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**Title:**

# The effects of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of patients with type 2 diabetes mellitus: Implications for Nursing Education.

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A thesis submitted in fulfilment of the requirements for

the degree of Doctor of Philosophy

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**2024**

**Certificate of original authorship**

I, Odai Al-ma'aitah, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Nursing and Midwifery (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.

This research is supported by the Australian Government Research Training Program.

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**Preface**

This thesis stands as a testament to the culmination of rigorous academic inquiry and personal perseverance. In embarking upon this academic journey, I find myself humbled by the opportunity to contribute to the medical field. The culmination of countless hours of research, reflection, and collaboration, this thesis represents a significant milestone in my academic pursuit.

I express my profound gratitude to Mutah University, the generous provider of the scholarship that enabled me to pursue my Doctoral studies at the University of Technology Sydney. I am deeply thankful for the opportunity Mutah University has afforded me, allowing me to contribute to the field of Nursing through this research.

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As this thesis finds its place in the academic discourse of Nursing, I hope it contributes to the ongoing dialogue and advances our understanding in this noble profession.

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**ABSTRACT**

**Background:** Many countries, including Jordan, implemented lockdowns as a COVID-19 pandemic public health strategy. However, little is known about the effect of these strategies for diabetes self-management in people with Type 2 Diabetes Mellitus (T2DM). This study aimed to 1) synthesize the current evidence about glycaemic control and associated factors in people with T2DM in the Middle East and North Africa, 2) determine measurements indicative of glycaemic control in people with T2DM, and identify whether glycaemic control differed in people with T2DM before and after the first COVID-19 lockdown in Jordan, 3) determine factors predictive of the level of glycaemic control during the pandemic (before and after lockdown) in Jordan and 4) create a consensus of expert opinions regarding the recommendations to be drawn from the findings of this study for nursing education and practice preparation for any future pandemic. **Methods:** This mixed-methods study unfolded in three phases. Phase I analysed routine blood glucose data for people with T2DM from multi-regional hospitals in Jordan, comparing values six months pre-lockdown with three months post-lockdown. Phase II evaluated characteristics that might be affected by the COVID-19 pandemic and its management, investigating their influence on glycaemic management in people with T2DM. Phase III entailed a modified Delphi consultation to generate recommendations for nursing education and practice.

**Results:** In Phase I, 323 people with T2DM were studied, mean age was 57.8 ± 11.7 years, and 51.4% were female. Post-lockdown, HbA1c values increased significantly (8% vs. 7.7%, $p < 0.001$) along with the proportion of people with inadequate glycaemic management (>7%; 78.6% vs. 68.4%, $p < 0.002$) compared to six months pre-lockdown. Pre-lockdown, insulin usage and

hypertension were associated with poor glycaemic management; post-lockdown, insulin/Glimepiride use, severe anxiety, mild to moderate stress, higher Body Mass Index (BMI), and physical activity were associated with an increased risk of inadequate glycaemic management.

In Phase II, Participants expressed fears of contracting the virus and reduced their exercise and consistency with healthy diets. During the Delphi Round, experts recommended home-based exercise programs and emphasized the essential role of telehealth systems in T2DM care. Future pandemic management plans should include home-based exercise programs and provide upskilling and systems to support telehealth delivery. There was a unanimous call for a national workshop to learn from nurses' responses to COVID-19. Experts underscored the need for adaptable nursing education and updated curricula to prepare nurses for future pandemics.

**Conclusion:** Sanctions for COVID-19 containment in Jordan, particularly lockdowns, resulted in significant deterioration in glycaemic management among people with T2DM, highlighting the necessity to include diabetes self-care support programs in future pandemic management plans. Nursing curricula could be updated to better prepare nurses to support people with diabetes during future pandemics.

## DEFINITIONS

**Adequate glycaemic management:** was defined for this project as fasting blood glucose (FBG) values ≤ 7.2 mmol/l (or ≤ 130 mg/dl) in line with the National Institute of Health (NIH) guidelines and as HbA1c values < 7% (or 53 mmol/mol) as recommended by the American Diabetes Association (ADA, 2022).

