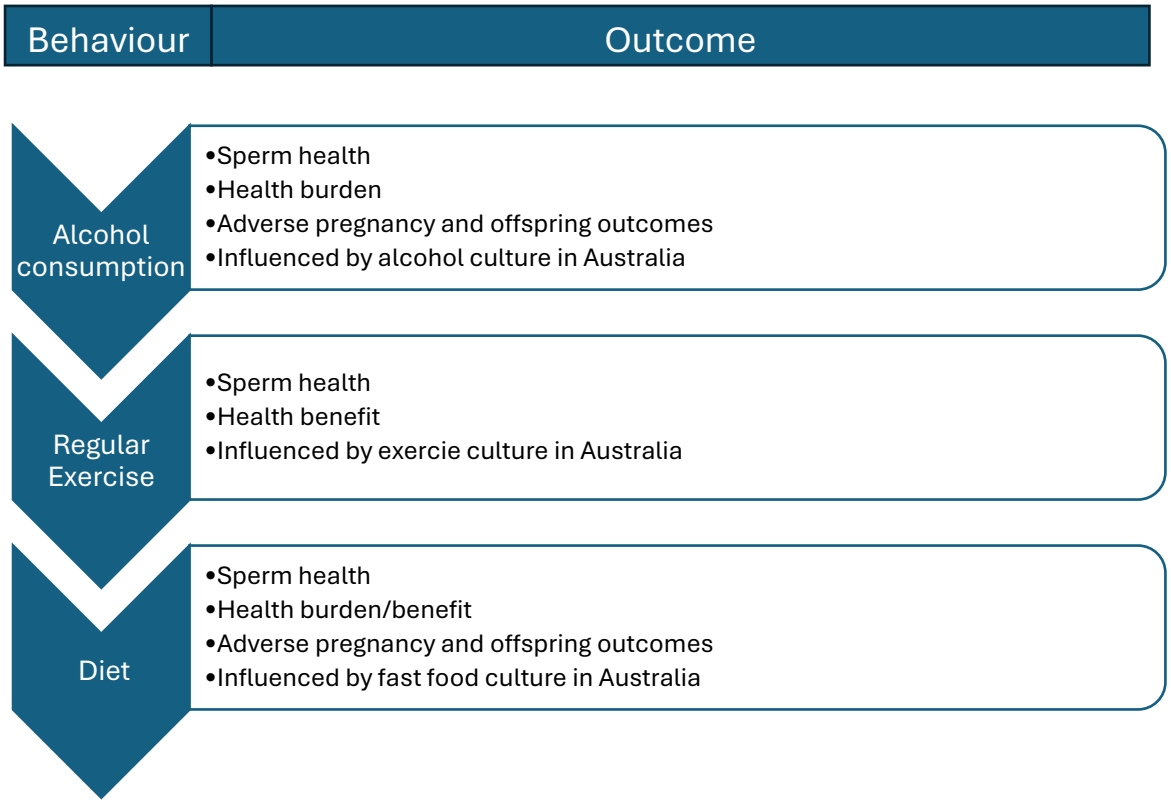
pregnancy and offspring health. The consequences of preconception health behaviours are significant, with implications relevant to health behaviour change, and the risk factors that can influence them can have understandable consequences on the spermatogenesis process (340, 353) and have substantial epigenetic influences (319), which then relate to pregnancy and offspring health. Further public health research is required to identify preconception health behaviours and risk factors prevalent among Australian males during the preconception period. This evidence base will be a foundation from which a national preconception framework can be implemented, and clinical issues are supported.

In reference to non-modifiable risk factors, few relate to the findings of this research. Regarding Australian males, a non-modifiable risk factor, such as aging, is acknowledged to impair semen characteristics, which may include sperm volume, sperm counts, and sperm motility (486). Therefore, Australian males over the age of 40 can have significantly less likelihood of pregnancy and may also have greater likelihood of adverse pregnancy outcomes, such as increased time to pregnancy (487).

Numerous paternal preconception modifiable risk factors have been identified, several are associated with adverse pregnancy and offspring outcomes (Refer to chapter 4, sections 4.4.1 – 4.4.7). Commonly reported modifiable risk factors and preconception health behaviours relevant to Australian males include i) alcohol consumption and tobacco use, ii) unhealthy body composition, iii) illicit substance use and pharmaceutical use, iv) imbalances in nutrition and diet, v) limited physical activity, and v) elevated prolonged terms of psychological stress. A modifiable risk factor such as prescription pharmaceutical usage can also impact male reproductive health (488). In addition, other risk factors and health behaviours, such as psychological stress, sleeping patterns, and social interactions, are also relevant to the preconception health of males yet have not gained as much research attention to date. Importantly, males may not always consider the impact of their lifestyle behaviours and modifiable risk factors on their health and on the health of their offspring (87). An increased preconception health awareness of males is critical to support health behaviour changes which will mitigate the risks of modifiable health behaviours.

Key modifiable risk factors and influential health behaviours identified in the findings of this thesis are reported below (Refer to Figure 9.1).

Figure 9.1 The influential health behaviours of Australian males during preconception



9.3.3.3.1 The influence of alcohol consumption and tobacco use on the preconception health of Australian males

Findings of this thesis demonstrate a consistent association between paternal preconception smoking and increased risk for adverse infant outcomes (See chapter 4 section 4.4.5), such as offspring heart defects, which mirror the maternal preconception smoking literature (115, 300, 301). This finding is notable given approximately 44% of Australian males with a history of smoking are current smokers and many still smoke in the three months before pregnancy (See chapter 6 section 6.5.3). Globally, tobacco smoking, as a modifiable behaviour, is acknowledged as one of the biggest public health threats facing the world (489). Despite the steady decline in smoking rates over the last three decades (490), smoking remains a substantial health burden as the leading preventable cause of death and disease in Australia (51) and potential contributor to defects in the epigenetic profiles of spermatozoa (18, 19).

Thesis findings also indicate that 62% of Australian males consume alcohol during the three months prior to their partner's pregnancy (See chapter 7 section 7.4.3). While many Australian males (85.7%) reportedly meet the guidelines for safe alcohol consumption (Refer to chapter 5 section 5.4.2), the effects of alcohol on an individuals' preconception health, and on their safety within community, cannot be underestimated (481-483). Alongside tobacco smoking, alcohol is also a burden to the preconception health of Australian males (491). The preconception alcohol use in women is attributed to adverse birth outcomes (9, 10),

male alcohol use during preconception has received less attention. Patterns of regular alcohol consumption are foreseeable amongst males during the preconception period as alcohol is a socially acceptable legal drug in Australia, is readily available, and it's consumption is culturally encouraged even vindicated promoting the normalization of excessive consumption in Australian society and a 'culture of intoxication' (407). Further research is needed to deem that the safe levels of alcohol consumption reported for the general population are equally appropriate for individuals planning pregnancy.

Australian males, compared with females, are more likely to engage in risk taking behaviours during the preconception period, including tobacco smoking (305, 492) and alcohol consumption (492), and less likely to consult a GP (113). Given these figures, attention must be paid to the intergenerational effects of such paternal preconception behaviours. Some males believe they can contribute meaningfully toward a healthy pregnancy and offspring by living a healthy lifestyle (199). However, preconception care is not always viewed as a high priority or an important health issue for men of childbearing age (21). Some males believe they can contribute meaningfully toward a healthy pregnancy and offspring by living a healthy lifestyle (199). However, preconception care is not always viewed as a high priority or an important health issue for men of childbearing age (21). Therefore, males do not always recognise the need to reduce drinking alcohol or stop smoking before their partner becomes pregnant (197). Fortunately, paternal health and wellbeing is promoted for by collaborations including the International Society of Men's Health (493) and the Global Action on Men's Health (494) empowering men to pursue healthier lives and decrease health risk factors, including smoking and alcohol use.

9.3.3.3.2 The influence of physical activity on the preconception health of Australian males

Thesis findings reveal many Australian males (69.5%) undertake some form of physical activity in the three months preceding their partners pregnancy (Refer to chapter 6 section 6.5.3). The finding highlights a general willingness among numerous males to participate in physical activity during the preconception period, a key modifiable health behaviour and beneficial preconception health indicator associated with beneficial health effects (377). Alongside alcohol consumption, regular physical activity is a health behaviour consistently reported by the majority of Australian males surveyed in this thesis. However, males who became first time fathers were less likely than other males to meet the guidelines for moderate of vigorous physical activity (Refer to chapter 5 section 5.4.5). Alongside alcohol consumption, regular physical activity is a health behaviour consistently reported by the majority of Australian males surveyed in this thesis.

Health behaviours such as regular physical activity can have pregnancy and offspring health benefits, as documented for overweight and obese females of reproductive age (495). Regular physical activity during the preconception period is also recommended for males (142) as paternal preconception physical activity may influence pregnancy and offspring outcomes (Refer to chapter 4 section 4.4.4). However, the evidence to support such associations remains scant. Regular physical activity by males during the preconception period offsets the health risks involved with physical inactivity, such as obesity, and mitigates the risk of specific chronic diseases, such as Type 2 Diabetes.

The findings from chapters 5 and 6 reveal inconsistencies in male physical activity patterns during the preconception period. Although many males report undertaking physical activity, numerous males do not meet exercise guidelines and therefore their exercise frequency and intensity raises concerns. Furthermore, many males are classified as overweight or obese (Refer to section 9.3.3.3.4), which also raises concerns regarding the effectiveness of their physical activity to regulate body composition and bodyweight. The inconsistent findings presented in chapters 5 and 6 and the limited evidence presented in chapter 4 highlight the need for further research to advance our understanding of male physical activity and its influence on pregnancy and offspring outcomes.

9.3.3.3.3 The influence of nutrition and dietary intake on the preconception health of Australian males

Thesis findings report one in every two Australian males do not meet the recommended daily intake of vegetables (see Chapter 5 section 5.4.2) which is a public health threat given the reported associations between paternal preconception vegetable consumption and adverse pregnancy and offspring outcomes (Refer to Chapter 4 section 4.4.7). National statistics align with the thesis findings from chapter 5; the majority of Australians do not meet daily vegetable consumption guidelines or the daily fruit guidelines (496) despite the preconception literature highlighting the importance of initiating healthful dietary regimes for males during preconception as an important public health issue (114, 416). Limited preconception research exists on the topic and national data sources remain underutilised (178, 216, 497) which constrains our understanding of Australian paternal preconception nutrition and dietary intake in regard to pregnancy and offspring outcomes. Although, emerging evidence supports the impact of paternal preconception nutrition and dietary influence (497, 498) and its interconnection with other preconception health indicators and health behaviours including physical activity habits (497, 498), or mental health conditions (499).

One explanation of the findings from chapter 5 is the influence of cultural and social norms among Australian males, particularly the regular consumption of fast food across many

Australian communities (500) (500, 501). Fast food is often comprised of nutritionally imbalanced meals with few vegetables, sodium rich, simple carbohydrates, saturated fats, trans fats, and alcohol (501), all of which are factors relevant to chronic disease-related risks (496) and pose a threat to the preconception health of males (502). In addition, fast food includes the consumption of sugar-sweetened beverages and caffeine intake, both of which are associated with reduced fecundability among males (255, 256). Evidence suggests males who consume fast food frequently have an increased risk of fathering an infant born earlier than expected (247, 255, 256).(255) The prolonged patterns of insufficient vegetable intake and excessive fast-food consumption of males reflect a nutritional and dietary trajectory that may pose a substantial risk to their preconception health across their life course and requires further investigation.

The current state of paternal preconception nutrition in Australia, particularly the insufficient vegetable consumption by Australian males, warrants attention, despite the emphasis placed on nutrition in Government policy (36). Few experienced health practitioners are appropriately trained in nutritional interventions (503) and provide effective support to implement behavioural changes for male to consume adequate levels of fruit and vegetables and avoid excessive fast-food consumption during the preconception period. Consequently, the responsibility of paternal preconception nutrition and dietary adequacy is left to the individual. This responsibility may also extend to reproductive partners who can assist to support males toward healthful nutrition and dietary choices. The self-efficacy of Australian males to adopt a healthy diet during the preconception period, and the role their reproductive partners can play in the process, should not be discounted. Future research endeavours which prioritise nutrition and dietary factors relevant to paternal preconception health and care, such as vegetable consumption, are required to better understand nutrition and dietary requirements in the border context of preconception health behaviours of males.

9.3.3.3.4 The influence of body composition and BMI on the preconception health of Australian males

Thesis findings highlight a positive association between higher paternal preconception BMI and offspring birthweight (see chapter 4 section 4.5). This finding is pertinent considering nearly half of the Australian males who report a planned pregnancy, or with ambivalent or unplanned pregnancy, have a BMI outside the healthy range (Refer to chapter 6 – section 6.5.2). The findings from chapter 4 and 6 are supported by external literature which link overweight or obese fathers with adverse outcomes for their offspring, including overweight or obese (270, 378) and asthma (237).

In the context of preconception health, females tend to exhibit higher obesity rates than males globally, however, the difference between sexes vary between countries (504). To

address these factors, The National Obesity Strategy 2022-2032 (64) recommends Australians maintain a healthy body weight through their consumption of healthy food and limiting of sedentary behaviours, and alcohol consumption, to mitigate the risk of perpetuating intergenerational chronic disease from obesity (63). Males overweight or obese during the preconception period have reported several adverse pregnancy and offspring outcomes (see chapter 4 section 4.4.1). However, findings from chapters 4 and 6 should be interpreted with caution based upon the use of BMI to measure and determine a 'healthy body composition', which presents some fundamental limitations (505). The health considerations pertaining to body weight and unhealthy BMI present as a stark reminder for Australian males during the preconception period and when planning a pregnancy to be vigilant and accept that their current body composition may influence the birthweight of their children.

9.3.4 The beliefs and behavioural intentions of Australian males during the preconception period are not always aligned with their preconception health behaviours.

The beliefs and behavioural intentions held by Australian males during the preconception period are not always aligned with their preconception health behaviours (refer to chapter 7 section 7.4.4). This misalignment is evident for the three key behaviours reported in this thesis: alcohol avoidance, smoking avoidance, and consuming a healthy diet (Figure 9.1). Thesis findings evidence a disconnect in the belief-behaviour relationship for these key preconception health behaviours which implies there is some variability in the degree to which Australian males can address risky behaviours during the preconception period. Emerging data from a Swedish longitudinal study investigating males' pregnancy planning behaviour supports this finding revealing most men do not adjust their lifestyle to improve their health (120).

A variance between the beliefs, behavioural intentions, and behaviours of males identified in chapter 7, must be considered within the context of their beliefs and intentions which are captured utilizing the Theory of Planned Behaviour [TPB] (83). Few studies, in addition to the findings of this thesis, apply the TPB and report findings for males during the preconception period. As such, using the TPB to provide a theoretical foundation to underpin male preconception health behaviours is novel. A discord exists between the behavioural intentions of Australian males and them undertaking risky health behaviours can also suggest gaps in their preconception health awareness and/or knowledge as to their influence and impact on pregnancy and child health outcomes. Public health campaigns, initiatives, and research focusing on the behavioural intentions and health behaviours and risk factors which are prevalent among males during preconception is required to provide evidence

which can support clinical issues and build a framework which can consider the paternal contributions toward adverse pregnancy and offspring outcomes.

When applying the TPB, pregnancy intention can be theoretically linked to health behaviours. However, the findings of this thesis provide only limited evidence to support this relationship. Australian males' beliefs and behavioural intentions do not always translate into preconception behaviours and therefore misalign with their lifestyle behaviours such consumption of a healthy diet, alcohol avoidance, and to a lesser extent regular physical activity. Such key behaviours are acknowledged factors associated with body composition, such as being overweight or obese and require further exploration.

9.3.4.1 The preconception beliefs and intentions of Australian males to avoid alcohol

Thesis findings further reveal that while Australian males may believe that alcohol avoidance contributes toward a healthy child and intend to avoid alcohol during the 6-month period prior to their partners pregnancy, they still consume alcohol during this period (refer to chapter 7 sections 7.4.3 and 7.4.4). The thesis finding from chapter 7 offers negligible evidence to support the belief-behaviour relationship regarding the alcohol avoidance of males due to their misalignment of behavioural intentions and consequent alcohol consumption. Such a finding undermines the healthy dietary regimes incorporated into preconception care which aim to limit alcohol related harms (131). A disconnect between the beliefs and behavioural intentions of Australian males and their behaviour regarding alcohol consumption presents a finding which demonstrates an inconsistency toward alcohol avoidance during the preconception period.

One plausible explanation for this discrepancy is that alcohol, as an addictive drug, is embedded into Australian culture therefore alcohol consumption and availability is overt and even defended in Australian society (506). The culture of alcohol consumption in Australia may override the preconception beliefs and intentions of Australian males. Further, the belief-behaviour discrepancies of Australian males regarding alcohol consumption may also suggest they do not consistently consider their roles and responsibilities during the preconception period (485). Such an insight is important to acknowledge when addressing paternal preconception interventions, when counselling males, when tailoring health information towards males, and when identifying barriers to their preconception care engagement.

Australian males report alcohol consumption despite their behavioural intentions to avoid alcohol, a problematic finding due to the adverse health outcomes, and adverse pregnancy and offspring outcomes acknowledged as a result of preconception alcohol consumption

(247, 289). Large proportions of non-Australian males also report alcohol consumption in the three months before conception (87, 284), evidence to suggest that this thesis finding from chapter 7 may not explicitly relate to country relevant factors. The belief-behaviour incongruence of males may pose as a potential indicator regarding their beliefs and intentions for other risky preconception health behaviours, such as smoking, and more generally as a health indicator of the Australian public regarding other socially accepted addictive drugs. Behavioural intentions to avoid consuming alcohol will also impede the effectiveness of any efforts from health services and stakeholders who are attempting to provide preventive preconception care requirements and behavioural changes for males, based on their intentions. Australian males who report mixed behavioural intentions towards alcohol avoidance during the six months or even 12 months prior to pregnancy also may challenge any interpretations of the TPB and the belief-behaviour relationship.

Males planning for fatherhood need multifaceted support to avoid alcohol during the preconception period, and to maintain their beliefs and behavioural intentions regarding alcohol avoidance. Accurate information and resources created for Australian males, health services, and health practitioners are required to promote collaboration and general awareness between all stakeholders regarding effective interventions and treatment options to support Australian males during the preconception period, regardless of pregnancy intention. Further research is also needed to explore a range of confounding variables relevant to male's alcohol that may validate some of the social and cultural norms associated with the consumption of alcohol in the Australian context.

9.3.4.2 The preconception beliefs and intentions of Australian males to undertake regular physical activity

Thesis findings reveal Australian males' beliefs and behavioural control regarding regular physical activity are strongly associated with the behavioural intention to undertake physical activity (see chapter 7 section 7.4.4). This finding from chapter 7 aligns with the theoretical framework of the TPB which suggests behavioural intention to undertake regular physical activity serves as a predictor of actual behaviour. Such insights provide an emerging contribution toward understanding the preconception health beliefs and behavioural intentions of males regarding regular physical activity within the Australian context. The findings from chapter 7 highlight the importance of behavioural intentions on regular physical activity, which may support current efforts to address the obesity crisis in Australia (64), and suggests targeting behavioural intention to undertake physical activity during the preconception period could be an effective strategy to address health behaviour changes.

Among the key health behaviours examined in this thesis, the belief-behaviour association was most pronounced for regular physical activity which is promising albeit unremarkable considering only one in five Australian adults aged 18 to 64 years meet the physical activity guidelines (507). The concept of males during the preconception period intending to undertake regular physical activity and finally performing the activity is by no means novel but is relevant especially considering the cultural emphasis of physical activity in Australia (508). In addition to cultural influences and the acknowledged benefits of physical activity, males may intend to undertake regular physical activity during the preconception period for numerous other reasons including, team building, social inclusion, and leadership (508). As such, instances where the preconception behavioural intention of males translate into behaviour may be driven by many factors, some of which may be supported by social and cultural factors, such as a connection with nature and outdoor recreation including hiking (509, 510) or with various sporting activities, such as cricket (511) or football.

Exploration into Australian male's beliefs and behavioural intentions regarding regular physical activity during the preconception period should focus on the social and cultural factors associated with regular physical activity and any potential impacts on pregnancy and offspring outcomes. In order to advance our understanding of the belief-behaviour link regarding regular physical activity for males during the preconception period, research must move beyond overall health and wellbeing, body composition, and weight management, to incorporate psychological, social, and community related aspects, such as body image, mental health, and sports participation. Public health initiatives promoting regular physical activity are required as they can further leverage the behavioural intentions of males to undertake activities related to regular exercise that can effectively optimise preconception health.

9.3.4.3 The preconception beliefs and intentions of Australian males to consume a healthy diet

Australian males' beliefs and behavioural intentions regarding consumption of a healthy diet are not associated with actual dietary behaviour, according to the findings of this thesis (refer to chapter 7 section 7.4.4). These beliefs and behavioural intentions of Australian males were strongly influenced by their reproductive partners, more so than their personal beliefs or the considerations of their health care providers (refer to chapter 7 section 7.4.4).

Similar to alcohol avoidance (section 9.4.3.1), the findings from chapter 7 may be indicative of Australian males' broader beliefs and intentions regarding other preconception health behaviours. Such a theory remains unexplored, as the current research literature (413) only marginally investigates the preconception dietary beliefs of males which leaves a limited

evidence base to support the findings of this thesis. The findings identified in chapter 7 also highlight the influential role of the reproductive partner to shape the healthy eating behaviours of males during the preconception period. These reproductive partners can offer guidance and encouragement regarding health behaviours which can influence the preconception beliefs and intentions of males. Evidence reveals that reproductive partners can have both a direct and indirect influence on the preconception health behaviours of males, particularly for behaviours such as regular consumption of a healthy diet and healthful eating (512). The influence of the reproductive partner in respects to healthy eating for males during the preconception period is impactful and a development towards understanding and promoting effective behaviour change for males, which may include increasing vegetable consumption.

Future research investigating dietary beliefs and behavioural intentions of males and females would benefit by controlling for the influence of reproductive partners, primary health care providers, and social networks such as relatives, family, and friends who can shape the beliefs and intentions of males to undertake healthful eating patterns. In addition, accurate and current preconception nutrition and dietary relevant information, which emphasizes the importance of regular vegetable consumption, is urgently needed to inform Australian males beliefs and intentions to consume a healthy diet.

9.4 LIMITATIONS

This thesis provides a valuable insight into the preconception health and care needs of Australian males by exploring their health behaviours, beliefs, and intentions toward preconception health and pregnancy planning. However, thesis findings must be considered within the scope of certain challenges and limitations.

9.4.1.1 The Australian context

The aims and objectives of this thesis were developed to address the preconception health and care requirements of Australian males. Consequently, the findings of this thesis are specific to the Australian context and will not be generalizable to males from other countries and cultural backgrounds, whose preconception health behaviours and needs may vary. A narrowed focus on Australian males limits the applicability of the thesis findings when addressing the risks associated with adverse pregnancy and offspring outcomes of males from other countries and cultures.

9.4.1.2 Data collection and utilisation

9.4.1.2.1 Self-reported data

The findings identified in chapters 6 to 8 were based upon two online national cross-sectional surveys, both of which were self-reported and voluntarily completed. One survey requested respondents to recall health information from 12 months and up to 3 years prior. Self-reported data collected within such timeframes are subject to response bias and recall bias (355). Given the cross-sectional design of the surveys utilised in this thesis, causal relationships cannot be established from the thesis findings (457).

9.4.1.2.2 Secondary analysis of data

The data analysed in chapters 5 to 8 originated from existing survey datasets necessitating a secondary analysis of data which required ethics approval. All secondary data was void of identifying information, however, the relevance and adequacy of the existing surveys to address the research question could be challenged (513).

Specifically in chapter 5, the of Ten to Men survey data in four waves caused inconsistencies across iterations which did not allow for longitudinal data analysis.

9.4.1.2.3 Statistical limitations

When exploring the research literature relevant to paternal preconception health and pregnancy outcomes in chapters 2 and 4, numerous studies did not adjust for confounding factors associated to maternal exposures. Furthermore, the small sample sizes in the results chapters 6 to 8 limited the ability to explore interactions or moderating effects or adjust for potential confounding factors.

When exploring preconception beliefs and intentions in chapter 7, issues were identified with the SEM model fit for the healthy diet outcome. Researcher determination of each healthy diet variable may attract researcher-bias toward the final SEM model and regression results. Further, due to the model complexity, the SEM model did not account for individual characteristics which are relevant to health, such as BMI or smoking. The analysis applied in chapter 7 uses a proxy measure to support preconception behaviour as past behaviours were utilised to predict future intention.

9.4.1.3 Survey recruitment and sampling

This research project initially adopted a two-phase exploratory mixed methods framework combining cross sectional data from national surveys alongside qualitative data from focus groups or semi-structured interviews. However, the qualitative research component was discontinued due to issues with recruitment of focus group participants.

9.4.1.3.1 Sampling methods

9.4.1.3.1.1 COVID-19 pandemic

Due to the data collection timing for this thesis research, portions of the data utilised in the final analysis from chapter 6 to 8 were collected during the COVID-19 pandemic which presents numerous challenges, even online. Research data collected during the COVID-19 pandemic, for instance, may report a lower-than-expected number of participants, or a mis-represented number of participants, and have the potential to include bias survey responses (514) which may limit the external reliability of the results.

9.4.1.3.1.2 Internet access and social media

A portion of survey respondents were recruited via social media channels (chapters 6 and 7), and in some cases via email referrals from their reproductive partners. Participants were also identified via purposive convenience sampling using online methods (chapter 8). Consequently, individuals without internet access, including low socioeconomic and marginalised groups or those residing in rural or remote areas, will be underrepresented in the data. Online recruitment strategies introduce potential sampling bias (515, 516) and my limit the generalizability of the findings, particularly in representing the broader population of Australian males during preconception.

9.4.1.4 Preconception health and pregnancy intention measurements

9.4.1.4.1 London Measure of Unplanned Pregnancy (LMUP)

Pregnancy intention is nuanced, existing along a spectrum which can be assessed through varying degrees of ambivalence (356). Simplified measures of pregnancy intention, as applied in chapter 8, do not consider pregnancy ambivalence and may rely upon binary classifications of pregnancy being planned or unplanned. To address this limitation, the London Measure of Unplanned Pregnancy (LMUP) for Partners (224) (refer to chapter 6) was employed which offers and more detailed assessment of pregnancy intention and degrees of ambivalence, for instance, whether a male agrees the pregnancy was appropriately timed or has mutual agreement with their partner before becoming pregnant.

However, use of LMUP for Partners has only been piloted in the UK (172) and so has not been validated for Australian expectant partners as has the LMUP among pregnant Australian women (517). As such, the degree of pregnancy intention, including any ambivalence, was a consideration in only some findings. In addition, pregnancy intention measurements, such as the LMUP for Partners, are limited and may not reflect the broader circumstances of pregnancy regarding the information and advice males may seek, and the health services they may utilise during the preconception period. Furthermore, a survey data collection error was also identified when utilising the LMUP for women's partners (refer

to chapter 6) which meant that only five of the six questions in the LMUP survey could be allocated the maximum score.

9.4.1.4.2 Body Mass Index (BMI) measure

When addressing preconception health, the BMI measure does not account for variations in ethnic groups or body sizes, or differentiate between body lean mass and body fat mass (505). Accordingly, findings of this thesis may misclassify fit and healthy young males with an elevated muscle mass as overweight or obese. Nevertheless, the relative ease of measuring and interpreting BMI makes this the simplest and most cost-effective option for determining preconception obesity in the population (379).

Nevertheless, this timely body of research is novel as it pioneers the Australian preconception health landscape of Australian adult males. While this finding is within the Australian context, it may still inform understandings and insights for other countries and contexts, with the support of additional research.

Thesis findings are reinforced through a triangulation of data, collected during three distinct stages of the preconception period, and highlight shared partner support and responsibilities for preconception health and care and pregnancy planning. Thesis findings also emphasise the importance and urgency for males, and similarly for health services and health practitioners, to be aware, engaged, and educated regarding preconception health and care. By highlighting the preconception health behaviours of Australian males, findings from this thesis sustain current public health and preconception knowledge gaps and provide evidence to encourage the acceptance of males into preconception guidelines, policies, and procedures which can support their preconception engagement.

9.5 IMPLICATIONS FOR PRECONCEPTION HEALTH AND CARE IN AUSTRALIA

This thesis applies a conceptual framework (Refer to chapter 3, section 3.2) that identifies opportunities to improve preconception health in current and future generations (67) and outlines three strategies to address preconception health including i) preconception health service delivery, ii) preconception health promotion, and iii) preconception health policy. Such efforts are urgently required to address behavioural risk factors and their interconnection with unplanned and ambivalent pregnancy, with infertility, and with adverse pregnancy and offspring outcomes. With this in mind, the promotion of preconception health is a public health responsibility for health promotion practitioners, policymakers, health services and practitioners, and researchers.

9.5.1 Implications for policymakers

9.5.1.1 An Australian preconception framework

Preconception care priorities in Australia have been identified (518). However, a public heath focus by Australian policymakers is necessary to advance preconception opportunities and initiate a call to action to formulate and implement a national preconception framework (519). A national preconception framework will support the formulation of preconception policy and guidelines and can be a primary precursor to the advancement and engagement of paternal preconception health and care by directing future preventive and preconception-based initiatives and campaigns in Australia.

To ensure effective preconception policy is implemented, the formulation of a national paternal preconception interest group focused on addressing research gaps and promoting effective policy is necessitated. Existing initiatives and research groups in Australia, such as the Health in Preconception, Pregnancy, and Postpartum Early and Mid-career Researcher Collective (520) may provide a preconception research basis from which the inclusion of Australian males can be adapted.

Policies targeting preconception health should be effectively supported by national preconception guidelines and informed by research gaps to shape the future of preconception care (136). Governments worldwide can improve preconception health through policies that address health behaviour changes, or more broadly address organisational level determinants, such as access to health services (67).

9.5.1.2 Male inclusive preconception policy

A comprehensive Australian preconception framework must include policies which can be formulated in consideration of integrating and engaging males into preconception care (41). An overt call to integrate Australian males into the preconception care space and to advance their preconception considerations have been identified in the other relevant Australian Government policies such as the Male Health strategy [2020- 2030] (37) and the Preventive health Strategy [2021- 2030] (36).

Effective implementation of preconception policy should be initiated by raising awareness of preconception health among males and health practitioners. This foundational step will support the development of guidelines and regulations which can support the creation of a preconception framework. Australian males' preconception health awareness, and their engagement with preconception care, may be enhanced if preconception health is considered a cornerstone of public health, within health promotions, to be addressed and implemented within health frameworks and guidelines.

Future policy initiatives and campaigns to address preconception health awareness and education for Australian males can be strategically formulated to include key indicators of health. These efforts can be guided and directed by Australian initiatives, such as Healthy Male (141) ,or through a collective of organisations and individuals, such as the Paternal Plus Network (143) who collaborate with a wide range of stakeholders.

9.5.2 Implications for health promotion practitioners

9.5.2.1 Preconception health awareness and education

There is an urgent need for the Australian public, particularly adult males with reproductive capacity and capability, to be aware, engaged, and educated regarding their reproductive health (36, 37), to foster health behaviour change and optimise pregnancy and offspring outcomes. The effective portrayal of preconception health and care to Australian males can commence within Australian primary and high school classes which are directed at informing and creating preconception health awareness, at all life stages and across the life course, including during childhood, and adolescence. Informative sessions embedded into primary and high school curricula may influence Australian males to address preconception health and care and may also influence their pregnancy intentions and their attitudes towards pregnancy planning and preconception health and care (521). Such sessions, during childhood and adolescence, can be positioned to direct future parents toward healthful behaviours and provide opportunities for information transfer between generations. Preconception health education being embedded into the Australian education curriculum would go some way towards advancing Australian males preconception health awareness, engagement, and education (522). Providing preconception resources to Australian males and raising their awareness, and promoting their preconception care engagement, education, and knowledge may be the crucial first steps and catalysts toward the creation of preconception policy in Australia.

Our understanding of paternal preconception health and care, engagement, and collaboration among all stakeholders, including Australian adult males, can be advanced by increasing public health awareness and health promotion of the preconception health behaviours of males. Such promotions can emphasise how their health can relate to pregnancy and offspring outcomes. Preconception health awareness and education for health professionals is also a necessary step to normalise preconception discussions with male patients during clinical encounters and are key to developing a bidirectional therapeutic relationship between practitioners and patients, which can allow for and enable health behaviour change.

9.5.2.2 Preconception health resource creation and information dissemination

Developers of future preconception heath and preconception education resources have the responsibility to provide gender-specific materials that will effectively engage males with messaging targeting health behaviours and risk factors during the preconception period can how they impact pregnancy and offspring health outcomes. The creation and dissemination of such resources also promotes preconception care gender inclusion and gender equity. Additionally, preconception health resources targeted at Australian males may also highlight their unique health conditions, complications, and co-morbidities, which may differ from those of females.

9.5.3 Implications for health services and practitioners

9.5.3.1 Male inclusive preconception care

The ongoing need to promote preconception health awareness among Australian adult males highlights the importance of educating health practitioners and health services to initiate and effectively deliver preconception care. All providers with the capacity to deliver robust healthcare system in Australia should be equipped to effectively engage reproductively aged males and cater for paternal preconception care as standard treatment.

9.5.3.2 Multidisciplinary preconception care

As frontline health support, Australian GPs are integral for broaching pregnancy planning or preconception health and care subject matter (124) as they can identify information from clients, such as intentions to conceive in the following 12 months (148). GPs function with medical authority and perceived ability to promote health knowledge and awareness of health. Thus, GPs can play the role of advisors along the preconception journey of males. behaviour risks and can promote behaviour change with their clients. In addition to GPs, preconception care can also be effectively provided by holistic and complementary health experts who focus on chronic disease and person-centred care (523), and who are trained to guide their patients through health behaviour changes, such as alcohol avoidance and diet modification.

The effective promotion and administration of preconception care in Australia is best modelled upon multidisciplinary and integrated preconception care services. These services must incorporate the male reproductive partner to comprehend their willingness to undertake health behaviour change and address their health risks. A range of health care professionals can provide benefits for male health during the preconception period which is a pivotal consideration for future policymakers to consider when addressing a framework to support paternal preconception care in Australia. Indeed, whole health system approach is

necessitated and collaboration between all stakeholders is required in a bid to optimise interdisciplinary treatment options and support paternal preconception care.

9.6 FUTURE DIRECTIONS IN PRECONCEPTION RESEARCH

This thesis is positioned within an emerging body of evidence that highlights gaps in the Australian preconception health landscape, particularly the absence of preconception health policy frameworks, preconception clinical standards, male relevant research, and a integration of preconception health data. The future of preconception health and care research must account for shared gender responsibility regarding preconception health and care and pregnancy planning.

Future preconception health and care research developments are also encouraged to support the creation of a preconception data bank and information repository. Such infrastructure will be key to collating the existing sources of preconception health data and knowledge of health exposures relevant to males during preconception, both nationally and globally. A preconception data bank is critical to amalgamate the findings from data sources across the globe. Such a resource would enable the identification of preconception research priorities and gaps to inform future research proposals that address the preconception needs of Australian males. Systematically collating data will assist to build a sustainable public health evidence base which will investigate male's preconception beliefs and intentions and health behaviours. The future research directions in preconception health can be classified to align with the three strategies to address preconception health (refer to section 9.5)

9.6.1 Epidemiological and observational studies

Observational study designs can advance our understanding of offspring outcomes associated with paternal preconception health behaviours and exposures. Evidence gaps in paternal preconception health research (16, 26) highlight the need to understand a male's involvement and engagement with their preconception heath and care. Important areas to be addressed include how males access, share, and use preconception health information and how they can be effectively influenced through health promotion initiatives.

Future observational research can also address some of the methodological challenges that currently present in the preconception literature, such as the maternal reporting of paternal preconception data utilised to calculate BMI. In addition, when addressing maternal preconception risk factors, many of the existing studies do not control for paternal exposures linked with the same outcome. Paternal exposures can also be used as confounders to ensure that the research outcomes are not over or underestimating the risk of maternal exposures.

Longitudinal studies that examine the health and health behaviours of individuals over their life course can also provide valuable datasets to inform the preconception health information and health promotion requirements for males. Such studies include the Ten to Men Longitudinal Study on Male Health (217), the Dunedin Study by Otago University, and the Victorian Intergenerational Health Cohort Study (VIHCS) (178).

9.6.2 Health economic studies

Future research must also consider the economic viability and cost effectiveness of administrating preconception care interventions or research methodologies to Australian males. A cost benefit analysis should be undertaken to determine, for example, the cost of proactively managing preventable health conditions and non-communicable diseases (NCDs) for males compared with the benefits of implementing public health initiatives and education programs to foster their preconception health awareness to reduce the incidence of preventable health conditions and NCDs.

9.6.3 Qualitative research

9.6.3.1 Focus groups and semi-structured interviews

The advancement of paternal preconception health and care requires further research employing mixed methods, with an emphasis on qualitative approaches. Focus groups are a valuable method to collectively explore males' health service experiences and perspectives and they allow a diversity of participants. A semi-structured interview is also valuable to address one-on-one discussions. The facilitation of focus groups can incorporate a mixture of adult males relevant to the preconception period including males 1) of various ages, 2) who are planning or attempting pregnancy (prospective account), and 3) as fathers or expectant fathers (retrospective account). A focus group study design, or semi-structed interviews, are key to addressing the experiential and lived experiences of males which will include an in-depth exploration of their beliefs and behavioural intentions towards pregnancy planning and preconception health.

9.6.4 Intervention studies

Evidence suggests preconception health can have long term consequences on offspring health. To identify, manage, and mitigate any potential risks, intervention studies and controlled trials are required to address male's preconception health behaviour changes and health services utilisation. Such intervention studies can focus on limiting their risk-taking behaviours, such as smoking and alcohol consumption, which can have substantial preventive health benefits and far-reaching intergenerational consequences which extend

beyond the cost effectiveness of implementing and delivering effective preconception care strategies. Preconception health and care services in Australia, using a multi-modality practitioner-based research network (PBRN) (524), can address the integration of males into preconception care strategies and facilitate health promotion programs.

9.7 DISCUSSION CONCLUSION

In chapter 9, a summary outlined the main findings from each chapter and how these findings align with the research aim and objectives. The main findings were tabulated and cross checked against each research objective to determine the integrated thesis findings. Thesis findings were synthesized by integrating the main results from chapters 4, 5, 6, 7 and 8. The implications for preconception health and care in Australia were discussed as recommendations relevant to key stakeholders within the thesis conceptual framework. Any research limitations and their potential influence on the thesis findings were also considered and detailed. This chapter precedes the final chapter which presents the thesis conclusions drawn from the integrated findings.

9.8 CHAPTER SUMMARY

This discussion chapter is the culmination of findings from chapters 4, 5, 6, 7 and 8. Four integrated point of discussion were identified and each related to aspects of the research conceptual framework. The first integrated discussion point was relevant to the preconception information and advice seeking of Australian males and determined that the internet and social media were a common point of contact during the preconception period. The second integrated discussion point focused on the health services utilisation of Australian males and revealed that many consulted a variety of health professionals during the preconception period, but they did not always have regular checkups with a GP. Preconception health behaviours were the focus for the third discussion point. Findings revealed that most Australian adult males had behavioural risk factors that may impact their health and can influence pregnancy and offspring outcomes, regardless of their pregnancy intention. The final integrated point of discussion was relevant to Australian male's beliefs and behavioural intentions. The beliefs and behavioural intentions of Australian males during the preconception period were not always aligned with their preconception health behaviours. This chapter concludes with a summary of the research limitations, implications for preconception health and care in Australia, and future directions in preconception research.

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10 CONCLUSION

This thesis examined the preconception health and care landscape for Australian males with a focus on their preconception heath behaviours, and the social determinants associated with engaging in such health behaviours. This exploration included the health services Australian males utilise and the treatments they are recommended during the preconception period. This thesis also investigated Australian males' beliefs and intentions regarding pregnancy planning and preconception health and care. The research project drew upon the individual characteristics of Australian males within three distinct stages of the preconception period, i) as adult males who became first-time fathers, ii) when planning pregnancy or attempting pregnancy, iii) as expectant partners with a pregnant female partner.

A systematic review of the literature (chapter 2) introduced the beliefs, attitudes, and intentions of males towards pregnancy planning and preconception care. This review included nine peer-reviewed articles analysed in three main themes 1) importance of preconception health and care, 2) paternal preconception behaviours, and 3) inequalities in preconception health and preconception care. Findings indicated that males do not always attend preconception care consultations as they believed they already knew enough about a healthy pregnancy. A male's beliefs and attitudes also revealed a tendency to direct a greater a level of responsibility to the female than themselves regarding preconception health. Such findings suggested further research was required which focused on the male experience regarding preconception health. In response to this identified gap, this thesis applied an existing preconception conceptual framework and triangulated data sources across four study phases to investigate Australian males' preconception health behaviours, and beliefs and intentions towards preconception care.

A review of contemporary evidence (chapter 4) introduced the health behaviours of males by addressing paternal preconception modifiable risk factors for adverse pregnancy and offspring outcomes. Chapter 4 addressed research objective 2 which is to identify the prevalence of clinically relevant preconception health behaviours of Australian males. This review included cohort (n=56) and case control studies (n=9) which were categorized into seven exposures 1) body composition, 2) alcohol, 3) cannabis, 4) physical activity, 5) smoking, 6) stress, 7) nutrition. Findings from this review identified an association between paternal preconception smoking and increased risk of adverse infant outcomes, such as birth defects and leukemia. Chapter findings also revealed an association between an increasing BMI and offspring bodyweight. The findings from this review then informed the analysis for the preconception health behaviours and preconception beliefs, and intentions in Phases 2 and 3.

A longitudinal study examined the preconception health and health behaviours of Australian males as first-time fathers (chapter 5) which extended upon the findings identified in chapter 4. Chapter 5 addressed research objectives 2, 3, and 4. Study findings indicated a high proportion of males who consulted with a GP prior to becoming a father for the first time. Many males who became a father for the first time were more likely to meet the guidelines for daily safe alcohol consumption but less likely to meet the recommendations for moderate physical activity or vigorous physical activity in the previous seven days compared with others who did not become a first-time father. In addition, more than half of the Australian males in the study did not meet the daily recommendation for vegetable consumption prior to becoming first-time fathers. These findings underscore the need for targeted research into the preconception health behaviours of Australian males. Such efforts are essential for mitigating health risks associated with pregnancy and improving outcomes for both parents and offspring

Chapter 6 incorporated a cross-sectional study which examined the preconception health and health behaviours of Australian males, as expectant partners with a pregnant female partner. This chapter extended upon chapters 4 and 5 by exploring preconception health and health behaviours based upon pregnancy intention. Chapter 6 addressed research objectives 1, 2, 3, and 5. Findings from chapter 6 revealed a commonality in the sociodemographic characteristics of expectant partners with many males who intended pregnancy being aged between 30-39, in a committed relationship, and without financial manageability issues. Other findings suggested that a large portion of Australian males undertook physical activity in the three months prior to their partner's pregnancy. Furthermore, several males who planned a pregnancy completed immunization checks in the 12 months prior to their partners pregnancy and most Australian males actively sought preconception information and advice using the internet. However, expectant partners who report any longstanding illness, disability, or infirmity more often reported an ambivalent or unplanned pregnancy than a planned pregnancy. This study provided a foundation for future large-scale research aimed at enhancing clinicians' understanding of male preconception health, including their information and advice seeking behaviours.