**Diabetes:** a person was accepted as having diabetes in the presence of a FBG ≥ 7.0 mmol/l, HbA1c ≥ 6.5% (48 mmol/mol), when prescribed use of glucose-lowering drugs or following a medically determined diagnosis.

**Diabetes self-management**: referred to the activities and behaviours an individual undertakes to manage, control and treat their condition. Diabetes self-management typically occurred in the home and included:

- Regularly monitoring their health for signs or symptoms caused by diabetes including conducting self-checks of their feet
- Taking medications as prescribed and adjusting medications as needed
- Consuming balanced meals with appropriate portion sizes
- Drinking water and avoiding dehydration
- Engaging in regular exercise
- Testing blood sugar (glucose): People who consume oral anti-diabetes with acceptable outcomes could monitor fasting and post-prandial blood glucose once to twice weekly. Insulin users with recurrent hypoglycaemia or poor glycaemic management should test a minimum of 4 times a day (fasting, pre-lunch, pre-dinner, and sleep). When

signs/symptoms of hypoglycaemia occur, a capillary blood glucose prick test should be done (Banerjee et al., 2020).

**Lockdown:** Employed as COVID-19 containment measures in many countries, the first COVID-19 lockdown in Jordan occurred from March 21, 2020, to June 06, 2020.

**Metabolic equivalent of task (MET):** a unit of measure of the rate at which the body expends energy relative to body mass; that is, energy expenditure based on the amount of oxygen consumed while sitting at rest, equal to 3.5 ml O2 per kg body weight per minute (Jetté et al., 1990).

**Obesity**: defined as Body Mass Index (BMI) values ≥ 30 kg/m2; overweight was defined as BMI values of 25.0 – 29.9 kg/m2 in line with the World Health Organization (2010).

# 1. CHAPTER 1 INTRODUCTION

## 1.1. Overview of the problem of this thesis

This thesis seeks to synthesize evidence on glycaemic control and associated factors in T2DM patients in the Middle East and North Africa, assess glycaemic control measurements in Jordanian T2DM patients before and after the first COVID-19 lockdown, identify predictive factors for glycaemic control levels during the pandemic as well as gather recommendations for nursing education and practice based on study findings for future pandemics. Diabetes, a disease affecting a large proportion of Jordan's population, was affected during the period when a national lockdown was imposed to manage the first wave of the COVID-19 pandemic.

In late 2019, multiple cases of pneumonia with unidentified aetiology were reported in Wuhan, China. Three months later, the World Health Organization (WHO) declared the newly identified coronavirus (SARS-COV2) a pandemic. By 30 January 2021, globally reported COVID-19 cases had surpassed one hundred million (more than 1% of the total world population), with two million deaths (Dong et al., 2020). According to the WHO report, on 8 June 2022, there were over 530 million confirmed cases and over six million deaths worldwide (WHO, 2022b). The total number of cases of COVID infection in Jordan reached 1.6 million with 14 thousand deaths in the period from the start of the pandemic to April 2022. During the surge in COVID-19 cases between 1 January 2020 and 31 December 2021, the estimated excess mortality rate in Jordan was 114.4 deaths (95% uncertainty intervals (UI) 90.2 to 140.5) per 100000, with a reported COVID-19 mortality rate of 53.5 per 100000 (Wang et al., 2022).

Diabetes mellitus (DM) is a chronic condition characterized by disturbance of glucose uptake and metabolism by peripheral cells. It is a prevalent health concern affecting an estimated 529 million