The survey data used for Chapter 6 was also analysed to explore the preconception health beliefs, and intentions among expectant male partners to predict health behaviours. The results of this additional analysis were reported in Chapter 7. This chapter addressed research objectives 1, 2, and 3. The beliefs of expectant partners toward alcohol avoidance during the preconception period were associated with a greater intention to avoid alcohol. However, most expectant partners consumed alcohol in the three months before conception. In addition, the healthy diets of some expectant partners were often influenced by their

reproductive partners. Further research is needed to examine paternal preconception health beliefs, intentions, and the underlying motivations for male health behaviours. These insights will inform the development of targeted health promotion messages and interventions that enable men to optimise their preconception health.

A final cross-sectional study was utilised to explore the paternal preconception health services utilisation, and treatments during the preconception period (chapter 8). Such factors were determined based upon males either planning pregnancy in the next 12 months or attempting pregnancy. The research objectives which addressed this chapter include objectives 3, 4, and 5. Similarly to chapter 5, GPs were the most commonly consulted health practitioner. This study also found a high proportion of western herbal medicine treatments or yoga practice were recommended to males attempting or planning pregnancy by a medical doctor or pharmacist.

Preconception health and health behaviours of males must therefore be facilitated through a multidisciplinary collaboration of health professions who can transition the onus of preconception care from frontline health practitioners specifically, such as GPs, to health care practitioners more generally and within all cultural contexts. The results from chapters 4, 5, 6, 7, and 8 were tabulated to determine four integrated points of discussion (chapter 9). The first integrated discussion point was relevant to the preconception information and advice seeking of Australian males and determined that the internet and social media were a common point of contact during the preconception period. The second integrated discussion point focused on the health services utilisation of Australian males and revealed that many consulted a variety of health professionals during the preconception period, but they did not always have regular checkups with a GP. Preconception health behaviours were the focus for the third discussion point. Findings revealed that most Australian adult males had behavioural risk factors that may impact their health and can influence pregnancy and offspring outcomes, regardless of their pregnancy intention. The final integrated point of discussion was relevant to Australian male's beliefs and behavioural intentions. The beliefs and behavioural intentions of Australian males during the preconception period were not always aligned with their preconception health behaviours. This chapter also detailed the implications for future research, in the context of the three strategies to address preconception health including i) preconception health service delivery, ii) preconception health promotion, and iii) preconception health policy. Research limitations and future directions of preconception research conclude the chapter.

Both males and females and integral to the reproductive process and to promotion of intergenerational health. However, preconception health efforts have traditionally focused on

the female and often overlook the role of the male prior to conception. Given the critical influence of preconception health on pregnancy and offspring outcomes, it is essential that preconception health policies, health promotion strategies, and health services engage all individuals, regardless of their gender, to improve population health globally. Prioritising paternal preconception health and care not only promotes gender equity in preconception health but also acknowledges the influence of a male's health on maternal behaviours, pregnancy outcomes, and family well-being. Men's health prior to conception can shape maternal health practices, contribute to a stable family environment into the future, and support active paternal involvement throughout a child's life course.

11 APPENDICES

APPENDIX 2.1 SEARCH STRATEGY FOR SYSTEMATIC REVIEW

Medline (OVID)

Controlled vocabulary – Medical subject headings [MESH]

^mp – multi-purpose

^sh – MesH Subject Heading

#	Query	Results from 3rd January, 2024
S1	(preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception or pregnan* plan* or inten* pregnan*).mp.	18,172
S2	Preconception care .sh.	2,709
S3	S1 OR S2	18,172
S4	(Male* or father* or husband* or paternal or men's health).mp.	9,746,058
S5	(Male or Fathers or Men's health) .sh.	9,404,876
S6	S4 OR S5	9,746,058
S7	(health adj1 belief*) or (health adj1 attitude*) or (health adj1 intention*) or (health adj1 acceptance*) or (health adj1 thought*) or (health adj1 viewpoint*) or (health adj1 perspective*) or (health adj1 perception*) or (health adj1 outlook*) or (health adj1 approach*) or (health adj1 opinion*) .mp.	22,480
S8	(Attitude to health or Intention or Health, Knowledge, Attitudes, Practice).sh.	220,164
S9	S7 OR S8	237,694
S10	S3 AND S6 AND S9	201

*Truncation

Embase (OVID)

Controlled vocabulary – Science Thesaurus [Emtree]

^mp – multi-purpose

^sh – Subject Headings

#	Query	Results from 3rd January, 2024
S1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception or pregnan* plan* or inten* pregnan*) .mp.	26,934
S2	Prepregnancy care .sh.	3,074
S3	S1 OR S2	26,934
S4	(Male* or father* or husband* or paternal or men's health) [^mp]	11,939,455
S5	(Male or Father or Husband or Men's health) .sh.	11,547,606
S6	S4 OR S5	11,939,455
S7	(health adj1 belief*) or (health adj1 attitude*) or (health adj1 intention*) or (health adj1 acceptance*) or (health adj1 thought*) or (health adj1 viewpoint*) or (health adj1 perspective*) or (health adj1 perception*) or (health adj1 outlook*) or (health adj1 approach*) or (health adj1 opinion*) [^mp]	40,864
S8	(Health belief or Attitude to health or Attitude to pregnancy or Paternal attitude).sh.	146,421
S9	S7 OR S8	168,829
S10	S3 AND S6 AND S9	125

*Truncation

PubMed

Controlled vocabulary – Medical subject headings [MESH].

^af – All fields

^sh – MeSH Terms

#	Query	Results from 3rd January, 2024
S1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception or pregnan plan* or inten* pregnan*).af.	76,565
S2	Preconception care .sh.	2,708
S3	S1 OR S2	76,565
S4	(Male* or father* or husband* or paternal or men's health) .af.	9,807,096
S5	(Male or men or fathers or paternal behavior) .sh.	9,725,632
S6	S4 OR S5	9,889,355
S7	"health belief" [Title/Abstract: ~1] or "health attitude" [Title/Abstract: ~1] or "health intention" [Title/Abstract: ~1] or "health acceptance" [Title/Abstract: ~1] or "health thought" [Title/Abstract: ~1] or "health viewpoint" [Title/Abstract: ~1] or "health perspective" [Title/Abstract: ~1] or "health perception" [Title/Abstract: ~1] or "health outlook" [Title/Abstract: ~1] or "health approach" [Title/Abstract: ~1] or "health opinion" [Title/Abstract: ~1]	30,092
S8	(Attitude to health or health belief model or intention) .sh.	634,381
S9	S7 OR S8	655,184
S10	S3 AND S6 AND S9	1,411

*Truncation

CINAHL (EBSCO)

Controlled vocabulary – Subject headings [subject headings authority profile]

^TX – all text

^MM – Major subject heading

#	Query	Results from 3rd January, 2024
S1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception or pregnan* plan* or inten* pregnan*). TX. or (Prepregnancy care).MM.	13,680
S2	Male* or father* or husband* or paternal or men's health).TX. or (Male or men or fathers or men`s health or paternal role).MM.	2,055,151
S3	(health W1 belief*) or (health W1 attitude*) or (health W1 intention*) or (health W1 acceptance*) or (health W1 thought*) or (health W1 viewpoint*) or (health W1 perspective*) or (health W1 perception*) or (health W1 outlook*) or (health W1 approach*) or (health W1 opinion*).TX.	42,789
S4	(Health beliefs or intention or paternal attitudes or parental attitudes or attitude to pregnancy or social attitudes).MM.	28,477
S5	S3 OR S4	63,140
S6	S1 AND S2 AND S5	158

*Truncation

APA PsycINFO (EBSCO)

Controlled vocabulary – APA Thesaurus of Psychological Index Terms

^TX – all text

^MA – MeSH subject heading

#	Query	Results from 3rd January, 2024
S1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception or pregnan* plan* or inten* pregnan*).TX.	161,483
S2	(Male* or father* or husband* or paternal or men's health).TX.	2,172,731
S3	(health W1 belief*) or (health W1 attitude*) or (health W1 intention*) or (health W1 acceptance*) or (health W1 thought*) or (health W1 viewpoint*) or (health W1 perspective*) or (health W1 perception*) or (health W1 outlook*) or (health W1 approach*) or (health W1 opinion*).TX.	73,474
S4	(Male attitudes or attitudes or attitude formation or attitude measures or intention) .MA.	97,957
S5	S3 OR S4	134,867
S6	S1 AND S2 AND S5	4,118

*Truncation

Scopus

Controlled vocabulary – *Note Scopus does not use a controlled vocabulary/ subject heading.

^– Search within Article title, Abstract, Keywords

#	Query	Results from 3rd January, 2024
S1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception or pregnan* W/1 plan* or inten* W/1 pregnan*) ^	5,794
S2	(Male* or father* or husband* or paternal or men's health) ^	1,814,478
S3	(health W/1 belief*) or (health W/1 attitude*) or (health W/1 intention*) or (health W/1 acceptance*) or (health W/1 thought*) or (health W/1 viewpoint*) or (health W/1 perspective*) or (health W/1 perception*) or (health W/1 outlook*) or (health W/1 approach*) or (health W/1 opinion*) ^	415,851
S4	S1 AND 2 AND 3	160

*Truncation

ISI Proceedings/Web of Science

Controlled vocabulary – *Note ISI Proceedings does not use a controlled vocabulary/ subject heading.

^af – All fields

#	Query	Results from 3rd January, 2024
S1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception or pregnan* plan* or inten* pregnan*) .af.	3,961
S2	(Male* or father* or husband* or paternal or men's health) .af.	104,800
S3	(health belief*) or (health attitude*) or (health intention*) or (health acceptance*) or (health thought*) or (health viewpoint*) or (health perspective*) or (health perception*) or (health outlook*) or (health approach*) or (health opinion*) .af.	111,794
S4	S1 AND S2 AND S3	48

*Truncation

APPENDIX 2.2 NEWCASTLE OTTAWA SCALE (NOS) – CROSS SECTIONAL STUDIES

Newcastle-Ottawa Critical Analysis (Cross-sectional) - Criteria									
First author & Year	**SELECTION***				**COMPARABILITY****	**OUTCOME*****		**TOTAL**	**Quality**
	Representativeness of the sample	**Sample size**	**Non-Response rate**	**Ascertainment of the exposure^**	**Potential confounders were investigated**	**Assessment of the outcome ^^**	**Statistical test**		
Mello et al, 2019	☒			☒	☒	☒	☒	5	Fair
Kransdorf et al., 2016				☒	☒	☒	☒	4	Fair
Maas, 2022	☒			☒	☒	☒	☒	5	Fair
Cassinelli et al., 2023	☒	☒		☒			☒	4	Fair
Goossens et al., 2019					☒	☒	☒	3	Poor
Bassett-Gunter et al., 2013	☒				☒	☒	☒	4	Fair
Mazlan et al., 2024	☒			☒ ☒	☒	☒	☒	6	Fair

*A maximum of five (5) stars can be awarded for the selection domain
^A maximum of two stars (2) can be awarded for the ascertainment of exposure
** A maximum of two (2) stars can be awarded for the comparability domain
*** A maximum of three (3) stars can be awarded for the outcome domain
^^ A maximum of two (2) stars can be awarded for the ascertainment of outcome

APPENDIX 2.3 CRITICAL APPRAISAL SKILLS PROGRAMME (CASP) – QUALITATIVE STUDIES

| The Critical Appraisal Skills Programme [CASP] (Qualitative) - Criteria | | |

					explained. Also, open text survey responses do not provide rich and meaningful qualitative data.	participants are covered.	approved the study		to report for males only.	to the field and opportunities for future research. Also, the discussion focused mainly on women not men.

APPENDIX 3.1 EXPECTANT PARTNERS PRE-PREGNANCY HEALTH INFORMATION AND HEALTH BEHAVIOURS

Expectant Partner's Pre-pregnancy Health Information and Health Behaviours

Default Question Block

Welcome to the Survey of Expectant Partner's Pre-pregnancy health information and health behaviours

Have you received and read the Participant Information Sheet for this study?

- ○ Yes
- ○ No

Preconception care beliefs, attitudes and behaviours of women and men (HREC# ETH20-4726)

WHO IS DOING THE RESEARCH?

My name is Dr Amie Steel and I am an academic at the University of Technology Sydney (UTS). My research team includes Dr Erica McIntyre (UTS), Dr Jane Frawley (UTS), Professor Jon Adams (UTS), Dr Danielle

Schoenaker (University of Wollongong), Dr Anna Gavine (University of Dundee), Ms Adina Lang (Monash University) and Dr Jenny Hall (University College London).

WHAT IS THIS RESEARCH ABOUT?

This research is to find out about the preconception beliefs, attitudes and behaviours of pregnant women and their reproductive partners.

FUNDING

Funding for this project has been received from the Faculty of Health at UTS.

WHY HAVE I BEEN ASKED?

You have been invited to participate in this study because you are a pregnant woman or the reproductive partner of a pregnant woman.

IF I SAY YES, WHAT WILL IT INVOLVE?

If you decide to participate, I will invite you to complete a survey about your beliefs, attitudes and behaviours in the time before you were pregnant and during your current pregnancy. The survey will take approximately 30 minutes to complete and can be filled out on your own device. You will be asked to provide your email address so that an email containing a link to the survey can be sent to you. A second email containing a link to an survey for your partner to complete will also be sent to the same email address and you are invited to share this link with your partner. Both your survey responses and the responses provided by your partner, should they choose to participate, also, will be linked through a shared ID code. This ID code will be linked to your email address in a database separate from your survey responses. No other identifying information, such as yours or your partner's name, postal address or phone number, will be collected in any aspect of this project.

If you are unable to complete the survey in one sitting, you will be able to save your responses and return to the survey on the same device at a later time. Once started, you will have up to 14 days to complete the survey.

Upon completing the survey, you will be provided a link to enter a competition to win a $100 voucher to spend online at fishpond.com.au in acknowledgement of your time. The details you provide to enter the competition will not be in anyway linked to your survey response or used for any purpose other than

selecting the winner of the draw. No third party will have access to these details. After the winner is notified and the voucher is delivered, your details will be deleted.

ARE THERE ANY RISKS/INCONVENIENCE?

Yes, there are some risks or inconvenience. You will be asked some personal health questions including about your pregnancy history. Some of these questions may cause emotional distress to some people.

DO I HAVE TO SAY YES?

Participation in this study is voluntary. It is completely up to you whether or not you decide to take part.

WHAT WILL HAPPEN IF I SAY NO?

If you decide not to participate, it will not affect your relationship with the researchers or the University of Technology Sydney. If you wish to withdraw from the study once it has started, you can do so at any time before you return the survey to the research team at the clinic where you were first told about the study, or via post. However, it is not possible to withdraw your data from the study results after the survey items have been completed as all surveys will be anonymous.

CONFIDENTIALITY

By completing the survey, you consent to the research team collecting and using information about you for the research project. All this information will be treated confidentially. All survey responses will be anonymous and will not be able to be identified to you. Your information will only be used for the purpose of this research project. Your survey will be matched to your partners survey via an unidentifiable code. We plan to publish the results in peer-reviewed scientific journals.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I can help you with, please feel free to contact me on 0418 786 186 or amie.steel@uts.edu.au

A copy of this information sheet will be included in the email you were sent with the link to this survey.

NOTE: This study has been approved in line with the University of Technology Sydney Human Research Ethics Committee [UTS HREC] guidelines. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number (ETH20-4276). Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

This questionnaire will ask questions about your health, your knowledge of pre-pregnancy health, and any experiences relating to pre-pregnancy care that you may have had prior to your partner's current pregnancy. You can either complete this now during your clinic visit or at a later stage. It will take about 30 minutes to complete. Any information you provide will remain anonymous.
Note: Participation in this study is voluntary. You are not required to participate even if your partner has chosen to participate.

By completing the survey, you agree to the following:

I have read the participant information sheet, or someone has read it to me in a language that I understand. I understand the purposes, process and risks of the research described. I have had an opportunity to

ask questions and I am satisfied with the answers I have received. I have not completed this survey previously. I freely agree to participate in the research survey described and understand that I am free to withdraw at any time without affecting the health care I receive.

- ○ Yes
- ○ No

Please read each question carefully. Please answer every question to the best of your knowledge. If you are unsure about how to answer a question, mark the option that most closely describes your response.

Please note that you can take a break from responding to the survey and return at a later stage but you will need to access it with the same browser and device as you are currently using.

Section 1: About You

What is your age (in years)?

What is your gender?

- ○ Female
- ○ Male
- ○ Transgender

- ○ Other

What is your residential postcode?

What is your relationship status?

- ○ Married
- ○ De facto
- ○ Not currently in a relationship
- ○ In a relationship but not living with my partner
- ○ Other (please give details

What is the highest qualification you have completed?

- ○ No formal qualification
- ○ Year 10 or equivalent
- ○ Year 12 or equivalent
- ○ Trade or apprenticeship
- ○ Certificate or diploma
- ○ University degree (e.g. Bachelor)
- ○ Higher university degree (e.g. Masters, PhD)

What best describes your employment status?

- ○ Full time work (35 hours or more per week)
- ○ Part time work (less than 35 hours per week)
- ○ Casual or temporary work (irregular hours)
- ○ Currently looking for work
- ○ Not currently in the paid workforce, nor looking

How do you manage financially at the moment?

- ○ It is impossible
- ○ It is difficult all the time
- ○ It is difficult some of the time
- ○ It is not too bad
- ○ It is easy

Do you currently have private health insurance?

- ○ No
- ○ Yes

Do you currently have a Health Care Card?

- ○ Yes

- ○ No

How tall are you? (in centimetres)

What is your current weight? (in kilograms)

What other adults do you live with?

- ○ wife
- ○ wife and (your/your wife's) parents
- ○ partner
- ○ partner and (your/your partner's) parents
- ○ alone
- ○ your parents
- ○ other relatives or friends
- ○ other (e.g. living in accommodation provided with your job, etc)

Is English your first language?

- ○ Yes
- ○ [ ] No, please list your first language:

Do you identify as Aboriginal or Torres Strait Islander?

- ○ Yes
- ○ No
- ○ I would rather not say

Were you born in Australia?

- ○ Yes
- ○ [ ] No, please give details:

Block 2

The remainder of this survey relates to your partner's current pregnancy.

Section 2: Your current pregnancy

How many weeks pregnant is your partner now?

What is the estimated due date for your partner's pregnancy?

How many weeks pregnant was your partner when you found out she was pregnant?

How did you find out your partner was pregnant?

- ○ Home pregnancy test
- ○ From a health professional
- ○ My partner told me
- ○ Other

Is this current pregnancy the result of you or your partner receiving fertility treatments?

- ○ Yes
- ○ No

How long before trying to become pregnancy were you thinking about having a baby?

- ○ I was not trying to become pregnant
- ○ Less than 1 month
- ○ Between 1 and 2 months
- ○ Between 3 and 5 months
- ○ Between 6 and 12 months
- ○ More than 12 months

Are there any other circumstances related to this pregnancy which you would like to share?

Below are some questions that ask about your circumstances and feelings around the time you became pregnant. Please think of your current pregnancy when

answering the questions below (please tick the statement that most applies to you):

In the month that your partner became pregnant...

- ○ I/we were not using contraception (including no need for contraception, e.g. fertility treatment, female partner, etc.)
- ○ I/we were using contraception, but not on every occasion
- ○ I/we always used contraception, but knew that the method had failed (i.e. broke, moved, came off, came out, not worked etc) at least once
- ○ I/we always used contraception

In terms of becoming a father (first time or again), I feel that my pregnancy happened at the...

- ○ Right time
- ○ Ok, but not quite right time
- ○ Wrong time

Just before your partner became pregnant...

- ○ I intended my partner to get pregnant
- ○ My intentions kept changing
- ○ I did not intend for my partner to get pregnant

Just before your partner became pregnant...

- ○ I wanted to have a baby
- ○ I had mixed feelings about having a baby
- ○ I did not want to have a baby

Before your partner became pregnant...

- ○ My partner and I had agreed that we would like me to be pregnant
- ○ My partner and I had discussed having children together, but hadn't agreed for me to get pregnant
- ○ We never discussed having children together

Section 3: Your Health Behaviours

Before your partner became pregnant, did you do anything to improve your health in preparation for her becoming pregnant?

- ○ Stopped or cut down smoking
- ○ Stopped or cut down drinking alcohol
- ○ Ate more healthily
- ○ Sought medical/health advice
- ○ Took some other action, please describe

○ I did not do any of the above before her pregnancy

Did you do any of the following before your partner became pregnant?

- ☐ Follow a weight loss diet during the 6 months before your partner became pregnant
- ☐ Get tested for any sexually transmitted infections (e.g. chlamydia) during the 6 months before your partner became pregnant
- ☐ Visit the dentist during the 12 months before your partner became pregnant
- ☐ Check that your immunisations were up to date during the 12 months before your partner became pregnant
- ☐ Undergo surgery to help you lose weight (e.g. bariatric surgery, gastric band, gastric balloon, gastric bypass) at any time before your partner became pregnant

Were you doing any physical activity or exercise during the 3 months before your partner became pregnant?

- ○ Yes - please provide details in the next question
- ○ No

Physical activity details...

Number of hours per week

Type(s) of exercise/activity

Have you ever smoked?

- Yes
- No

Which of the following have you smoked?

- Cigarettes
- E-cigarettes
- Other (please give details)

Did you smoke in the 3 months before your partner became pregnant?

- No

○ Yes, - please write the number of cigarettes or equivalent you were smoking per day

[ ]

Did anyone (e.g. partner, family, friends, work colleagues) smoke indoors where you lived or worked before your partner became pregnant?

○ No

○ [ ] Yes (please give details)

Have you ever drunk alcohol?

○ Yes

○ No

On average, how many units of alcohol did you have during the week in the 3 months before you became pregnant? How many units of alcohol did you have on the weekend? (*if none please state '0'*).

Note: a unit of alcohol is equivalent to half a pint of beer, 1 small glass of wine, or a single measure of spirits)

Units of alcohol during the week (Monday to Thursday)	
Units of alcohol during the weekend (Friday to Sunday)	

Some individuals take medications to manage health complaints before their partner's pregnancy.

(a) Please list any medications you have taken in the 3 months before your partner became pregnant. Include any pharmaceutical or non-pharmaceutical medications (e.g. herbal medicines) not already listed by you in this questionnaire. Include tablets, creams, drops, injections and inhalers either prescribed for you or bought over the counter. You can put the type of medication if you do not know the name.

(b) Please identify any medications that have been reviewed or discussed with a health professional before your partner became pregnant.

	(a)	(b)			(b)
	Health condition/reason	Reviewed BEFORE being pregnant	GP	Midwife	Naturopath

	(a) Health condition/reason	(b) Reviewed BEFORE being pregnant	GP	Midwife	(b) Naturopath
Medication 1 (please write)		☐	☐	☐	☐
Medication 2 (please write)		☐	☐	☐	☐
Medication 3 (please write)		☐	☐	☐	☐
Medication 4 (please write)		☐	☐	☐	☐
Medication 5 (please write)		☐	☐	☐	☐
Medication 6 (please write)		☐	☐	☐	☐
Medication 7 (please write)		☐	☐	☐	☐

In the 3 months before your partner became pregnant were you seeing any health professionals for ongoing assistance with your health (e.g. doctor for medical

condition, counsellor for depression etc). (*If none, please write 'none'*)

	Reason for visit (please write)
Type of health professional (please write)	
Type of health professional (please write)	
Type of health professional (please write)	

Did you use any contraception in the 6 months before your partner became pregnant?

- ○ Yes
- ○ No—I was trying to conceive
- ○ No—I was not trying to conceive

Did you use any of the following methods of contraception in the 6 months before your partner became pregnant (*Please select all that apply*)

	Never	Some of the time	Every time
Withdrawal	○	○	○
Condoms	○	○	○
Abstinence (i.e. not having sex)	○	○	○

	Never	Some of the time	Every time
Intercourse timed around ovulation (e.g. Billings method)	○	○	○
Other (please give details)	○	○	○

If you stopped using contraception to try for your partner to become pregnant, how long (in *weeks* or *months*) was it before your partner became pregnant?

Weeks ☐

OR Months ☐

Some people take vitamins or supplements before their partner becomes pregnant.

Did you take any vitamins or supplements before your partner became pregnant?
(a) If 'No', please tick the box
(b) If 'Yes', how many weeks before your partner became pregnant did you start taking each vitamin or supplement?

(c) If 'Yes', how often did you take each vitamin or supplement?

	(a)	(b)	(c)			
	No	Number of weeks before pregnant	Every day	Most days	Occasionally	Other
Folic acid	☐		○	○	○	○
Ordinary multivitamin	☐		○	○	○	○
Vitamin C	☐		○	○	○	○
Zinc	☐		○	○	○	○
Omega 3 (e.g. fish oils)	☐		○	○	○	○
Antioxidants	☐		○	○	○	○
Herbal medicines	☐		○	○	○	○
Other (please give details)	☐		○	○	○	○
Other (please give details)	☐		○	○	○	○

On average, how many units of alcohol are you currently drinking during the week? How many units of alcohol do you drink on the weekend? (*if none please state '0'*).

Note: a unit of alcohol is equivalent to half a pint of beer, 1 small glass of wine, or a single measure of spirits)

Units of alcohol during the week (Monday to Thursday)

Units of alcohol during the weekend (Friday to Sunday)

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Definitely true 0	1	2	3	4	5	6	Definitely false 7
I exercised regularly for at least 6 months before my partner became pregnant								
I ate a healthy diet for at least 6 months before my partner became pregnant								
I avoided alcohol for at least 6 months before my partner became pregnant								

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Important 0	1	2	3	4	5	6	Not important 7
My doing regular exercise during the 6 months prior to my partner becoming pregnant is:								
My eating a healthy diet during the 6 months prior to my partner becoming pregnant is:								
My avoiding alcohol during the 6 months prior to my partner becoming pregnant is:								

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Pleasant 0	1	2	3	4	5	6	Unpleasant 7	
My doing regular exercise during the 6 months prior to my partner becoming pregnant is:									
My eating a healthy diet during the 6 months prior to my partner becoming pregnant is:									
My avoiding alcohol during the 6 months prior to my partner becoming pregnant is:									

Please answer each of the following questions by moving the marker to the number that best describes your

opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Good 0	1	2	3	4	5	6	Bad 7
My doing regular exercise during the 6 months prior to my partner becoming pregnant is:								
My eating a healthy diet during the 6 months prior to my partner becoming pregnant is:								
My avoiding alcohol during the 6 months prior to my partner becoming pregnant is:								

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Extremely likely 0	1	2	3	4	5	6	Extremely unlikely 7
Most people like me exercise regularly for 6 months before their partner becomes pregnant								
Most people like me eat a healthy diet for 6 months before their partner becomes pregnant								
Most people like me avoid alcohol for 6 months before their partner becomes pregnant								
If I maintain a healthy weight for 6 months before my partner becomes pregnant my child will be healthy								

	Extremely likely 0	1	2	3	4	5	6	Extremely unlikely 7
If I avoid alcohol for 6 months before my partner becomes pregnant my child will be healthy	○	○	○	○	○	○	○	○
If I exercise regularly for 6 months before my partner becomes pregnant my child will be healthy	○	○	○	○	○	○	○	○
If I eat a healthy diet for 6 months before becoming pregnant my child will be healthy	○	○	○	○	○	○	○	○
If I take vitamin supplements for 6 months before my partner becomes pregnant my child will be healthy	○	○	○	○	○	○	○	○

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Extremely likely 0	1	2	3	4	5	6	Extremely unlikely 7
If I take good care of my health for 6 months before my partner becomes pregnant my child will be healthy								
I intend to exercise regularly for at least 6 months before my partner becomes pregnant								
I am confident I can exercise regularly for 6 months before my partner becomes pregnant								

	Extremely likely 0	1	2	3	4	5	6	Extremely unlikely 7
I am confident I can avoid drinking alcohol for 6 months before my partner becomes pregnant								
I will make an effort to exercise regularly for at least 6 months before my partner becomes pregnant								
I will make an effort to avoid alcohol for at least 6 months before my partner becomes pregnant								
I am confident I can eat a healthy diet for 6 months before my partner becomes pregnant								

	Extremely likely 0	1	2	3	4	5	6	Extremely unlikely 7
Avoiding alcohol for 6 months before my partner becomes pregnant is up to me								
I intend to avoid alcohol for at least 6 months before my partner becomes pregnant								
I intend to eat a heathy diet for at least 6 months before my partner becomes pregnant								
Exercising regularly for 6 months before my partner becomes pregnant is up to me								

	Extremely likely 0	1	2	3	4	5	6	Extremely unlikely 7
I will make an effort to eat a heathy diet for at least 6 months before my partner becomes pregnant								
Eating a healthy diet for 6 months before my partner becomes pregnant is up to me								
If I do not smoke for 6 months before my partner becomes pregnant my child will be healthy								

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

Strongly agree Strongly disagree

	0 Strongly agree	1	2	3	4	5	6	7 Strongly disagree
	0	1	2	3	4	5	6	7
My reproductive partner thinks it's important for me to exercise regularly for 6 months before my partner becomes pregnant								
My reproductive partner thinks it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant								
My reproductive partner thinks it's important for me to avoid alcohol for 6 months before my partner becomes pregnant.								

Please answer each of the following questions by moving the marker to the number that best describes your

opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7
My older female relatives (e.g., mother, grandmother, aunt) think it's important for me to exercise regularly for 6 months before my partner becomes pregnant	○							☐
My older female relatives (e.g., mother, grandmother, aunt) think it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant	○							☐

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7
My older female relatives (e.g., mother, grandmother, aunt) think it's important for me to avoid alcohol for 6 months before my partner becomes pregnant								

Please answer each of the following questions by circling the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7
My female friends and family of similar age thinks it's important for me to exercise regularly for 6 months before my partner becomes pregnant								

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7
My female friends and family of similar age thinks it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant								
My female friends and family of similar age thinks it's important for me to avoid alcohol for 6 months before my partner becomes pregnant								

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7

	Strongly agree						Strongly disagree
	0	1	2	3	4	5	6	7
My older male relatives (e.g., father, grandfather, uncle) think it's important for me to exercise regularly for 6 months before my partner becomes pregnant	○							
My older male relatives (e.g., father, grandfather, uncle) think it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant	○							

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7
My older male relatives (e.g., father, grandfather, uncle) think it's important for me to avoid alcohol for 6 months before my partner becomes pregnant								

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7
My male friends and family of similar age thinks it's important for me to exercise regularly for 6 months before my partner becomes pregnant								

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7
My male friends and family of similar age thinks it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant								
My male friends and family of similar age thinks it's important for me to avoid alcohol for 6 months before my partner becomes pregnant								

Please answer each of the following questions by moving the marker to the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

	Strongly agree 0	1	2	3	4	5	6	Strongly disagree 7

	Strongly agree						Strongly disagree
	0	1	2	3	4	5	6	7
My health care provider thinks it's important for me to exercise regularly for 6 months before my partner becomes pregnant	○							
My health care provider thinks it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant	○							
My health care provider thinks it's important for me to avoid alcohol for 6 months before my partner becomes pregnant	○							

Section 4: Prepregnancy health information and advice

In the year before your partner became pregnant, did you look at any information about becoming pregnant?

- ○ Yes, I went looking for information and found it
- ○ Yes, I did not go looking for information but found it anyway
- ○ No, I went looking for information but did not find any
- ○ No, I did not go looking for information and did not find any

To whom did the pre-pregnancy health and care information you saw relate to?

- ○ Me only
- ○ My partner only
- ○ Both me and my partner

Which sources of pre-pregnancy health and care information can you remember seeing in the year before your partner became pregnant? (*Select all that apply*)

- ☐ Books
- ☐ Leaflets
- ☐ Internet
- ☐ Magazines
- ☐ Family or friends
- ☐ General practitioner (GP)
- ☐ Midwife

- ☐ Obstetrician/Gynecologist
- ☐ Pharmacist
- ☐ Naturopath
- ☐ Doula
- ☐ [ ] Other (please give details)

Before your partner became pregnant, did anyone give you information about any of the following topics within the context of preparing for pregnancy?

(a) If 'No', please tick the box

(b) If 'Yes', please indicate who provided the information

	(a)	(b) Yes, the information was provided by:				
	No	GP	Midwife	Obstetrician/ Gynecologist	Naturopath	Family/ Friends
Eating a healthy diet	☐	☐	☐	☐	☐	☐
Being the right weight for your height	☐	☐	☐	☐	☐	☐
Physical activity	☐	☐	☐	☐	☐	☐
Caffeine	☐	☐	☐	☐	☐	☐
Alcohol	☐	☐	☐	☐	☐	☐
Smoking	☐	☐	☐	☐	☐	☐
Street drugs	☐	☐	☐	☐	☐	☐

	(a)	(b) Yes, the information was provided by:				
	No	GP	Midwife	Obstetrician/ Gynecologist	Naturopath	Family/ Friends
Immunisation	☐	☐	☐	☐	☐	☐
Sexually transmitted infections	☐	☐	☐	☐	☐	☐
	No	GP	Midwife	Obstetrician/ Gynecologist	Naturopath	Family/ Friends
Stopping contraception	☐	☐	☐	☐	☐	☐
Conception/fertility	☐	☐	☐	☐	☐	☐
Air pollution	☐	☐	☐	☐	☐	☐
Pesticides	☐	☐	☐	☐	☐	☐
Exposure to heavy metals (e.g. lead or mercury)	☐	☐	☐	☐	☐	☐
Genetic screening	☐	☐	☐	☐	☐	☐
Reviewing medications	☐	☐	☐	☐	☐	☐
Domestic violence	☐	☐	☐	☐	☐	☐
Mental health	☐	☐	☐	☐	☐	☐

Some people take vitamins or supplements before their partner becomes pregnant.

Before your partner became pregnant, did anyone give you information about vitamins or supplements within the context of preparing for pregnancy?
(a) If 'No', please tick the box
(b) If 'Yes', please tick the box to indicate who provided you the information

	(a)	(b) Yes, the information was provided by:				
	No	GP	Midwife	Obstetrician/ Gynecologist	Naturopath	Family/ Friends
Folic acid	☐	☐	☐	☐	☐	☐
Ordinary multivitamin	☐	☐	☐	☐	☐	☐
Vitamin C	☐	☐	☐	☐	☐	☐
Zinc	☐	☐	☐	☐	☐	☐
Omega 3 (e.g. fish oils)	☐	☐	☐	☐	☐	☐
Antioxidants	☐	☐	☐	☐	☐	☐
Herbal medicines	☐	☐	☐	☐	☐	☐

In the year before you become pregnant did you visit a health professional about becoming pregnant?

- ○ Yes
- ○ No

If you were given pre-pregnancy health and care information by a health professional, who was the provided pre-pregnancy information about?

	Health professional visited for advice	Information about...			
	Did not visit	Me only	My partner only	Me and my partner	None provided
GP	☐	○	○	○	○
Midwife	☐	○	○	○	○
Naturopath	☐	○	○	○	○
Other (please give details)	☐	○	○	○	○

The next questions are similar to those asked earlier in the questionnaire. This time please answer them thinking about since you became pregnant with your current pregnancy.

Since your partner became pregnant, did you come across any information about becoming pregnant?

- ○ Yes, I went looking for information and found it
- ○ Yes, I did not go looking for information but found it anyway
- ○ No, I went looking for information but did not find any

○ No, I did not go looking for information and did not find any

Click to write the question text

- ☐ Books
- ☐ Leaflets
- ☐ Internet
- ☐ Magazines
- ☐ Family or friends
- ☐ Doula
- ☐ General practitioner (GP)
- ☐ Midwife
- ☐ Pharmacist
- ☐ Naturopath
- ☐ Obstetrician/Gynecologist
- ☐ Other (please give details)

To whom did the pre-pregnancy health and care information you saw relate to?

- ○ Me only
- ○ My partner only
- ○ Both me and my partner

Section 4: Your Health History

How would you describe your current health generally? Would you say it is (please tick one)

- ○ Excellent
- ○ Good
- ○ Fair
- ○ Poor

Do you have any longstanding illness, disability or infirmity? (Note: *Longstanding* means anything that has troubled your over a period of time or that is likely to affect you over a period of time)

- ○ Yes
- ○ No

In the 3 months before your partner became pregnant were you taking any medications/receiving treatment for OR had been diagnosed with any of the conditions listed below? (*Please tick all that apply*)

- ☐ Acne
- ☐ ADHD
- ☐ Allergies

- [ ] Anaemia
- [ ] Anxiety
- [ ] Asthma
- [ ] Bipolar disorder
- [ ] Coeliac disease
- [ ] Depression
- [ ] Insulin-dependent diabetes
- [ ] Non insulin-dependent diabetes
- [ ] Eating disorder (e.g. anorexia, bulemia)
- [ ] Endometriosis
- [ ] Epilepsy
- [ ] Heart disease
- [ ] High blood pressure
- [ ] HIV
- [ ] Kidney disease
- [ ] Lung disease
- [ ] Lupus
- [ ] Polycystic ovarian syndrome (PCOS)
- [ ] Phenylketonuria (PKU)
- [ ] Sexually transmitted infection
- [ ] Other (please give details)

How many pregnancies have you had with your current or previous partners before this current pregnancy? (Please put the number. If none, put '0')

How many, if any, of these previous pregnancies had the following complications... (Please put the number. If none, put '0')

Miscarriage	
Ectopic pregnancy (or tubal pregnancy)	
Still birth (i.e. birth of a baby that is not alive, past 24 weeks pregnancy)	
Terminated because of fetal/genetic abnormalities	

If you have experienced any of the above conditions you might like to someone about how you are feeling. You could ring Lifeline on 131114 (local call)

Are you the genetic parent for any children?

- ○ Yes
- ○ No

What is the year of birth for each of your children?

Child 1

Child 2

Child 3

Child 4

Child 5

Child 6

Please complete the table below for each child. Please tick if they have had any of the medical conditions. (Please tick all that apply)

	Child 1 Yes	Child 2 Yes	Child 3 Yes	Child 4 Yes	Child 5 Yes	Child 6 Yes
Born more than 3 weeks prematurely	☐	☐	☐	☐	☐	☐
Low birth weight (less than 2.5kg/5lb)	☐	☐	☐	☐	☐	☐

	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6
	Yes	Yes	Yes	Yes	Yes	Yes
Allergies	☐	☐	☐	☐	☐	☐
Asthma	☐	☐	☐	☐	☐	☐
Autism	☐	☐	☐	☐	☐	☐
Cerebral palsy	☐	☐	☐	☐	☐	☐
Cleft lip or palate	☐	☐	☐	☐	☐	☐
Downs syndrome	☐	☐	☐	☐	☐	☐
Neural tube defects	☐	☐	☐	☐	☐	☐
Spina bifida	☐	☐	☐	☐	☐	☐
Other major health condition or illness	☐	☐	☐	☐	☐	☐

Block 7

What is today's date?

Have we missed anything? If you have anything else you would like to tell us, please write it below

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APPENDIX 3.2 THE NATIONAL SURVEY OF HEALTH SERVICES UTILISATION IN THE AUSTRALIAN POPULATION

CM Use, Health and Disclosure in the Australian Population

Start of Block: Consent to participate

QID48
About this survey
Complementary Medicine Use, Health and Disclosure in the Australian Population

WHO IS CONDUCTING THIS RESEARCH?
My name is Dr Amie Steel and I am a Senior Research Fellow at the Australian Research Centre in Complementary and Integrative Medicine (ARCCIM), University of Technology Sydney (UTS). My colleagues are Distinguished Professor Jon Adams at ARCCIM, UTS, Dr Erica McIntyre, a Research Consultant at the Institute for Sustainable Future, UTS, and Dr Joanna Harnett, a Senior Lecturer at the University of Sydney.

WHAT IS THE RESEARCH ABOUT?
This research is to find out about the patterns of complementary medicine use in the Australian population. It is also designed to explore the patient experience and communication surrounding complementary medicine use in Australia.

WHY HAVE I BEEN INVITED?
You have been invited to participate because you are a member of the Australian population.

WHAT DOES MY PARTICIPATION INVOLVE?
If you decide to participate, we will invite you to complete an online questionnaire that will take between 15 and 40 minutes of your time, depending on your answers.

ARE THERE ANY RISKS/INCONVENIENCE?
Yes, there is some inconvenience as the survey will take up to 40 minutes to complete. The survey also asks questions about your physical and mental health and your experiences of health care, which may cause some discomfort if you have had distressing experiences in these areas. In the event that you feel distressed, you may wish to:
1. Take a short break for a few minutes
2. Contact one of the free support services listed here: https://www.healthdirect.gov.au/mental-health-helplines
3. Withdraw from the survey at any time without consequences by closing the browser window.

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HLD)

4. If you experience continued feelings of distress after the survey, the services listed in the above link can guide you in the process of seeking ongoing support from a suitable source – you may wish to save the link now for future reference.

DO I HAVE TO TAKE PART IN THIS RESEARCH PROJECT?

Participation in this study is voluntary. It is completely up to you whether or not you decide to take part. If you decide not to participate, or to withdraw from the study, it will not affect your relationship with the researchers or the University of Technology Sydney.

WHAT IF I WITHDRAW FROM THIS RESEARCH PROJECT?

If you wish to withdraw from the survey once it has started, you can do so at any time without having to give a reason, by closing your browser window. However, because your data is anonymous, we are unable to remove your responses if you withdraw.

WHAT WILL HAPPEN TO INFORMATION ABOUT ME?

By ticking the box on the next page and continuing to the survey, you consent to the research team using your questionnaire responses for the research project. All this information will be anonymous. It is anticipated the results of this research will be published and/or presented in a variety of forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified, as your responses will be anonymous. This survey may be repeated in future to capture changes occurring over time, in which case the data from this project may be used to draw comparisons.

The results of this research may also be shared through open access (public) scientific databases, including internet databases. This will enable other researchers to use the data to investigate other important research questions. Results shared in this way will always be anonymous as you will not be asked to provide any identifying information during the study.

WHAT IF I HAVE ANY QUERIES OR CONCERNS?

If you have queries or concerns about the research that you think we can help you with, please feel free to contact us on Amie.Steel@uts.edu.au.

NOTE: This study has been approved in line with the University of Technology Sydney Human Research Ethics Committee [UTS HREC] guidelines. If you have any concerns or complaints about any aspect of the conduct of this research that you wish to raise independently of the research team, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number ETH21-6461. Any matter raised will be treated confidentially, investigated and you will be informed of the outcome.

Qualtrics privacy notice

This survey has been developed by the Australian Research Centre in Complementary and Integrative Medicine, Faculty of Health, at the University of Technology Sydney (UTS). Information is being collected for the purposes outlined above. We invite you to compete this survey. Competing the survey is voluntary and your response to the survey will be anonymous. The information we are collecting will be used as outlined above. Information may also be used

and analysed at an aggregate level for quality improvement and planning purposes.

This survey is provided through Qualtrics. The survey responses will be stored on behalf of UTS by Qualtrics and extracted for use by UTS. Any personal information will not otherwise be disclosed unless you have provided express consent, or where required or permitted by law. Further information on privacy can also be found in the Qualtrics privacy statement.

If you wish to access or correct information held about you in relation to this survey, contact UTS at the details below. Note that information that is anonymous may not be identified for access or correction. For further information, contact Dr Amie Steel at Amie.Steel@uts.edu.au.

Page Break

*

QID1 **Consent to participate**

To continue with the survey, read the statements below and indicate your consent by checking the boxes.

☐ I agree to participate in the research project being conducted by Dr Amie Steel (4)

☐ I have read the Participant Information Sheet above or someone has read it to me in a language that I understand. (5)

☐ I understand the purposes, procedures and risks of the research as described in the Participant Information Sheet. (6)

☐ I have had an opportunity to contact the research team and I am satisfied with the information I have. (7)

☐ I freely agree to participate in this research project as described and understand that I am free to withdraw at any time without affecting my relationship with the researchers or the University of Technology Sydney. (8)

☐ I am aware that I can contact Dr Amie Steel (Amie.Steel@uts.edu.au) if I have any concerns about the research. (9)

Page Break

*

Q58 What was your age at your last birthday?

_____

*

QID5 What is your residential postcode?

_____

End of Block: Consent to participate

Start of Block: Section 1: Health

QID15 About your health and wellbeing
The following questions ask you how satisfied you feel, on a scale from 0 to 10. Zero means you feel no satisfaction at all and 10 means you feel completely satisfied.

QID13 Thinking about your own life and personal circumstances...

0	10

How satisfied are you with **your life as a whole**? ()	
How satisfied are you with **your standard of living**? ()	
How satisfied are you with **your health**? ()	
How satisfied are you with **what you are achieving in life**? ()	
How satisfied are you with **your personal relationships**? ()	
How satisfied are you with **how safe you feel**? ()	
How satisfied are you with **feeling part of your community**? ()	
How satisfied are you with **your future security**? ()	
How satisfied are you with **your spirituality and religion**? ()	

Page Break

QID18 In general, would you say your health is:

- ○ Excellent (1)
- ○ Very good (2)
- ○ Good (3)
- ○ Fair (4)
- ○ Poor (5)

Page Break

QID19 For how long (if at all) has your **health limited you** in **each** of the following activities?

	Limited for more than 3 months (1)	Limited for less than 3 months (2)	Not limited at all (3)
The kinds or amounts of **vigorous** activities you do, like lifting heavy objects, running or participating in strenuous sports (1)	○	○	○
The kinds or amounts of **moderate** activities you do, like moving a table, carrying groceries or bowling (2)	○	○	○
Walking uphill or climbing a few flights of stairs (3)	○	○	○
Bending, lifting, or stooping (4)	○	○	○
Walking one block (5)	○	○	○
Eating, dressing, bathing, or using the toilet (6)	○	○	○

Page Break

QID20 How much **bodily** pain have you had during the **past 4 weeks**?

- ○ None at all (1)
- ○ A little (2)
- ○ A moderate amount (3)
- ○ A lot (4)
- ○ A great deal (5)

QID21 Does your health **keep you** from working at a job, doing work around the house, or going to school?

- ○ YES, for more than 3 months (1)
- ○ YES, for 3 months or less (2)
- ○ NO (3)

QID22 Have you been unable to do **certain kinds or amounts** of work, housework or schoolwork because of your health?

- ○ YES, for more than 3 months (1)
- ○ YES, for 3 months or less (2)
- ○ NO (3)

Page Break

QID23 For **each** of the following questions, please select the one answer that comes **closest** to the way you have been feeling **during the past month**

	All of the time (1)	Most of the time (2)	A good bit of the time (3)	Some of the time (4)	A little of the time (5)	None of the time (6)
How much of the time, during the past month, has your **health limited your social activities** (like visiting with friends or close relatives)? (1)	○	○	○	○	○	○
How much of the time, during the past month, have you been a **very nervous person?** (2)	○	○	○	○	○	○
During the past month, how much of the time have you felt **calm and peaceful?** (3)	○	○	○	○	○	○
How much of the time, during the past month, have you felt **downhearted and blue?** (4)	○	○	○	○	○	○
During the past month, how much of the time have you been a **happy person?** (5)	○	○	○	○	○	○

How often, during the past month, have you felt so **down in the dumps that nothing could cheer you up?** (6)	○	○	○	○	○	○

Page Break

QID24 Please select the answer that **best** describes whether **each** of the following statements is **true** or **false** for you.

	Definitely true (1)	Mostly true (2)	Not sure (3)	Mostly false (4)	Definitely false (5)
I am somewhat ill (1)	○	○	○	○	○
I am as healthy as anybody I know (2)	○	○	○	○	○
My health is excellent (3)	○	○	○	○	○
I have been feeling bad lately (4)	○	○	○	○	○

Page Break

QID25 In the **last 3 years**, have you been **diagnosed with or treated for** (Mark all that apply):

- [ ] type 1 diabetes mellitus (1)
- [ ] non-insulin dependent diabetes (2)
- [ ] insulin-dependent diabetes (3)
- [ ] cancer (benign) (4)
- [ ] cancer (malignant) (5)
- [ ] heart disease (6)
- [ ] hypertension (high blood pressure) (7)
- [ ] dislipidaemia (high cholesterol/triglycerides) (8)
- [ ] COVID-19 (9)
- [ ] chronic fatigue syndrome/myalgic encephalomyelitis (19)
- [ ] fibromyalgia (20)
- [ ] migraine (59)
- [ ] an autoimmune condition (21)
- [ ] osteoarthritis (34)
- [ ] other musculoskeletal condition (35)
- [ ] asthma (36)
- [ ] bronchitis (37)
- [ ] other respiratory condition (38)

- [ ] endometriosis (39)
- [ ] polycystic ovary syndrome (PCOS) (40)
- [ ] other female reproductive health condition (41)
- [ ] benign prostatic hyperplasia (enlarged prostate) (42)
- [ ] other male reproductive health condition (43)
- [ ] irritable bowel syndrome (IBS) (44)
- [ ] inflammatory bowel disease (Crohn's, ulcerative colitis) (45)
- [ ] coeliac disease (46)
- [ ] gastrooesophageal reflux disease (GERD/GORD) (47)
- [ ] chronic constipation (48)
- [ ] other gastrointestinal condition (49)
- [ ] mood disorder (e.g. depression) (50)
- [ ] anxiety disorder (51)
- [ ] sleep disorder (52)
- [ ] substance use disorder (53)
- [ ] schizophrenia or other psychotic disorder (54)
- [ ] other mental health condition (55)
- [ ] Other long-term health condition (please specify) (56)

_____

☐ ⊗ None of the above (57)

Page Break

QID14 Are you or your partner currently pregnant?

- Yes (1)
- No (2)
- Unsure (3)

Display This Question:
If Are you or your partner currently pregnant? != Yes

QID16 Are you or your partner currently attempting to become pregnant?

- Yes (1)
- No (2)
- Unsure (3)

QID17 Do you or your partner plan to become pregnant in the next 12 months?

- Yes (1)
- No (2)
- Unsure (3)

End of Block: Section 1: Health

Start of Block: Section 2: Products and Practices

QID42 Did you use any of the following treatments in the **previous 12 months**? Please select all the responses that best apply to you

- [ ] prescription-only pharmaceuticals (1)
- [ ] over-the-counter pharmaceuticals (2)
- [ ] Chinese herbal medicines (3)
- [ ] Western herbal medicines (12)
- [ ] vitamin/mineral supplements (4)
- [ ] yoga practice (5)
- [ ] tai chi or qi gong practice (13)
- [ ] aromatherapy oils (used externally e.g., applied to the skin or inhaled) (6)
- [ ] aromatherapy oils (taken internally) (14)
- [ ] homeopathic remedies (7)
- [ ] flower essences (8)
- [ ] relaxation techniques/meditation/mindfulness practice (9)
- [ ] other - please specify: (10) _____

Display This Question:

If Did you use any of the following treatments in the previous 12 months? Please select all the resp... = prescription-only pharmaceuticals

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = over-the-counter pharmaceuticals

And If

Did you use any of the following treatments in the previous 12 months? Please select all the resp... = Chinese herbal medicines

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = Western herbal medicines

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = vitamin/mineral supplements

Q60 How often did you take **pharmaceuticals** on the same day as taking **herbal medicines/vitamin/mineral supplements**?

- ○ Never (1)
- ○ Rarely (2)
- ○ Sometimes (3)
- ○ Often (4)
- ○ Always (5)

Page Break

Display This Question:

If Did you use any of the following treatments in the previous 12 months? Please select all the resp... = prescription-only pharmaceuticals

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = over-the-counter pharmaceuticals

Q63 On average, how many **pharmaceutical medicines** (prescribed or over-the-counter) did you take **regularly** over the past 12 months?

_____

Display This Question:

If Did you use any of the following treatments in the previous 12 months? Please select all the resp... = Chinese herbal medicines

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = Western herbal medicines

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = vitamin/mineral supplements

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = aromatherapy oils (taken internally)

Q64 On average, how many **complementary medicine products** did you **regularly** take internally over the past 12 months?

Complementary medicines are treatments not normally considered part of mainstream healthcare, such as herbal medicine or nutritional supplements

_____

End of Block: Section 2: Products and Practices

Start of Block: Products and Prescriptions Loop

QID49 You said you used **${lm://Field/1}** in the **previous 12 months**. Who recommended or prescribed them to you? Please select the responses that best apply to you

- [ ] General practitioner (GP) (1)
- [ ] Specialist doctor (2)
- [ ] Hospital doctor (in outpatients or casualty) (9)
- [ ] Pharmacist (3)
- [ ] Pharmacy/healthfood retail assistant (4)
- [ ] Complementary medicine practitioner (e.g., naturopath, acupuncturist, chiropractor, etc) (5)
- [ ] Self-selected (6)
- [ ] Family member or friend (8)

QID50 And how much do you estimate you have spent on **${lm://Field/1}** in the **previous 12 months?** Write amount below.
If you did not spend anything, write '**0**'. If you can not recall, write '**unsure**'.

_____

End of Block: Products and Prescriptions Loop

Start of Block: Section 3: Health Service Utilisation

QID30 What was the **frequency of your visits** to the following health professionals in the **previous 12 months**? Please select the responses that best apply to you:

general practitioner (GP) (19)	▼ None (1) ... More than 6 (5)
specialist doctor (20)	▼ None (1) ... More than 6 (5)
hospital doctor (in outpatients or casualty) (21)	▼ None (1) ... More than 6 (5)
pharmacist (22)	▼ None (1) ... More than 6 (5)
counsellor or other mental health worker (23)	▼ None (1) ... More than 6 (5)
community nurse/nurse practitioner (24)	▼ None (1) ... More than 6 (5)
physiotherapist (25)	▼ None (1) ... More than 6 (5)
chiropractor (26)	▼ None (1) ... More than 6 (5)
dietician (27)	▼ None (1) ... More than 6 (5)
osteopath (28)	▼ None (1) ... More than 6 (5)
massage therapist (29)	▼ None (1) ... More than 6 (5)
acupuncturist (30)	▼ None (1) ... More than 6 (5)
naturopath (31)	▼ None (1) ... More than 6 (5)
Western herbalist (32)	▼ None (1) ... More than 6 (5)
traditional Chinese medicine practitioner (33)	▼ None (1) ... More than 6 (5)
homeopath (34)	▼ None (1) ... More than 6 (5)
yoga teacher (36)	▼ None (1) ... More than 6 (5)
Other - please specify (or select 'none') (37)	▼ None (1) ... More than 6 (5)

End of Block: Section 3: Health Service Utilisation

Start of Block: Condition-Profession Loop

Carry Forward Unselected Choices from "What was the frequency of your visits to the following health professionals in the previous 12 months? Please select the responses that best apply to you:"

QID35 Which, if any, of the following health care providers did you visit in the **previous 12 months** specifically **for your** ${lm://Field/1}?

- [ ] general practitioner (GP) (1)
- [ ] specialist doctor (2)
- [ ] hospital doctor (in outpatients or casualty) (3)
- [ ] pharmacist (4)
- [ ] counsellor or other mental health worker (5)
- [ ] community nurse/nurse practitioner (6)
- [ ] physiotherapist (7)
- [ ] chiropractor (8)
- [ ] dietician (9)
- [ ] osteopath (10)
- [ ] massage therapist (11)
- [ ] acupuncturist (12)
- [ ] naturopath (13)
- [ ] Western herbalist (14)
- [ ] traditional Chinese medicine practitioner (15)
- [ ] homeopath (16)
- [ ] yoga teacher (17)

☐ Other - please specify (or select 'none') (18)

End of Block: Condition-Profession Loop

Start of Block: Health Service Ute Loop

QID34 What was the **reason** for visiting a ${lm://Field/1} in the **previous 12 months**? Please select the responses that best apply to you.

☐ For an acute illness/condition, one that lasted less than 1 month (1)

☐ To treat a long-term health condition (one that lasted more than 1 month), or its symptoms (2)

☐ To improve wellbeing (3)

☐ Other - please specify (4)

*

QID37 What was the estimated cost to you **per** ${lm://Field/1} **visit** ($) - consultation fees only

Page Break

QID41 How did you attend your consultation/s with a ${lm://Field/1} **in the previous 12 months?** (select all that apply)

- [ ] In person (1)
- [ ] Telehealth (by phone or computer) (2)

QID27 What was the **outcome** of your visit with your ${lm://Field/1}? (select all that apply)

- [ ] I was provided an adequate explanation of my health complaint (1)
- [ ] I was provided a formal diagnosis of my health condition (2)
- [ ] I was prescribed an acceptable treatment plan to manage my health complaint (3)
- [ ] I am still bothered by the same health concern (4)
- [ ] I am bothered by a new health concern (5)
- [ ] Other - please specify: (6) _____

Page Break

QID60 During your visit, did the ${lm://Field/1} provide you with any of the following types of information? (Select all that apply)

- ☐ A verbal explanation (1)
- ☐ An individualised handout they gave to you during your visit (2)
- ☐ A pre-prepared handout that they gave to you during your visit (7)
- ☐ Directions on how to access information from another source (e.g. website or book) after your visit (8)
- ☐ Other - Please describe (9) _____
- ☐ ⊗ They did not provide me with any information (10)

Page Break

QID62 During your visit with the ${lm://Field/1}, did you share any of the following types of knowledge or information with them? (select all that apply)

- ☐ Knowledge based on your personal experience of living with your health condition (1)
- ☐ Information you acquired when visiting with another health professional (2)
- ☐ Information from books you have read (10)
- ☐ Information you found through social media (11)
- ☐ Information you found through broadcast media (e.g. radio, television) (12)
- ☐ Information you found through friends and family (13)
- ☐ Information you read in a journal article (14)
- ☐ Information you found through a research organisation (15)
- ☐ Information you found through a government website (16)
- ☐ Other - please describe (17) _____
- ☐ ⊗ I did not share any knowledge or information with them (18)

Page Break

QID64 During your visit with a ${lm://Field/1}, please indicate whether you **accessed care for**: (select all that apply)

- ☐ COVID symptoms (after diagnosis) (1)
- ☐ COVID symptoms (before diagnosis) (2)
- ☐ Prevention of COVID (3)
- ☐ ⊗ None of the above (7)

QID65 During your visit with a ${lm://Field/1}, please indicate whether you **discussed**: (select all that apply)

- ☐ COVID-related information (1)
- ☐ COVID vaccination information (2)
- ☐ ⊗ None of the above (7)

Page Break

QID31 When thinking about your **most recent visit** with your **${lm://Field/1}**, how much do you agree or disagree with the following statements?

	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
I feel seen and heard as a unique individual by my ${lm://Field/1} (1)	○	○	○	○	○
My ${lm://Field/1} has a full picture of me as a unique individual (2)	○	○	○	○	○
My ${lm://Field/1} is really interested in finding and addressing my health problems (3)	○	○	○	○	○
The root causes of my problems are **identified** by my ${lm://Field/1} (4)	○	○	○	○	○
The root causes of my problems are being **treated** by my ${lm://Field/1} (5)	○	○	○	○	○
The treatment is individualised for me at each consultation (6)	○	○	○	○	○
My ${lm://Field/1} **receives** feedback from my body that guides treatment	○	○	○	○	○

(7) My${lm://Field/1} **asks me** for feedback from my body that guides treatment (8)	○	○	○	○	○
I know what to expect during consultations and treatment (9)	○	○	○	○	○
My ${lm://Field/1} teaches me ways to relieve symptoms myself (10)	○	○	○	○	○

Page Break

Display This Question:

If Loop 19: general practitioner (GP), Current Loop

Or Loop 20: specialist doctor, Current Loop

Or Loop 21: hospital doctor (in outpatients... Current Loop

Or Loop 22: pharmacist, Current Loop

And If

Did you use any of the following treatments in the previous 12 months? Please select all the resp... = Chinese herbal medicines

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = Western herbal medicines

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = vitamin/mineral supplements

QID39

The following question relates to the disclosure of information about your use of health treatments to health professionals providing your health care in the **previous 12 months.**

Complementary medicines are treatments not normally considered part of mainstream healthcare, such as herbal medicine, nutritional supplements or homeopathy

Please select the response that best reflects your experience with your **${lm://Field/1}**...

- ○ I told them about ALL complementary medicines I was using (1)
- ○ I only told them about SOME of my complementary medicine use (2)
- ○ I DID NOT tell them about my complementary medicine use (3)

Page Break

Display This Question:

If Loop current: The following question relates to the disclosure of information about your use of health treatmen... = I only told them about SOME of my complementary medicine use

Or Loop current: The following question relates to the disclosure of information about your use of health treatmen... = I DID NOT tell them about my complementary medicine use

QID40
The following questions relate to your interactions with a medical doctor in the **last 12 months**. Please indicate your level of agreement with the following statements

I **did not disclose** my complementary medicine use to my **${Im://Field/1}** because...

	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
They did not ask me about my complementary medicine use (1)	○	○	○	○	○
I did not think they would understand my choice (2)	○	○	○	○	○
I was worried they would judge me (3)	○	○	○	○	○
Complementary medicines are safe (4)	○	○	○	○	○
They did not need to know (5)	○	○	○	○	○
There was not enough time in the consultation (6)	○	○	○	○	○
I felt uncomfortable discussing it with them (7)	○	○	○	○	○
I was worried they wouldn't support my treatment decisions (8)	○	○	○	○	○
I did not think they would know anything about complementary	○	○	○	○	○

medicine (9)					
It is none of their business (10)	○	○	○	○	○
I was worried they would try to discourage my use of complementary medicine (11)	○	○	○	○	○
They do not approve of my use of complementary medicine (12)	○	○	○	○	○
I was worried they would respond negatively (13)	○	○	○	○	○
I previously had a negative experience when I disclosed complementary medicine use (14)	○	○	○	○	○

Page Break

Display This Question:

If Loop current: The following question relates to the disclosure of information about your use of health treatmen... = I told them about ALL complementary medicines I was using

Or Loop current: The following question relates to the disclosure of information about your use of health treatmen... = I only told them about SOME of my complementary medicine use

QID36
The following questions relate to your interactions with a medical doctor in the **last 12 months**. Please indicate your level of agreement with the following statements

I **disclosed** my complementary medicine use to my ${lm://Field/1} because...

	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
I wanted them to fully understand my health status (1)	○	○	○	○	○
I was concerned about drug interactions with the complementary medicine I was using (2)	○	○	○	○	○
I thought they might know something useful about complementary medicine (3)	○	○	○	○	○
The asked me about my use of complementary medicine (4)	○	○	○	○	○
I have a good relationship with them (5)	○	○	○	○	○
I felt comfortable discussing complementary medicine with them (6)	○	○	○	○	○
I knew they would be willing to discuss my complementary	○	○	○	○	○

medicine use (7)					
I wanted their approval of my complementary medicine use (8)	○	○	○	○	○
I knew they would understand about my complementary medicine use (9)	○	○	○	○	○
They have a good attitude towards complementary medicine (10)	○	○	○	○	○
They are open-minded (11)	○	○	○	○	○
I thought they could help with my treatment decisions (12)	○	○	○	○	○
They support my use of complementary medicine (13)	○	○	○	○	○
They understand my treatment goals (14)	○	○	○	○	○
They have my best interests at heart (15)	○	○	○	○	○
I wanted their advice about complementary medicines (16)	○	○	○	○	○

Page Break

Display This Question:

If Loop 26: chiropractor, Current Loop

Or Loop 28: osteopath, Current Loop

Or Loop 29: massage therapist, Current Loop

Or Loop 30: acupuncturist, Current Loop

Or Loop 31: naturopath, Current Loop

Or Loop 32: Western herbalist, Current Loop

Or Loop 33: traditional Chinese medicine pr... Current Loop

Or Loop 34: homeopath, Current Loop

And If

Did you use any of the following treatments in the previous 12 months? Please select all the resp... = prescription-only pharmaceuticals

Or Did you use any of the following treatments in the previous 12 months? Please select all the resp... = over-the-counter pharmaceuticals

QID44

The following questions relate to the **disclosure** of information about your use of **conventional medicines** to **complementary medicine practitioners** providing you health care.

Conventional medicines are treatments that are considered part of mainstream healthcare, such as pharmaceutical drugs.

Please select the response that best reflects your experience with your **${lm://Field/1}** in the **previous 12 months**...

- ○ I told them about ALL conventional medicines I was using (1)
- ○ I only told them about SOME of my conventional medicine use (2)
- ○ I DID NOT tell them about my conventional medicine use (3)

Page Break

Display This Question:

If Loop current: The following questions relate to the disclosure of information about your use of conventional me... = I only told them about SOME of my conventional medicine use

Or Loop current: The following questions relate to the disclosure of information about your use of conventional me... = I DID NOT tell them about my conventional medicine use

QID52

The following questions relate to your interactions with complementary medicine practitioners (e.g. naturopath, herbalist, homeopath) in the **last 12 months**. Please indicate your level of agreement with the following statements

I **did not disclose** my conventional medicine use to my **${lm://Field/1}** because...

	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
They did not ask me about my conventional medicine use (1)	○	○	○	○	○
I did not think it was important (2)	○	○	○	○	○
I did not think they would understand my choice (3)	○	○	○	○	○
I was worried they would judge me (4)	○	○	○	○	○
They did not need to know (5)	○	○	○	○	○
There was not enough time in the consultation (6)	○	○	○	○	○
I felt uncomfortable discussing it with them (7)	○	○	○	○	○
I was worried they wouldn't support my treatment decisions (8)	○	○	○	○	○
I did not think they would know	○	○	○	○	○

anything about conventional medicines (9)					
I forgot to mention it (10)	○	○	○	○	○
It is none of their business (11)	○	○	○	○	○
I was worried they would try to discourage my use of conventional medicines (12)	○	○	○	○	○
They do not approve of my use of conventional medicines (13)	○	○	○	○	○
I was worried they would respond negatively (14)	○	○	○	○	○
I do not use conventional medicines regularly enough (15)	○	○	○	○	○
I previously had a negative experience when I disclosed using conventional medicine (16)	○	○	○	○	○

Page Break

Display This Question:

If Loop current: The following questions relate to the disclosure of information about your use of conventional me... = I told them about ALL conventional medicines I was using

Or Loop current: The following questions relate to the disclosure of information about your use of conventional me... = I only told them about SOME of my conventional medicine use

QID45

The following questions relate to your interactions with complementary medicine practitioners (e.g. naturopath, herbalist, homeopath) in the **last 12 months**. Please indicate your level of agreement with the following statements

I **disclosed** my conventional medicine use to my **${lm://Field/1}** because...

	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
I wanted them to fully understand my health status (1)	○	○	○	○	○
I was concerned about interactions with the conventional medicine I was using (2)	○	○	○	○	○
I thought they might know something about conventional medicines (3)	○	○	○	○	○
They asked me about my use of conventional medicines (4)	○	○	○	○	○
I have a good relationship with them (5)	○	○	○	○	○
I felt comfortable discussing conventional medicines with them (6)	○	○	○	○	○
I knew they would be willing to discuss my	○	○	○	○	○

conventional medicine use (7)					
I wanted their approval of my conventional medicine use (8)	○	○	○	○	○
I knew they would understand about my conventional medicine use (9)	○	○	○	○	○
They have a good attitude towards conventional medicine (10)	○	○	○	○	○
They are open-minded (11)	○	○	○	○	○
I thought they could help with my treatment decisions (12)	○	○	○	○	○
They support my use of conventional medicines (13)	○	○	○	○	○
They understand my treatment goals (14)	○	○	○	○	○
They have my best interests at heart (15)	○	○	○	○	○

I was concerned about side-effects of conventional medicines (16)	○	○	○	○	○
I wanted their advice about conventional medicines (17)	○	○	○	○	○

End of Block: Health Service Ute Loop

Start of Block: Ethics Risk/Harm reminder for potential distress

Ethics
We appreciate the responses you have provided so far regarding your health and experiences of health care.
If these questions have caused you any discomfort or distress, remember that you can access free support services at this link:
https://www.healthdirect.gov.au/mental-health-helplines
You are almost at the end of the survey.

End of Block: Ethics Risk/Harm reminder for potential distress

Start of Block: Section 4: Demographics

QID2 About You
Which gender do you identify with?

- ○ Female (1)
- ○ Male (2)
- ○ Non-binary (3)
- ○ Prefer to self-describe/other (please specify): (4) _____

QID4 What is your age range?

- ○ 18-24 (1)
- ○ 25-34 (2)
- ○ 35-44 (3)
- ○ 45-54 (4)
- ○ 55-64 (5)
- ○ 65 and over (6)

Page Break

QID6 How do you manage financially at the moment?

- ○ It is impossible (1)
- ○ It is difficult all of the time (2)
- ○ It is difficult some of the time (3)
- ○ It is not too bad (4)
- ○ It is easy (5)

QID7 What is the highest qualification you have completed?

- ○ No formal qualifications (1)
- ○ Year 10 or equivalent (2)
- ○ Year 12 or equivalent (3)
- ○ Trade/apprenticeship (4)
- ○ Certificate/diploma (5)
- ○ University degree (6)
- ○ Higher university degree (e.g. Masters, PhD) (7)

Page Break

QID8 Do you currently have private health insurance?

- ○ Yes (1)
- ○ No (2)

QID9 Do you currently have a Health Care Card?

- ○ Yes (1)
- ○ No (2)

QID10 What best describes your current employment status?

- ○ Full time work (35 or more hours per week) (1)
- ○ Part time work (less than 35 hours per week) (2)
- ○ Casual/temp work (irregular hours) (3)
- ○ Looking for work (4)
- ○ Not in the paid workforce (5)

Page Break

QID11 What is your present relationship status?

- ○ Never married (1)
- ○ Married (opposite sex) (2)
- ○ Married (same sex) (3)
- ○ De facto (opposite sex) (4)
- ○ De facto (same sex) (5)
- ○ Separated (6)
- ○ Divorced (7)
- ○ Widowed (8)

Page Break

Display This Question:

If Do you currently have private health insurance? = Yes

QID12 If you currently have private health insurance for ancillary services, please indicate which services are covered:

- ☐ ⊗ I do not have private health insurance for ancillary services (1)
- ☐ Physiotherapy (2)
- ☐ Psychology services (3)
- ☐ Chiropractic (4)
- ☐ Osteopathy (5)
- ☐ Acupuncture (6)
- ☐ Chinese medicine/herbs (7)
- ☐ Remedial massage/massage therapy (8)
- ☐ Nutrition/dietetics (9)
- ☐ ⊗ Not sure (10)

Page Break

End of Block: Section 4: Demographics

Start of Block: Block 9

End We appreciate the responses you have provided today.
If any questions have caused you discomfort or distress, remember that you can access free support services at this link:
https://www.healthdirect.gov.au/mental-health-helplines

End of Block: Block 9

APPENDIX 4.1 PUBLISHED MANUSCRIPT ASSOCIATED WITH RESULTS REPORTED IN CHAPTER FOUR

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BMC Public Health

RESEARCH Open Access

Paternal preconception modifiable risk factors for adverse pregnancy and offspring outcomes: a review of contemporary evidence from observational studies

Tristan Carter[1*], Danielle Schoenaker[2,3], Jon Adams[1] and Amie Steel[1]

Abstract

Background The preconception period represents transgenerational opportunities to optimize modifiable risk factors associated with both short and long-term adverse health outcomes for women, men, and children. As such, preconception care is recommended to couples during this time to enable them to optimise their health in preparation for pregnancy. Historically, preconception research predominately focuses on maternal modifiable risks and health behaviours associated with pregnancy and offspring outcomes; limited attention has been given to inform paternal preconception health risks and outcomes. This systematic review aims to advance paternal preconception research by synthesising the current evidence on modifiable paternal preconception health behaviours and risk factors to identify associations with pregnancy and/or offspring outcomes.

Methods Medline, Embase, Maternity and Infant care, CINAHL, PsycINFO, Scopus, and ISI Proceedings were searched on the 5th of January 2023, a date limit was set [2012–2023] in each database. A Google Scholar search was also conducted identifying all other relevant papers. Studies were included if they were observational, reporting associations of modifiable risk factors in the preconception period among males (e.g., identified as reproductive partners of pregnant women and/or fathers of offspring for which outcomes were reported) with adverse pregnancy and offspring outcomes. Study quality was assessed using the Newcastle–Ottawa Scale. Exposure and outcome heterogeneity precluded meta-analysis, and results were summarised in tables.

Results This review identified 56 cohort and nine case control studies. Studies reported on a range of risk factors and/or health behaviours including paternal body composition ($n=25$), alcohol intake ($n=6$), cannabis use ($n=5$), physical activity ($n=2$), smoking ($n=20$), stress ($n=3$) and nutrition ($n=13$). Outcomes included fecundability, IVF/ISCI live birth, offspring weight, body composition/BMI, asthma, lung function, leukemia, preterm birth, and behavioural issues. Despite the limited number of studies and substantial heterogeneity in reporting, results of studies assessed as good quality showed that paternal smoking may increase the risk of birth defects and higher paternal BMI was associated with higher offspring birthweight.

Conclusion The current evidence demonstrates a role of paternal preconception health in influencing outcomes related to pregnancy success and offspring health. The evidence is however limited and heterogenous, and further

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high-quality research is needed to inform clinical preconception care guidelines to support men and couples to prepare for a health pregnancy and child.

Keywords Paternal, Preconception, Modifiable, Risk factor, Pregnancy outcomes, Offspring outcomes

Plain English Summary

The time prior to conception, preconception, is widely acknowledged as an integral period whereby a woman's health, lifestyle, and diet influence the outcomes of future pregnancy and the health of future offspring. Similarly, the influence of a man's health, lifestyle, and diet during preconception on pregnancy and offspring outcomes must be considered. However, the male reproductive partner's role during preconception has attracted much less researcher attention when compared to maternal exposures and outcomes and may be undervalued.

Therefore, this review explores the modifiable risk factors of males in the preconception period and how these risks influence adverse pregnancy and/or offspring outcomes. A total of 65 papers are included for review which examined risks associated with factors such as alcohol use, physical activity, stress, and nutrition. Overall, the papers identified some consistent results: paternal smoking increased risk of adverse offspring outcomes, while increased paternal body mass index was associated with higher offspring birthweight. Nevertheless, this review concludes that paternal preconception modifiable risk factors remain largely underexplored. Evidently, more high-quality research must be conducted to better understand the health, lifestyle, and diets of males in the preconception period and how various paternal modifiable risks can influence their partner's pregnancy and the health and developmental outcomes of their offspring.

Introduction

Preconception care is defined as the provision of health interventions (behavioural, social, and/or biomedical) to women and couples prior to conception [1]. It addresses the transgenerational opportunity of enabling and optimizing health while limiting risk factors associated with both short- and long-term adverse health outcomes for women, men, and their children. There is global consensus on the key aspects of preconception care [2], yet a consistent definition and clear attributes of the preconception population remain elusive [3]. Preconception research predominately focuses on maternal modifiable risks or health behaviours associated with offspring outcomes [4] as demonstrated by a scoping review of preconception health behaviours which found only 11% of all studies included paternal modifiable risks or health behaviours [5]. Nonetheless, the research community recognizes the father or male partner's contribution to child health and development before birth [6, 7] and the need to balance our gaze on men in preconception care [8]. This is further supported by the increasing number and diversity of publications about paternal preconception health [9] and formulation of the Paternal Origins of Health and Disease (POHaD) model [10]. As such, the preconception population may include all reproductively aged individuals in a period from their birth to the conception of their (or their partner's) pregnancy. The care provided during this period must respond to a clear set of identified risk factors and exposures as relevant to each individual.

Indeed, when planning parenthood, males find themselves within a contentious grey zone; concurrently involved while also considered an outsider [11]. A recent survey in the UK found that men are interested in engaging in positive preconception health behaviours [7]. Of the over 500 men surveyed, 19% had visited a primary health provider for preconception health advice, and those who had received advice were more likely to adopt positive health behaviours before their partner's pregnancy. On the other hand, general practitioners (GPs) report low confidence in their knowledge about paternal preconception health care and modifiable factors affecting male fertility [12, 13]. They describe feeling apprehensive or even sensitive to the subject matter and/or challenged by navigating the stereotypical masculine predispositions toward fertility and preconception care [14]. In general, preconception risks are not raised by GPs with male patients unless subfertility is involved and preconception discussions are often encumbered by numerous impediments including the limited time, financial constraints, and knowledge of GPs, plus in some cases, a lack of GP motivation and perceived need for health care [12]. A systematic review of preconception care guidelines found that six of the 11 guidelines included provided preconception care guidance for men [15]. Only one guideline, a position paper from the American Academy of Family Physicians, contained a dedicated section outlining recommendations on preconception interventions for men [16]. Evidently, there is an unmet need for health professionals, and men, to readily access current relevant information regarding paternal preconception health exposures and outcomes, informing clinical practice and directing health decisions.

Evidence supporting paternal preconception care considers males contribution to child health and development before conception via direct (genetic and epigenetic contributions – health and lifestyle behaviours, exposure to environmental toxins, life stressors, and neuroendocrinology) and indirect pathways (the couple's relationship, and the influence of men on their partner's health and health behaviours) [17]. Yet, there is a stark contrast between the magnitude of research investigating maternal preconception health risks—including body composition, lifestyle behaviours, and diet/nutrition – and the relative scarcity of research attention directed towards understanding paternal health exposures and outcomes. In direct response, this systematic review aims to advance paternal preconception research by synthesising the current evidence on associations of modifiable paternal preconception health behaviours and risk factors with pregnancy and/or offspring outcomes.

Methods

This review was prospectively registered in PROSPERO (Registration Number: CRD42021209994), and reported in line with PRISMA 2020 guidance [18] and the AMSTAR 2 critical appraisal tool [19].

Search strategy

A search was conducted on January 5th 2023, (See Supplementary File 1 Search strategy), through the following databases: 1) Medline (OVID) 2) Embase (OVID), 3) Maternity and Infant care [MIDIRS] (OVID) 4) CINAHL (EBSCO), 5) PsycINFO (EBSCO), 6) Scopus, & 7) ISI Proceedings. For each database, a date limit of 2012–2023 was set. When available, subject headings identified from the controlled vocabulary of each database were also included in the search. On January 11th 2023, a Google Scholar search was conducted for the search term 'Paternal preconception', applying the filter to limit articles published since 2022 and searching through to page seven, identifying any other recently published relevant papers. Google Scholar was also used to identify relevant studies citing each included paper. Reference lists of each included paper were then checked for additional relevant studies.

Selection criteria

Papers were included if they were original contemporary observational research (cross-sectional, cohort or case–control study designs) involving males in the preconception period, examining an association or correlation of a modifiable risk factor or health behaviour to pregnancy and/or offspring health and developmental outcomes. The male participants must identify as being the partner of the pregnant women and/or the biological father of the child for which pregnancy and offspring outcomes were reported (Table 1 – PICO).

Observational study designs are generally utilized to identify correlations and establish findings at the population level hence are solely considered in this review.

Papers were excluded if they were: reviews, did not report new empirical findings from original studies (i.e. commentaries, opinion-pieces and editorials), not studying humans, not examining male parent exposures, did not differentiate between maternal and paternal preconception exposures, or if the exposure examined specific illness populations. Papers were also excluded when the exposure was not assessed or retrospectively recalled during the preconception period, the outcome was not related to pregnancy or offspring health or development, or the risk factor or health behaviour was not modifiable. Google Translate was used to decipher any studies located in languages other than English.

Data extraction

Papers were imported into Covidence systematic review software [20], and duplicates removed by automation. Titles and abstracts were screened by TC, AS and DS. Full-text articles were obtained for relevant studies and reviewed based on inclusion criteria by TC who then extracted data from each included paper. AS or DS randomly reviewed the extracted data of ten included studies for accuracy and completeness. Any conflicts were resolved by consensus.

Data extracted from each paper included: the authors and year, study design and duration, location, the preconception population, total number of participants, the paternal exposures (and exposure measures), paternal outcomes (and outcome measures), any covariates considered and the main results from each association reported.

Quality assessment

The quality of each paper was assessed by TC using the Newcastle–Ottawa Scale (NOS). The NOS comprises three domains 1) selection of participants, 2) comparability of study groups, and 3) outcome of interest (cohort studies) or ascertainment of exposure (case–control studies), assigning stars in each domain to a maximum of nine stars [21]. Papers were then categorized as good quality (7–9 stars), fair quality (4–6 stars) or poor quality (0–3 stars) using groupings employed in previous research [22].

A meta-analysis was considered, but not possible due to exposure and outcome heterogeneity.

Table 1 PICO (Population, Intervention, Comparison, Outcome) inclusion criteria

Population	Intervention/Exposure	Comparison	Outcome
Males who identified as being the partner of the pregnant women and/or the biological father of the child for which outcomes were reported	Exposure to modifiable risk factor(s) in the pre-conception period	No exposure to modifiable risk factor(s) in the preconception period (or comparison group as defined by individual studies)	Adverse pregnancy and offspring outcomes

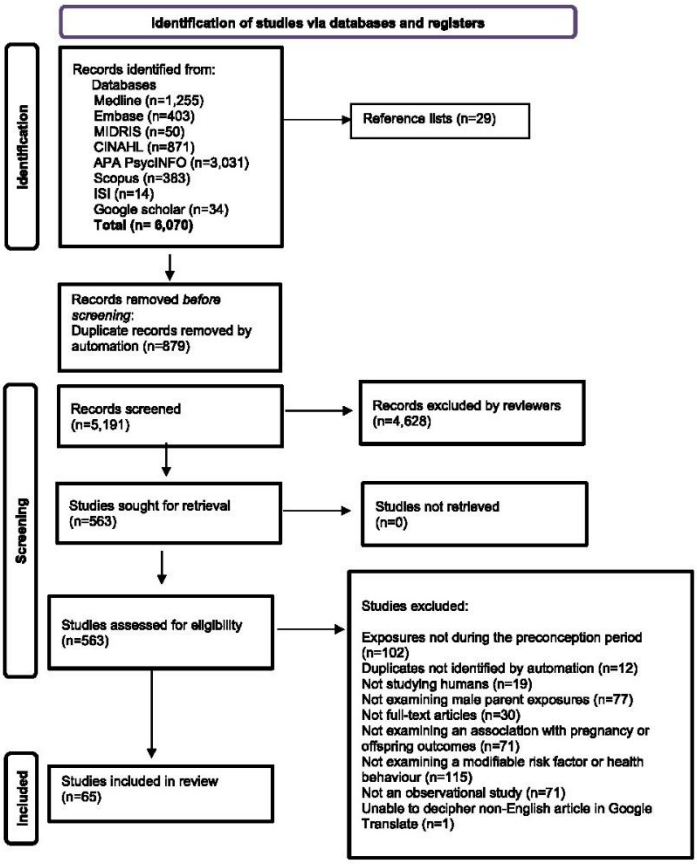

Fig. 1 PRISMA Flowchart

Results

A total of 65 papers were included in this review (Fig. 1 – PRISMA Flowchart) [18], comprising cohort ($n=56$) and case control studies ($n=9$) (Table 2 – Summary Table) & (Table 3 – Summary Table Findings). The majority of papers were conducted in the USA ($n=18$), Europe and the UK ($n=19$), and China ($n=17$), several papers were from Australia [23–29] or included an Australian health centre [30–34]. Approximately half of all papers ($n=29$) included a sample size between 370 and 2,900, while others included > 20,000 ($n=11$) or ≤ 200 participants ($n=13$).

Study participants were diverse consisting of couples either intending pregnancy or pregnant ($n=25$), sub-fertile and seeking fertility treatment undergoing IVF/ICSI ($n=11$), or mothers and fathers of infants ($n=26$). Two studies included adolescents followed into parenthood as adults [42, 80], and one study included individual respondents of a national family growth survey, actively attempting pregnancy [59].

Modifiable preconception risk factors and/or health behaviour exposures examined include paternal body composition ($n=25$), alcohol intake ($n=6$), cannabis use ($n=5$), physical activity ($n=2$), smoking ($n=20$), stress ($n=3$), and nutrition ($n=13$) (including dietary folate intake and consumption of foods and dietary patterns). Two papers investigated multiple exposures [42, 43].

Table 2 Summary table

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Body Composition									
Bowatte et al. 2022 [25]	Australia	Cohort [Prospective] Tasmanian Longitudinal Health Study (TAHS) 1968—2021	Mothers & **Fathers (*N* = 836)** of offspring (*n* = 1,938)	Paternal height and weight obtained from school medical records	*BMI* – BMI trajectory from early childhood (4–6 years) to late childhood (9–10 years) and adolescence (14–15 years)	1)Maternal report of asthma at 14 years 2) Paternal report of asthma at 14 years 3) Grandfather or Grandmother ever asthma 4) Smoking status of Grandfather or Grandmother during paternal childhood 5) Grandfather's occupation	1) 'Ever' Allergic asthma 2) Asthma onset before 10 years old 3) Asthma onset after 10 years old	Offspring asthma	5
Broadney et al. 2017 [35]	USA	Cohort [Retrospective] Upstate KIDS Study (Population-based) 2008–2010	Mothers & **Fathers (*N* = 2,974)** of infants (*n* = 3,555)	Maternal report of paternal weight & height on baseline questionnaire at 4 months postpartum	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Maternal age, 2) Race/ethnicity, 3) Education, 4) Private insurance, 5) Maternal smoking during pregnancy, 6) Alcohol use during pregnancy, 7) Parity, 8) Infant plurality, 9) Maternal pre-pregnancy BMI	Inflammatory biomarker [CRP] and Ig levels	Inflammation & immune response of neonates	6
Casas et al. 2017 [36]	Spain	Cohort [Prospective] INfancia y Medio Ambiente- Environment and Childhood [INMA] (Population-based) 2003–2008	Pregnant couples & their expectant children **(*N* = 1,827)**	Maternal report of paternal weight & height at first prenatal visit approximately 14 weeks of gestation	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parental age, 2) Sex of the child, 3) Parental education, 4) Parental social class, 5) Parity, 6) Maternal IQ, 7) Maternal employment status during pregnancy and at 5 years, 8) Breastfeeding duration, 9) Daycare attendance, 10) Child physical activity, 11) Maternal BMI	**1)** McCarthy Scales of Children's Abilities (MSCA) [contexualized to Spanish], & **2)** The attention deficit hyoperactivity disorder [ADHD] Criteria of Diagnostic and Statistical Manual of Mental Health Disorders—4th Edition (ADHD-DSM-IV)	Neuropsychological development of preschool children around 5 years old	9
Chen et al. 2021 [37]	China	Cohort [Retrospective] Women's Hospital, School of Medicine, Zhejiang University (Hospital-based) 2013—2016	Subfertile couples **(Males [*N* = 2,318])** undergoing IVF/ICSI fresh embryo transfer cycles resulting in singletons (*n* = 1,366) and twins (*n* = 952)	Third Party—Measurement of paternal weight and height by trained nurse	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Parental age, 2) type of infertility, 3) duration of infertility, 4) ovulatory dysfunction, 5) endometriosis, 6) maternal prepregnancy BMI	International classification of Diseases, 10th Revision (ICD-10) into 9 subcategories	Birth defect	5

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Fang et al. 2020 [38]	China	Cohort [Retrospective] National Free Preconception Health Examination Project (NFPHEP) (Population-based) 2012–2016	Couples planning to conceive **[Males [*N* = 50,927])**	Third Party—Measurement of paternal weight and height by physician	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Age, 2) type of household, 3) education, 4) smoking, 5) alcohol consumption, 6) psychosocial pressure and ready for pregnancy 7) cycle regularity, 8) age of menarche, 9) gravidity, 10) spontaneous abortion, 11) induced abortion	Time to pregnancy (TTP) = interval between the date of enrolment and last menstrual period (LMP)	Fecundability	5
Fleten et al. 2012 [39]	Norway	Cohort [Prospective] Norwegian Mother and Child cohort study (MoBa) (Population-based) 1999–2009	Pregnant couples & their expectant children **(*N* = 29,216)**	Paternal self-report of weight and height (20%) OR maternal report of paternal weight and height (80%) at approximately 17 weeks of gestation	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parental educational level (years), 2) Paternal and maternal prenatal smoking, 3) Maternal coffee consumption during pregnancy, 4) Parental BMI	Body mass index (BMI) at 3 years old	Offspring adiposity	6
Guo et al. 2022 [40]	China	Cohort [Retrospective] National Free Pre-conception Check-up Projects (NFPCP) 2013–2017	Nulliparous couples attempting pregnancy **(Males [*N* = 4,719,813])**	Third Party—Physician measurement of paternal weight and height	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared) during participation in the NFPCP	1)Maternal and paternal age at last menstrual period, 2) Maternal and paternal height 3) Education level, 4) Parity, 5) Ethnicity, 6) Area of residence 7) Maternal Diabetes, 8) Maternal Hypertension, 9) Smoking 10) Alcohol use 11) Passive smoking 12) History of adverse pregnancy incl preterm birth, stillbirth, or spontaneous abortion in previous pregnancies	**1)** Large-for-gestational- age (LGA) = birthweight above 90th percentile according to birthweight centiles for a Chinese population, & **2)** Small-for-gestational-age (SGA) = birthweight below the tenth percentile on birthweight centiles for a Chinese population	Offspring birthweight	6
Hoek et al. 2022 [41]	The Netherlands	Cohort [Prospective] Rotterdam Periconception Cohort (PREDICT Study) (Hospital-based) 2017–2019	Subfertile couples (**Males [N = 221])** undergoing IVF/ICSI with cultured embryos (*n* = 757)	Third party—Anthropometric assessment completed by a trained nurse at baseline	*BMI*—"Preconceptional" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Total motile sperm count [TMSC], 2) Age, 3) Ethnicity, 4) Smoking, 5) Alcohol use, 6) Education	**1)** Fertilization rate, **2)** TMSC **3)** Embryo developmental morphokinetics, **4)** Embryo quality assessed by a time-lapse prediction algorithm (KIDScore), & **5)** Live birth rate	IVF/ICSI induced live birth	8

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Johannessen et al. 2020 [33]	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013–2016	Mothers & **Fathers (*N* = 2044),** of adult offspring (*n* = 2,822)	Paternal self-report based upon validated figural drawing scale of 9 sex-specific silhouettes	*BMI*—"Overweight status"To identify subjects at risk for overweight body size (BMI, 25–30 kg/m^2) at 8 years old, at puberty, and at age 30 years before offspring conception	1)Paternal asthma status, 2) Education level 3) Maternal overweight status 4) Maternal asthma status 5) Offspring sex 6) Offspring age	Parent report in the RHINESSA questionnaire	Adult offspring asthma with or without nasal allergies	6
Lonnebotn et al. 2022 [34]	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013–2016	Mothers & **Fathers (*N* = 308)** of adult offspring (*n* = 420)	Paternal self-report based upon validated figural drawing scale of 9 sex-specific silhouettes	*BMI*—"Overweight status"To identify subjects at risk for overweight body size (BMI, 25–30 kg/m^2) at 8 years old and at puberty	1)Maternal education 2) Paternal education 3) Offspring age 4) Smoking history	Pre/post bronchodilator forced expiratory volume in one second (FEV1) & forced vital capacity (FVC)	Adult offspring lung function	7
Moss et al. 2015[a] [42]	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994–2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants **(*N* = 372)**	Third party—Anthropometric assessment completed by a trained professional at baseline	*BMI*—"Preconception" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al. 2014[a] [43]	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006–2007	Pregnant couples & their expectant children **(*N* = 2,264)**	Paternal self-report of weight and height on baseline questionnaire during third trimester or within 6 months postpartum	*BMI*—"Prepregnancy" Body mass index [BMI] at conception	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist	Spontaneous preterm birth & Small for gestational age (SGA)	3

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Noor et al. 2019 [44]	USA	Longitudinal cohort [Prospective] Project Viva birth cohort study of mothers and children 1999–2019	Pregnant couples & their expectant children (***N*** **= 429**)	Maternal report of paternal weight & height at first prenatal visit approximately 10 weeks gestation	*BMI*—"Periconception" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Maternal prepregnancy BMI, 2) Maternal Age, 3) Gestational weight gain, 4) Household income, 5) Maternal education, 6) Maternal smoking, 7) Maternal alcohol use, 8) Marital status, 9) Infant's sex, 10) Race/ethnicity, 11) Gestational age at delivery, 12) Mode of delivery, 13) Birth weight, 14) Batch effects, 15) Estimated nucleated cell types from cord blood 16) WBC's	Blood samples collected at birth, age 3 years & 7 years	Genome-wide DNA methylation patterns and birthweight in offspring	7
Pomeroy et al. 2015 [23]	Australia	Cohort [Prospective] Mater-University of Queensland Study of Pregnancy (MUSP) 1982–1983	Mothers and **Fathers** of infants (***N*** **= 1,041**)	Maternal report of paternal weight and height at first prenatal visit approximately 18 weeks of gestation	*BMI*—"Pre-pregnancy" height & body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parity, 2) Maternal education, 3) Maternal smoking in the last trimester, 4) Maternal age at birth	**1)** Birthweight, **2)** Neck-rump length 3) Head circumference, **3)** Absolute and proportional limb segment and trunk lengths & **4)** Subcutaneous fat	Neonatal body measurements	6
Retnakaran et al. 2021 [45]	China	Cohort [Prospective] Liuyang Preconception cohort 2009 -	Newly married couples attempting pregnancy and their expectant children (***N*** **= 1,292**)	Third party—Anthropometric assessment completed by trained staff at baseline	*BMI*—"Pregravid" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Age, 2) Years of education, 3) Smoking status, 4) BMI, 5) Household income 6) Length of gestation, 7) Total gestational weight gain, 8) Gestational diabetes, 9) Preeclampsia, & 10) Infant sex	**1)** Large-for-gestational- age (LGA) = birthweight above 90th percentile according to birthweight centiles for a Chinese population, & **2)** Small-for-gestational-age (SGA) = birthweight below the tenth percentile on birthweight centiles for a Chinese population	Offspring birthweight	8

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Robinson et al. 2020 [46]	USA	Cohort [Prospective] Upstate KIDS study (Population-based) 2008–2010	Mothers and **Fathers** of children **(*N* = 1,915)**	Maternal report of paternal weight & height on baseline questionnaire at 4 months postpartum	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Maternal & paternal age, 2) Insurance status, 3) Child sex, 4) Maternal race/ethnicity, 5) Education, 6) Marital status, 7) History of polycystic ovary syndrome (PCOS) and/or diagnosis, 8) Smoking, 9) Alcohol intake, 10) Maternal & paternal history of affective disorders, 11) BMI, 12) Maternal prepregnancy BMI	**1)** Positive history of attention deficit hyperactivity disorder (ADHD) or anxiety disorder **2)** Positive screening for ADHD and the inattentive or hyperactive/impulse sub scales OR report of clinical ADHD diagnosis **3)** Parental report of child borderline behavioural problems at 7 or 8 years of age	Offspring behavioural problems and psychiatric symptoms at 7–8 years	7
Sun et al. 2022 [47]	China	Cohort [Prospective] Hunan Maternal and Child Health Hospital (Hospital-based) 2013–2019	Couples receiving antenatal care **(Males [*N* = 34,104)**	Third party – Paternal height and weight measured at 14–16 weeks gestation	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Paternal age, 2) maternal age, 3) maternal BMI, 4) residence location, 5) education level, 6) nationality, 7) history of smoking, 8) history of drinking, 9) history of betel nut consumption, 10) history of drug use, 11) history of preterm birth, 12) per capita monthly household income	Delivery before 37 weeks gestation & Birth weight < 2,500 g	Preterm birth & Low birth weight	7
Sundaram et al. 2017 [48]	USA	Cohort [Prospective] Longitudinal Investigation of Fertility and the Environment [LIFE]) 2005–2009	Couples attempting pregnancy **(Males [*N* = 501])**	Third party—Anthropometric assessment completed by a trained nurse at baseline	*BMI*—Body mass index [BMI] (Weight in kilograms over height in meters squared) and waist/hip measurements	1) Female partner's age, 2) Difference between the male and female age, 3) Both partner's smoking status, 4) Both partner's number of days of vigorous physical activity per week, 5) Both partner's free cholesterol level 6) Both partner's race 7) Both partner's education 8) Average acts of intercourse per menstrual cycle 9) Menstrual cycle regularity	Time to pregnancy (TTP) in menstrual cycles	Pregnancy	8

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Umul et al. 2015 [49]	Turkey	Cohort [Retrospective]	Couples **(Males [*N* = 155])** undergoing intracytoplasmic sperm injection (ICSI) cycles (n = 177)	Third party—Anthropometric measurements	*BMI*—*B*ody mass index [BMI] (Weight in kilograms over height in meters squared) during fertility treatment	Nil	**1)** Fertilization rate, **2)** Implantation rate, **3)** Clinical pregnancy rate, & **4)** Live birth rate	ICSI induced live birth	2
Wei et al. 2022 [50]	China	Cohort [Prospective] Hunan Provincial Maternal and Children Health Care Hospital (Hospital-based) 2013–2019	Pregnant couples **(Males [*N* = 40,650])**	Paternal self-report of weight and height on baseline antenatal questionnaire between 8- and 14-weeks' gestation	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Maternal and paternal age 2) ethnicity, 3) educational level, 4) parity, 5) family income per month, 6) active smoking before pregnancy, 7) passive smoking before pregnancy, 8) alcohol consumption before pregnancy 9) folic acid consumption before or during pregnancy, 10) history of adverse pregnancy outcomes, 11) history of pregnancy complications, 12) gestational weight gain recommendation range, 13) pregnancy complications in this pregnancy, 14) smoking status before pregnancy, 15) alcohol consumption before pregnancy	Low birth weight = < 2,500 g Very low birthweight = < 1,500 g Extremely low birthweight < 1,000 g	Offspring birthweight	6
Wei et al. 2021 [51]	China	Cohort [Retrospective] Guangxi Zhuang Birth Cohort (GZBC) (Hospital-based) 2015–2018	Parents with singleton birth **(Males [*N* = 1,082])**	Paternal self-report of weight and height at first antenatal interview	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1)Parental age at delivery, 2) offspring sex, 3) gestational age, 4) offspring birth weight), 5) maternal residential place, 6) gravidity, 7) parity, 8) drinking before pregnancy, 9) maternal passive smoking during pregnancy, 10) pregnancy comorbidities or complications, 11) caesarean section	Real-time polymerase chain reaction (qPCR)	Newborn telomere length (TL)	6

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Xu et al. 2021 [52]	China	Cohort [Prospective] Shanghai Jiao Tong University 2015	Pregnant couples and their expectant children (***N*** **= 1,810**)	Paternal self-report of weight and height at first prenatal visit approximately 16 weeks of gestation	*BMI*—"Preconception" body mass index [BMI] (Weight in kilograms over height in meters squared) during fertility treatment	1) Delivery gestational week, 2) Maternal age, 3) Gestational weight gain (GWG), 4) Education , 5) Parity, 6) Family history of metabolic diseases, 7) Haemoglobin, 8) Systolic blood pressure, 9) Diastolic blood pressure, 10) Dyslipidemia, 11) Fasting plasma glucose at the first prenatal check-up 12) Offspring sex, 13) Preconception BMI	Assessed within 1 h of birth using digital scales	Offspring birthweight	7
Yang et al. 2015 [53]	China	Case–control [Retrospective] (Population-based) 2011–2013	Mothers & **Fathers** of cases (***N*** **= 870**) and controls (***N*** **= 5,471**)	Paternal self-report of weight and height at postpartum baseline interview	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Infant's gender, 2) Gestational age, 3) Parental age, 4) Family income, 5) Parental education level, 6) Gravidity, 7) Parity, 8) Paternal smoking status during pregnancy, 9) Parental prepregnancy weight, 10) Parental height, 11) Parental BMI, 12) Maternal alcohol consumption during pregnancy, 13) Maternal weight gain during pregnancy, 14) Maternal BMI gain during pregnancy	Live macrosomic birth (> 4,000 g)	Macrosomia	6

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Zalbahar et al. 2017 [24]	Australia	Cohort [Prospective] Mater-University of Queensland Study of Pregnancy (MUSP) 1981–1983	Mothers and **Fathers** of infants **(*N* = 1,494)**	Maternal report of paternal weight and height at first prenatal visit at approximately 18 weeks of gestation	*BMI*—"Pre-pregnancy" weight and body mass index [BMI] (Weight in kilograms over height in meters squared)	1) Parental education, 2) Family annual income, 3) Maternal gestational weight gained, 4) Maternal smoking habit, 5) Offspring birth weight, 6) Offspring gender, 7) Gestational age, 8) Breastfeeding duration, 9) Offspring's lifestyle at 14 years, 10) Maternal or paternal BMI, 11) Maternal age at birth, 12) Offspring birth weight, 13) Offspring gender	Physical assessment using measuring tape and digital scales at 5, 14 and 21 year follow-ups	Offspring weight & BMI changes from childhood (5 years) into adulthood (21 years)	5
Zhang et al. 2020 [54]	China	Cohort [Retrospective] National Free Pre-conception Check-up Projects (NFPCP) 2015–2017	Nulliparous couples attempting pregnancy **(Males [*N* = 2,301,782])**	Third Party—Physician measurement of paternal weight and height	*BMI*—"Pre-pregnancy" body mass index [BMI] (Weight in kilograms over height in meters squared) during participation in the NFPCP	1) Age, 2) Ethnic background, 3) Educational level, 4) Occupation, 5) Household registration and region, 6) Alcohol intake, 7) Tobacco exposure, 8) Hypertension, 9) HBs Ag positive status based on male individual model A	Time to pregnancy (TTP) = [Date of the last menstruation (pregnant couples) or Date of the most recent follow-up (non-pregnant couples) - Date of baseline questionnaire completion)]/Average menstrual cycle length] + 1	Pregnancy	9
Alcohol									
Luan et al. 2022 [55]	China	Cohort [Prospective] Shanghai-Minhang Birth Cohort Study 2012 -	Mothers and Fathers of infants **(*N* = 796)**	Maternal report of paternal preconception alcohol consumption at 12–16 weeks gestation	*Alcohol* – 3 months before conception	1)Paternal age 2) Paternal BMI 3) Paternal education 4) Paternal smoking 5) Maternal age 6) Parity 7) Maternal depressive symptoms during pregnancy 8) Maternal preconception folic acid supplements, 9) Multivitamin supplements during pregnancy 10) Gestational weeks 11) Sex	Child Behaviour Checklist (CBCL) at offspring ages 2, 4, & 6 years old	Offspring behavioural problems	7

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Milne et al. 2013 [26]	Australia	Case–control [Retrospective] Aus-ALL 2003–2006 Aus-CBT 2005–2010	Mothers and **Fathers** of children with ALL (Cases [*n* = 281] Controls [*n* = 672) & CBTs (Cases [*n* = 221]) and Controls [*n* = 717]	Paternal self-report on baseline questionnaire	*Alcohol* – Any alcohol 12 months before pregnancy	1)Year of birth group 2) Maternal age, 3) Ethnicity 4) Household income 5) Birth order 6) Maternal smoking 7) Child's age 8) Child's sex 9) State of residence 10) Paternal smoking 11) Paternal age group 12) Household income	Diagnosis from one of 10 paediatric oncology centres in Australia	Childhood acute lymphoblastic leukemia (ALL) & Childhood brain tumours (CBTs)	6
Moss et al. 2015[a] [42]	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994–2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants (***N* = 372**)	Paternal self-report of health behaviours at wave III interview	*Alcohol*—preconception intake greater than once a month	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al. 2014[a] [43]	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006–2007	Pregnant couples & their expectant children (***N* = 2,264**)	Paternal self-report on baseline questionnaire during third trimester or within 6 months following delivery	Alcohol intake (units/week) 6 months prior to conception and up to delivery	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist	Spontaneous preterm birth & Small for gestational age (SGA)	3
Xia et al. 2018 [56]	China	Cohort [Prospective] Shanghai-Minhang Birth Cohort Study 2012	Mothers and F**athers** of infants (***N* = 980**)	Paternal self-report at baseline interview between 12 to 16 weeks of gestation	*Alcohol*—Intake at least once a week 3 months before conception	1) Parental age, 2) Parental BMI before conception, 3) Gestational age, 4) Gravidity, 5) Birth weight of offspring, 6) Paternal education, 7) Maternal passive smoking before conception (yes/no), 8) Paternal smoking (yes/no), 9) Days between birth and 12-month measurement	**Males—**AGD-AP (centre of anus to penis) AGD-AS (centre of anus to scrotum) **Females—**AGD-AC (centre of anus to clitrous) AGD-AF (centre of anus to fourchette)	Offspring anogenital distance (AGD)	8

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Zuccolo et al. 2016 [57]	Norway	Cohort [Prospective] The Norwegian Mother and Child Cohort Study (MoBa) (Population based) 1999–2009	Mothers & **Fathers** of children (***N*** **= 68,244**)	Paternal self-report on baseline questionnaire at approximately 17 weeks of gestation	*Alcohol*—intake in the 6 months prior to pregnancy and up to week 18 of gestation	1) Year of birth, 2) Folic acid use around conception, 3) Whether the pregnancy was planned, 4) Maternal diabetes, 5) Parity, 6) Ethnicity, 7) Financial strain, 8) Parental age, 9) Height, 10) BMI, 11) Gross Income, 12) Education, 13) Smoking/drug use in pregnancy, 14) Other parent's exposure	Sex-standardised head circumference (expressed as standard deviation [SD] scores), based on the distribution of all MoBa newborns by sex	Offspring head circumference	4
Cannabis									
Har-Gil et al. 2021 [58]	Canada	Cohort [Retrospective] (Clinic-based) 2016–2019	Female ($n = 15$) & **male (*N* = 53)** cannabis users & non-users (***N*** **= 654**) undergoing IVF	Paternal self-report on baseline questionnaire	*Cannabis*—use prior to fertility treatment	Nil	1) Sperm volume 2) Sperm quality, 3) Fertilization rate 4) Implantation rate (IR) 5) Ongoing pregnancy rate (OPR)	IVF/ICSI induced live birth	2
Kasman et al. 2018 [59]	USA	Cross sectional cohort [Retrospective] National Survey of Family Growth (NSFG) (Population-based) 2002–2015	Female ($n = 1,076$) **& male (*N* = 758)** respondents of the National Survery of Family Growth (NSFG)	Paternal self-report at baseline interview	*Cannabis*—use over the previous 12 months	1) Age, 2) Marital status, 3) Previous children, 4) Partner age (for men), 5) Previous fertility evaluation/treatment, 6) Year of survey, 7) Income, 8) Race, 9) Education	Estimated time to pregnancy (TTP) using the current-duration appaorach	Pregnancy	6
Moss et al. 2015[a] [42]	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994–2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants (***N*** **= 372**)	Paternal self-report of health behaviours at wave III interview	*Cannabis*—use in the last 12 months	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Nassan et al. 2019 [60]	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2005–2017	Subfertile couples (**Males [*N* = 200]**) undergoing IVF cycles (*n* = 368)	Paternal self-report on baseline questionnaire	*Cannabis*—use ever	1) Age, 2) Race, 3) BMI, 4) Tobacco smoking, 5) Coffee and alcohol consumption, 6) Cocaine use	**1)** Implantation, **2)** Clinical pregnancy, **3)** Live birth per assisted reproductive technology (ART) cycle, & **4)** Pregnancy loss	IVF/ICSI induced live birth	7
Wise et al. 2018 [61]	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013–2017	Couples attempting pregnancy (**Males *N* = 1,125**)	Paternal self-report on baseline questionnaire	*Cannabis*—use in the previous 2 months	1) Age, 2) Race/ethnicity, 3) Education, 4) Annual household income, 5) Cigarette smoking history, 6) Alcohol intake, 7) Caffeine intake, 8) Intercourse frequency, 9) Doing something to improve chances of conception, 10) PSS-10 score, 11) MDI score, 12) Sugar-sweetened soda intake, 13) Average sleep duration 14) Employment status	Time to pregnancy (TTP) = (Menstrual cycles of attempt at study entry) + [(Last menstrual period [LMP] date from the most recent followup questionnaire – date of baseline questionnaire completion)/ usualmenstrual cycle length] + 1	Fecundability	6
Physical activity									
Moss et al. 2015[a] [42]	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994–2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants (***N* = 372**)	Paternal self-report of health behaviours at wave III interview	*Physical activity*—sessions in the last week	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al. 2014[a] [43]	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006–2007	Pregnant couples & their expectant children (***N* = 2,264**)	Paternal self-report on baseline questionnaire during third trimester or within 6 months following delivery	*Physical activity*—moderate intensity for 30 min per day ≥ once a week 6 months prior to conception and up to delivery	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist	Spontaneous preterm birth & Small for gestational age (SGA)	3

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Smoking									
Accordini et al. 2021 [32]	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013–2016	Mothers & **Fathers (*N* = 274),** investigated in the European Community Respiratory Health Survey (ECRHS), of adult offspring (*n* = 383)	Paternal self-report at baseline interview and ECRHS examinations	*Smoking* – Prepubertal smoking [smoking < 15 years old] & smoking ≥ 15 years old	1)Grand parents education level 2) Paternal age 3) Paternal education level 4) Paternal occupational class 5) Maternal smoking before or after offspring birth 6) Offspring age 7) Offspring sex 8) Offspring education level 9) Offspring smoking	Pre/post bronchodilator forced expiratory volume in one second (FEV1) & forced vital capacity (FVC)	Adult offspring lung function	8
Accordini et al. 2018 [31]	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] European Community Respiratory Health Survey (ECRHS) (Population-based) 1998–2013	Mothers and **Fathers (*N* = 1,964)** of adult offspring (*n* = 4,192)	Paternal self-report at baseline interview and ECRHS examinations	*Smoking* – Prepubertal smoking [smoking < 15 years old] & smoking ≥ 15 years old	1)Grandmother smoking 2) Father's ever asthma 3) Education level 4) Smoking initiation 5) Offspring gender 6) Age	Parent report in the ECRHS questionnaire	Adult offspring asthma with or without nasal allergies	7
Carslake et al. 2016 [62]	Norway	Combined cohort [Prospective] HUNT Study [Adult ≥ 20 years] (1984 – 2008)/ YoungHUNT Study [Child 13–19 years] (1995 – 2007)	Mothers and **Fathers ([**HUNT] of offspring [YoungHUNT] **(*N* = 221)**	Paternal self-report at baseline interview	*Smoking* – Prepubertal smoking [smoking < 11 years old]	1)Offspring birth order 2) Maternal education 3) Paternal employment 4) Maternal and Paternal smoking status at time of offspring conception 5) Offspring sex	Body Mass Index (BMI)	Offspring adiposity	6
Deng et al. 2013 [63]	China	Case–control [Retrospective] Gene-environmental interaction study on CHD occurrence (Hospital-based) 2010–2011	Pregnant couples & their expectant children as CHD cases **(*N* = 267)** & controls **(*N* = 386)**	Maternal report at baseline interview during pregnancy but after prenatal diagnosis of CHD	*Smoking*—"Periconceptional" being 3 months before conception through to the first trimester of pregnancy	1) Maternal residence, 2) Age, 3) Education, 4) Prepregnancy BMI, 5) Parental alcohol use during the 3 months before and 3 months after conception, 6) Folic acid intake during the 3 months before and 3 months after conception, 7) Family history of CHD, 8) Parity	Diagnosed via prenatal echocardiography	Congenital heart defects (CHD) in offspring	8
Frederiksen et al. 2020 [64]	Costa Rica	Case–control [Retrospective] Costa Rican Childhood Leukemia Study (CRCLS) (Population-based) 2001–2003	Mothers and Fathers **(*N* = 198)** of offspring suffering leukemia (*N* = 292) [Cases] & cancer free age matched offspring (*N* = 578) [controls]	Paternal self-report at baseline interview	*Smoking* – Tobacco smoking 12 months before conception	1)Child sex 2) Birth year 3) Parental education 4) Paternal age 5) Maternal smoking	Diagnosis, between 1995–2000 in Costa Rica while aged < 15 years, of Acute Lymphoblastic Leukemia (ALL) (*N* = 252) or Acute Myeloid Leukemia (AML) (*N* = 40)	Childhood leukemia	7

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Knudsen et al. 2020 [30]	**Northern Europe** Denmark Norway Sweden Iceland Estonia & Spain Australia	Cohort [Prospective] The Respiratory Health in Northern Europe, Spain and Australia multigeneration study (RHINESSA) (Population-based) 2013–2016	Mothers & **Fathers (*N* = 2,111)** of adult offspring (*n* = 2,939)	Paternal self-report at baseline interview and examinations	*Smoking* – Prepubertal smoking [smoking before 15 years old] & smoking ≥ 15 years old. Preconception smoking [≥ 2 years before offspring birth year]	1)Parental education 2) offspring sex	**1)** BMI [weight (kg)/height (m)^2] **2)** Bioelectrical impedance analysis **3)** Fat mass index (FMI) [fat mass (kg)/height (m)^2]	Adult offspring BMI index and FMI index	5
Ko et al. 2014 [65]	Taiwan	Longitudinal cohort [Prospective] Taiwan Birth Cohort Study (National) 2005–2006	Mothers & **Fathers** of infants **(*N* = 21,248)**	Maternal report at baseline interview 6 months postpartum	*Smoking*—Preconception tobacco being before pregnancy and up to four months postpartum	1) Maternal age, 2) Nationality, 3) Education, 4) Parity, 5) Total weight gain during pregnancy, 6) Infant gender, 7) Multifetus, 8) Paternal smoking in the same period	**1)** Low Birth weight (LBW) < 2,500 g, **2)** Small for gestational age (SGA)—Birth below the 10th percentile of gender-specific birth weight for gestational age based on the 1998–2002 nationwide percentiles & **3)** Preterm birth < 37 weeks	Offspring birthweight & incidence of preterm delivery	5
Milne et al. 2013 [27]	Australia	Case–control [Retrospective] The Australian Study of Childhood Brain Tumors (Aus-CBT) (Population-based) 2005–2010	Mothers and Fathers (*N* = 1048) of children with childhood malignancy and brain tumors (CBT) (*n* = 247) & controls (*n* = 801)	Paternal self-report on mailed questionnaire	*Smoking*—Average number of cigarettes smoked per day in each calendar year from age 15 until year after child's birth	1)Child's ethnicity, 2) year of birth group, 3) Mother's age group, 4) Father's age group, 5) alcohol consumption during pregnancy, 6) household income	Diagnosis at one of 10 Australian paediatric oncology centres	Childhood brain tumors (CBT)	5
Moss et al. 2015[a] [42]	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994–2008	Adolescents (grades 7 - 12) followed into adulthood becoming Mothers & **Fathers** of infants **(*N* = 372)**	Paternal self-report of health behaviours at wave III interview	*Smoking*—At least one cigarette per day over the last 30 days	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7
Mutsaerts et al. 2014[a] [43]	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006–2007	Pregnant couples & their expectant children **(*N* = 2,264)**	Paternal self-report on baseline questionnaire during third trimester or within 6 months following delivery	*Smoking*- cigarettes per day in the 6 months prior to conception and up to delivery	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist	Spontaneous preterm birth & Small for gestational age (SGA)	3

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Northstone et al. 2014 [66]	UK	Cohort [Prospective] The Avon Longitudinal Study of Parents and Children (ALSPAC) 1991–1992	Pregnant couples where **fathers** identified as smoking regularly ($n=5,376$) including before 11 years old **($N=166$)**	Paternal self-report on baseline questionnaire completed during pregnancy	*Smoking*—Prepubertal tobacco before 11 years of age	1) Parity of the mother at the time of birth of the offspring (primiparae vs multiparae), 2) Highest maternal education level 3) Housing tenure 4) Maternal smoking during pregnancy 5) Paternal smoking at conception	**1)** BMI, **2)** Waist circumference, **3)** Total-body fat mass, & **4)** Lean mass	Offspring adiposity	7
Orsi et al. 2015 [67]	France	Case–Control [Retrospective] ESTELLE study (Population-based) 2010—2011	Mothers and fathers **($N=247$)** of offspring suffering childhood acute leukemia (CL) ($N=69$) [Cases] & cancer free age matched offspring ($N=178$) [Controls]	Paternal self-report on baseline questionnaire	*Smoking*—Tobacco smoking during the 3-month period preceding conception; the "pre-conception period"	1)Offspring Age 2) Offspring Sex 3) Mother's age at child's birth 4) Mother's education 5) Birth order	Diagnosed with CL < 15 years old as per the National Registry of Childhood Hematopoietic Malignancies (NRCH) criteria	Childhood acute leukemia (CL)	7
Sapra et al. 2016 [68]	USA	Cohort [Prospective] Longitudinal Investigation of Fertility and the Environment [LIFE]) 2005–2009	Couples attempting pregnancy **(Males [$N=501$])**	Paternal self-report at baseline interview	*Smoking*—Lifetime exposure to tobacco products (including cigarettes, electronic cigarettes, cigars, pipes, waterpipes, chewing tobacco, snuff and dip)	1) Race/ethnicity, 2) Education, 3) Income, 4) Age, 5) Alcohol use, 6) Caffeine use, 7) BMI, 8) Blood cadmium in each partner, 9) Couple's mean age, 10) Difference in partners' ages	Time to pregnancy (TTP) in menstrual cycles	Pregnancy	7
Svanes et al. 2017 [69]	**Northern Europe** Norway, Sweden, Iceland, Denmark, Estonia	Combined Cohort [Prospective] European Community Respiratory Health Survey (ECRHS) (1989–1992) & Respiratory Heath in Northern Europe (RHINE) (Population-based) 1991—2012	Mothers and **Fathers ($N=3,777$)** of offspring aged 2–51 years ($n=24,168$)	Paternal self-report on RHINE III questionnaire	*Smoking*—Tobacco smoking prior to conception including period around birth	1)Age 2) Study centre 3) Parental age 4) Parental asthma before age 10, 5) Parental education	Diagnosis via parental report	Offspring asthma before/after 10 years	6
Wang et al. 2022 [70]	China	Cohort [Retrospective] National Free Pre-Pregnancy Check-ups Project (NFPCP) (Population-based) 2010–2016	Non-smoking women and their smoking husbands **($N=190,529$)**	Paternal self-report at preconception health examination	*Smoking*—Tobacco while attempting conception in the following 6 months	1) Maternal and paternal age at last menstrual period, 2) Higher education, 3) Han ethnicity, 4) Preconception body mass index (BMI), 5) Alcohol drinking, 6) Parental passive smoking, 7) History of adverse pregnancy outcomes, 8) Region of the service station	Delivery before 37 completed gestational weeks	Preterm birth (PTB)	5

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Wang et al. 2018 [71]	China	Cohort [Retrospective] National Free Pre-Pregnancy Check-ups Project (NFPCP) (Population-based) 2010–2016	Non-smoking women and their **husbands (*N* = 5,770, 691)**	Paternal self-report at preconception health examination	*Smoking*—Tobacco while attempting conception in the following 6 months	1) Maternal and paternal age at last menstrual period, 2) Higher education, 3) Han ethnicity, 4) Preconception body mass index (BMI), 5) Alcohol drinking, 6) Parental passive smoking, 7) History of adverse pregnancy outcomes, 8) Region of the service station	Fetal death before week 28 of gestation	Spontaneous abortion (SA)	6
Wesselink et al. 2019 [72]	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013–2018	Couples attempting pregnancy **(Males *N* = 1,411)**	Paternal self-report on baseline questionnaire	*Smoking*—Tobacco while attempting conception for ≤ 6 menstrual cycles	1) Age, 2) Race/ethnicity, 3) Education, 4) Annual household income, 5) BMI, 6) Sugar sweetened beverage intake, 7) Healthy eating index score, 8) Multivitamin or folic acid supplement use, 9) Sleep duration, 10) PSS-10 score, 11) MDI score, 12) Parity, 13) Intercourse frequency, 14) Doing something to improve chances of conception	Pregnancy attempt time = (Menstrual cycles of attempt time at baseline) + [(Last menstrual period [LMP] date from most recent followup questionnaire—date of baseline questionnaire)/Cycle length] + 1	Fecundability	5
You et al. 2022 [73]	China	Cohort [Prospective] Children lifeway Cohort 2018 -	Mothers and **Fathers (*N* = 1,037)** of first grade students (7–8 years old)	Paternal self-report at baseline interview	*Smoking*—Tobacco smoking before conception	1)Sex 2) Actual age 3) Father overweight, 4) Mother overweight 5) Percentage of food expenditure 6) Educational level of parents 7) Caesarean Sect. 8) Birthweight 9) Breastfeeding 10) Other household smoking 11) Mother exposed to SHS during pregnancy 12) Picky eaters 13) TV watching time 14) physical exercise 15) Frequency of eating fried/baked food 16) Late-night dinners 17) Vegetable and fruit 18) Snack consumption	Age and sex specific BMI cut-off points according to the growth standard of China "Screening for overweight and obesity among school-age children and adolescents"	Offspring overweight/obesity	7

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Zhou et al. 2020 [74]	China	Cohort [Prospective] National Preconception Health Care Project (NPHCP) (Population-based) 2010–2012 * with matched case control	Couples attempting pregnancy **(Males [*N* = 566,439])**	Paternal self-report at baseline interview	*Smoking*—Tobacco smoking before conception	1) Maternal age, 2) Education, 3) Occupation, 4) Residence status, 5) Self-reported medical history, 6) Smoking, 7) Second hand smoking, 8) Alcohol consumption, 9) Folic acid supplement, 10) Paternal alcohol consumption	[*Primary] Birth defects = diagnosis on hospital records of first 42 days after delivery [*Secondary] Birth defect types = congenital heart disease, limb anomalies, clefts, digestive tract anomalies, gastroschisis and neural tube defects	Offspring birth defects	7
Zwink et al. 2016 [75]	Germany	Case–control [Retrospective] (Population based) 2009-Ongoing	Mothers **& Fathers** of cases **(*N* = 158)** and controls **(*N* = 474)**	Maternal report on baseline interview at approximately 8 years postpartum	*Smoking* -"Periconceptional" tobacco being 3 months before conception until the fourth month of pregnancy	1) Gender, 2) Birth year of the child, 3) Maternal age, 4) BMI, 5) Maternal body weight	Diagnosis of **1)** Esophageal atresia with or without tracheoesophageal fistula (EA/TEF) or **2)** Anorectal malformations (ARM) ARM's	Offspring malformations	4
Stress									
Bae et al. 2017 [76]	USA	Cohort [Prospective] Longitudinal Investigation of Fertility and the Environment [LIFE]) (Population-based) 2005–2009	Couples attempting pregnancy and their expectant children **(*N* = 235)**	Paternal self-report at baseline interview assessed by Cohen's Perceived Stress Scale [PSS-4]	*Stress*—& lifetime history of physician-diagnosed anxiety and/or mood disorders	1) Age, 2) Serum cotinine, 3) Annual income, 4) Maternal parity	Secondary sex ratio (SSR) [Males:Females at birth]	Offspring sex	6
Mutsaerts et al. 2014[a] [43]	The Netherlands	Cohort [Prospective] Groningen Expert Center for Kids with Obesity [GECKO] Drenthe cohort (Population-based) 2006–2007	Pregnant couples & their expectant children **(*N* = 2,264)**	Paternal self-report on baseline questionnaire during third trimester or within 6 months following delivery	*Stress*—Paid working hours < 16 h per week	Nil	Questionnaire, shortly after birth, completed by midwife or gynaecologist	Spontaneous preterm birth & Small for gestational age (SGA)	*3*
Wesselink et al. 2018 [77]	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013–2018	Couples attempting pregnancy **(Males *N* = 1,272)**	Paternal self-report on baseline questionnaire assessed by the Perceived stress scale [PSS]	*Stress*—Perceived stress in the last month	1) Age, 2) BMI, 3) Race/ethnicity, 4) Education, 5) Household income, 6) Employment status, 7) Work duration, 8) Physical activity	Pregnancy attempt time = (Menstrual cycles of attempt time at baseline) + [(Last menstrual period [LMP] date from most recent followup questionnaire—date of baseline questionnaire)/Cycle length] + 1	Fecundability	7

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Nutrition									
Bailey et al. 2014 [29]	Australia	Case–control [Prospective] The Australian Study of Causes of acute lymphoblastic leukemia (ALL) in children (Aus-ALL). (Population-based) 2003–2007	Mothers and Fathers of children with ALL ($n=285$) and controls ($n=595$)	Paternal self-report on food frequency questionnaire (FFQ)	*Folate & Vitamins B6/B12*—during the 6 months before conception	1)Birth order 2) best parental education, 3) paternal age, 4) paternal smoking in the conception year, 5) year of agreement and FFQ version, 6) supplement use (folate, B6, or B12), 7) control state, 8) control sex, 9) control age	Diagnosis at one of 10 Australian paediatric oncology centres	Childhood acute lymphoblastic leukemia (ALL)	5
Greenop et al. 2015 [28]	Australia	Case–control [Retrospective] The Australian Study of Childhood Brain Tumors (Aus-CBT) (Population-based) 2005–2010	Mothers and Fathers ($N=866$) of children with childhood malignancy and brain tumors (CBT) ($n=237$) & controls ($n=629$)	Paternal self-report on food frequency questionnaire (FFQ)	*Folate & Vitamins B6/B12*—during the 6 months before conception	1)Control age, 2) control sex, 3) control state of residence, 4) child's year of diagnosis/recruitment, 5) paternal age, 6) best parental education, 7) child's ethnicity, 8) paternal preconceptional high alcohol consumption	Diagnosis at one of 10 Australian paediatric oncology centres	Childhood brain tumors (CBT)	5
Hatch et al. 2018 [78]	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013–2017	Couples attempting pregnancy **(Males *N* = 1,045)**	Paternal self-report on food frequency questionnaire (FFQ) at baseline	*Sugar sweetened beverage intake* –Servings per week in the past month	1)Male and female age, 2) male and female BMI, 3) age, 4) race/ethnicity, 5) education, 6) annual household income, 7) smoking history, 8) BMI, 9) physical activity, 10) caffeine intake, 11) alcohol intake, 12) sleep duration, 13) perceived stress scale score, 14) intercourse frequency	Time to pregnancy (TTP) [(menstrual cycles of attempt time at baseline) + [(LMP date from most recent follow-up questionnaire—date of baseline questionnaire)/cycle length] + 1]	Fecundability	6
Hoek et al. 2019 [79]	The Netherlands	Cohort [Prospective] Rotterdam Periconception Cohort (PREDICT Study) (Hospital-based) 2010–2015	Pregnant couples **(*N* = 511)** producing spontaneous pregnancy ($n=303$) or IVF/ICSI pregnancy ($n=208$)	Paternal self-report on baseline questionnaire	*Folate*—"Periconceptional" status being 14 weeks before pregnancy and up to 10 weeks of gestation	1) Gestational age at the time of ultrasound, 2) Paternal age, 3) Paternal smoking and alcohol, 4) Geographic origin, 5) Maternal age, 6) Maternal BMI, 7) Maternal smoking and alcohol, 8) Parity, 9) RBC folate levels, 10) Education level, 11) Geographic origin, 12) Fetal gender	**1)** Crown-rump length (CRL) & **2)** Embryonic volume (EV) at 7, 9 and 11 weeks of gestation	Embryonic growth trajectories	7

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality±
Lippevelde et al. 2020 [80]	Norway	Combined cohort [Prospective] Young-Health Study in Nord-Trondelag (Young-HUNT 1 1995–1997 & Young-HUNT 3 2006–2008)	Adolescents (13–19 years old) followed into adulthood becoming Mothers & Fathers of infants. Young-HUNT 1 **Father**-offspring dyads (***N*** **= 2,140**). Young-HUNT 3 **Father**-offspring dyads (***N*** **= 391**)	Adolescent self-report on baseline questionnaire	*Diet*—Dietary exposures during adolescence	**1)** Adolescents age, **2)** BMI z-score **3)** Education plans **4)** Chewing tobacco use **5)** Smoking **6)** Alcohol use	**1)** Birthweight (g) **2)** Length (cm) **3)** Head circumference (cm) **4)** Placenta weight (g), **5)** Gestational length (weeks) & **6)** Ponderal index—Adiposity ([Birthweight (g) /Birth length^3 (cm)]*100)	Neonatal health of offspring	8
Martin-Calvo et al. 2019 [81]	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007–2017	Subfertile couples undergoing fertility treatment **(Males *N* = 108)** producing singletons [*n* = 85), twins (*n* = 54) & triplets [*n* = 3])	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Folate*—Preconception intake prior to or up to 12 weeks after the day of peak oestradiol concentration during a fertility treatment cycle (IVF/ICSI/IUI)	1) Age, 2) Choline, betaine, methionine, vitamin B6, vitamin B12, 3) Total energy intake, 4) Diet quality, 5) Maternal BMI, 6) Maternal smoking status, 7) Infertility diagnosis, 8) Type of fertility treatment	**1)** Gestational age at delivery (days), **2)** Live birth of a neonate ≥ 24 weeks of gestation, & **3)** Gestational age-adjusted birthweight	IVF/ICSI/IUI induced live birth	7
Mitsunami et al. 2021 [82]	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007–2018	Subfertile couples (**Males [*N* = 231]**) undergoing IVF cycles (*n* = 407)	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Diet*—patterns 1 (processed foods) & 2 (whole/unprocessed foods) over the previous 12 months	1) Men's age, 2) Total caloric intake, 3) BMI, 4) Race, 5) Smoking status, 6) Education level, 7) Physical activity, 8) Women's age + BMI, 9) Couple's primary infertility diagnosis, 10) Treatment protocol, 11) Women's adherence to the two dietary patterns, 12) Women's race, 13) Women's smoking status	**1)** Fertilization rate, **2)** Probability of implantation, **3)** Clinical pregnancy, & **4)** Probability of live birth per initiated treatment cycle	IVF/ICSI induced live birth	7
Moss et al. 2015[a] [42]	USA	Longitudinal cohort [Prospective] National Longitudinal Study of Adolescent Health (Add Health) 1994–2008	Adolescents (grades 7 -12) followed into adulthood becoming Mothers & **Fathers** of infants (***N*** **= 372**)	Paternal self-report of health behaviours at wave III interview	*Diet*—Fast food consumption	1) Parents age at birth, 2) Race/ethnicity, 3) Immigrant status, 4) Education level, 5) Socioeconomic status, 6) Infant sex, 7) Initiation of prenatal care, 8) Parity, 9) Time between wave III interview and conception, 10) Relationship type at wave III	Respondent self-report on Wave IV questionnaire	Gestational age & offspring birthweight	7

Table 2 (continued)

First Author & Year	Location	Design & Duration	Sample	Exposure Measure	Paternal Exposure	Confounders	Outcome Measure	Outcome	Quality[±]
Oostingh et al. 2019 [83]	The Netherlands	Cohort [Prospective] Rotterdam Periconception Cohort (PREDICT Study) (Hospital-based) 2010–2016	Pregnant couples **(Males [*N* = 638])**	Paternal self-report on baseline food frequency questionnaire (FFQ) before 8 weeks of gestation	*Diet*—Habitual food intake and dietary patterns in a four week period during periconception being 14 weeks before and up to 10 weeks following conception	1) Gestational age, 2) Maternal and paternal total energy intake, 3) Maternal and paternal BMI, 4) Maternal age, 5) Maternal and paternal smoking, 6) Nulliparous, 7) Fetal gender	**1)** Longitudinal crown-rump length (CRL), & **2)** Embryonic volume (EV), via transvaginal ultrasound, at 7, 9 and 11 weeks of gestation	First trimester embryonic growth	6
Twigt et al. 2012 [84]	The Netherlands	Cohort [Prospective] 'Achieving a Healthy Pregnancy' (AHP) (Hospital-based) 2007–2010	Subfertile couples **(Males [*N* = 199])** with IVF treatment and embryo transfer within 6 months after AHP	Paternal self-report on baseline questionnaire	*Diet* –Main food groups 1)Whole wheat 2) Unsaturated oils 3) Vegetables 4) Fruits 5) Meat 6) Fish	1)Maternal age 2) Maternal smoking 3)Preconception Dietary Risk Score [PDR] of the partner 4) Maternal and Paternal BMI	A pregnancy with positive fetal heart action at around 10 weeks after embryo transfer confirmed by ultrasonography	IVF/ICSI induced ongoing pregnancy	5
Wesselink et al. 2016 [85]	USA	Cohort [Prospective] Preconception pregnancy planner cohort study online (PRESTO) 2013–2017	Couples attempting pregnancy **(Males *N* = 662)**	Paternal self-report on food frequency questionnaire (FFQ) at baseline	*Diet* – Caffeinated beverages; approximate servings per week	1) Age, 2) race/ethnicity, 3) education, 4) BMI, 5) smoking history, 6) alcohol intake, 7) intercourse frequency, 8) sleep duration, 9) work time	Time to pregnancy (TTP) [(menstrual cycles of attempt time at baseline) + [(LMP date from most recent follow-up questionnaire—date of baseline questionnaire)/cycle length] + 1]	Fecundability	6
Xia et al. 2016 [86]	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007–2014	Subfertile couples **(Males [*N* = 142])** undergoing IVF/ICSI cycles (*n* = 248)	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Diet*—Dairy intake in the previous 12 months	1) Age, 2) BMI, 3) Smoking status, 4) Total exercise time, 5) Dietary patterns, 6) Alcohol, 7) Caffeine, 8) Total energy intake, 9) Female dairy intake, 10) Female age, 11) Prudent dietary pattern, 12) Western dietary pattern	**1)** Fertilization rate, **2)** Implantation rate, **3)** Clinical pregnancy rate & **4)** Live birth rate per initiated cycle	IVF/ICSI induced live birth	7
Xia et al. 2015 [87]	USA	Cohort [Prospective] Environment and Reproductive Health Study [EARTH] 2007–2014	Subfertile couples **(Males [*N* = 141])** undergoing IVF/ICSI cycles (*n* = 246)	Paternal self-report on baseline food frequency questionnaire (FFQ)	*Diet*—Meat intake in the previous 12 months	1) Age, 2) Total energy intake, 3) BMI, 4) Alcohol, 5) Caffeine, 6) Prudent dietary pattern, 7) Western dietary pattern, 8) Infertility diagnoses, 9) Mode of insemination, 10) Female meat intake	**1)** Fertilization rate, **2)** Implantation rate, **3)** Clinical pregnancy rate & **4)** Live birth rate per initiated cycle	IVF/ICSI induced live birth	7

[a] Studies covered in multiple exposure sections

[b] Total scores from quality assessment using the Newcastle–Ottawa Scale

Table 3 Summary table of findings from included studies

First Author & Year	Results from paternal exposure	Quality score ±
Body composition		
Bowatte et al. 2022 [25]	Both ever asthma risk in offspring and asthma before age 10 years old were associated with father's high BMI trajectory (relative risk ratio [RRR] = 1.72 [95% CI: 1.00, 2.97] and RRR = 1.70 [95% CI: 0.98, 2.93], respectively). In the sex-stratified analysis, only the high BMI trajectory of fathers was associated with offspring ever allergic asthma (RRR = 2.04 [95% CI: 1.12, 3.72]; *P* = 0.02)	5
Broadney et al. 2017 [35]	Paternal pre-pregnancy body mass index [BMI] categories overweight [25.0—29.9 kg/m^2], obese class I [30.0—34.9 kg/m^2], and obese class II/III [> 35 kg/m^2] are associated with reduced neonatal IgM levels (β = -0.08, [95% CI: -0.13, -0.03], *P* = 0.001); (β = -0.07, [95% CI: -0.13, -0.01], *P* = 0.029)]; (β = -0.11, [95% CI: -0.19, -0.04], *P* = 0.003). Paternal overweight or obesity (class I or II/III) is not associated with the neonatal inflammation score (β = 0.003, [95% CI: -0.10, 0.11]); (β = 0.05, [95% CI: -0.07, 0.17]); (β = 0.07, [95% CI: -0.09, 0.23]) or CRP level (β = 0.02, [95% CI: -0.04, 0.09]); (β = 0.01, [95% CI: -0.07, 0.09]); (β = 0.004, [95% CI: -0.10, 0.10])	6
Casas et al. 2017 [36]	Zero association identified between paternal pre-pregnancy underweight [< 18.5 kg/m^2] or obese fathers [≥ 30 kg/m^2] and cognitive and psychomotor scores; Global cognitive index (β = 2.78, [95% CI: -8.40, 13.97]), (β = 0.51, [95% CI: -1.68, 2.69]); Memory (β = 4.63, [95% CI: -7.04, 16.31]), (β = 1.67, [95% CI: -0.62, 3.95]); Motor (β = -5.42, [95% CI: -17.51, 6.67]), (β = -0.96, [95% CI: -3.35, 1.42]). There is also no association between behavioural outcomes at pre-school age and underweight or obese fathers; ADHD Inattention (IRR = 3.46, [95% CI: 0.77, 15.49]), (IRR = 2.12, (95% CI: 0.73, 6.17); Hyperactivity (IRR = 1.38, [95% CI: 0.39, 4.76]), (IRR = 1.38, [95% CI: 0.96, 1.99]); Childhood Asperger Syndrome Test [CAST] (IRR = 0.85, [95% CI: 0.50, 1.46]), (IRR = 1.01, [95% CI: 0.91, 1.13])	9
Chen et al. 2021 [37]	The birth defect rate was significantly higher when paternal prepregnancy BMI ≥ 25 kg/m2 in IVF cycles (aOR 1.82, 95% CI: 1.06,3.10). Couples with paternal prepregnancy BMI ≥ 25 kg/m2 had a four-fold increased risk of congenital malformations of the musculoskeletal system (aOR 4.38, 95% CI: 1.31,14.65) *P* = 0.017 compared to couples with paternal prepregnancy BMI < 25 kg/m2. This association still remained after adjustment for confounding factors (aOR 4.55, 95% CI 1.32–15.71). No association was seen between paternal prepregnancy BMI and risk of other subcategories of birth defects	5
Fang et al. 2020 [38]	Pre-pregnancy BMI was roughly associated with TTP among men with BMI ≥ 24 (FOR 0.97 95%CI: 0.95,0.99); however, this association for men disappeared after adjusting for demographic characteristics (aFOR 1.01 95%CI: 0.98,1.02). Following logistic regression, no association was observed between male pre-pregnancy BMI ≥ 24 and subfecundity (aOR 0.97 95%CI: 0.92 – 1.03)	5
Fleten et al. 2012 [39]	Using absolute BMI values, paternal pre-pregnancy BMI and offspring BMI at age 3 years are associated (β = 0.038, [95% CI: 0.033, 0.044], *P* = 0.018). Using BMI as z-score [standard deviation] (β = 0.125, [95% CI: 0.107, 0.143], *P* = 0.805), there is no longer an association	6
Guo et al. 2022 [40]	Following multivariate adjustment, husbands who were underweight had significantly higher risk (OR = 1·17 [95% CI: (1·15, 1·19)] of SGA compared with the husband with normal BMI. In addition, a significant and increased risk of LGA was observed for overweight and obese men (OR = 1·08 [95% CI: 1·06,1·09]); (OR = 1·19 (95% CI: 1·17, 1·20)] respectively. Reduced paternal BMI was associated with an increased risk of SGA when paternal BMI was less than 22·64 (*P* non-linear < 0·001). Meanwhile, increasing paternal BMI were associated with an increased risk of LGA when paternal BMI was more than 22·92 (*P* non-linear < 0·001)	6
Hoek et al. 2022 [41]	Paternal periconceptional BMI is negatively associated with the fertilization rate (β = −0.01, [SE = 0.004], *P* = 0.002]); for every increase in paternal BMI point the fertilization rate decreased 1%. Paternal BMI is not associated with the TMSC (β = −2.48, [SE = 1.53], *P* = 0.11]), the KIDScore (β = −0.01, [SE = 0.02], *P* = 0.62]), the embryo usage rate (β = −0.001, [SE = 0.004], *P* = 0.84]), a positive pregnancy (β = 0.03, OR = 1.03, *P* = 0.49), fetal heartbeat (β = 0.03, OR = 1.03, *P* = 0.51) or live birth (β = 0.01, OR = 1.01, *P* = 0.82)	8
Johannessen et al. 2020 [33]	Among offspring with ECRHS/RHINE fathers who had become overweight during puberty, there was an increased risk of adult offspring's asthma without nasal allergies (RRR = 2.36 [95% CI: 1.27, 4.38]), compared with fathers who had never been overweight. Offspring's overweight status at age 8 years was positively associated with adult offspring's asthma without nasal allergies (RRR = 1.50 [95% CI: 1.05, 2.16]. The risk of offspring's overweight status at age 8 years was greater if the father was overweight at the same period [OR = 2.23 [95% CI: 1.45, 3.42] compared with the offspring having fathers who had never been overweight	6
Lonnebotn et al. 2022 [34]	Fathers' overweight before puberty had a negative indirect effect, mediated through sons' height, on sons' forced expiratory volume in one second (FEV_1) (beta (95% CI): −144 (−272, −23) mL) and forced vital capacity (FVC) (beta (95% CI): −210 (−380, −34) mL), and a negative direct effect on sons' FVC (beta (95% CI): −262 (−501, −9) mL); statistically significant effects on FEV_1/FVC were not observed	7
Moss et al. 2015[a] [42]	Paternal preconception overweight [25.0—29.9 kg/m^2] and obesity [> 30 kg/m^2] is not associated with gestational age (-0.19, [95% CI: -1.30, 0.91], *P* = 0.37); (-0.39, [95% CI: -1.71, 0.94], *P* = 0.28), or offspring birthweight (35.6, [95% CI: -1.40, 211.3], *P* = 0.34); (76.8, [95% CI: -74.6, 228.1], *P* = 0.16)	7
Mutsaerts et al. 2014[a] [43]	No association identified between paternal pre-pregnancy BMI and spontaneous preterm birth (OR = 0.99, [95% CI: 0.93, 1.06]) or SGA (0.96, [95% CI: 0.91, 1.01])	3

Table 3 (continued)

First Author & Year	Results from paternal exposure	Quality score ±
Noor et al. 2019 [44]	Cord blood DNA methylation at 9 CpG sites is associated with paternal BMI independent of maternal BMI ($P = < 0.05$). Methylation at cg04763273, between TFAP2C and BMP7, decreased by 5% in cord blood with every 1-unit increase in paternal BMI ($P = 3.13 \times 10^{-9}$), decreases persist at ages 3 ($P = 0.002$) and 7 ($P = 0.004$). Paternal BMI is associated with methylation at cg01029450 in the promoter region of the ARFGAP3 gene; methylation at this site is also associated with lower infant birthweight ($\beta = -0.0003$; SD = 0.0001; $P = 0.03$)	7
Pomeroy et al. 2015 [23]	Paternal pre-pregnancy BMI is positively associated with neonatal neck-rump length ($\beta = 0.12$, $P = 0.008$) and the distal limb segments [lower arm/lower leg length] ($\beta = 0.09$, $P = 0.006$);($\beta = 0.09$, $P = 0.003$). Neonatal birthweight ($\beta = 0.08$, $P = 0.003$), proximal limb segments [upper arm/thigh length] ($\beta = 0.10$, $P = 0.001$);($\beta = 0.08$, $P = 0.008$), relative upper limb length ($\beta = 0.10$, $P = 0.002$) and relative lower limb length ($\beta = 0.09$, $P = 0.004$) are associated with paternal height only. Neonatal head circumference and adiposity are only associated with maternal pre-pregnancy height and BMI	6
Retnakaran et al. 2021 [45]	Offspring birthweight increases by 10.7 g per unit increase in paternal pregravid BMI ([95% CI: 0.5, 20.9], $P = 0.04$), yet paternal pregravid BMI is not an independent predictor for LGA (aOR = 1.15, [95% CI: 0.92, 1.44]) or SGA (aOR = 0.88, [95% CI: 0.67, 1.17]). When modelled separately, paternal pregravid weight ($P = 0.04$), not height ($P = 0.43$), is associated with offspring birthweight	8
Robinson et al. 2020 [46]	No association identified between paternal BMI overweight [≥ 25 kg/m^2- < 30 kg/m^2], obese class I [≥ 30 kg/m^2- < 35 kg/m^2] and obese class II [≥ 35 kg/m^2] and offspring behavioural issues or psychiatric symptoms at 7–8 years; P trend for behavioural outcomes range from 0.13 [Maternal reported ADHD diagnosis] to 0.79 [Prosocial behaviours]	7
Sun et al. 2022 [47]	Compared with normal weight men, paternal pre-pregnancy overweight was associated with a significantly increased risk of preterm birth (aOR 1.34 95% CI: 1.25,1.45) and low birth weight (aOR 1.60 95% CI: 1.46–1.74) in offspring. There was also an increased risk of preterm birth (aOR 1.26 95% CI: 1.14,1.40) and low birth weight (aOR 1.40 95% CI: 1.25,1.58) in offspring of paternal pre-pregnancy obesity	7
Sundaram et al. 2017 [48]	Male BMI [25—< 35 kg m^2] and [≥ 35 kg m^2] is not associated with TTP, when modelled individually; (aFOR = 0.92, [95% CI: 0.70, 1.22]), (aFOR = 0.83, [95% CI: 0.53,1.28]). Obese class II couples (BMI. > 35.0 kg/m2) associate with fecundability (aFOR = 0.41, [95% CI: 0.17, 0.98]) having a longer TTP in comparison to couples with normal BMI (< 25 kg/m2) (aFOR = 0.91, [95% CI: 0.25, 3.37])	8
Umul et al. 2015 [49]	Increasing paternal BMI is inversely associated with sperm concentration ($P = 0.02$), sperm motility ($P = 0.04$), the clinical pregnancy rate ($P = 0.04$), and the live birth rate ($P = 0.03$). Zero association identified between paternal BMI and the fertilization rate ($P = 0.89$) or the implantation rate ($P = 0.62$)	2
Wei et al. 2022 [50]	Paternal pre-pregnancy overweight and obesity are associated with a higher risk of low birth weight (LBW) (overweight: OR = 1.637, 95% CI: 1.501,1.784); (obesity: OR = 1.454, 95% CI: 1.289, 1.641) and very low birth weight (VLBW) (overweight: OR = 1.310, 95% CI: 1.097,1.564); (obesity: OR = 1.320, 95% CI: 1.037, 1.681). Paternal pre-pregnancy underweight is associated with a lower risk of LBW (OR = 0.660, 95% CI: 0.519, 0.839). Parents who were both excessive-weights in pre-pregnancy BMI, as well as overweight mothers and normal-weight fathers before pre- pregnancy, were more likely to have offspring with LBW, VLBW, and extremely low birth weight (ELBW)	6
Wei et al. 2021 [51]	Paternal pre-pregnancy BMI overweight (OW) did not present associations with newborn relative telomere length (TL) in cord blood, even following adjustments (percentage change 0.93 (95% CI: -5.59,8.14));$P = 0.772$ or stratification by newborn sex (percentage change 2.09 (95% CI: -7.53,12.72));$P = 0.686$. Analysis of the combined effects of parental weight status on newborn TL showed that TL was significantly shortened among newborns whose mothers were overweight and fathers were of healthy weight when compared with those whose mothers and fathers were both of normal weight (percentage change − 8.38 (95% CI: − 15.47, − 0.92)); $P = 0.028$	6
Xu et al. 2021 [52]	Each standard deviation (SD) increment of paternal BMI (approx 3.27 kg/m^2) is associated with an additional 29.6 g increase of birth weight ([95% CI: 5.7, 53.5], P = 0.02). As a continuous variable, one-unit increase in paternal BMI (1.0 kg/m^2) is associated with a 9.6 g increase of offspring birth weight ([95% CI: 2.3, 17.0], P = 0.01). The association between paternal preconception body weight and offspring's birth weight is pronounced in male neonates and neonates with overweight mothers or mothers with excessive gestational weight gain [GWG] ($P = < 0.05$)	7
Yang et al. 2015 [53]	Fathers overweight [BMI 24.0—27.9 kg/m^2] or obese [BMI ≥ 28.0 kg/m^2] before pregnancy have an elevated risk of giving birth to a macrosomic infant, compared with their normal weight counterparts (aOR = 1.33, [95% CI: 1.11, 1.59]);(aOR = 1.99 [95% CI: 1.49,2.65]). Paternal pre-pregnancy weight only [≥ 75.0 kgs], not height, is associated with increased risk of macrosomia (aOR = 1.49, [95% CI: 1.16, 1.92])	6
Zalbahar et al. 2017 [24]	Overweight or obese [OW/OB] fathers [> 25 kg/m^2] and normal weight mothers [< 25 kg/m^2] have an increased risk of offspring OW/OB at both the 5 to 14 year plus the 14 to 21 year follow-up (aOR = 2.34, [95% CI: 1.50, 3.65]);(aOR = 2.27, [95% CI: 1.60, 3.24]). This risk increases further when both parents are OW/OB (aOR = 9.95, [95% CI: 5.60, 17.69]); (aOR = 12.47, [95% CI: 7.40, 21.03]); for every unit increase in paternal and maternal BMI z-score, offspring BMI z-score increased, on average, by between 0.15% (kg m^2) and 0.24% (kg m^2) throughout the 5, 14 and 21 year follow-up	5

Table 3 (continued)

First Author & Year	Results from paternal exposure	Quality score ±
Zhang et al. 2020 [54]	Underweight [< 18.5 kg/ m^2] male partners prolong a couples' TTP (aFOR = 0.95, [95% CI: 0.94, 0.96]) compared to male partners with normal BMI [18.5—23.9 kg/m^2]. A combination of normal BMI women and overweight men [24.0—28.9 kg/m^2] have the greatest opportunity for pregnancy (aFOR = 1.03, [95% CI: 1.02, 1.03]), a combination of obese women and underweight men have the least opportunity for pregnancy (aFOR = 0.70, [95% CI: 0.65, 0.76])	9
Alcohol		
Luan et al. 2022 [55]	The risks of rating scores on anxious/depressed were increased by 33% (RR = 1.33 [95% CI: 1.09, 1.61]) and 37% (RR = 1.37 [95% CI: 1.02,1.84]) among girls in the exposed group at ages 4 and 6, respectively. Risks of somatic complaints were increased by 18% (RR = 1.18 [95% CI: 1.00, 1.40]) and 65% (RR 1.65,[95% CI: 1.14, 2.38]) among boys in the exposed group at ages 4 and 6. Also, there was the increased risks of sleep problems (RR = 1.25[95% C:I 1.00,1.55]) in girls at age 4, thought problems (RR = 1.32 [95% CI: 1.01, 1.73]) in girls at age 6, and rule-breaking behaviours (RR = 1.35 [95% CI: 1.09, 1.67]) in boys at age 6	7
Milne et al. 2013 [27]	For both ALL and CBT case/control, there was some evidence of a U-shaped relationship between the amount of alcohol fathers consumed in the 12 months before the pregnancy and risk of both cancers. The odds ratios (ORs) fell with increasing consumption, to a minimum at 14–21 standard drinks a week, ALL (OR = 0.51 [95% CI: 0.32, 0.81]);CBT (OR = 0.58 [95% CI: 0.35,0.96]), and rose to a maximum at 28 drinks a week; ALL (OR = 1.20 [95% CI: 0.79,1.83); CBT (OR = 1.53 [95% CI:0.95, 2.44]). The p values for the quadratic terms in the ALL and CBT models were 0.005 and 0.02, respectively	6
Moss et al. 2015[a] [42]	Paternal preconception alcohol intake > once a month is not associated with offspring birthweight (−85.9, [95% CI: -336.2, 164.3], *P* = 0.50) or offspring gestational age (−0.10, [95% CI: -0.96, 0.77], *P* = 0.83)	7
Mutsaerts et al. 2014[a] [43]	Paternal preconception alcohol intake > 7 units/week is not associated with spontaneous preterm birth (OR = 1.08, [95% CI: 0.64, 1.83]) or SGA (OR = 1.07, [95% CI: 0.73, 1.56])	3
Xia et al. 2018 [56]	In the paternal alcohol-exposed group [> 81 g/wk], male offspring have shorter mean AGDs; for AGD-AP at birth (β = —1.73, P = 0.04) and 12 months (β = -7.29, *P* = 0.05), and shorter mean AGD-AS at 6 months (β = —4.91, *P* = 0.02). Female offspring have shorter mean AGD-AF (β = -0.72, *P* = 0.02) at birth yet longer mean AGD AC (β = 2.81, *P* = 0.04) and AGD-AF (B = 1.91, *P* = 0.04) at 12 months	8
Zuccolo et al. 2016 [57]	Increased odds of microcephaly at birth with alcohol dose per occasion at 5 + units/sitting; [1—2 units] (OR = 1.48, [95% CI: 0.77, 2.84], *P* = 0.238), [3–4 units] (OR = 1.64, [95% CI: 0.85, 3.16], *P* = 0.140), [5 + units] (OR = 1.93, [95% CI: 1.01, 3.70], *P* = 0.048). The average paternal preconception alcohol dose per occasion and general head circumference at birth is not associated [1—2 units] (β = -0.00, [95% CI: -0.05, 0.04], *P* = 0.831), [3–4 units] (β = -0.00, [95% CI: -0.05, 0.04], *P* = 0.915), [5 + units] (β = -0.02, [95% CI: -0.07, 0.02], *P* = 0.293)	4
Cannabis		
Har-Gil et al. 2021 [58]	Sperm quality is associated with cannabis use (6 [1.4], *P* = 0.022), compared with non-use (6[2.2], *P* = 0.50). Sperm volume (2.69/2.5 [1.6]), IVF fertilization (53/53 [59]), the IR (*P* = 0.46) and OPR (*P* = 0.508) are not associated with male cannabis use	2
Kasman et al. 2018 [59]	Zero association identified between male cannabis use and TTP, regardless of frequency; [< 1/month] (aTR = 0.9, [95% CI: 0.7, 1.2], *P* = 0.43), [Monthly] (aTR = 0.9, [95% CI: 0.5, 1.8], *P* = 0.73), [Weekly] (aTR = 1.0, [95% CI: 0.3, 2.9], *P* = 1.00), [Daily] (aTR = 1.1, [95% CI: 0.79, 1.5], *P* = 0.65)	6
Moss et al. 2015[a] [42]	Paternal preconception cannabis use is not associated with gestational age (0.41, [95% CI: -0.43, 1.25], *P* = 0.34) or offspring birthweight (201.9, [95% CI: -97.6, 501.3], *P* = 0.19)	7
Nassan et al. 2019 [60]	Compared to males who are past or never cannabis users, couples where the male partner is a cannabis user at enrolment (*n* = 23) have increased probability of implantation (77.9, [95% CI: 53.5, 91.5], *P* = < 0.05) and live birth (47.6, [95% CI: 32.4, 63.3], *P* = < 0.05), independent of women's cannabis use. Clinical pregnancy is not associated with male cannabis use; (60.1, [95% CI: 42.6, 75.4])	7
Wise et al. 2018 [61]	Male current cannabis users (*n* = 100) present no association between cannabis use and fecundability (aFR = 1.01, [95% CI: 0.81, 1.27]) even following stratification by intercourse frequency (aFR = 1.35, [95% CI: 0.72, 2.53]) and timing of sexual intercourse (aFR = 1.05, [95% CI: 0.76, 1.45]). Paternal cannabis use [< 1 time/week] has slightly decreased fecundability (FR = 0.87, [95% CI: 0.66, 1.15]), compared with non-current users	6
Physical activity		
Moss et al. 2015[a] [42]	Zero association identified between paternal preconception bouts of physical activity per week and gestational age (0.02, [95% CI: -0.04, 0.07], *P* = 0.53) or offspring birthweight (1.7, [95% CI: -13.0, 16.4], *P* = 0.82)	7
Mutsaerts et al. 2014[a] [43]	Paternal preconception physical activity of moderate intensity < 1 time/week is not associated with spontaneous preterm birth (OR = 0.76, [95% CI: 0.45, 1.27]) or SGA (OR = 1.33, [95% CI: 0.95, 1.87])	3

Table 3 (continued)

First Author & Year	Results from paternal exposure	Quality score ±
Smoking		
Accordini et al. 2021 [32]	Fathers' smoking initiation in prepuberty (generation G1) had a negative direct effect on their own FEV1/FVC (Δz-score − 0.36, 95% CI: − 0.68, -0.04) compared with fathers' never smoking. This exposure had a negative direct effect on both offspring's FEV1 (− 0.36, 95% CI: − 0.63, − 0.10) and FVC (− 0.50, 95% CI: − 0.80, − 0.20) (generation G2). Fathers' smoking initiation at later ages also had a negative direct effect on their own FEV1 (− 0.27, 95% CI: − 0.51, − 0.02) and FEV1/FVC (− 0.20, 95% CI: − 0.37, − 0.04), but no effect found on offspring's lung function	8
Accordini et al. 2018 [31]	Fathers' smoking before they were 15 years old were associated with asthma without nasal allergies in their offspring [relative risk ratio ((RRR) = 1.43 95% CI: 1.01, 2.01]. The risk of fathers' asthma (generation F1) was higher if their parents (generation F0) had ever had asthma (grandmothers' asthma: (OR = 3.08 [95% CI: 1.96,4.85]); grandfathers' asthma: (OR = 2.38 [95% CI: 1.51, 3.75]). The risk of asthma with or without nasal allergies in offspring (generation F2) was higher if the offspring's father had ever had asthma (RRR = 2.37 and 1.70), respectively	7
Carslake et al. 2016 [62]	Paternal smoking during pre-adolescence (< age 11) is not reliably or strongly associated with BMI among sons, with an estimated association close to zero (mean difference in kg m-2 (95% CI) was -0.18 (-1.75, 1.39) for sons aged 12 ± 19 and 0.22 (-0.53, 0.97) for all ages). Among daughters, early-onset paternal smoking was imprecisely associated with an elevated BMI (mean difference was 1.50 (0.00, 3.00) for daughters aged 12 ± 19 and 0.97 (0.06, 1.87) for all ages)	6
Deng et al. 2013 [63]	During the periconceptional period, light paternal smoking [1–9 cigarettes/day] increases the risk of isolated conotruncal heart defects (aOR = 2.23, [95% CI: 1.05, 4.73]). Medium paternal smoking [10–19 cigarettes/day] increases the risk of septal defects (aOR = 2.04, [95% CI: 1.05, 3.98]) and left ventricular outflow tract obstructions (aOR = 2.48, [95% CI: 1.04, 5.95]). Heavy paternal smoking (≥ 20 cigarettes/day) provides even greater risk of isolated conotruncal heart defects (aOR = 8.16, [95% CI: 1.13, 58.84]) and left ventricular outflow tract obstructions (aOR = 13.12, [95% CI: 2.55, 67.39]). No association identified between paternal smoking and right ventricular outflow tract obstructions; light smoking (AOR = 1.84, [95% CI 0.88, 3.85]); medium smoking (aOR = 2.04, [95% CI: 0.71, 5.89]); heavy smoking (aOR = 6.02, [95% CI: 0.98, 36.77])	8
Frederiksen et al. 2020 [64]	Nil associations identified between paternal smoking before conception and childhood ALL (OR = 1.00, 95% CI: 0.73, 1.38). Paternal smoking before conception was associated with an increased risk of childhood AML in both the crude (OR = 2.55, 95% CI: 1.25, 5.21) and adjusted models (OR = 2.51, 95% CI: 1.21, 5.17)	7
Knudsen et al. 2020 [30]	In the unadjusted analysis, father's preconception smoking, both starting before or from age 15 years, was associated with increased offspring BMI. Following adjustments, father's smoking onset ≥ 15 years was significantly associated with increased BMI in their adult offspring (0.551, [95% CI: 0.174, 0.929]) $P = 0.004$. Father's preconception smoking onset ≥ 15 years was also associated with increased offspring FMI (2.590 [95% CI: 0.544, 4.63]) $P = 0.014$. Further, sons of fathers' who started to smoke ≥ 15 years of age (interaction $p = 0.014$) had significantly higher FMI compared to sons of never smoking fathers	5
Milne et al. 2013 [27]	Paternal preconception smoking showed no association with childhood brain tumor (CBT) risk (OR = 0.99 (95% CI: 0.71, 1.38); $P = 0.54$. There was also no association evident when paternal smoking was stratified by child's age	5
Ko et al. 2014 [65]	Paternal preconception smoking [11–20 cigarettes/day] has a negative effect on overall infant birthweight (β = -19.17 [7.74], $P = 0.013$) but is not associated with gestational age (β = -0.05 [0.028], $P = 0.108$). Paternal preconception smoking [> 20 cigarettes/day] is not associated with preterm delivery (1.07, [95% CI: 0.84, 1.35]), low birth weight (1.14, [95% CI: 0.87, 1.27]), or small for gestational age [SGA] (1.12, [95% CI: 0.90, 1.40])	5
Moss et al. 2015[a] [42]	Paternal preconception smoking at least one cigarette/day for one month is not associated with gestational age (− 0.31, [95% CI: − 1.20, 0.59], $P = 0.50$) or offspring birthweight (− 219.6, [95% CI: − 537.0, 97.8], $P = 0.18$)	7
Mutsaerts et al. 2014[a] [43]	Paternal smoking [1–10 cigarettes/day] or [< 10 cigarettes/day] 6 months prior to conception, is associated with an increased risk of SGA (OR = 1.69; [95% CI: 1.10, 2.59]); (OR = 2.25, [95% CI: 1.51, 3.37]) but not spontaneous preterm birth (OR = 1.34, [95% CI: 0.74, 2.41]); (OR = 1.13, 95% CI: 0.59, 2.14)	3
Northstone et al. 2014 [66]	In sons whose fathers started smoking < 11 years, mean differences in BMI, waist circumference, and fat mass all show increases in measures at ages 13, 15 and 17; at 13 years BMI (2.83, [95% CI: 1.20, 4.25]), waist circumference and fat mass (4.83, [95% CI: 0.98, 8.68], $P = 0.014$);(5.79, [95% CI: 2.67, 8.91] $P = < 0.0001$), and at 15 years BMI (2.03 [95% CI: 0.45, 3.6]), waist circumference and fat mass (4.84, [95% CI: 0.99, 8.66], $P = 0.006$); (5.50, [95% CI: 1.88, 9.30], $P = 0.004$). At 17 years there is an association with BMI (3.25 [95% CI: 1.15, 5.35]) and fat mass (10.6 [95% CI: 5.40, 15.9], $P = < 0.0001$); waist not recorded. Daughters' measurements vary with associations at ages 9 (all measurements), 11 (lean mass $P = 0.023$), 13 (waist circumference $P = 0.004$ & lean mass $P = 0.028$) and 17 (fat mass $P = 0.012$)	7
Orsi et al. 2015 [67]	Pre-conception paternal smoking was significantly associated with ALL (OR = 1.2 [95% CI: 1.1,1.5)] and AML (OR = 1.5 [95% CI: 1.0–2.3]). For ALL, the ORs were higher for smoking\10 cigarettes daily than for the highest consumption; no significant trend was evidenced. For AML, significant trends were evidenced for both periods (p trend = 0.03 and 0.02, respectively), with ORs of close to 2.0 for smoking more than 15 cigarettes daily. No joint effect of paternal and maternal smoking was detected	7

Table 3 (continued)

First Author & Year	Results from paternal exposure	Quality score ±
Sapra et al. 2016 [68]	Paternal cigarette smoking is associated with a longer TTP compared with never users (aFOR = 0.41, [95% CI: 0.24, 0.68]); attenuated slightly after adjusting for cadmium (aFOR = 0.44, 95% CI: 0.24, 0.79). When modelling partners together, paternal cigarette smoking remains associated with a longer TTP (aFOR = 0.46, [95% CI: 0.27, 0.79]), also attenuated after adjustment for cadmium (aFOR = 0.50, [95% CI 0.27—0.91]). Zero association identified between TTP and exposure to any other tobacco products including cigars (FOR = 0.70, [95% CI: 0.45, 1.08]) or snuff and chew tobacco (FOR = 1.17, [95% CI: 0.70, 1.95]	7
Svanes et al. 2017 [69]	Non-allergic early-onset asthma (asthma without hay fever) was more common in the offspring with fathers who smoked before conception (OR = 1.68 [95% CI: 1.18,2.41]). The risk was highest if father started smoking before age 15 years (OR = 3.24 [95% CI: 1.67,6.27]), even if he stopped more than 5 years before conception (OR = 2.68 [95% CI: 1.17, 6.13]).Both a father's early smoking debut ($P = 0.01$) and a father's longer smoking duration ($P = 0.01$) before conception increased non-allergic early-onset asthma in offspring, even with mutual adjustment and adjusting for number of cigarettes and years since quitting smoking. A father's smoking debut before age 11 years (102 fathers) showed the greatest increased risk (OR = 3.95, [95% CI: 1.07,14.60]), followed by smoking debut ages 11–14 (OR = 1.75, [95% CI: 1.07,1.86]) and smoking debut after age 15 (OR = 1.37, [95% CI: 1.00,1.86]). Longer duration of smoking was also associated with an increased risk, up to 1.8-fold for those smoking for more than 10 years (OR = 1.76, [95% CI: 0.96,3.25])	6
Wang et al. 2022 [70]	Hazard ratio (HR) of preterm birth (PTB) was 1.07 (95% CI, 1.06–1.09), compared with women without preconception paternal smoking. Compared with participants without preconception paternal smoking, the fully adjusted HRs of PTB were (1.04 [95% CI: 0.99,1.08]), (1.05 [95% CI: 1.01, 1.08]), (1.06 [95% CI: 1.03, 1.09]), (1.14 [95% CI: 1.07, 1.21]) and (1.15 [95% CI: 1.11, 1.19]) for participants whose husband smoked 1–4, 5–9, 10–14, 15–19, and ≥ 20 cigarettes/day respectively (P linear < 0.05)	5
Wang et al. 2018 [71]	Women with exposure to paternal preconception smoking have increased odds of SA (aOR = 1.11, [95% CI: 1.08, 1.14], $P = < 0.01$). This association is evident when smoking > 10 cigarettes/day, $P = < 0.01$; [10–14 cigarettes/day] (aOR = 1.11, [95% CI: 1.06, 1.16]), [15–19 cigarettes/day] (aOR = 1.21, [95% CI: 1.09, 1.33]) and ≥ 20 cigarettes/day (aOR = 1.23, [95% CI: 1.17, 1.30)	6
Wesselink et al. 2019 [72]	Male current regular smoking, current occasional smoking, and former smoking is not associated with fecundability (FR = 0.96, [95% CI: 0.70, 1.34]), (FR = 0.83, [95% CI: 0.61, 1.13]), (FR = 1.14, [95% CI: 0.97, 1.35])	5
You et al. 2022 [73]	For those with only preconception exposure, compared with children without paternal smoking, the risk of childhood overweight and obesity was increased (OR = 1.41 [95% CI: 1.17, 1.85]). Following further adjustments, for lifestyle and dietary factors, this effect remained statistically significant (OR = 1.54 [95% CI: 1.14, 2.08]). When stratified by sex, the effects of only preconception exposure on childhood overweight and obesity was statistically significant for only boys ($p < 0.05$)	7
Zhou et al. 2020 [74]	There is an increased risk of birth defects in the continued-smoking (OR = 1.87, [95% CI: 1.36, 2.56], $P < 0.001$) and decreased-smoking groups (OR = 1.41, [95% CI: 1.10, 1.82], $P = 0.007$). Continued paternal smoking is associated with an elevated risk of congenital heart diseases (OR = 2.51, [95% CI: 1.04, 6.05], P = 0.040), limb abnormalities (OR = 20.64, [95% CI: 6.26, 68.02], $P < 0.001$), digestive tract anomalies (OR = 3.67, [95% CI: 1.44, 9.37], P = 0.007) and neural tube defects (OR = 4.87, [95% CI: 1.66, 14.28], $P = 0.004$). There is no association between continued paternal smoking and clefts (OR 1.44, [95% CI: 0.34, 5.90], $P = 0.625$) or gastroschisis (OR = 2.63, [95% CI: 0.82, 8.40] $P = 0.103$)	7
Zwink et al. 2016 [75]	Paternal periconceptional tobacco consumption is lower in the fathers of EA/TEF patients [Any smoking] n = 20 (20%) $P = 0.003$, compared with fathers of isolated ARM patients [Any smoking] $n = 49$ (40%) $P = 0.003$	4
Stress		
Bae et al. 2017 [76]	There is a 76% increase in risk of fathering a male infant (RR = 1.76, [95% CI: 1.17, 2.65]) in men diagnosed with anxiety disorders compared with those not diagnosed. This association is strengthened (RR = 2.03, [95% CI: 1.46, 2.84]) when modelled jointly for the couple	6
Mutsaerts et al. 2014[a] [43]	Paternal paid working hours < 16 h/week is not associated with spontaneous preterm birth (OR = 2.21, [95% CI: 0.78, 6.26]) or SGA (OR = 0.76, [95% CI: 0.23, 2.45])	3
Wesselink et al. 2018 [77]	Men's baseline PSS scores are not associated with fecundability; [PSS score 10—14] (FR = 0.95 [95% CI: 0.79, 1.15]), [PSS Score 15–19] (FR = 1.07 [95% CI: 0.86, 1.33]), [PSS Score 20–24] (FR = 1.02 [0.76, 1.36]), [PSS Score ≥ 25] (FR = 1.03 [0.69, 1.54])	7
Nutrition		
Bailey et al. 2014 [29]	No significant associations identified with paternal dietary intake of folate or vitamin B6 or vitamin B12 and risk of ALL; (OR = 1.37 95% CI: 0.78, 2.40)	5
Greenop et al. 2015 [28]	No significant associations identified between risk of childhood brain tumors (CBT) and energy adjusted dietary folate > 509.5 (mcg) (OR = 0.85 95% CI: 0.56,1.28) or energy adjusted B6 > 1.71 (mg) (OR = 0.98 95% CI: 0.66,1.47). A high B12 intake (> 5.91(mcg)) was not significantly associated with an increased risk of CBT (OR = 1.74 95% CI: 1.14, 2.66)	5

Table 3 (continued)

First Author & Year	Results from paternal exposure	Quality score±
Hatch et al. 2018 [78]	Male intake of sugar-sweetened beverages is associated with reduced fecundability (aFR = 0.78 95% CI: 0.63, 0.95) for ≥ 7 sugar-sweetened beverages per week compared with none. Fecundability was further reduced among those who drank ≥ 7 servings per week of sugar-sweetened sodas (aFR = 0.67 95% CI: 0.51, 0.89). The largest reduction in fecundability was seen in men who consumed seven or more energy drinks per week (FR = 0.42; 95% CI: 0.20, 0.90). Diet sodas did not have significant association with fecundability at ≥ 7 servings per week (aFR = 0.93 95% CI: 0.71, 1.2)	6
Hoek et al. 2019 [79]	In spontaneously conceived pregnancies, there is a negative association between paternal RBC folate status and CRL trajectories, in Q2 [875–1,018 nmol/L,] (β = -0.14; [95% CI:—0.28, -0.006], $P = 0.04$) and Q4 [1,196–4,343 nmol/L] (β = —0.19, [95% CI:—0.33, -0.04], $P = 0.012$). A negative association also exists for EV trajectories in Q4 (β = —0.12, [95% CI: -0.20, -0.05], $P = 0.001$). No association identified between paternal RBC folate status and CRL or EV trajectories in IVF-ICSI pregnancies [Q4] (β = 0.03, [95% CI: -0.07, 0.13], $P = 0.55$), (β = 0.03, [95% CI: -0.03, 0.08], P = 0.32)	7
Lippevelde et al. 2020 [80]	In Young-HUNT1, an extra serving of fruit per week in the paternal diet, during adolescence, is associated with a 2.35 g increase in offspring placenta weight [95% CI: 0.284, 4.42], $P = 0.03$. A slightly shorter birth length is associated with increased paternal vegetable intake during adolescence (β = -0.048, [95% CI: -0.080, -0.016], $P = 0.003$) and a lower ponderal index is associated with paternal whole grain bread consumption (β = -0.003, [95% CI: -0.005, -0.001], $P = 0.01$). Paternal lunching regularly in adolescence is associated with an increase in offspring head circumference (β = 0.160, [95% CI: 0.001, 0.320], $P = 0.05$). Birthweight is not associated with any paternal dietary exposures; [Fruit] (β = 5.84 [95% CI: -0.983, 12.7], $P = 0.1$). These associations are not observed in Young-HUNT3	8
Martin-Calvo et al. 2019 [81]	A 400 µg/day increase in preconception paternal folate intake is associated with a 2.6-day longer gestation [95% CI: 0.8, 4.3], $P = 0.004$. This association is strongest in multifetal pregnancies (β = 10.7, [95% CI: 4.6, 16.8]). Zero association identified between paternal folate intake and gestational age-specific birthweight (β = -11.4, [95% CI: -28.2, 5.4])	7
Mitsunami et al. 2021 [82]	Paternal adherence to either dietary patterns 1 or 2 is not associated with the fertilization rate during IVF or ICSI ([Pattern 1] $P = 0.59$, [Pattern 2] $P = 0.06$), ([Pattern 1] $P = 0.72$, [Pattern 2] $P = 0.94$). Zero association identified between male dietary patterns and probabilities of implantation, clinical pregnancy, or live birth; ([Pattern 1] $P = 0.68$, [Pattern 2] $P = 0.43$), ([Pattern 1] $P = 0.35$, [Pattern 2] $P = 0.68$), ([Pattern 1] $P = 0.53$, [Pattern 2] $P = 0.10$)	7
Moss et al. 2015[a] [42]	Males eating fast food more frequently have infants born earlier than men who eat fast-food less frequently (-0.16, [95% CI: -0.32, 0.00], $P = 0.04$). There is no association between paternal fast-food consumption and birthweight (-36.0, [95% CI: -89.8, 17.8], $P = 0.19$)	7
Oostingh et al. 2019 [83]	Zero association identified between paternal dietary patterns and CRL or EV in spontaneous pregnancies; [Whole wheat grains and vegetables] (β = -0.006 [95% CI: -0.069, 0.058]), (β = 0.001 [95% CI: -0.022, 0.021]), and in IVF/ICSI pregnancies, (β = -0.015 [95% CI: -0.061, 0.031]), (β = -0.006 [95% CI: -0.025, 0.013]), independent of maternal dietary patterns	6
Twigt et al. 2012 [84]	Paternal Preconception Dietary Risk Score [PDR] did not affect the chance of pregnancy after IVF/ICSI treatment (OR = 0.95 [95% CI: 0.48,1.86]) $P = 0.88$	5
Wesselink et al. 2016 [85]	Total caffeine intake among males was associated with fecundability for ≥ 300 mg vs. < 100 mg/day (OR = 0.72, 95% CI: 0.54, 0.96)	6
Xia et al. 2016 [86]	Men's total dairy intake is not associated with the fertilization rate [Conventional IVF] (0.75, [95% CI: 0.60, 0.86], $P = 0.29$), [ICSI] (0.72, [95% CI: 0.58, 0.82], $P = 0.18$], the implantation rate (0.58, [95% CI: 0.40, 0.74], $P = 0.87$), the clinical pregnancy rate (0.51, [95% CI: 0.34, 0.68], $P = 0.54$), or the live birth rate (0.46, [95% CI: 0.28, 0.65], $P = 0.65$)	7
Xia et al. 2015 [87]	A positive association identified between paternal poultry intake and the fertilization rate, [Model 1] $P = 0.05$, [Model 2] $P = 0.03$, [Model 3] $P = 0.03$, [Model 4] $P = 0.04$, with a 13% higher fertilization rate among men in the highest quartile of poultry intake compared with those in the lowest quartile (78% vs. 65%) [Model 4]. Men's total meat intake is not associated with the implantation rate (0.52, [95% CI: 0.37, 0.67], $P = 0.67$), clinical pregnancy rate (0.45, [95% CI: 0.32, 0.59], $P = 0.56$), or live-birth rate (0.35, [95% CI: 0.22, 0.50], $P = 0.82$)	7

[a] Studies covered in multiple exposure sections

[b] Quality score based on assessment using Newcastle–Ottawa Scale

Outcomes examined include fecundability ($n = 6$) [38, 61, 72, 77, 78, 85], (time to) pregnancy ($n = 4$) [48, 54, 59, 68], IVF/ICSI ongoing pregnancy ($n = 1$) [84] or live birth ($n = 7$) [41, 49, 58, 60, 81, 82, 86, 87], offspring birthweight or adiposity ($n = 10$) [40, 42, 45, 47, 50, 52, 53, 62, 65, 66], including small for gestational age [SGA] [43], neonatal ($n = 1$) [23] and offspring body composition ($n = 4$) [24, 30, 39, 73]. Other outcomes examined include offspring asthma ($n = 4$) [25, 31, 33, 69] and lung function ($n = 2$) [32, 34], childhood leukemia ($n = 4$) [26, 29, 64, 67], childhood brain tumours ($n = 2$) [27, 28], and offspring behavioural issues ($n = 2$) [46, 55].

There was an increasing number of papers identified for inclusion in this review with the least number of papers published in 2012 and the greatest number of papers published in 2022 (see Fig. 2).

Results below are described for papers assessed as good quality with approximately half ($n=30$) rated good quality and two receiving a maximum nine-star rating [36, 54] (Table 4—Newcastle Ottawa Scale [NOS] quality assessment (Cohorts)) & (Table 5—Newcastle Ottawa Scale [NOS] quality assessment (Case controls)). Results for the fair and poor-quality papers are not further described.

Body Composition

Twenty-five papers investigated associations between paternal BMI and various offspring outcomes. These papers were derived from studies ($n=21$) conducted in the US, Europe, China, Australia, and Turkey and less than half ($n=11$) rated as good quality.

Less than half of the papers ($n=10$) used anthropometric assessment by the research team to determine BMI [37, 38, 40–42, 45, 47–49, 54]; heights and weights utilized to formulate BMI were determined in the preconception period, generally from males in couples undergoing IVF/ICSI [41, 49] or males in couples currently attempting pregnancy/pregnant [40, 45, 48, 54]. Of the papers validating the BMI utilizing anthropometric assessments, most were good quality and generally affirmed significant results. The remaining papers utilize retrospective reports of preconception paternal weight and height or collect paternal height and weight from medical records. Maternal reporting ($n=7$) occurred at approximately 10 to 18 weeks gestation; or up to four months postpartum [35, 46]. Paternal self-reporting of their own weight and height ($n=8$) occurred at approximately week 17 of gestation [39, 43, 50, 52, 53] or up to 6 months postpartum [43]. In two papers, overweight paternal status, when a child of 8 years, was reported years later through a validated drawing of silhouettes [33, 34].

The outcomes and outcome measures varied, however, ten studies assessed the association of paternal BMI with offspring BMI/bodyweight [23, 39, 40, 42, 45, 47, 50, 52, 53], and one paper assesses offspring weight and BMI changes from childhood (5 years) into adulthood (21 years) [24].

Results of associations between body composition and offspring outcomes were inconsistent. In some studies paternal preconception overweight (25.0—29.9 kg/m^2) and obesity (>30 kg/m^2) were not associated with offspring birthweight [42] and paternal pregravid BMI was not an independent predictor for large for gestational age (LGA) or small for gestational age (SGA) [45]. However, other studies found that offspring birthweight increased by 10.7 g per unit increase in paternal pregravid BMI (95% CI: 0.5, 20.9, $P=0.04$) [45], and each standard deviation (SD) increment of paternal BMI (approximately 3.27 kg/m^2) was associated with an additional 29.6 g increase of birth weight (95% CI: 5.7, 53.5, $P=0.02$) [52]. Further, compared with normal weight men, paternal pre-pregnancy overweight was associated with a significantly increased risk of preterm birth (aOR 1.34 95% CI: 1.25,1.45) and low birth weight (aOR 1.60 95% CI: 1.46–1.74) in offspring [47].

Paternal pregravid weight ($P=0.04$), not height ($P=0.43$), was associated with infant birth weight [45] and with increased risk of macrosomia (aOR = 1.49, [95%

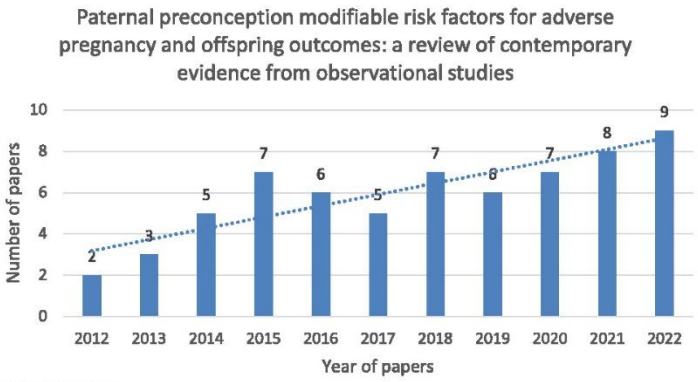

Fig. 2 Papers included in this review

Table 4 Newcastle Ottawa Scale [NOS] quality assessment (Cohorts)

First author & Year	Newcastle Ottawa Scale—Criteria									
	SELECTION				COMPARABILITY		OUTCOME			TOTAL
	Exposed cohort (representativeness)	Non-exposed cohort	Ascertainment of exposure	Outcome of interest not present at start of study	Based on design or analysis (AGE)	Based on design or analysis (OTHER FACTORS)	Assessment of outcome	Appropriate length of follow-up	Adequacy of follow-up of cohorts	
Accordini et al. 2021 [32]	*	*	*		*	*	*	*	*	8
Accordini et al. 2018 [31]	*	*	*		*	*		*	*	7
Bae et al. 2017 [80]		*	*	*	*	*		*		6
Bowatte et al. 2022 [25]		*	*			*		*	*	5
Broadney et al. 2017 [76]	*	*			*	*	*		*	6
Carslake et al. 2016 [62]	*	*				*	*	*	*	6
Casas et al. 2017 [74]	*	*	*	*	*	*	*	*	*	9
Chen et al. 2021 [75]		*	*		*	*	*			5
Fang et al. 2020 [42]	*	*	*		*	*				5
Fleten et al. 2012 [67]	*	*		*		*		*	*	6
Guo et al. 2022 [61]	*	*	*	*	*	*				6
Har-Gil 2021 [50]		*					*			2
Hatch et al. 2018 [44]		*		*	*	*		*	*	6
Hoek et al. 2022 [49]		*	*	*	*	*	*	*	*	8
Hoek et al. 2019 [88]		*	*		*	*	*	*	*	7
Johannessen et al. 2020 [33]	*	*			*	*		*	*	6
Kasman et al. 2018 [37]	*	*	*	*	*	*				6
Knudsen et al. 2020 [30]	*	*				*		*	*	5

Table 4 (continued)

First author & Year	Newcastle Ottawa Scale—Criteria									
	SELECTION				COMPARABILITY		OUTCOME			TOTAL
	Exposed cohort (representativeness)	Non-exposed cohort	Ascertainment of exposure	Outcome of interest not present at start of study	Based on design or analysis (AGE)	Based on design or analysis (OTHER FACTORS)	Assessment of outcome	Appropriate length of follow-up	Adequacy of follow-up of cohorts	
Ko et al. 2014 [60]	*	*	*		*	*				5
Lippevelde et al. 2020 [80]	*	*		*	*	*	*	*	*	8
Lonnebotn et al. 2022 [34]	*	*			*	*	*	*	*	7
Luan et al. 2022 [73]		*	*	*	*	*		*	*	7
Martin-Calvo et al. 2019		*	*	*	*	*		*	*	7
Mitsunami et al. 2021 [82]		*	*	*	*	*		*	*	7
Moss et al. 2015 [35]	*	*		*	*	*		*	*	7
Mutsaerts et al. 2014 [38]	*	*							*	3
Nassan et al. 2019 [52]		*	*	*	*	*		*	*	7
Noor et al. 2019 [77]		*		*	*	*	*	*	*	7
Northstone et al. 2014 [63]	*	*		*		*	*	*	*	7
Oostingh et al. 2019 [81]		*		*	*	*	*		*	6
Pomeroy et al. 2015 [23]		*			*	*	*	*	*	6
Retnakaran et al. 2021 [58]		*	*	*	*	*	*	*	*	8
Robinson et al. 2020 [72]	*	*		*	*	*		*	*	7
Sapra et al. 2016 [47]		*	*	*	*	*	*	*		7
Sun et al. 2022 [66]		*	*	*	*	*		*	*	7

Table 4 (continued)

First author & Year	Newcastle Ottawa Scale—Criteria									
	SELECTION				COMPARABILITY		OUTCOME			TOTAL
	Exposed cohort (representativeness)	Non-exposed cohort	Ascertainment of exposure	Outcome of interest not present at start of study	Based on design or analysis (AGE)	Based on design or analysis (OTHER FACTORS)	Assessment of outcome	Appropriate length of follow-up	Adequacy of follow-up of cohorts	
Sundaram et al. 2017 [45]		*	*	*	*	*	*	*	*	8
Svanes et al. 2017 [69]	*				*	*		*	*	6
Twigt et al. 2012 [48]		*		*	*	*			*	5
Umul et al. 2015 [57]		*					*			2
Wang et al. 2022 [65]	*	*	*		*	*				5
Wang et al. 2018 [85]	*	*	*	*	*	*				6
Wei et al. 2022 [50]		*		*	*	*	*	*		6
Wei et al. 2021 [51]	*	*	*		*	*	*			6
Wesselink et al. 2019 [40]		*		*	*	*		*		5
Wesselink et al. 2018 [41]		*	*	*	*	*		*	*	7
Wesselink et al. 2016 [43]		*		*	*	*		*	*	6
Wise et al. 2018 [39]		*		*	*	*		*	*	6
Xia et al. 2018 [78]		*	*	*	*	*	*	*	*	8
Xia et al. 2016 [55]		*		*	*	*	*	*	*	7
Xia et al. 2015 [56]		*		*	*	*	*	*	*	7
Xu et al. 2021 [59]		*	*	*	*	*		*	*	7

Table 4 (continued)

First author & Year	Newcastle Ottawa Scale—Criteria									
	SELECTION				COMPARABILITY		OUTCOME			TOTAL
	Exposed cohort (representativeness)	Non-exposed cohort	Ascertainment of exposure	Outcome of interest not present at start of study	Based on design or analysis (AGE)	Based on design or analysis (OTHER FACTORS)	Assessment of outcome	Appropriate length of follow-up	Adequacy of follow-up of cohorts	
You et al. 2022 [68]		*	*		*	*	*	*	*	7
Zalbahar et al. 2017 [24]		*			*	*	*	*		5
Zhang et al. 2020 [46]	*	*	*	*	*	*	*	*	*	9
Zhou et al. 2020 [86]		*	*	*	*	*		*	*	7
Zuccolo et al. 2016 [79]	*	*			*	*				4

Table 5 Newcastle Ottawa Scale [NOS] quality assessment (Case controls)

Newcastle–Ottawa Critical Analysis (Case controls)—Criteria										
First author & Year	SELECTION				COMPARABILITY		EXPOSURE			TOTAL
	Adequacy of case definition	Representativeness of the cases	Selection of controls	Definition of controls	Comparability of cases and controls (AGE)	Comparability of cases and controls (OTHER FACTORS)	Ascertainment of exposure	Same method of ascertainment for cases and controls	Non-Response rate	
Bailey et al. 2014 [29]	*		*		*	*	*			5
Deng et al. 2013 [83]	*	*		*	*	*	*	*	*	8
Frederiksen et al. 2020 [70]	*	*	*	*	*	*		*		7
Greenop et al. 2015 [28]	*		*		*	*	*			5
Milne et al. 2013 [27]	*	*	*		*	*		*		6
Milne et al. 2013 [27]	*		*		*	*	*			5
Orsi et al. 2015 [71]	*	*	*	*	*	*		*		7
Yang et al. 2015 [64]		*	*	*	*	*		*		6
Zwink et al. 2016 [87]	*			*	*	*				4

CI: 1.16, 1.92]) [53], while neonatal birth weight was associated with paternal height only (β = 0.08, $P = 0.003$) [23]. In another study, paternal pre-pregnancy BMI was only associated with offspring BMI when using absolute BMI values not BMI as a z-score [39].

Fathers' overweight before puberty had a negative indirect effect, mediated through sons' height, on sons' forced expiratory volume in one second (FEV_1) (beta (95% CI): − 144 (− 272, − 23) mL) and forced vital capacity (FVC) (beta (95% CI): − 210 (− 380, − 34) mL), and a negative direct effect on sons' FVC (beta (95% CI): − 262 (− 501, − 9) mL) [34].

Male BMI ≥ 25 kg m^2 was not associated with time to pregnancy (TTP) [48], yet underweight (< 18.5 kg/ m^2) was associated with a longer TTP (adjusted fecundability odds ratio [aFOR] = 0.95, [95% CI: 0.94, 0.96]) compared to normal BMI (18.5—23.9 kg/m^2) [54].

In couples undergoing IVF/ICSI, paternal periconceptional BMI was negatively associated with fertilization rate (β = − 0.01 [SE = 0.004], $P = 0.002$]), while paternal BMI was not associated with the total motile sperm count (TMSC), the KIDScore, the embryo usage rate, a positive pregnancy, fetal heartbeat, or live birth [41].

Offspring methylation was associated with paternal BMI independent of maternal BMI ($P = < 0.05$) [44]. Methylation decreased by 5% in cord blood with every 1-unit increase in paternal BMI ($P = 3.13 \times 10^{-9}$), decreases persist at 3 years old ($P = 0.002$) and 7 years old ($P = 0.004$) [44]. Paternal BMI was associated with methylation at cg01029450 in the promoter region of the ARFGAP3 gene; methylation at this site was also associated with lower infant birthweight (β = − 0.0003; SD = 0.0001; $P = 0.03$) [44].

No association was found between behavioural outcomes at pre-school age and underweight (< 18.5 kg/m^2) or obesity (≥ 30 kg/m^2) in fathers [36]. Equally, no associations were found between paternal BMI overweight (≥ 25 kg/m^2- < 30 kg/m^2), obese class I (≥ 30 kg/m^2- < 35 kg/m^2) and obese class II (≥ 35 kg/m^2) and offspring behavioural issues or psychiatric symptoms at 7–8 years [46].

Alcohol

Six papers examined alcohol as an exposure [26, 42, 43, 55–57]; three rated as good quality [42, 55, 56]. Excluding one, each paper used paternal self-reports of alcohol consumption with varying definitions; one article specified units/per week [43], the others assessed consumption more broadly either as intake ≥ 1/week [56], ≥ 1/month [42] or general intake [57]. A single study presented a maternal report of paternal preconception alcohol consumption, 3 months before conception, at 12–16 weeks gestation [55].

When examining an outcome of offspring anogenital distance (AGD), in the paternal alcohol-exposed group (> 81 g/wk), male offspring had shorter mean AGDs [56]; for AGD-AP [the centre of the anus to the cephalad insertion of the penis] at birth (β = —1.73, $P = 0.04$) and 12 months (β = -7.29, $P = 0.05$), and shorter mean AGD-AS [the centre of the anus to the posterior base of the scrotum] at 6 months (β = —4.91, $P = 0.02$) [56]. Female offspring had shorter mean AGD-AF [the centre of the anus to the posterior convergence of the fourchette) (β = -0.72, $P = 0.02$) at birth yet longer mean AGD AC [the centre of the anus to the clitoris] (β = 2.81, $P = 0.04$) and AGD-AF (B = 1.91, $P = 0.04$) at 12 months [56]. Further, the relative risks of anxiety or depression were increased by 33% (RR = 1.33 [95% CI: 1.09, 1.61]) and 37% (RR = 1.37 [95% CI: 1.02,1.84]) among girls in the exposed group at ages 4 and 6, respectively [55]. Paternal alcohol consumption greater than once per month was not associated with offspring birthweight or gestational age [42].

Cannabis

Paternal cannabis exposure was assessed in five papers [42, 58–61], two rate as good quality [42, 60]. Each paper has a sample size < 1,200 and each utilized paternal self-reporting of cannabis use broadly assessing general use, rather than specific amounts, over a pre-determined period (i.e., last 2 months or 12 months).

In sub-fertile couples undergoing IVF/ICSI, compared to males who were past or never cannabis users, couples where the male partner used cannabis at enrolment had increased probability of implantation (77.9, [95% CI: 53.5, 91.5], $P = < 0.05$) and live birth (47.6, [95% CI: 32.4, 63.3], $P = < 0.05$), independent of women's cannabis use [60]. Clinical pregnancy was not associated with male cannabis use [60], nor was gestational age or offspring birthweight [42].

Physical activity

The associations of paternal physical activity with offspring outcomes were assessed in two papers [42, 43], one rated as good quality [42]. This study found no association between paternal preconception bouts of physical activity per week and gestational age or offspring birthweight [42].

Smoking

The association of tobacco smoking with offspring outcomes was examined in 20 papers [27, 30–32, 42, 62–75, 88]; half ($n = 10$) were rated as good quality [31, 32, 42, 63, 64, 66–68, 73, 74] and nine papers adjusted for maternal smoking and/or paternal passive smoking in their analysis [32, 62, 64–66, 71, 73, 74].

Paternal cigarette smoking was associated with a longer TTP compared with never users (aFOR = 0.41, [95% CI: 0.24, 0.68]), while no associations were found for other tobacco products including cigars or snuff and chew tobacco [68].

Outcomes involving smoking and birth defects report that during the periconceptional period, light paternal smoking [1–9 cigarettes/day] increased the risk of isolated conotruncal heart defects (aOR = 2.23, [95% CI: 1.05, 4.73]) [63]. Medium paternal smoking [10–19 cigarettes/day] increased the risk of septal defects (aOR = 2.04, [95% CI: 1.05, 3.98]) and left ventricular outflow tract obstructions (aOR = 2.48, [95% CI: 1.04, 5.95]) [63]. Heavy paternal smoking (≥ 20 cigarettes/day) increased the risk of isolated conotruncal heart defects (aOR = 8.16, [95% CI: 1.13, 58.84]) and left ventricular outflow tract obstructions (aOR = 13.12, [95% CI: 2.55, 67.39]) [63]. Likewise, an increased risk of birth defects was found for continued-smoking (OR = 1.87, [95% CI: 1.36, 2.56], $P < 0.001$) and decreased-smoking groups (OR = 1.41, [95% CI: 1.10, 1.82], $P = 0.007$) compared with those fathers that quit smoking during early pregnancy and those who did not smoke at all during preconception [74].

Paternal preconception smoking at least one cigarette/day for one month was not associated with gestational age or offspring birthweight [42]. In contrast, a second study found sons whose fathers started smoking < 11 years, the adjusted mean differences in BMI, waist circumference, and fat mass all showed higher values at ages 13, 15, and 17 [66]. Further, the risk of childhood overweight and obesity was increased among children exposed to paternal preconception smoking compared to children without paternal smoking exposure (OR = 1.41 [95% CI: 1.17, 1.85]) [73].

Paternal preconception smoking 12 months prior to conception was associated with an increased risk of childhood acute myeloid leukemia (AML) (OR = 2.51, 95% CI: 1.21, 5.17) [64] and paternal smoking just 3 months prior to conception provided significant associations with acute lymphoblastic leukemia (ALL) (OR = 1.2 [95% CI: 1.1,1.5)] and acute myeloblastic leukemia (AML) (OR = 1.5 [95% CI: 1.0–2.3]) [67].

Paternal preconception smoking also provided significant associations with offspring lung function and asthma; fathers' smoking initiation in prepuberty (generation G1) had a negative direct effect on their own FEV1/FVC (difference in offspring's expected score − 0.36, 95% CI: − 0.68, -0.04) compared with fathers' never smoking. This exposure had a negative direct effect on both offspring's FEV1 (− 0.36, 95% CI: − 0.63, − 0.10) and FVC (− 0.50, 95% CI: − 0.80, − 0.20) (generation G2) [32]. Fathers' smoking before age 15 years was associated with higher risk of asthma without nasal allergies in their offspring [relative risk ratio ((RRR) = 1.43 95% CI: 1.01, 2.01] [31].

Stress

Paternal stress exposure was examined in three papers [43, 76, 77]; including one rated as good quality [77]. This study found men's baseline perceived stress scale [PSS] scores were not associated with fecundability [77].

Nutrition

Papers examining paternal nutrition ($n = 13$) evaluated the associations of a range of nutritional exposures including paternal preconception folate, vitamins B6 and B12, and general dietary patterns with numerous offspring outcomes. These papers utilized data from several studies ($n = 8$) originating in the US, Norway, The Netherlands, and Australia. Approximately half of these papers ($n = 7$) rated as good quality.

Paternal nutritional factors explored included dietary patterns [82, 83] or specific foods groups including dairy [86], and meat [87]. IVF/ICSI-induced live birth was an outcome examined in three papers [82, 86, 87]. A positive association was found between paternal poultry intake and fertilization rate, with a higher fertilization rate among men in the highest quartile of poultry intake [78%] compared with those in the lowest quartile [65%] [87]. Men's total dairy intake was not associated with fertilization rate, implantation rate, clinical pregnancy rate, or live birth rate [86]. Also, paternal adherence to specific dietary patterns [pattern 1 = greater intake of processed foods/meats/high fat/dairy/sugar; pattern 2 = greater intake of fruit/vegetables/legumes/whole grains/nuts/fish] was not associated with fertilization rate [82] when undergoing IVF cycles.

One paper investigated dietary exposures during adolescence and subsequent neonatal health [80]. In a sample of adolescents followed into adulthood becoming fathers ($n = 2{,}140$), an extra serving of fruit per week was associated with a 2.35 g increase in offspring placenta weight [95% CI: 0.284, 4.42], $P = 0.03$ [80]. Further, paternal lunching regularly in adolescence was associated with an increase in offspring head circumference ($\beta = 0.160$, [95% CI: 0.001, 0.320], $P = 0.05$) and whole grain bread consumption was associated with a lower ponderal index ($\beta = -0.003$, [95% CI: -0.005, -0.001], $P = 0.01$) [80]. Birthweight was not associated with any paternal dietary exposures [80].

Generally, paternal preconception dietary patterns were collected through paternal self-reports on standardised food frequency questionnaires (FFQ) at baseline and include fast foods [42]; males eating fast food more frequently had infants born earlier than men who eat fast food less frequently (-0.16, [95% CI: − 0.32, 0.00], $P = 0.04$) [42].

Two papers specifically investigated paternal folate [79, 81]. In males undergoing fertility treatment, a 400 µg/day

higher preconception folate intake was associated with a 2.6-day longer gestation [95% CI: 0.8, 4.3], $P=0.004$ [81]. In spontaneously conceived pregnancies, a significant negative association was found between paternal red blood cell [RBC] folate status and crown-rump length (CRL) trajectories, in Quartile 2 [875–1,018 nmol/L;] ($\beta=-0.14$; [95% CI:—0.28, -0.006], $P=0.04$) and Quartile 4 [1,196–4,343 nmol/L] ($\beta=—0.19$, [95% CI:—0.33, -0.04], $P=0.012$) compared with the reference values in Quartile 3 [79]. A negative association was also found for embryonic volume (EV) trajectories in Quartile 4 ($\beta=—0.12$, [95% CI: -0.20, -0.05], $P=0.001$) [79].

Discussion

This paper reports the first review collating literature assessing modifiable paternal health behaviours and risk factors in the preconception period and highlights clear disparity between the preconception research for women as compared to that for men. While single papers identified in our review do demonstrate adverse pregnancy and offspring outcomes associated with paternal risk factors in the preconception period, current research of paternal health behaviours and risk factors provides an emerging rather than mature evidence-base. Nevertheless, our review did identify a number of important findings.

One consistent finding of this review was the association between paternal preconception smoking and increased risk of adverse infant outcomes, including birth defects and childhood leukemia especially acute myeloid leukemia/acute myeloblastic leukemia (AML). Adverse outcomes such as birth defects are mirrored in maternal preconception smoking literature [89–91], yet the impact of maternal smoking on the risk of AML remains contentious [92, 93]. Smoking in the preconception period may be as perilous for males as for females, as smoking can potentially affect semen quality [94]. Many male smokers (and even more so in smoking couples) consider smoking an indispensable characteristic of their domestic, social and working lives [95] and many report a lack of motivation, willpower, and/or strength to successfully quit [96], in turn influencing female smoking patterns and family environments [95]. Paternal preconception smoking may well be contributing to the estimated 240,000 newborns dying worldwide annually due to birth defects [97]. The finding of paternal preconception smoking and the increased risk of adverse infant outcomes is altogether disconcerting considering the widespread use of tobacco, and that males are more likely than females to engage in risk-taking behaviours, including smoking [98]; the estimated global prevalence of male adolescent smokers in 133 countries is 23.29%.

The papers in this review which focus upon body composition with birthweight outcomes generally affirm positive associations between increasing paternal BMI and offspring birthweight. Indeed, this finding aligns with the literature outside this review which acknowledges that mothers and fathers with overweight or obesity are more likely to have children with overweight or obesity [99–102], compared with those with a normal weight. The positive associations between increasing paternal BMI and offspring bodyweight may, in part, be due to paternal contributions of sperm quality and potential changes to the epigenetic profiles of spermatoza [10, 103] resulting from unhealthy preconception environments and relationships with food. Food-based parenting strategies [100] and spending too much time sedentary [104] may also contribute to influencing offspring weight status. One paper in this review did chart offspring weight and BMI changes from childhood into adulthood [24], however, this reported research did not control for the offspring's diet and physical exercise.

Nonetheless, an individual's birthweight can influence both their body weight in childhood [105] and their body weight as they transition into adulthood [106]; external literature positively associates both a higher birthweight and childhood obesity with overweight/obesity at 15–20 years of age [107]. Frameworks to maintain healthy bodyweight, in turn promoting healthy birthweights, endure in the Global action plan on physical activity 2018–2030 [108] and in national overweight/obesity guidelines in countries such as Australia [109] and the Unites States [110].

It is important to note that most papers included in this review utilize retrospective reports (paternal self-reports or maternal reports) of anthropometric data collected at baseline. Such retrospective self-reporting is also evident in the maternal preconception literature [111, 112] and is often considered unreliable and subject to inaccuracies due to self-reporting bias or recall bias [113]. Inaccuracies and reporting bias may be present in particular in papers that utilize maternal reports of paternal preconception height and body weight at minimum 10 weeks of gestation in some papers up to 4 months postpartum. Consequently, retrospective reports of data at baseline may undermine the validity, accuracy, and therefore the reliability of BMI data used in these papers.

The majority of papers in our review report research undertaken in distinct geographical regions with the USA, Europe and the UK, and China heavily represented. As such, the implications for reduced geographical spread of the available research examining paternal preconception health exposures and outcomes must also be considered. It may be that existing region-specific idiosyncrasies of paternal health behaviours, and

associated adverse health outcomes for their children, are yet to be described due to the absence of research conducted in other countries and cultures. These gaps limit the opportunities for tailored preconception care policies and interventions and constrain the broader understanding of the potential importance of paternal preconception care. Notwithstanding, such issues foster opportunities for other countries and cultures to identify, learn from and support paternal health.

While almost all papers in this review adjust for some confounders, less than half ($n=23$) adjusted for the same maternal exposure (i.e., paternal BMI studies adjusting for maternal BMI). Many papers in this review did not adjust for maternal exposures and thus may present biased results and conclusions. Further, many maternal studies do not control for paternal exposures which is a limitation in the field that requires urgent research attention and refocus.

The date parameters set during the search may also represent a limitation as it may have resulted in manuscripts published before the 2012 being overlooked. However, up until recently the preconception research field has primarily focused on the effects of maternal exposures and as such it is unlikely that significant research was overlooked by this date restriction.

Further limitations of the review include the potential for missed citations due to issues with article indexing. Our search protocol did not employ search term truncations or singular synonyms in the final search string which may have resulted in some citations being missed. However, the search protocol was informed by an experienced health librarian, and additional methods – such as reference list and citation checking—were used to identify relevant manuscripts not identified through the primary search. Furthermore, previous search strings trialed for this review that used different synonyms, truncations and search term categories did not result in any additional relevant manuscripts being identified beyond those included in the final search. As such, the literature review is the most comprehensive review of the topic conducted to date.

This review is innovative in that it provides the first examination of paternal preconception risk factors and their association with adverse pregnancy and offspring outcomes. The rigour of the review is also bolstered through adhering to established systematic review reporting guidelines (PRISMA and AMSTAR).

Conclusion

Overall, this review shows that paternal preconception modifiable risk factors are largely underexplored; smoking and body composition appear to be important areas for consideration in paternal preconception care. While the current literature identifies an emerging evidence-base around paternal preconception modifiable risk factors, there is a need for further investigation to help better inform paternal preconception care and national and international preconception care guidelines. In particular, further research is necessary to identify and better understand the modifiable risk factors affecting males in the preconception period, and how these risk factors influence offspring outcomes, to inform clinical recommendations and health decisions. The future of paternal preconception care and the integration of such care into frontline health practice and policy rests with informed collaboration between clinicians, researchers and policymakers [8].

Abbreviations

AGD	Anogenital distance
BMI	Body mass index
CRL	Crown-rump length
EV	Embryonic volume
FFQ	Food frequency questionnaires
GPs	General practitioners
ICSI	Intracytoplasmic sperm injection
IVF	In-vitro fertilization
LGA	Large for gestational age
NOS	Newcastle–Ottawa Scale [NOS]
POHaD	Paternal Origins of Health and Disease
PICO	Population, Intervention, Comparison, Outcome
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SGA	Small for gestational age
TTP	Time to pregnancy
TAHS	Tasmanian Longitudinal Health Study
NFPCP	National Free Pre-conception Check-up Projects
RHINESSA	The Respiratory Health in Northern Europe, Spain and Australia multigeneration study
ALL	Childhood acute lymphoblastic leukemia
FEV1	Forced expiratory volume in one second
FVC	Forced vital capacity
CBCL	Child Behaviour Checklist
CBTs	Childhood brain tumours
ECRHS	European Community Respiratory Health Survey
CRCLS	Costa Rican Childhood Leukemia Study
AML	Acute Myeloid Leukemia
FMI	Fat mass index
CL	Childhood acute leukemia
NRCH	National Registry of Childhood Hematopoietic Malignancies
RHINE	Respiratory Heath in Northern Europe
PTB	Preterm birth
AHP	Achieving a Healthy Pregnancy
RRR	Relative risk ratio
OR	Odds ratio
CI	Confidence Interval
PDR	Preconception Dietary Risk Score
HR	Hazard ratio
TL	Telomere length
GZBC	Guangxi Zhaung Birth Cohort

Supplementary Information

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Additional file 1.

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Availability of data and materials
All data extracted for this systematic review are presented as part of the manuscript.

Declarations

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APPENDIX 4.2 SEARCH STRATEGY FOR A REVIEW OF CONTEMPORARY EVIDENCE

Medline (OVID)
Controlled vocabulary – Medical subject headings [MESH]
*af – All fields
*sh – MesH Subject Heading

Ovid MEDLINE(R) and In-Process, In-Data-Review & Other Non-Indexed Citations and Daily <1946 to December 30, 2022>

#	Query	Results from 02 February 2023
1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception) .af. OR Preconception care .sh.	15,897
2	(Male* or father* or expectant father* or spouse* or husband* or paternal* or men's health) .af. OR Male. sh. or men. sh. or fathers. sh. or spouses. sh. or husbands. sh. or Men`s Health. sh.	9,674,668
3	(Infertility or pregnancy outcome* or pregnancy complication* or maternal mortality or maternal behavior or maternal health* or maternal death* or fetal development or fetal death* or fetal mortality or fetal weight or perinatal care or perinatal mortality or perinatal death*) .af. OR Infertility. sh. or infertility, male. sh. or infertility, female. sh. or pregnancy outcome. sh. or pregnancy complications, hematologic. sh. or pregnancy complications, infectious. sh. or pregnancy complications, neoplastic. sh. or pregnancy complications, parasitic. sh. or maternal mortality. sh. or maternal behavior. sh. or maternal health. sh. or maternal death. sh.	442,249

	or fetal development. sh. or fetal death. sh. or fetal mortality. sh. or fetal weight. sh. or perinatal care. sh. or perinatal mortality. sh. or perinatal death.sh.	
4	(Child mortality or child health* or child development or infant health* or infant death* or infant mortality or congenital abnormalities or child behavior disorder* or fetal disease* or noncommunicable disease* or life change events) .af. OR Child mortality.sh. or child health.sh. or child development.sh. or infant health.sh. or infant death.sh. or infant mortality.sh. or congenital abnormalities.sh. or abnormalities, multiple.sh. or heart defects, congenital.sh. or adverse childhood experiences.sh. or child behavior disorders.sh. or fetal diseases.sh. or noncommunicable diseases.sh. or life change events.sh.	504,094
5	1 AND 2 AND 3	1266
6	1 AND 2 AND 4	798
7	5 OR 6	1,255

Embase (OVID)
Controlled vocabulary – Science thesaurus [Emtree]
*af – All fields
*sh – Subject Headings

Embase <1974 to 2022 December 30>

#	Query	Results from 2nd February 2023
1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception) .af. OR Prepregnancy care.sh. or maternal care.sh.	43,291
2	(Male* or father* or expectant father* or spouse* or husband* or paternal* or Men`s Health) .af. OR Male.ec. or father.ec or expectant father.ec or paternal behavior.ec or paternal exposure.ec or husband.ec.	11,425,826
3	(Infertility or pregnancy outcome* or pregnancy complication* or maternal mortality or maternal behavior* or maternal health* or maternal death* or fetal development or fetal death* or fetal mortality or fetal weight or perinatal care or perinatal mortality or perinatal death) .af. OR Infertility.sh. or female infertility. sh. or male infertility. sh. or pregnancy outcome. sh. or pregnancy complication. sh. or maternal death. sh. or maternal mortality. sh. or maternal exposure. sh. or fetus development. sh. or perinatal death. sh. or childhood mortality. sh. or childhood disease. sh. or congenital disorder. sh. or congenital malformation. sh. or fetus disease sh. or fetus death. sh. or fetus mortality. sh.	704,124

4	(Child mortality or child health* or child development or infant health* or infant death* or infant mortality or congenital abnormalities or child behavior disorder* or fetal disease* or noncommunicable disease* or life change events) .af. OR Infant mortality.sh. or infant disease.sh. or non-communicable disease.sh. or maternal exposure.sh. or adverse outcome.sh. or clinical outcome.sh. or fetus outcome.sh. or patient- reported outcome.sh.	810,343
5	1 AND 2 AND 3	2757
6	1 AND 2 AND 4	1618
7	5 OR 6	403

Maternity and Infant Care MIDRIS (OVID)
Controlled vocabulary – Map Term to Subject Heading
*af – All fields
*hw – Heading word

Maternity & Infant Care Database (MIDIRS) <1971 to December 13, 2022>

#	Query	Results from 2nd February 2023
1	(Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception) .af. OR Preconception. hw. or pre-conception. hw. or periconception. hw. or peri-conception. hw. or prepregnancy. hw. or pre-pregnancy. hw. or interconception. hw.	6,925
2	(Male* or father* or expectant father* or spouse* or husband* or paternal* or Men`s Health) .af. OR Male*. hw. or father*. hw or expectant father*. hw or spouse*. hw. or husband*. hw. or paternal*. hw or Men`s Health. hw.	14,882
3	(Infertility or pregnancy outcome* or pregnancy complication* or maternal mortality or maternal behavior* or maternal health* or maternal death* or fetal development or fetal death* or fetal mortality or fetal weight or perinatal care or perinatal mortality or perinatal death* or child mortality or child health* or child development or infant health* or infant death* or infant mortality or congenital abnormalities or child behavior disorder* or fetal disease* or noncommunicable disease* or life change events) .af.	76,445
4	Infertility. hw. or pregnancy outcome*. hw. or pregnancy complication*. hw. or maternal mortality. hw. or maternal behavior*. hw. or maternal health*. hw. or maternal death*. hw. or fetal development.	42,402

	hw. or fetal death*. hw. or fetal mortality. hw. or fetal weight. hw. or or perinatal care. hw. or perinatal mortality. hw. perinatal death*. hw. or child mortality. hw. or child health*. hw. or child development. hw. or infant health*. hw. or infant death*. hw. or infant mortality. hw. or congenital abnormalities. hw. or child behavior disorder*. hw. or fetal disease*. hw. or noncommunicable disease*. hw. or life change events. hw. Limit 1 to yr="2012-Current"	
5	1 AND 2 AND 3	163
6	1 AND 2 AND 4	47
7	5 OR 6	50

CINAHL (EBSCO)
Controlled vocabulary – Subject headings [subject headings authority profile]
*TX – all text
*MW – Word in subject heading
*MM – Major subject heading

Expanders – Apply equivalent subjects
Search modes - Boolean/Phrase

#	Query	Results from 5th January 2023
1	(TX Preconception or TX pre-conception or TX periconception or TX peri-conception or TX prepregnancy or TX pre-pregnancy or TX interconception) Published date: 20120101 -20221231	6,470
2	(MW Preconception or MW pre-conception or MW periconception or MW peri-conception or MW prepregnancy or MW pre-pregnancy or MW interconception) Published date: 20120101 -20221231	1,463
3	(MM "Prepregnancy care") Published date: 20120101 -20221231	947
4	(MM "Perinatal Care") Published date: 20120101 -20221231	2,434
5	S1 OR S2 OR S3 OR S4	8,851
6	(TX Males or TX fathers or TX expectant fathers or TX spouses or TX husbands or TX paternal or TX Men`s Health) Published date: 20120101 -20221231	1,189,991
7	(MW Males or MW fathers or MW expectant fathers or MW spouses or MW husbands or MW paternal or MW Men`s Health) Published date: 20120101 -20221231	13,166

8	(MM ”Expectant Fathers”) or (MM ”Fathers”) Published date: 20120101 -20221231	2,390
9	(MM ”Male”) Published date: 20120101 -20221231	103
10	or (MM ”Men”) or (MM ”Mens’ Health”) Published date: 20120101 -20221231	7,187
11	(MM” Paternal Behavior”) or (MM “Paternal Exposure”) Published date: 20120101 -20221231	259
12	(MM “Spouses”) Published date: 20120101 -20221231	4,501
13	S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12	1,191,559
14	TX Infertility or TX pregnancy outcomes or TX pregnancy complications or TX maternal mortality or TX maternal behavior or TX maternal health or TX maternal death or TX fetal development or TX fetal death or TX fetal mortality or TX fetal weight or TX perinatal care Published date: 20120101 -20221231	102,235
15	TX perinatal mortality or TX perinatal death or TX child mortality or TX child health or TX child development or TX infant health or TX infant death or TX infant mortality or TX congenital abnormalities or TX child behavior disorders or TX fetal diseases or TX noncommunicable diseases Published date: 20120101 -20221231	84,238
16	TX life change events or	49,780

	MW Infertility or MW pregnancy outcome or MW pregnancy complications or MW maternal mortality or MW maternal behavior or MW maternal health or MW maternal death or MW fetal development or MW fetal death or MW fetal mortality or MW fetal weight Published date: 20120101 -20221231	
17	MW perinatal care or MW perinatal mortality or MW perinatal death or MW child mortality or MW child health or MW child development or MW infant health or MW infant death or MW infant mortality or MW congenital abnormalities or MW child behavior disorders or MW fetal diseases Published date: 20120101 -20221231	53,777
18	MW noncommunicable diseases or MW life change events	5,138
19	(MM ”Infertility”) Published date: 20120101 -20221231	7,230
20	(MM ”Pregnancy outcomes”) or (MM ”Pregnancy complications, psychiatric”) or (MM ”Pregnancy complications, neoplastic”) or (MM ”Pregnancy complications, hematologic”) or (MM ”Pregnancy complications, parasitic”) or (MM ”Pregnancy complications, infectious”) or (MM ”Pregnancy complications, cardiovascular”) Published date: 20120101 -20221231	13,760
21	(MM” maternal behavior”) or (MM ”maternal mortality”) or (MM ”maternal exposure”) Published date: 20120101 -20221231	4,951

22	(MM" fetal weight") or (MM "fetal abnormalities") or (MM "fetal well-being") or (MM" fetal diseases") or (MM "fetal development") Published date: 20120101 -20221231	4,940
23	(MM "perinatal death") or (MM "perinatal care") Published date: 201220101 -20221231	5,334
24	(MM "child mortality") or (MM "child health") or (MM "child development disorders") or (MM "child development") Published date: 201220101 -20221231	15,416
25	(MM "infant death") or (MM "infant mortality") or (MM "infant, premature, diseases") or (MM "infant development disorders") Published date: 201220101 -20221231	4,949
26	S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25	187,328
27	S5 AND S13 AND S26	871

APA PsycINFO (EBSCO)
Controlled vocabulary – APA Thesaurus of Psychological Index Terms
*TX – all text
*MA – MeSH subject heading

Expanders – Apply related words; Apply equivalent subjects
Search modes – Boolean/Phrase

#	Query	Results from 5th January 2023
1	TX Preconception or TX pre-conception or TX periconception or TX peri-conception or TX prepregnancy or TX pre-pregnancy or TX interconception or MA prenatal care or MA prenatal exposure Publication year 2012-2023	75,946
2	TX Males or TX fathers or TX expectant fathers or TX spouses or TX husbands or TX paternal or TX Men`s Health) Publication year 2012-2023	985,485
3	MA human males or MA men or MA fathers or MA expectant fathers or MA husbands or MA spouses Publication year 2012-2023	4,070
4	S2 OR S3	985,532
5	TX Infertility or TX pregnancy outcomes or TX pregnancy complications or TX maternal mortality or TX maternal behavior or TX maternal health or TX maternal death or TX fetal development or TX fetal death or TX fetal mortality or TX fetal weight or TX perinatal care Publication year 2012-2023	21,984
6	TX perinatal mortality or TX perinatal death or TX child mortality or TX child health or TX child development or TX infant health or TX	92,934

	infant death or TX infant mortality or TX congenital abnormalities or TX child behavior disorders or TX fetal diseases or TX noncommunicable diseases Publication year 2012-2023	
7	TX life change events or MA Infertility or MA pregnancy outcomes or MA mortality risk or MA health outcomes or MA child death or MA congenital disorders or MA death and dying or MA prenatal development or MA infant development or MA child health or MA life span Publication year 2012-2023	15,522
8	S5 OR S6 OR S7	116,920
9	S1 AND S4 AND S8	3,031

Scopus
Controlled vocabulary – *Note Scopus does not use a controlled vocabulary/ subject heading.

#	Query	Results from 5th January 2023
1	Preconception or pre-conception or periconception or peri-conception or prepregnancy or pre-pregnancy or interconception AND (LIMIT-TO (PUBYEAR, 2023) OR (LIMIT-TO (PUBYEAR, 2022) OR(LIMIT-TO (PUBYEAR, 2021) OR(LIMIT-TO (PUBYEAR, 2020) OR(LIMIT-TO (PUBYEAR, 2019) OR(LIMIT-TO (PUBYEAR, 2018) OR(LIMIT-TO (PUBYEAR, 2017) OR(LIMIT-TO (PUBYEAR, 2016) OR(LIMIT-TO (PUBYEAR, 2015) OR(LIMIT-TO (PUBYEAR, 2014) OR(LIMIT-TO (PUBYEAR, 2013) OR(LIMIT-TO (PUBYEAR, 2012)	50,107
2	Males or fathers or (expectant AND fathers) or spouses or husbands or paternal or (men's AND health) AND (LIMIT-TO (PUBYEAR, 2023) OR (LIMIT-TO (PUBYEAR, 2022) OR(LIMIT-TO (PUBYEAR, 2021) OR(LIMIT-TO (PUBYEAR, 2020) OR(LIMIT-TO (PUBYEAR, 2019) OR(LIMIT-TO (PUBYEAR, 2018) OR(LIMIT-TO (PUBYEAR, 2017) OR(LIMIT-TO (PUBYEAR, 2016) OR(LIMIT-TO (PUBYEAR, 2015) OR(LIMIT-TO (PUBYEAR, 2014) OR(LIMIT-TO (PUBYEAR, 2013) OR(LIMIT-TO (PUBYEAR, 2012)	880,110
3	Infertility or pregnancy or (pregnancy AND outcome) or (pregnancy AND complications) or (maternal AND mortality) or (maternal AND behavior) or (maternal AND health) or (maternal AND death) or (fetal AND development) or (fetal AND death) or (fetal AND mortality) or (fetal AND weight) or (perinatal AND care) or (perinatal AND mortality) or (perinatal AND death) or (child AND mortality) or (child AND health) or (child AND development) or (infant AND health) or (infant AND death) or (infant AND mortality) or (congenital AND abnormalities) or (child AND behavior AND disorders) or	3,643

	(fetal AND diseases) or (noncommunicable AND diseases) or (life AND change AND events) AND (LIMIT-TO (PUBYEAR, 2023) OR (LIMIT-TO (PUBYEAR, 2022) OR(LIMIT-TO (PUBYEAR, 2021) OR(LIMIT-TO (PUBYEAR, 2020) OR(LIMIT-TO (PUBYEAR, 2019) OR(LIMIT-TO (PUBYEAR, 2018) OR(LIMIT-TO (PUBYEAR, 2017) OR(LIMIT-TO (PUBYEAR, 2016) OR(LIMIT-TO (PUBYEAR, 2015) OR(LIMIT-TO (PUBYEAR, 2014) OR(LIMIT-TO (PUBYEAR, 2013) OR(LIMIT-TO (PUBYEAR, 2012)	
4	1 AND 2 AND 3	383

ISI Proceedings
Controlled vocabulary – *Note ISI Proceedings [Web of Science] does not use a controlled vocabulary/subject heading.

***ALL – All fields**

#	Query	Results from 5th January 2023
1	(ALL = (Preconception) or ALL = (pre-conception) or ALL = (periconception) or ALL = (peri-conception) or ALL = (prepregnancy) or ALL = (pre-pregnancy) or ALL = (interconception) Publication date 2012-01-01 to 2023-01-05	721
2	ALL = (males) or ALL = (fathers) or ALL = (expectant fathers) or ALL = (spouses) or ALL = (husbands) or ALL = (paternal) or ALL = (men's health) Publication date 2012-01-01 to 2023-01-05	26,468
3	ALL = (Infertility) or ALL = (pregnancy) or ALL = (pregnancy AND outcome) or ALL = (pregnancy AND complications) or ALL = (maternal AND mortality) or ALL = (maternal AND behavior) or ALL = (maternal AND health) or ALL = (maternal AND death) or ALL = (fetal AND development) or ALL = (fetal AND death) or ALL = (fetal AND mortality) or ALL = (fetal AND weight) or ALL = (perinatal AND care) or ALL = (perinatal AND mortality) or ALL = (perinatal AND death) or ALL = (child AND mortality) or ALL = (child AND health) or ALL = (child AND development) or ALL = (infant AND health) or ALL = (infant AND death) or ALL = (infant AND mortality) or ALL = (congenital AND abnormalities) or ALL = (child AND behavior AND disorders) or ALL = (fetal AND diseases) or ALL = (noncommunicable AND diseases) or ALL = (life AND change AND events) Publication date 2012-01-01 to 2023-01-05	64,323

4	1 AND 2 AND 3	14

APPENDIX 6.1 PUBLISHED MANUSCRIPT ASSOCIATED WITH RESULTS REPORTED IN CHAPTER 6

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Pregnancy intention, preconception health, health behaviours, and information and health advice seeking among expectant male partners

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Abstract

Background Attempting pregnancy as a conscious decision (pregnancy intention) can impact the likelihood that a future parent receives or seeks preconception health information, initiates discussions with health professionals, and ultimately optimises their health and behaviours in preparation for healthy pregnancy and child. Knowledge about the relationship between men's preconception health behaviours and their pregnancy intention is only emerging.

Methods This study aimed to describe the preconception health status, behaviours, information- and advice-seeking of male expectant partners, and to explore differences in these preconception factors based on pregnancy intention. An online retrospective cross-sectional survey was completed by male reproductive partners of pregnant females. Their pregnancy intention was assessed using the London Measure of Unplanned Pregnancy (LMUP). Participants were recruited via social media and all variables were self-reported by expectant partners. Chi-square tests examined differences by LMUP categories (planned or ambivalent/unplanned).

Results Of 156 expectant partners who consented to survey participation, 138 completed all LMUP questions and were included in analysis. Most expectant partners reported their partner's current pregnancy as planned ($n = 90$;65.2%), less than half reported looking for and finding information about becoming pregnant (40.0%). Expectant partners with planned pregnancy more often reported physical exercise three months before pregnancy compared with partners with unplanned/ambivalent pregnancy ($p = 0.001$). Expectant partners with ambivalent/unplanned pregnancy more often experienced longstanding illness, disability, or infirmity ($p = 0.002$) or disregarded contraception ($p < 0.001$). Despite perceiving good or excellent health, and undertaking physical exercise, numerous expectant partners with planned pregnancy had overweight. Further research exploring the reproductive life plan process for males with longstanding chronic illness or disability may help promote pregnancy planning and preconception health amongst this sub-population.

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Conclusions Further large-scale studies are needed to enable clinicians to better understand pregnancy intentions and preconception health of males and for policy makers to formulate health policies aimed at supporting male preconception health and awareness.

Keywords Preconception, Male, Pregnancy intention, Health behaviours

Introduction

Preconception is the period prior to conception when individuals and couples can seek or be provided with support to optimise their health status as well as reduce behaviours and environmental exposures that may contribute to adverse pregnancy and offspring outcomes [1]. However, an individual's ability to capitalise on the opportunities afforded by the preconception period and seek care to promote health is affected by the degree to which becoming pregnant is a conscious decision, a complex multidimensional construct [2, 3] referred to as 'pregnancy intention'. Intending pregnancy is an important public health measure [4], and a principal preconception concept for couples and individuals alike, which may result in pregnancy planning and preparation. However, unplanned pregnancies, including pregnancies that are either mistimed [5] or occur when parents are ambivalent to becoming pregnant, are also common [3, 6]. Healthful preconception behaviours such as physical activity [7] or taking folate [8] and personal attributes such as relationship stability [9], and health seeking information in preparation for pregnancy [10] have been associated with intended pregnancies among females.

Public awareness must rebalance the gaze and consider males too provide genetic contributions toward their offspring and therefore healthy male sperm is a vital consideration before pregnancy to ensure healthy pregnancy and offspring outcomes. However, circumstances such as being overweight or obese can negatively impact sperm quality [11] and adversely influence pregnancy and offspring outcomes and fertilisation rates [12]. Opportunities for males to receive or seek preconception health information, initiate discussions with health professionals, and optimise health and behaviours in preparation for a healthy pregnancy and child are important aspects of preconception health and care which are interrelated with pregnancy intention. Preconception awareness for males is considered by a public health and health promotion agency in Australia which has developed a male preconception checklist that outlines the importance of men managing their weight, restricting smoking, and exercising regularly as well as booking a preconception health check with a general practitioner (GP) [13]. Males with pregnant partners (referred to here as 'expectant partners') are role models for their future children so may have considered altering their health behaviours before pregnancy, to minimise adverse pregnancy and offspring outcomes [14], in turn providing a foundation for positive contributions toward family health, a stable family environment, and an active role in a child's life [15, 16],

Research from the United Kingdom has reported that up to 20% of expectant partners draw upon sources of preconception diet and lifestyle information from peers, family, and friends and via books and online resources to optimise their preconception health and wellbeing for the sake of their expectant children [17]. Health services can play a key role among males during preconception by assisting to source information and to provide advice on paternal preconception matters [18, 19].

Pivoting from intended to unintended pregnancies, approximately 40% of pregnancies globally are estimated to be unintended [20], which has been associated with unhealthy behaviours among women such as preconception substance use [21], smoking and alcohol consumption [22], and adverse maternal and infant outcomes [23]. For males, unintended pregnancies are often reported with insecure financial circumstances, less stable relationships, and false assumptions about contraception use [24]. Unintended pregnancies, alongside the problematic approach to motivate men to attend primary health-services [25] and GPs' limited knowledge about factors which affect male fertility [26], hinder progress towards paternal preconception care. Several barriers to discussing fertility and preconception health with males are reported among GP's [26] and unwavering challenges endure for primary health services generally especially due to a lack of male preconception primary health-care initiatives [25]. As such, preconception care discussions are not always initiated with males who consult with health care services or who attend primary health care [26] and exposure to a range of preconception services and information, including immunization checking, dietary advice, and smoking cessation assistance is also sometimes absent. Consequently, males may not always consider the impact of their lifestyle behaviours and modifiable risk factors on either their own health or that of their offspring [17].

To provide further evidence on how to guide and support males during preconception and when planning a pregnancy, this study aimed to describe the preconception health status, behaviours, information, and advice-seeking of male expectant partners, and to explore differences in these preconception factors based on pregnancy intention.

Materials and methods

Study design

An observational retrospective cross-sectional study utilizing data from an online survey was conducted between December 2020 and September 2021. The survey involved a convenience sample of pregnant women and their expectant partners. Informed written consent was obtained from all participants and the study was performed in accordance with the Declaration of Helsinki [27]. Ethics approval was obtained by University of Technology Sydney (UTS) Human Research Ethics Committee (HREC) (ETH20-4726).

Participants and survey administration

Eligible survey participants included those who self-identified as a female, aged 18 to 49 years, and at any stage of pregnancy living in Australia. Expectant partners of eligible participants were also eligible to participate. Targeted advertising was utilized on social media platforms (i.e. Instagram, Facebook, Twitter) to recruit participants and an incentive was provided. A screening instrument was utilized to ensure that participants met the eligibility criteria and to collect their name and email address. Any individual who met the study eligibility criteria and consented to participate was able to complete the survey via the online survey platform Qualtrics™. Eligible females received a hyperlink whereby they were instructed to complete their own survey and forward the second survey onto their partners. Eligible male expectant partners were also directly targeted for recruitment and, following consent, received a hyperlink being instructed to complete their own survey and forward the second survey onto their pregnant partners.

Analysis provided in this paper includes only the male expectant partners of eligible study participants i.e. not female partners.

Survey instrument and data

A paper-based survey was developed and tested by three individuals, feedback was provided which resulted in the survey being built into Qualtrics™ and retested before finalising (Supplementary Material 1). This survey of partners of pregnant women was developed in tandem with the survey instrument designed for pregnant women. The *Expectant partner's pre-pregnancy health information survey* consists of 80-items across five sections including preliminary survey consent, date, and post survey comments (4-items), [1] "About you" (sociodemographic characteristics, height and weight) (15-items); [2] "Your current pregnancy" (retrospective assessment of the degree and timing of pregnancy planning incorporating the version of the London Measure of Unplanned Pregnancy [LMUP] for partners [28] (12-items); [3] "Your health behaviours" (history of and changes in preconception health and health behaviours) (31-items); [4] "Prepregnancy health information and advice" (knowledge on the importance of preconception health, the content of preconception care, and the source(s) of this information) (10-items); and [5] "Your health history" (health history, general health status, and pregnancy history) (8-items).

Sociodemographic characteristics

The survey obtained participant gender, age, residential postcode, private health insurance cover, highest qualification completed, employment status, relationship status, financial management status, identity as Aboriginal or Torres Strait Islander, first language spoken, country of birth, and health care card access.

Health status and health history

Expectant partners rated their current general health status (excellent-poor), responded to questions about any longstanding illness and health conditions diagnosed (3 months before partner's pregnancy) and reported their body weight and height. The survey also asked about participant's contraception use (6 months before pregnancy) and if they had have ever smoked and/or ever consumed alcohol.

Health behaviours

Survey questions identified participant's actions in preparing for pregnancy overall (Stop/cut back smoking and alcohol, eat healthier, seek medical advice, use vitamin supplements). Health behaviours were then identified based upon three preconception time periods: three, six and twelve months prior to pregnancy. Behaviours identified three months prior to pregnancy included alcohol consumption, smoking, and physical activity levels plus the consulting with health professionals for ongoing assistance. Health behaviours in the six months prior to pregnancy that were identified included following a weight loss diet, testing for sexually transmitted infections (STIs), and use of contraception methods. Health behaviours in the 12 months prior to pregnancy that were identified included any actions before partner became pregnant (visit a dentist, check immunizations) and consulting with a health professional about their partner becoming pregnant.

Preconception health information and advice

Questions further established if expectant partners had searched for information about becoming pregnant, and if so, asked about the source of this information and who (which partner) did this information related to. Also, questions explored whether expectant partners were provided with information about diet and lifestyle options for example eating a healthy diet, smoking,

consuming alcohol, or taking vitamin C supplements before pregnancy.

Pregnancy intention

Pregnancy intention was assessed using the London Measure of Unplanned Pregnancy (LMUP) for women's partners; a measure developed in the UK which identifies the degree of planning for a current/recent pregnancy [28].

Data analysis

Survey data were imported into Stata 17.1 and prepared for analysis by the research team. Survey participants comprise those who consented to participate in the survey, reported their sex as male, and completed all the survey questions directly related to the LMUP. The LMUP was scored as per the instrument's guide; participants response to each item score a minimum 0 and maximum 2 which then combine to a total score [29]. Technical issues with the online survey did not allow the last question of the LMUP to select multiple items but only one item. As a result, the maximum score awarded for this question is 1 instead of the standard maximum of 2. The LMUP scoring guide was followed for analysis. Two participants had a single missing value in one LMUP variable and were excluded from the analysis; imputation was not considered.

Based on the LMUP scoring, new categorical variables were generated as 'Planned' (LMUP score 10 or 11), 'Ambivalent' (between 4 and 9), or `Unplanned' pregnancy (3 or less) [28]. A binary variable was then generated to combine the 'Ambivalent' and `Unplanned' categories (ambivalent/unplanned) as only one participant had a score of 3 or less [30]. Data was tabulated into categories describing participant demographics, health status and history, health behaviours and health information. Variables of interest were then analysed according to planned and ambivalent/unplanned pregnancies.

Binary variables were created from categorial variables to determine descriptive statistics for health status and health history, participant health behaviours, and health information and advice. Body mass index (BMI) was calculated using the participants height and weight and then categorized according to the World Health Organization classifications [31]. Participants with missing data were not included in the analysis. Chi-square tests were utilized to examine differences by LMUP categories (planned or ambivalent/unplanned). If a cell count was less than 5, a Fisher's exact test was conducted. ANOVA tests were employed to compare differences in medians according to LMUP category for continuous variables. An alpha value below 0.05 was considered statistically significant and effect size was determined using Cramer's V [32]. Results for Cramer's V range between 0 and 1, greater values indicate stronger associations between variables; > 0.25 equals a very strong association, > 0.15 equals a strong association, > 0.10 equals a moderate association, > 0.05 equals a weak association and >0 equals a very weak association [33].

Results

A total of 156 expectant partners were eligible and provided consent to participate in the survey. The LMUP for partners includes six questions and has a maximum total score of 12 with higher scores indicating a greater degree of pregnancy planning [30] (Supplementary Material 2). Most expectant partners ($n = 138$) completed all the LMUP questions and were included in the analysis. The majority of expectant partners had a planned pregnancy ($n = 90$;65.2%).

Demographics

Overall, the most common age range of expectant partners was 30–39 years (61.7%) and most were employed full-time (89.1%) and married (70.2%) (Table 1). A small percentage of expectant partners identified as Aboriginal or Torres Strait Islander (3.6%). When comparing expectant partners with planned pregnancy and expectant partners with ambivalent/unplanned pregnancy, a very strong association was identified between the LMUP categories and relationship status ($V = 0.26$;$p = 0.006$) indicating that expectant partners with planned pregnancy were more often married. A moderate association was identified for expectant partners with an ambivalent/unplanned pregnancy who more often spoke a primary language other than English ($V = 0.16$;$p = 0.05$).

Health status and health history

Most expectant partners reported their general health status as "good" (60.4%) and approximately half (49.2%) reported no contraception use in the 6 months before their partners pregnancy as they were trying to conceive (Table 2). According to the BMI classifications, expectant partners with planned pregnancy were most often overweight (42.0%). A comparison of the LMUP categories provided evidence to support very strong associations; expectant partners with ambivalent/ unplanned pregnancy more often had a longstanding illness, disability, or infirmity ($V = 0.31$;$p = 0.005$) and more often did not use contraception ($V = 0.37$;$p < 0.001$).

Preconception health behaviours

Numerous expectant partners reported physical exercise in the three months before their partner's pregnancy (69.5%); generally, expectant partners reported an average number of five hours of physical activity per week (SD 3.0–7.5) (Table 3). The majority of expectant partners had ever consumed alcohol (84.7%) and approximately

Table 1 Sociodemographic characteristics of expectant male partners

	LMUP category			
	All (*n* = 138)	**Planned (*n* = 90)**	**Ambivalent/ Unplanned (*n* = 48)**	**P (Cramer's V)**
	n (%)	*n (%)*	*n (%)*	
Age (n = 128)				
*Less than 29 years^*	39 (30.4)	22 (25.5)	17 (40.4)	0.06
30–39 years	79 (61.7)	59 (68.6)	20 (47.6)	
40 years +	10 (7.8)	5 (5.8)	5 (11.9)	
State of residence (n = 138)				
New South Wales	45 (32.6)	28 (31.1)	17 (35.4)	0.11
Victoria	41 (29.7)	22 (24.4)	19 (39.5)	
Queensland	23 (16.6)	17 (18.8)	6 (12.5)	
*Other**	29 (21.0)	23 (25.5)	6 (12.5)	
Private health insurance (n = 138)	85 (61.5)	59 (65.5)	26 (54.1)	0.19
Highest educational qualification (n = 138)				
*Up to year 12 or equivalent***	15 (10.8)	9 (10.0)	6 (12.5)	0.52
Vocational education (e.g. Apprenticeship/Diploma)	45 (32.6)	27 (30.0)	18 (37.5)	
University degree or Higher	78 (56.5)	54 (60.0)	24 (50.0)	
Employment status (n = 138)				
Full-time work (≥ 35 h/week)	123 (89.1)	82 (91.1)	41 (85.4)	0.58
Part time or casual temp work	11 (7.9)	6 (6.6)	5 (10.4)	
Not currently working	4 (2.9)	2 (2.2)	2 (4.1)	
Relationship status (n = 138)				
Married	97 (70.2)	71 (78.8)	26 (54.1)	0.006 (0.26)
De facto	38 (27.5)	18 (20.0)	20 (41.6)	
In a relationship but not living with my partner	3 (2.1)	1 (1.1)	2 (4.1)	
Financial manageability (n = 138)				
*It is impossible/It is difficult****	34 (24.6)	19 (21.1)	15 (31.2)	0.36
It is not too bad	73 (52.9)	51 (56.6)	22 (45.8)	
It is easy	31 (22.4)	20 (22.2)	11 (22.9)	
Identify as Aboriginal or Torres Strait Islander (n = 138)	5 (3.6)	2 (2.2)	3 (6.1)	0.15
First language other than English (n = 138)	16 (11.5)	7 (7.7)	9 (18.7)	0.05 (0.16)
Born outside Australia (n = 138)	32 (23.1)	20 (22.2)	12 (25.0)	0.71
Health care card (n = 138)	42 (30.4)	25 (27.7)	17 (35.4)	0.35

^ One participant was identified under 20 years of age

*Other includes South Australia/ACT/Tasmania/Western Australia/Northern Territory

** Includes no formal qualifications, year 10 or equivalent, and year 12 or equivalent

*** Combined it is impossible; is difficult all the time; it is difficult some of the time

one third of expectant partners had ever smoked (36.3%). Almost one third of expectant partners reported seeing any health professional 12 months before their partner's pregnancy (32.2%). A small number of expectant partners reported using folic acid before their partner's pregnancy (5.0%).

A very strong association was observed for physical activity three months before the partner's pregnancy with LMUP category (V = 0.27;p = 0.001) indicating that a greater proportion of expectant partners with planned pregnancy reported physical exercise. A very strong association was identified between checking immunizations 12 months before partner's pregnancy and planned pregnancy (V = 0.26;p = 0.26) while a strong association was identified between having ever smoked and reporting an ambivalent/unplanned pregnancy (V = 0.24;p = 0.005).

Preconception health information and advice

Almost one third of all expectant partners reported looking for and finding information about becoming pregnant (31.8%) (Table 4). A large proportion of expectant partners sourced preconception information from the internet (92.0%) and in many instances the preconception information related to both males and females (76.0%). When preparing for pregnancy, many expectant partners received information regarding immunizations (21.1%), smoking (20.0%), and alcohol (20.0%), yet fewer received information about maintaining a healthy weight (11.5%) or sexually transmitted diseases (11.5%). Upon comparing LMUP categories, a strong association was identified between planned pregnancy and looking for and finding information about becoming pregnant (V = 0.23;p = 0.005).

Table 2 The health status and health history of expectant male partners

	LMUP category			
	All (n = 138)	**Planned (n = 90)**	**Ambivalent/ Unplanned (n = 48)**	**P (Cramer's V)**
	n (%)	***n (%)***	***n (%)***	
General Health Status (n = 96)				
Excellent	22 (22.9)	14 (21.5)	8 (25.8)	0.74
Good	58 (60.4)	41 (63.0)	17 (54.8)	
Fair/Poor	16 (16.6)	10 (15.3)	6 (19.3)	
Longstanding illness, disability, or infirmity (n = 96)	15 (15.6)	5 (7.6)	10 (32.2)	0.005 (0.31)
Diagnosed or taking medications for any conditions [3 months before partner's pregnancy]	31 (22.4)	21 (23.3)	10 (20.8)	0.73
***Contraception use*[6 months before partner's pregnancy] (n = 128)**				
Yes	43 (33.5)	30 (35.7)	13 (29.5)	< 0.001 (0.37)
No – Was trying to conceive	63 (49.2)	48 (57.1)	15 (34.0)	
No – Was not trying to conceive	22 (17.1)	6 (7.1)	16 (36.3)	
	Median (Q1, Q3)	***Median (Q1, Q3)***	***Median (Q1, Q3)***	
***Body Mass Index [BMI]*(n = 136)**	27.4 (23.6, 30.9)	27.7 (24.8, 31.0)	26.6 (23.4, 30.7)	0.56
***BMI Classification*(n = 136)**	***n (%)***	***n (%)***	***n (%)***	
Normal weight [BMI 18.5–24.9] *	46 (33.8)	26 (39.5)	20 (41.6)	0.30
Overweight [BMI 25.0–29.9)	50 (36.7)	37 (42.0)	13 (27.0)	
Obesity class I [BMI 30.0–34.9]	26 (19.1)	17 (19.3)	9 (18.7)	
Obesity class II [BMI 35.0–39.9] & class III [BMI > 40]	14 (10.2)	8 (9.0)	6 (12.5)	

* Zero participants were underweight [BMI < 18.5]

Discussion

This study on paternal pregnancy intention and planning identified several key findings of importance for public health and reproductive health broadly and more specifically for expectant partners preconception health and care, and their efforts to seek, source, identify, and consult for preconception information and advice. According to the LMUP for Women's Partners [28], the proportion of expectant partners with a planned pregnancy in our study (69%) was lower than in other studies exploring males' pregnancy intention (81–95%) [24, 34]. Our study also reported a proportion of expectant partners with planned pregnancy less than the planned pregnancy rate generally reported for women (83%) [35] and similar to the estimated global planned pregnancy rate (60%) [20]. The public health implications of this research rebalance the social gaze to consider the impact of male health during preconception and to prompt males to take opportunities to sustain health during preconception. Noteworthy findings within our study are discussed below.

When comparing the sociodemographic characteristics of expectant partners in our study according to pregnancy intention, some findings align with existing evidence describing the target population. For example, male expectant partners with intended pregnancy were most commonly aged 30–39 age [36], were often in committed relationships [37], and generally did not report issues with financial manageability [38]. Other findings in our study present potential areas for exploration and future research; a significant proportion of expectant partners who had a first language other than English or who had ever smoked reported ambivalent pregnancies.

A large proportion of expectant partners in our study with a planned pregnancy undertook physical activity in the three months prior to their partner's pregnancy (69.5%), averaging five physical activity hours per week. Regular exercise plays an important role in regulating body weight and BMI [39], and with general physical function and health related well-being; [40] a lack of exercise is considered a major cause of chronic disease [41]. However, the health benefits of preconception interventions including regular exercise is only emerging for reproductive males [13]. Our finding of expectant partners undertaking physical activity during preconception is promising and may even substantiate why many expectant partners in our study report their health status as good or excellent. Despite perceiving their health as good or excellent, and undertaking physical activity, numerous expectant partners who planned pregnancy in our study had overweight status with a BMI between 25.0 and 29.9 (42%). The literature exploring males having overweight or obese suggests that their offspring are more likely to also have overweight or obesity [42, 43] and asthma [44]. Expectant partners having overweight and intending pregnancy should feel supported to optimise their body weight and reduce their risks, given that a sustained and increased BMI can signpost numerous

Table 3 The health behaviours of expectant male partners

Participant health behaviours	LMUP category			
	All (n = 138)	Planned (n = 90)	Ambivalent/ Unplanned (n = 48)	*P* (Cramer's V)
	n (%)	*n* (%)	*n* (%)	
Vitamins/supplements before partner's pregnancy				
Folic acid (n = 80)	4 (5.0)	3 (5.6)	1 (3.7)	0.58
Ordinary multivitamin (n = 86)	16 (11.5)	12 (13.3)	4 (8.3)	0.28
Vitamin C (n = 82)	9 (6.5)	6 (6.6)	3 (6.2)	1.00
Zinc (n = 81)	7 (5.0)	6 (6.6)	1 (2.0)	0.23
Omega 3 (n = 84)	7 (5.0)	3 (3.3)	4 (8.3)	0.19
Antioxidants (n = 79)	2 (1.4)	2 (2.2)	0 (0.0)	0.42
Herbal medicines (n = 80)	3 (2.1)	2 (2.2)	1 (2.0)	1.0
Other (n = 80)	8 (5.8)	6 (6.6)	2 (4.1)	0.71
Any folic acid[#]	18 (13.0)	14 (15.5)	4 (8.3)	0.29
Any natural health product[##]	30 (21.7)	22 (24.4)	8 (16.6)	0.29
Physical activity [3 months before partner's pregnancy] (n = 134)	96 (69.5)	71 (78.8)	25 (52.0)	0.001 (0.27)
	Median (Q1, Q3)	**Median (Q1, Q3)**	**Median (Q1, Q3)**	
Number of physical activity hours per week (n = 95)	5 (3, 7.5)	5 (3, 7.5)	5 (3, 6)	0.10
	***n* (%)**	***n* (%)**	***n* (%)**	
Ever smoked (n = 134)	50 (36.3)	25 (27.7)	25 (52.0)	0.005 (0.24)
Cigarettes	42 (84.0)	19 (76.0)	23 (92.0)	0.20
E-cigarettes	4 (8.0)	4 (16.0)	0 (0.0)	
Other	4 (8.0)	2 (8.0)	2 (8.0)	
Smoking [3 months before partner's pregnancy] (n = 50)**	22 (44.0)	9 (36.0)	13 (52.0)	0.25
	Median (Q1, Q3)	**Median (Q1, Q3)**	**Median (Q1, Q3)**	
Number of cigarettes or equivalents per day (n = 20)	8 (2,18.5)	8 (2, 16)	8 (3, 20)	0.61
	***n* (%)**	***n* (%)**	***n* (%)**	
Ever consumed alcohol (n = 132)	117 (84.7)	78 (86.6)	39 (81.2)	0.39
Alcohol consumption [3 months before partner's pregnancy]***				
	Median (Q1, Q3)	**Median (Q1, Q3)**	**Median (Q1, Q3)**	
Units during the week (Monday to Thursday) (n = 113)	2 (0, 4)	2 (0, 4)	1 (0,3)	0.11
Units during the weekend (Friday to Sunday) (n = 114)	4 (1, 6)	4 (1, 6)	4 (1, 8)	0.76
Any action before partner became pregnant [6 months before partner's pregnancy]				
Followed a weight loss diet	15 (19.7)	10 (18.1)	5 (23.8)	0.74
Get tested for a sexually transmitted disease	10 (13.1)	9 (16.3)	1 (4.7)	0.26
Contraception methods [6 months before partner's pregnancy] ****				
Condoms (n = 39)	27 (69.2)	19 (70.3)	8 (66.6)	0.81
Other^ (n = 116)	18 (15.5)	12 (16.2)	6 (14.2)	0.78
Any action before partner became pregnant [12 months before partner's pregnancy]				
Visit a dentist	59 (42.7)	42 (46.6)	17 (35.4)	0.20
Check immunizations	22 (15.9)	20 (22.2)	2 (4.1)	0.02 (0.26)
Seeing any health professional about becoming pregnant [12 months before partner's pregnancy] (n = 96)	31 (32.2)	21 (32.3)	10 (32.2)	0.99

[#] Folic acid or multivitamin

[##] Use of any vitamin/supplement including folic acid, multivitamin, vitamin c, zinc, omega 3, antioxidants, herbal medicines, other

** only asked of those participants who reported having `ever smoked'. *** only asked of those participants who reported having `ever consumed alcohol'

**** only asked of those participants who reported `using contraception in the 6 months before pregnancy'

^ Other includes abstinence, withdrawal, and timed intercourse

Table 4 Preconception health information and advice for expectant male partners

Participant preconception health information and advice	LMUP category			
	All (n = 138)	Planned (n = 90)	Ambivalent/ Unplanned (n = 48)	*P*
	n (%)	*n* (%)	*n* (%)	
Look at information about becoming pregnant [12 months prior]				
Yes – I went looking for information and found it	44 (31.8)	36 (40.0)	8 (16.6)	0.005 (0.23)
Yes- I did not go looking for information but found it anyway	6 (4.3)	4 (4.4)	2 (4.1)	1.00
No – I went looking for information but did not find any	2 (1.4)	1 (1.1)	1 (2.0)	1.00
No - I did not go looking for information and did not find any	46 (33.3)	26 (28.8)	20 (41.6)	0.12
Who did the information relate to**				
My partner only	11 (22.0)	10 (25.0)	1 (10.0)	0.42
Both me and my partner	38 (76.0)	29 (72.5)	9 (90.0)	0.24
Sources of preconception information/*****				
Books	19 (38.0)	17 (42.5)	2 (20.0)	0.27
Leaflets	14 (28.0)	11 (27.5)	3 (30.0)	1.00
Internet	46 (92.0)	37 (92.5)	9 (90.0)	0.79
Magazines	3 (6.0)	2 (5.0)	1 (10.0)	0.61
Family of friends	19 (38.0)	14 (35.0)	5 (50.0)	0.45
GP	25 (50.0)	20 (50.0)	5 (50.0)	1.00
Midwife	7 (14.0)	6 (15.0)	1 (10.0)	0.57
Obstetrician/Gynaecologist	7 (14.0)	5 (12.5)	2 (20.0)	0.61
When preparing for pregnancy, did anyone give you information about…				
Immunisation (n = 88)	23 (16.6)	19 (21.1)	4 (8.3)	0.06
Smoking (n = 88)	27 (19.5)	18 (20.0)	9 (18.7)	0.86
Alcohol (n = 88)	25 (18.1)	18 (20.0)	7 (14.5)	0.43
Physical activity (n = 88)	20 (14.4)	13 (14.4)	7 (14.5)	0.98
Stopping contraception (n = 88)	20 (14.4)	14 (15.5)	6 (12.5)	0.62
Eating a healthy diet (n = 88)	19 (13.7)	15 (16.6)	4 (8.3)	0.20
Folic acid (n = 88)	18 (13.0)	13 (14.4)	5 (10.4)	0.60
A healthy weight (n = 88)	16 (11.5)	12 (13.3)	4 (8.3)	0.57
Sexually transmitted diseases (n = 88)	16 (11.5)	12 (13.3)	4 (8.3)	0.57
Ordinary multivitamin (n = 87)	15 (10.8)	12 (13.3)	3 (6.2)	0.25
Omega 3 (n = 84)	7 (5.0)	3 (3.3)	4 (8.3)	0.23
Zinc (n = 84)	6 (4.3)	5 (5.5)	1 (2.0)	0.66
Vitamin C (n = 84)	5 (3.6)	3 (3.3)	2 (4.1)	1.00
Antioxidants (n = 84)	3 (2.1)	2 (2.2)	1 (2.0)	1.00
Herbal medicines (n = 84)	3 (2.1)	2 (2.2)	1 (2.0)	1.00

** only asked of those participants who reported 'looking at information about becoming pregnant' in the year before their partner became pregnant

*** Naturopaths, Pharmacists, and Doulas not included in final analysis due to nil results

ailments [45] and, along with waist and hip measurements, presents a health risk factor [46]. Although, according to BMI, having overweight does not always equate to being `unhealthy' and boundaries can seem blurred between BMI and health [47] due to the limitations of BMI due to its lack of distinction between fat and muscle tissue or determining body weight distribution [48]. Expectant partners having the perception of reasonable health yet living with overweight underscores the importance for males planning a pregnancy to be aware that despite undertaking physical activity, their preconception BMI may influence the health of their child later in life. Males during the preconception period and specifically the 3-month period prior to conception require further exploration to determine the influence of their regular exercise on pregnancy and offspring outcomes and to determine the efficacy of paternal preconception health and care treatment plans incorporating regular exercise.

Expectant partners with planned pregnancy in our study actively sought information and advice and often used the internet as a source of preconception information (92.0%). More broadly, previous research has shown that how males plan and prepare for pregnancy is varied; [34] one Australian study identified that males often only seek information regarding fertility when experiencing difficulties conceiving [49] while another study from England suggests that one in two males have looked at information about their partners pregnancy before conception from a variety of sources [17]. For many males, seeking

information or advice about pregnancy planning may now be a process governed online and by social media whereby familiar digitized social platforms are used to support decision making when planning a pregnancy [50]. Thus, online resources, social media platforms, and primary health care services all play a key role and have an onus to promote and provide accurate and reliable preconception information to reproductively aged males, especially those who are planning pregnancy.

Our study also shows that close to one quarter (22.2%) of expectant partners who planned a pregnancy completed immunization checks in the 12 months prior to their partners pregnancy and that approximately one fifth (21.1%) of expectant partners who planned a pregnancy received information or advice about immunization. The research exploring immunisation status during preconception is primarily focused on women [51–53] and checks for females before pregnancy are actively encouraged in the resources available for pregnancy planning [54, 55], are advocated by Governments worldwide [56, 57], and also recommend in the guidelines utilized by GPs for preventive activities in general practice [58]. As messages are directed and disseminated mainly toward the birthing parent not the couple or the male [59], and even when males check immunizations during preconception, immunization information will not always translate to immunisation currency or even immunization acceptance. Our results regarding immunisation may underscore the emphasis placed on immunization information, advice, and messages during the times of COVID-19 for both women and men [60]. Post COVID-19, preconception equality advocates that males should also reduce the risks of various infectious diseases to promote health [61] and thus preconception immunization status screening and information should be incorporated into consultations for all reproductive males intending pregnancy, including males who report any longstanding illness, disability, or infirmity.

Another key finding in this study is that expectant partners who report any longstanding illness, disability, or infirmity (15%) more often have an ambivalent or unplanned pregnancy than a planned pregnancy. Evidence suggests that approximately one in three adults live with multiple chronic conditions [62]. Males with longstanding chronic illness, including preconception paternal comorbidity such as metabolic syndrome, threaten the health of their gametes and have been associated with higher odds of pre-term birth or low birth weight than males without comorbidities [63]. Previous research also identifies that the partners of disabled fathers are at higher risk of unintended pregnancy compared with the partners non-disabled fathers [64]. Hence, for expectant partners with health-related issues which may manifest as a longstanding chronic illness, disability, or infirmity, their partner's pregnancy may not always be intended or may even result in adverse pregnancy outcomes [65]. Therefore, tailoring a reproductive life plan specifically to males with longstanding chronic illness or disability may help promote pregnancy intention and paternal preconception health amongst this sub-population. All reproductive males, including those with longstanding chronic illness or a disability, are likely to benefit from preconception care and require targeted information regarding the importance of pregnancy planning and preparation.

Strengths and limitations

Our study captures the preconception health behaviours and information seeking behaviours of expectant partners through the lens of pregnancy intention, nevertheless, it is important to acknowledge several limitations. Firstly, this study was cross-sectional in nature and therefore represents the preconception intentions, health, health behaviours, and information and health advice seeking among expectant partners in a 12-month period only. Expectant partners were recruited via social media, and completed an online survey, both processes which can be predisposed to data collection bias or sampling and selection bias [66]. Although social media does have hundreds of millions of users, and is becoming more frequently used by the general public [66], utilizing social media to recruit survey participants for this study may not have provided a true representation of males during preconception. Further, recruiting only males with pregnant partners also does not provide a true representation of males during preconception. Due to the reliance upon self-reported data in the survey, there is potential for response bias whereby participants may have provided socially desirable responses which has been mitigated by ensuring questions were articulated without an emphasis on socially acceptable answers or being right or wrong [67]. The self-reported measures identified in this study were also not considered alongside objective data which would enhance the rigour of the fundings. Further, a survey data error meant that only five of the six questions in the LMUP for women's partners survey could be allocated the maximum score. Also, the use of LMUP for Partners has only been piloted in the UK [28] and so has not been validated for Australian expectant partners as has the LMUP among pregnant Australian women [68]. Finally, due to the sample size, there was insufficient statistical power to perform multivariate analysis. Despite these limitations, this study still provides valuable insights to an understudied population on a topic that is critical to public health for multiple generations.

Conclusion

The majority of expectant partners in our study had a planned pregnancy, yet close to one third of the expectant partners in our study remain ambivalent about their current pregnancy. Key differences, including undertaking physical activity and checking immunisations, were evident in the health behaviours of expectant partners with a planned pregnancy compared with ambivalent/unplanned pregnancy. Our study establishes a foundation for further large-scale research to be conducted to build a knowledge base for clinicians to better understand preconception health for males and their information and advice seeking behaviours and also enable policy makers to formulate health policies and initiatives aimed at improving male preconception health and awareness.

Abbreviations

GP	General Practitioner
RACGP	Royal Australian College of General Practitioners
UTS	University of Technology Sydney
HREC	Human Research Ethics Committee
LMUP	London Measure of Unplanned Pregnancy
STI's	Sexually transmitted infections
BMI	Body mass index

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

AS initiated the survey, administered the survey process, and collected data. TC analyzed and tabulated the data and was a major contributor to the writing of the manuscript. This manuscript was overseen by faculty supervisors AS, JA, & DS. All authors read and approved the final manuscript.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Study ethics approval was obtained from the Human Research Ethics Committee (HREC) at the University of Technology Sydney (UTS) (ETH20-4726), in accordance with the Declaration of Helsinki. Informed consent was obtained from each participant prior to survey commencement.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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APPENDIX 6.2 LONDON MEASURE OF UNPLANNED PREGNANCY (LMUP) ITEM RESPONSES AND SCORES

In the month that your partner became pregnant…. (n=138)	
Not using contraception	129 (93.4)
Using contraception, but inconsistently	7 (5.0)
Always used contraception but knew that the method had failed at least once	1 (0.7)
Always used contraception	1 (0.7)
In terms of becoming a father, I feel that the pregnancy happened at…. (n=138)	
Right time	112 (81.1)
Ok, but not quite right time	24 (17.4)
Wrong time	2 (1.4)
Just before your partner became pregnant… (n=138)	
I intended my partner to get pregnant	113 (81.8)
My intentions kept changing	13 (9.4)
I did not intend for my partner to get pregnant	12 (8.7)
Just before your partner became pregnant…(n=138)	
I wanted to have a baby	116 (84.0)
I had mixed feelings about having a baby	21 (15.2)
I did not want to have a baby	1 (0.7)
Before your partner became pregnant…. (n=138)	
My partner and I agreed that we would like me to be pregnant	119 (86.2)
My partner and I had discussed having children together, but hadn't agreed for me to get pregnant	17 (12.3)
We never discussed having children together	2 (1.4)
LMUP Score (n=138)	
Planned (10-11)	90 (65.2)
Ambivalent (4-9)	47 (34.7)
Unplanned (0-3)	1 (0.7)

APPENDIX 7.1 PUBLISHED MANUSCRIPT ASSOCIATED WITH RESULTS REPORTED IN CHAPTER 7

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Preconception health beliefs and intentions predict behaviours among expectant male partners: a cross-sectional study

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Abstract

Background The preconception period allows couples to plan and prepare for pregnancy. However, males can often consider this integral public health topic as a female domain. To better understand and support behaviour change for males before conception, this study aimed to identify and explore the preconception and pregnancy planning health beliefs and intentions of expectant male reproductive partners of pregnant women in Australia.

Methods An online cross-sectional survey [2020–2021] among males aged 18–49 years who were the reproductive partner (expectant partner) of a pregnant female. Recruitment occurred via social media. The 80-item survey consisted of five sections. Survey items regarding beliefs and intentions were formulated using the Theory of Planned Behaviour. Associations between participants' beliefs, subjective norms, perceived behavioural control, and intentions related to three outcomes (regular exercise, healthy diet, and alcohol avoidance) were estimated using Structural Equation Modelling.

Results Expectant partners' ($n=136$) had a mean age of 31 years. Their beliefs toward regular exercise and their perceived behavioural control to exercise regularly were associated with a greater intention to exercise regularly (Standardised estimate $\beta=0.54$; $p=0.0087$ and $\beta=0.43$; $p=0.02$, respectively). The beliefs of expectant partners toward alcohol avoidance and their perceived behavioural control toward alcohol avoidance were associated with a greater intention to avoid alcohol ($\beta=0.43$; $p<0.001$ and $\beta=0.36$; $p<0.001$, respectively). For the healthy diet outcome, subjective norms of expectant partners, and perceived behavioural control to adopt a healthy diet were associated with an intention to adopt a healthy diet ($\beta=0.23$; $p=0.04$ and $\beta=0.47$; $p<0.001$, respectively). Intention was in turn associated with behaviour for all three outcomes.

Conclusion Our study demonstrated that the preconception intentions of expectant partners were associated with their preconception behaviours; especially for the intention to exercise regularly or to avoid alcohol. Further studies examining paternal preconception health beliefs, and intentions and the motivations behind health behaviours for males are needed to help develop targeted preconception health promotion messages and interventions that support males to optimise their preconception health.

Keywords Preconception, Pregnancy planning, Male, Beliefs, Intentions

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Text box 1. Contributions to the literature

- Highlights the influence of engaging expectant male partners before pregnancy.
- The beliefs of expectant partners regarding alcohol consumption before pregnancy were incongruent with their behaviours.
- Partner opinion is an important consideration regarding expectant partners consumption of a healthy diet before pregnancy.
- Further public health research to better understand how expectant partners' beliefs regarding preconception health behaviours influence their intentions and behaviours is warranted.

Introduction

Health prior to a pregnancy - preconception health - is synonymous with preventive health and is considered a public health priority for reproductively aged populations across the globe [1]. A conscious decision to attempt pregnancy, referred to as 'pregnancy intention', allows couples to plan and prepare for pregnancy by initiating healthful behaviours such as undertaking regular exercise, adopting a healthy diet, and avoiding alcohol to improve their chance of a healthy pregnancy and child. Preconception health and health behaviours, as well as pregnancy spacing and timing, are important considerations for both females and males with research suggesting preconception health behaviours and modifiable risk factors can have both short and long-term health implications for parents and their children [2–4]. Males are duly recognised as having a direct and indirect influence on pregnancy and offspring outcomes whereby they can indirectly support maternal behaviours during preconception [5, 6] while their own preconception behaviours can have direct genetic [7] and epigenetic consequences [8]. Yet, evidence describing reproductive males' preconception health and health behaviours is only newly emerging, partly because capturing and reporting the preconception health behaviours of males can be difficult [9]. From the available evidence, a recent review of paternal preconception modifiable risk factors identifies several health behaviours of males which report adverse pregnancy and offspring outcomes such as alcohol, smoking, and nutritional exposures [3]. This review also highlighted many gaps in understanding male preconception health for behaviours such as physical activity, a healthy diet, and alcohol consumption that needed to be addressed through further research.

Males have been identified as often not aware of the concept of preconception health nor its importance [10, 11] and they may appear reluctant during discussions [12]. Moreover, males less frequently seek health care support than females [9] and health care professionals, including general practitioners, often do not feel comfortable with their knowledge regarding male preconception health and fertility issues [13]. Often males consider such integral public health topics to be a female domain [12] despite often agreeing with the importance placed on paternal preconception health and care [14] and possessing a general willingness to use preconception care services [10]. A Swedish longitudinal study investigating males' pregnancy planning behaviour, for example, examined males' preparations for pregnancy and found only a small portion of men (17%) adjusted their preconception behaviours to improve their health [15].

It is important for researchers, practitioners, policy makers and all stakeholders of preconception health to understand the relationships between paternal preconception behaviours and paternal preconception beliefs, and intentions to better support behaviour change for males before conception, and effectively target appropriate preconception messages and interventions [16]. Exploring the belief-behaviour relationship that drives the motivational factors of male's behavioural intentions can assist to better understand subsequent paternal preconception behaviours. Therefore, the aim of this study was to examine pathway associations of preconception and pregnancy planning health beliefs with intentions and behaviours among expectant male reproductive partners (expectant partners) of pregnant women.

Methods

Study design

We conducted an observational study utilizing data from an online cross-sectional survey conducted between December 2020 and September 2021. The survey included a convenience sample of expectant partners.

Participants and survey administration

Expectant partners were eligible to participate if they were male, aged 18 to 49 years, and the reproductive partner of a pregnant female. Targeted advertising was utilized on social media platforms (i.e. Instagram, Facebook, Twitter) for participants to be recruited from the general public; a small financial incentive was provided for participation. A screening instrument was used at the start of the survey to ensure participants met the eligibility criteria [an Australian male, aged 18 to 49 years, and the reproductive partner of a pregnant female] and to collect their name and email address. Any individual meeting the study eligibility criteria and who consented to participate then completed the survey via the online survey platform Qualtrics™. The recruitment strategy was also initiated by the pregnant female who received a hyperlink instructing them to complete the survey and to also forward a survey link onto their male reproductive partners.

Survey instrument and data

A paper-based survey was initially developed and tested by three individuals, feedback was provided which

resulted in the survey being built into Qualtrics™ and retested (See Supplementary File 1). The final survey consisted of 80-items across five sections including [1] "About you" (sociodemographic characteristics); [2] "Your current pregnancy" (retrospective assessment of the degree and timing of pregnancy planning using the partners version of the London Measure of Unplanned Pregnancy (LMUP) [17]; [3] "Your health behaviours" (changes in preconception health and health behaviours); [4] "Pre-pregnancy health information and advice" (knowledge on the importance of preconception health, the content of preconception care, and the source(s) of this information); and [5] "Your health history" (health and pregnancy history).

Participant demographics

The survey sought expectant partners' gender, age, private health insurance cover, highest qualification completed, employment status, relationship status, financial manageability status, identity as Aboriginal or Torres Strait Islander, first language spoken, country of birth, and health care card access.

Participant health history, health status, and pregnancy planning

Expectant partners rated their current general health [excellent-poor] and reported any longstanding illness, disability or infirmity; as well as body weight and height which were used to calculate and classify body mass index (BMI). The survey examined how the pregnancy was identified, their pregnancy intention, if the pregnancy resulted from fertility treatment, and contraception use 6 months before pregnancy.

Participant health behaviours

Survey questions identified expectant partners' health behaviours before pregnancy including alcohol consumption, smoking, physical activity, healthy diet, and supplements used. Alcohol consumption, a healthy diet, smoking, and physical activity were identified based on any history of use and use three months and six months prior to pregnancy. In addition, proximal preconception outcomes were reported related to physical activity, alcohol, and a healthy diet (i.e. I exercised regularly, ate a healthy diet, and avoided alcohol) for at least 6 months before their partners' pregnancy. Other potential preconception health behaviours such as following a weight loss diet, getting tested for a sexually transmitted disease (STI), visiting a dentist, checking immunization status, or undergoing surgery to help lose weight were also reported.

Participant preconception beliefs, and intentions

Survey items regarding beliefs and intentions were formulated using the Theory of Planned Behaviour (TPB), a framework best suited to the research question and widely utilized. The TPB examines the belief-behaviour relationship and aims to provide an explanation for the influences of behaviour, thereby understanding and even predicting behaviour [18]. The TPB model suggests that belief-based measures drive intentions, which are controlled by norms, subjective norms, and perceived behavioural control to determine behaviour [19]. This study reported the beliefs, intentions, subjective norms, and perceived behavioural control for three outcomes which have been identified as research gaps in the preconception literature for males [3, 20] (1) regular exercise, (2) healthy diet, and (3) alcohol avoidance. Each outcome was measured on a seven-point scale; expectant partners' beliefs were measured in the survey ranging from important to not important, being pleasant to unpleasant, being good to bad, or from being extremely likely to extremely unlikely (i.e. My doing regular exercise during the 6 months prior to partners pregnancy is… important/not important). Intentions were measured in the survey by questions reporting from extremely likely to extremely unlikely for participants (i.e. I intend to exercise regularly for at least 6 months before my partner becomes pregnant… extremely likely/unlikely). Expectant partners' behaviours in the survey were measured in one question which ranged from definitely true to definitely false (i.e. I exercised regularly for at least 6 months before my partner became pregnant…true/false).

Data analysis

Survey data were imported into STATA statistical software – version 17, cleaned, and prepared for analysis by the research team. Descriptive statistics detailed participant demographic characteristics, preconception health history, health status and pregnancy intention, as well as preconception health behaviours, beliefs, and intentions. BMI was calculated using participant weight and height and classified according to the World Health Organization (WHO) BMI classification [21]. Pregnancy intention was evaluated using the LMUP for women's partners; a validated and widely used measure to identify the degree of planning/intention for a current/recent pregnancy [17]. The LMUP score ranges from 0–12, with a higher score indicating greater pregnancy planning/intention [22]. The LMUP score was categorised as 'Planned' (10 or 11), 'Ambivalent' (between 4 and 9), or `Unplanned' (3 or less) [17].

Structural Equation Modelling (SEM) was used to estimate associations between TPB concepts, using survey items to construct latent variables. Parcelling [16] was applied to items used to estimate the latent constructs if

convergence or an acceptable model fit was unable to be achieved, and then if this was unsuccessful the concepts were represented by single items in a path model. The indicators used in the path model were rationalized by two members of the research team and comprised a single variable for each construct (See Supplementary Table 1). Regression paths were included to estimate the level of association between beliefs, subjective norms, perceived behavioural control, and intention, and between intention and behaviour. Model fit was established through the Comparative Fit Index (CFI), Tucker Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA) and Standardised Root Mean Square Residual (SRMR). Item non-response was dealt with by using full information maximum likelihood when estimating the model. Standardised path coefficients were estimated. The analysis was conducted with the Lavaan package [23] in R (version 4.3.1). A power analysis was not conducted on the sample. A formal sample size calculation for a specific effect size prior to the analysis as was not conducted as this research was based upon a secondary analysis question. The proposed model was not like models used in simulations for sample size requirements [24] so the 'sample size lower bound' [25] was checked for an anticipated effect size of regression paths of 0.4, and with up to 5 latent variables. The lower bound was 100, which was considered close enough to the study sample ($n = 94$) that analysis would proceed.

Results

The study sample comprised 156 expectant partners and most identified as reproductive males ($n = 146$) who were included in this study. The proportion of planned pregnancies in this study (65.2%) is higher than the proportion of intended pregnancies for Australian couples (60%) [26].

The proposed models for each type of behaviour, including the paths between latent variables and the items used to estimate each concept appear in Fig. 1.

Participant demographics

The mean age of expectant partners was 31 years (see Table 1). A large proportion of expectant partners were employed full-time [≥ 35 hours/week] (87.6%) and married (69.1%) while over half held private health insurance (59.9%) and/or a university qualification (53.4%) and/or reported that 'It is not too bad' to manage financially (52.7%). A small proportion of expectant partners identified as Aboriginal and Torres Strait Islander (4.1%).

Participant health history, status, and pregnancy planning

Expectant partners generally rated their health status as good (60.8%) with some reporting a longstanding illness, disability, or infirmity (15.4%) (see Table 2). About one third of expectant partners had a normal weight (33.3%), overweight (35.4%), or obesity (31.2%). According to the LMUP categories, most pregnancies were planned (65.2%), while a very small minority were unplanned (0.7%). Further, many expectant partners confirmed the pregnancy using a home pregnancy test (71.9%) and one in 10 pregnancies were conceived via fertility treatment

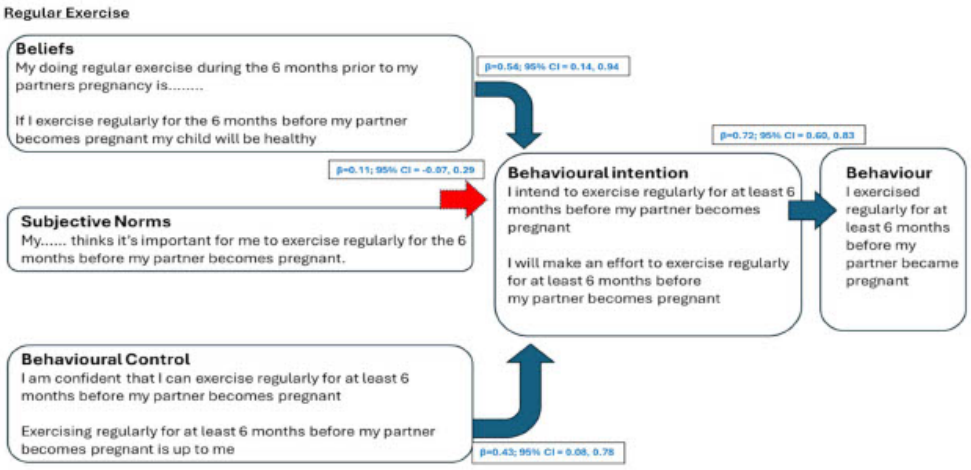

Fig. 1 Theory of Planned Behaviour (TPB) path models

Table 1 Sociodemographic characteristics of expectant male partners

Characteristics	Mean (SD; min, max)
Age (*n* = 136)	31.0 (4.6; 19, 44)
Highest level of education (*n* = 146)	**N (%)**
Year 10 or less	7 (4.7)
Year 12 of equivalent	10 (6.8)
Vocational education [Apprenticeship/Diploma/Certificate]	51 (34.9)
University qualification	78 (53.4)
Private health insurance (*n* = 146)	87 (59.9)
Employment status (*n* = 146)	
Full-time work (≥ 35 h/week)	128 (87.6)
Part-time work (< 35 h/week)	10 (6.8)
Casual/temp work (irregular hours)	3 (2.0)
Not currently working	5 (3.4)
Relationship status (*n* = 146)	
Married	101 (69.1)
De facto	41 (28.0)
Other	4 (2.7)
Financial manageability (*n* = 146)	
It is impossible/It is difficult all the time	12 (8.2)
It is difficult some of the time	26 (17.8)
It is not too bad	77 (52.7)
It is easy	31 (21.2)
Identify as Aboriginal or Torres Strait Islander (*n* = 146)	6 (4.1)
First language other than English (*n* = 145)	16 (11.0)
Born outside Australia (*n* = 146)	32 (21.9)
Health care card (*n* = 146)	45 (30.8)

(9.5%). Half of the expectant partners reported that they did not use contraception prior to their most recent pregnancy as they were trying to conceive (50.0%).

Participant preconception health behaviours

The majority of expectant partners reported history of any alcohol consumption (88.8%) (see Table 3). Many expectant partners who reported a history of alcohol consumption also reported alcohol consumption in the three months before pregnancy (62.0%). Less than half of all expectant partners had a history of ever smoking (37.5%) and of those with a history of ever smoking, less than half were smoking in the three months prior to conception (45.1%). The majority of expectant partners reported any exercise in the three months before conception (71.3%) with a mean number of hours per week at approximately six (mean 6.3; SD 5.3). The most common health behaviours before pregnancy were visiting a dentist (76.9%) or checking immunization status (28.2%), while the most common supplements used before pregnancy were an ordinary multivitamin (10.0%) or omega 3 (6.3%).

The associations between preconception beliefs, subjective norms, perceived behavioural control, and intentions and behaviours

Median scores, and the interquartile range (IQR, 25% and 75% percentiles), for preconception beliefs, norms, perceived behavioural control, and intentions and behaviours were measured on a seven-point scale from extremely likely to extremely unlikely (see Table 4). SEM model fit for the outcomes exercise and alcohol was adequate (Supplementary Table 2), and a path model was used for diet due to issues with convergence and model fit. The models for each concept are presented in Figs. 1 and 2, and Fig. 3.

For the exercise outcomes, results indicated that the beliefs of expectant partners toward regular exercise and their perceived behavioural control to exercise regularly were associated with a greater intention to exercise regularly (Standardised estimate $\beta = 0.54$; $p = 0.0087$ and $\beta = 0.43$; $p = 0.02$, respectively). The subjective norms of expectant partners were not associated with an intention to exercise regularly $\beta = 0.11$; $p > 0.05$). Similarly for alcohol, the beliefs of expectant partners toward alcohol avoidance and their perceived behavioural control toward alcohol avoidance were associated with a greater intention to avoid alcohol ($\beta = 0.43$; $p < 0.001$ and $\beta = 0.36$; $p < 0.001$, respectively). For the healthy diet outcome, subjective norms regarding a healthy diet as expressed by

Table 2 Health history, health status, and pregnancy planning of expectant male partners

Characteristics	*N* (%)
General health status (*n* = 97)	
Excellent	22 (22.6)
Good	59 (60.8)
Fair	15 (15.4)
Poor	1 (1.0)
Longstanding illness, disability, or infirmity (*n* = 97)	15 (15.4)
BMI classification (*n* = 144)	
Underweight	0 (0.0)
Normal weight	48 (33.3)
Pre-obesity	51 (35.4)
Obese class I	30 (20.8)
Obese class II/III	15 (10.4)
LMUP Category (*n* = 139)	
Planned	90 (65.2)
Ambivalent	48 (34.7)
Unplanned	1 (0.7)
Confirmation of pregnancy (*n* = 146)	
Home pregnancy test	105 (71.9)
From a health professional	8 (5.4)
My partner told me	33 (22.6)
Pregnancy resulting from fertility treatment (*n* = 146)	14 (9.5)
Contraception use [6 months before partner's pregnancy] (*n* = 130)	
Yes	43 (33.0)
No – I was trying to conceive	65 (50.0)
No – I was not trying to conceive	22 (16.9)

LMUP, London Measure of Unplanned Pregnancy

an expectant partner and perceived behavioural control to adopt a healthy diet were associated with an intention to adopt a healthy diet ($\beta = 0.23$; $p = 0.04$ and $\beta = 0.47$; $p < 0.001$, respectively). The beliefs of expectant partners toward a healthy diet and the subjective norms of their health care providers towards a healthy diet were not associated with the intention for a healthy diet ($\beta = 0.07$; $p > 0.05$ and $\beta = 0.13$; $p > 0.05$, respectively). Intention was in turn associated with behaviour for all three outcomes.

Discussion

Our study advances the understanding of paternal preconception health by examining the relationships and pathways between expectant partner's health beliefs, and intentions and behaviours around dietary practices, alcohol avoidance, and regular exercise before pregnancy. Considering the majority of pregnancies in our study were planned (65.2%), key findings suggest that preconception beliefs about exercise and alcohol predict intention to exercise regularly and to avoid alcohol. Further, the confidence/control about being able to exercise regularly, eat a healthy diet and avoid alcohol all predict intention for these behaviours amongst expectant partners. Partner opinion on the importance of eating a healthy diet was an important predictor for intention to eat a healthy diet. Also, expectant partners' intentions for all three behaviours predicted behaviour, most strongly for exercise.

Most expectant partners in our study undertook regular exercise in the three months before conception. Previous research investigating behavioural intention to exercise has explored mixed gender populations, such as university students [27, 28]. This work provides varied results and suggests that intention to exercise does not always translate into practice [29]. Evidence exploring physical activity specifically among males during preconception is lacking [3]. However, evidence does suggest that the health behaviours of males can have a direct and indirect influence on pregnancy and offspring outcomes. Nuances in sociodemographic characteristics such as being educated may justify the intent for physical activity among expectant partners in our study given approximately one in two held a university qualification. In our study, when comparing regular exercise with a healthy diet or avoiding alcohol, the behavioural intention to regularly exercise was not influenced by the subjective expectations of others. Specifically, our study found expectant partners' intention to exercise may be less often influenced by other individuals in their lives, such as their reproductive partners or male or female family and friends. The reason for this finding, however, is unclear. It is possible that men are instead relying on their own personal beliefs

Table 3 Preconception health behaviours of expectant male partners ^*All items scored on a 7-point scale (0–7)*

Characteristics	*N* (%)
Alcohol behaviours (*n* = 134)	
History of alcohol consumption ever	119 (88.8)
Consumption in the three months before conception (n = 116)	72 (62.0)
	Mean (SD; min, max)
*Total average units consumed per week in the 3 months before conception *During the week*	2.6 (3.5; 0,20)
*Total average units consumed per week in the 3 months before conception *On the weekend*	4.9 (5.3; 0, 30)
I avoided alcohol for at least 6 months before my partners pregnancy ^ (n = 95)	4.4 (2.6; 0,7)
Smoking behaviours (*n* = 136)	**N (%)**
History of ever smoking	51 (37.5)
Smoking in the three months prior to conception (n = 51)	23 (45.1)
Exercise behaviours (*n* = 136)	
Any exercise in the 3 months before conception	97 (71.3)
	Mean (SD: min, max)
Hours of exercise per week in the 3 months before conception (n = 97)	6.3 (5.3: 1, 35)
I exercised regularly for at least 6 months before my partners pregnancy (n = 95)	3.1 (2.4; 0,7)
Preconception health behaviours (*n* = 78)	**N (%)**
Follow a weight loss diet	15 (19.2)
Get tested for a sexually transmitted infection	11 (14.1)
Visit the dentist	60 (76.9)
Check immunisation status	22 (28.2)
Undergo surgery to help lose weight	-
I ate a healthy diet for at least 6 months before my partners pregnancy (n = 93)	2.7 (1.5;0,7)
Supplements used before pregnancy	
Folic acid (n = 82)	3 (3.6)
Ordinary multivitamin (n = 80)	8 (10.0)
Vitamin C (n = 82)	2 (2.4)
Zinc (n = 79)	3 (3.8)
Omega 3 (n = 79)	5 (6.3)
Antioxidants (n = 80)	1 (1.2)
Herbal medicines (n = 80)	1 (1.2)
Other (n = 80)	6 (7.5)

and responding to their personal health needs, and the subsequent individualised health benefits resulting from a regular exercise regime, rather than relying on external factors as motivations to exercise regularly. Considering the inherent risks of sedentary lifestyles and the rising global prevalence of overweight and obesity [30, 31], our finding that intention to exercise regularly is related to exercise behaviour is promising for paternal preconception intervention development. However, our finding relating to expectant partners preconception exercise must also consider the influence of their beliefs, subjective norms, and their perceived control of their behaviour on their intention to exercise. These three factors underpinning intention must be targeted in future research to develop a clear understanding of exercise for males during preconception. The health impacts of regular exercise have been investigated for males during preconception in a limited number of studies; a review exploring paternal preconception modifiable risk factors identified only two papers relevant to exercise and both papers reported no associations between paternal preconception physical activity and adverse pregnancy or offspring outcomes [3]. Hence, further studies are needed to explore opportunities for promoting physical activity among males who plan to become a parent during the preconception period to motivate and facilitate a behaviour change to support their own life-long health and possibly that of their family.

The beliefs of expectant partners in our study toward alcohol avoidance during preconception were associated with a greater intention to avoid alcohol. However, most expectant partners consumed alcohol in the three months before conception. The disconnect between expectant partners' beliefs about alcohol (avoiding alcohol is important) and their behaviours regarding alcohol (avoiding alcohol) before pregnancy may be due to alcohol, as an addictive drug, being culturally encouraged in Australia [32] despite public health campaigns

Table 4 Preconception health beliefs and intentions of expectant male partners **All items scored on a 7-point scale (0–7)*

CONSTRUCT		Behaviour		
		Regular Exercise (*n* = 95)	Healthy Diet (*n* = 93)	Alcohol Avoidance (*n* = 95)
		Median (IQR)	Median (IQR)	Median (IQR)
Past behaviour	I…… regularly for at least 6 months before becoming pregnant [definitely true/definitely false]	3 (1,5)	3 (2,4)	5 (2,7)
Beliefs	My……. during the 6 months prior to becoming pregnant is			
	[important/not important]	3 (2,4.5)	2 (1,4)	4 (2,6)
	[pleasant/unpleasant]	2 (1,4)	2 (1,3)	3 (1,5)
	[good/bad]	1 (0,3)	1 (1,3)	2 (1,4)
	If I……. for 6 months before becoming pregnant my child will be healthy [extremely likely/extremely unlikely]	3 (2,4)	3 (2,4)	3 (2,4)
Intentions	I intend to…… for at least 6 months before becoming pregnant [extremely likely/extremely unlikely]	3 (1,4)	2 (1,4)	3 (1,6)
	I will make an effort to…… for at least 6 months before becoming pregnant [extremely likely/extremely unlikely]	3 (1,4)	2 (1,4)	3 (1,6)
Control	I am confident I can……. for at least 6 months before becoming pregnant [extremely likely/extremely unlikely]	3 (1,4)	2 (1,3)	3 (1,5)
	……for 6 months before becoming pregnant is up to me [extremely likely/extremely unlikely]	1 (0,2)	1 (1,2)	1 (0,3)
Norms	Most people like me ……. for 6 months before becoming pregnant [extremely likely/extremely unlikely]	4 (2,5)	4 (3,5)	4 (3,6)
Subjective Norms	My reproductive partner thinks it's important for me to…… for 6 months before becoming pregnant [strongly agree/strongly disagree]	3 (2,4)	2 (1,4)	3.5 (2,5)
	My older female relatives (e.g., mother, grandmother, aunt) thinks it's important for me……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	3 (2,5)	3 (2,5)	3 (2,5)
	My older male relatives (e.g., father, grandfather, uncle) thinks it's important for me to……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	4 (3,5)	4 (2,5)	4 (3,6)
	My male friends and family of similar age thinks it's important for me to…… for 6 months before becoming pregnant [strongly agree/strongly disagree]	4 (2,5)	4 (2,5)	4 (2,6)
	My female friends and family of similar age thinks it's important for me to……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	3 (2,5)	3 (2,4)	3 (2,5)
	My health care provider thinks it's important for me to……. for 6 months before becoming pregnant [strongly agree/strongly disagree]	2 (1,3)	2 (1,3)	2 (1,4)

highlighting the general health risks and adverse effects of alcohol use [33]. Considering the normalization of alcohol consumption in Australian society, due to social acceptability and regular availability, a 'culture of intoxication' [32] exists, especially for younger males [34]. It may be that the cultural context and addictive properties of alcohol both play their part in challenging the beliefs of males to abstain from drinking alcohol during preconception, as is demonstrated in our study. Health behaviours such as alcohol consumption and tobacco smoking can interrelate and often co-exist [35] within a complex environment of social and cultural norms [36] and this link may also explain why close to half of the expectant partners in our study who had ever smoked chose to smoke in the three months prior to their partners pregnancy. Expectant partners in our study who hold the belief to avoid alcohol during preconception yet report alcohol consumption or smoking in the three months before conception is concerning due to the potential for adverse pregnancy and offspring outcomes such as foetal birth defects [37] and child behavioural problems [38]. Associations between alcohol consumption or smoking and adverse and pregnancy outcomes have also been identified in a recent review of paternal preconception modifiable risk factors [3]. Understanding future fathers' resistance to changing alcohol consumption and smoking patterns during preconception requires further research which can guide Governments to consider instituting overarching preconception guidelines focusing on males as well as females, and couples. To better support the disparity between males' preconception beliefs and their behaviours towards alcohol, and their behaviours while consuming alcohol such as smoking, industry collaborations must be strengthened to facilitate the effective translation of alcohol related information between researchers, practitioners, health and community organisations, and the general public.

Many expectant partners in our study did not report consuming a healthy diet in the six months before conception. However, our analysis did reveal that the healthy

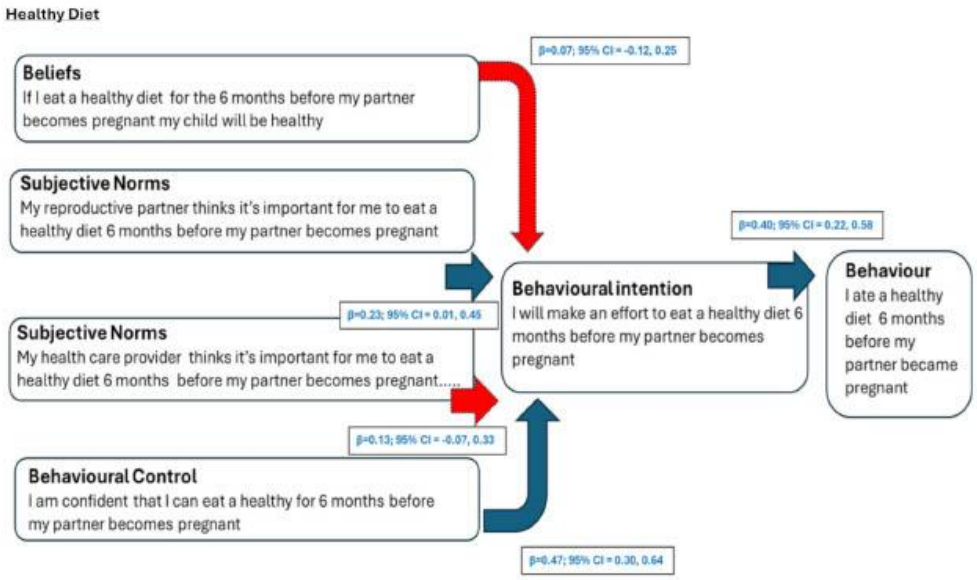

Fig. 2 Theory of Planned Behaviour (TPB) path models

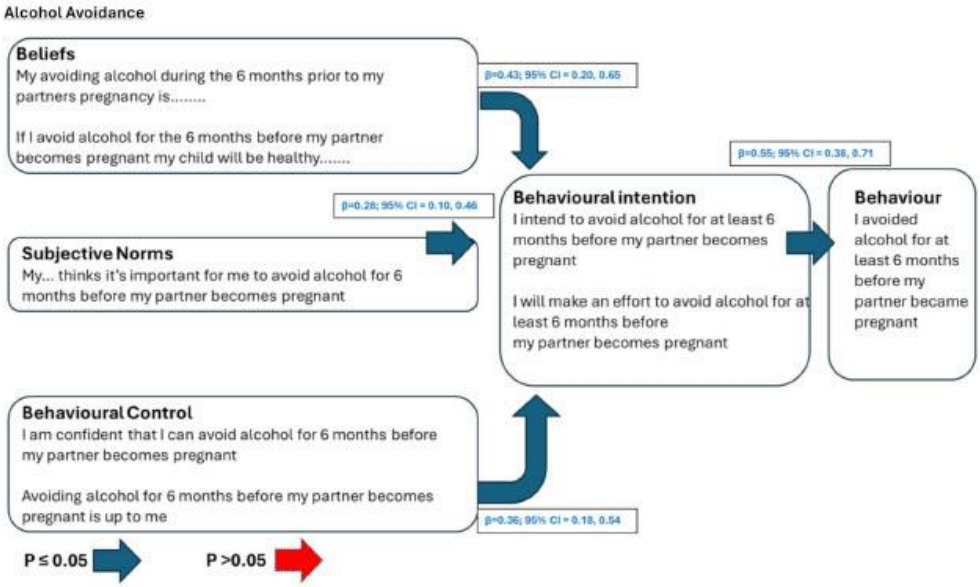

Fig. 3 Theory of Planned Behaviour (TPB) path models

diet of some expectant partners was most often influenced by their reproductive partners, more so than their health care provider. The dietary beliefs of males, for example beliefs regarding healthy eating or binge drinking, are only marginally investigated, among male consumers [39], and are often based on outdated evidence [40, 41]. More recent literature highlights the importance of initiating healthful dietary regimes for males during preconception, validating the effects of poor paternal dietary patterns and paternal nutrition on pregnancy and offspring outcomes [3, 42]. Most expectant partners in our study were married and, indeed, being in a committed relationship can have an influence on an individual's behaviours which impact their health [43] including their diet. Many expectant partners in our study worked full-time and, due to the convenience, cost and availability of certain foods, may have resorted to foods often deemed nutritionally imbalanced or even 'unhealthy' such as packaged, preprepared or 'fast food' [44]. The diets of expectant partners in our study must also be understood within the context of wider cultural stereotypes such as masculine eating and drinking beliefs often associated with a low concern for unhealthy eating/drinking [39] and the consumption of disproportionate amounts of macronutrients [45]. Our study identifies an expectant partner's healthy diet as influenced by their reproductive partner. As such, the influence of the couple or the family on a male's diet is noteworthy and signals an important challenge for public health policy makers and researchers to pursue the food habits of males and to assess the perceived behavioural control of males to maintain a healthy diet during preconception and when planning a pregnancy.

Our study provides new insights, being the first to examine the influence of males, as expectant partners, and their beliefs, norms, and perceived behavioural control on intentions and subsequent preconception health behaviours. This sample also displays a number of other health conditions which may further affect the behavioural decisions of expectant partners. Future research should examine some of the potential influence of health status and other factors on intentions for expectant partners. A key strength of our study is the data collection directly from male expectant partners rather than being reported by their female partners and while their partner was still pregnant – addressing an important gap in paternal preconception research to date [3]. Although, our study is not without limitations. Firstly, when conducting analysis, issues were identified with using the SEM model to fit the healthy diet outcome which could only be resolved by utilizing a path model which was selected by two members of the research team. As such, the determination of each healthy diet variable may attract researcher-bias toward the final SEM model and regression results. Also, participants were recruited via social media; hence, sampling bias may influence the findings of this study. Despite the global use and acceptance of social media, recruitment via this medium is unlikely to provide a true representation of the target population during preconception. As such, the absence of national data describing demographic characteristics of expectant fathers in Australia limits the ability to determine the representativeness of the study sample. Therefore, the study recruitment strategy and small sample size of this study may not report an entirely accurate representation of Australian male ethnicities or males as reproductive partners of pregnant Australian women [46, 47]. In addition, the SEM model did not account for characteristics such as BMI or smoking due to the complexity of the model and the need for extra paths to different latent variables. Furthermore, this study uses past behaviours to predict future intention and therefore had to be supported by a proxy measure of preconception behaviour. Finally, self-reporting on a survey may also present the potential for self-reporting bias.

Conclusion

Our study highlights the importance of engaging males as expectant partners during preconception to characterize their beliefs and intentions which are exacted through their personal values (norms), the values of others (subjective norms) and their perceived behavioural control. Overall, our study demonstrated that expectant partners' preconception beliefs about exercise and alcohol predict their intention to exercise regularly and avoid alcohol. Further, the confidence/ perceived behavioural control about being able to exercise regularly, eat a healthy diet and avoid alcohol all predict intention for these behaviours. Partner opinion on the importance of eating a healthy diet was an important predictor for expectant partners' intention to eat a healthy diet. Importantly, expectant partners' intentions for all three behaviours predicted behaviour, most strongly for exercise. Further studies examining paternal preconception health beliefs, and intentions and the motivations behind health behaviours for males are needed to help develop targeted preconception health promotion messages and interventions that support males to optimise their preconception health.

Abbreviations

TPB	Theory of Planned Behaviour
LMUP	London Measure of Unplanned Pregnancy
STI	Sexually transmitted disease
BMI	Body mass index
UK	United Kingdom
SEM	Structural Equation Modelling
CFI	Comparative Fit Index
TLI	Tucker Lewis Index
RMSEA	Root Mean Square Error of Approximation
SRMR	Standardised Root Mean Square Residual

NIHR	Health and Social Care Research
UTS	University of Technology Sydney
HREC	Human Research Ethics Committee

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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Author contributions
AS initiated the survey, administered the survey process, and collected data. TC, AS, KR and DS developed the analysis plan. KR undertook the SEM analysis and TC was responsible for descriptive data analysis. AS, JA, DS and KR contributed to interpretation of results. TC drafted the manuscript with input from AS, JA, DS and KR. All authors read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Study ethics approval was obtained from the Human Research Ethics Committee [HREC] at the University of Technology Sydney [UTS] (ETH24-9519), in accordance with the Declaration of Helsinki. Informed consent was obtained from each participant prior to survey commencement.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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APPENDIX 7.2 PATH MODEL FOR THE HEALTHY DIET OUTCOME

Belief
If I eat a healthy diet for 6 months before my partner becomes pregnant my child will be healthy *(Extremely likely/Unlikely)*
Justification
Arguably, rating the importance, pleasantness, or morality (being pleasant/unpleasant or good/bad) does not provide a true representation of healthy eating beliefs. Participant beliefs regarding eating healthy are best portrayed by their understanding of the link between their own health and the health of their children i.e. the likelihood (extremely likely/unlikely) that eating a healthy diet 6 months before their partner's pregnancy will sustain a healthy child.
Intention
I will make an effort to eat a healthy diet for at least 6 months before my partner becomes pregnant (Extremely likely/Unlikely)
Justification
To question intention explicitly may not result in the most accurate determination of the intention to eat healthy. To report intention accurately, a subtle approach is suggested whereby participant reluctance to report intentions is considered while maintaining the connections made by participants to their own efforts to eat healthy.
Behavioural control
I am confident that I can eat a healthy diet for 6 months before my partner becomes pregnant (Extremely likely/Unlikely)
Justification
Rating the confidence to eat healthy provides greater significance for a control mechanism than the participant simply affirming that to eat healthy is their prerogative.
Subjective Norms
My reproductive partner thinks it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant (Strongly agree/Disagree)
My health care provider thinks it's important for me to eat a healthy diet for 6 months before my partner becomes pregnant (Strongly agree/Disagree)
Justification

Subjective norms selected based upon the individuals who were most likely to influence males to eat a healthy diet.
Norms*
Most people like me eat a healthy diet for 6 months before their partner becomes pregnant (Extremely likely/Unlikely).
Behaviour*
I ate healthy for at least 6 months before my partner became pregnant (True/False)

* Only one variable available to select

APPENDIX 7.3 STRUCTURAL EQUATION MODELLING – MODEL FIT

Model	Chi square	Number of parameters	Comparative Fit Index	Tucker-Lewis Index	Root Mean Square Error of Approximation	Standardized Root Mean Square Residual
Exercise	39.63	33	0.96	0.93	0.10	0.06
Alcohol	75.38	41	0.96	0.95	0.08	0.05

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