adults globally aged between 20.0 and 79.0. Over 90.0% of diabetes cases worldwide are T2DM, as reported by the International Diabetes Federation (IDF, 2021). Notably, the highest rates of diabetes prevalence have been observed in North Africa and the Middle East, specifically at 9.3% (Ong et al., 2023). In Jordan, the prevalence of diabetes among adults aged 20.0 to 79.0 years is 14.8% with a 95% confidence interval (CI) of 12.5% to 17.9%, and the size of this problem is expected to increase in the region (IDF, 2021). The link between diabetes and poorer prognosis in people with COVID-19 may relate to the effect of hyperglycaemia on the immune system, where an inflammatory reaction may lead to severe pneumonia and fatal outcomes. Unfortunately, people with diabetes (and other chronic disease) were found to be worse affected during the COVID-19 pandemic, with a recent meta-analysis showing COVID-19 people with DM more likely to be admitted to the intensive care unit (ICU) and to need mechanical ventilation [OR (95% CI): 2.8 (1.8, 4.3) and 3.33 (2.1, 5.4), respectively] (Gaba et al., 2022). This underscores the importance of maintaining good glycaemic management.

Diabetes self-management (DSM) enables the maintenance of optimal individualized glycaemic management for people with diabetes through comprehensive lifestyle management, medication taking and self-monitoring of glucose levels (Nguyen et al., 2022). In primary care diabetes clinics, nurses promote DSM through effective nurse-patient relationships (Al Mahrouqi et al., 2022), assisting patients and offering training and support in diabetes management to patients and healthcare professionals (Kamalam & Angelina, 2021).

To protect people during the COVID-19 pandemic, countries used a variety of strategies including instituting so-called lockdowns (Hartmann-Boyce et al., 2020). Throughout this period patient education, self-care training and management of diabetes complications posed great challenges for nurses, but especially during lockdowns (Ahn, 2020; Romero-Castillo et al., 2022). During this

period closure of outpatient clinics, reduced inpatient capacity, staff and medicine shortages, unaffordable medicines and transportation difficulties resulted in delayed care seeking and limited self-care practices, all reported as placing diabetes management under pressure (Mohseni et al., 2021). Little is known about how patients responded, or how their self-care was affected.

The purpose of this thesis study was to identify what can be learnt from the events of this extraordinary situation in order to make recommendations for nursing to better support preparation and management for people with diabetes during any future pandemics.

### 1.2. SARS-COV2 virus and COVID-19 disease

Coronaviruses cause highly transmittable human pathogenic viral infections, and research into their behaviour is nearly a century old (Weiss, 2020). In late 2019, a novel coronavirus discovered in Wuhan, China, rapidly spread worldwide ( Pekar et al., 2021). In February 2020, the World Health Organization (WHO) named as COVID- 19 the "coronavirus disease 2019", a disease characterised by severe acute respiratory syndrome caused by Coronavirus 2 (SARS- CoV2). This disease was previously identified as 2019-nCoV (WHO, 2020). Viral pneumonia is its most significant clinical manifestation, characterized by fever, cough, dyspnoea, hypoxemia, and bilateral chest radiograph opacities (Chen et al., 2020).

#### 1.2.1. History of coronavirus:

Coronaviruses are a large viral family that infects various animals and may cause mild to serious respiratory diseases in humans. In 2002 and 2012, two extremely virulent coronaviruses of zoonotic origin, severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV), caused fatal respiratory diseases in humans,

making coronaviruses a new public health issue in the 21st century (Cui et al., 2019). However, coronavirus research has a long history extending back to the 1930s, of repeated population-wide infections that played a crucial role in developing a large knowledge base and technical tools for investigating these human pathogens(Weiss, 2020). Like other RNA viruses, the coronavirus mutates naturally over time. Therefore, researchers have anticipated the emergence of new variants of SARS-CoV-2, potentially including some more contagious and destructive strains, creating new challenges for global healthcare systems (Islam et al., 2022).

In 1965, Tyrrell and Bynoe isolated virus B814 from the respiratory tract of an adult with a common cold, passing it into human embryonic tracheal organ cultures ( Kahn & McIntosh, 2005). Soon after, the term coronavirus (from the prefix corona, which refers to the crown-like shape of the surface projections) was adopted to represent this new genus. The subfamily Coronavirinae is currently divided into four groups: Alphacoronavirus, Betacoronavirus, Gammacoronavirus, and Deltacoronavirus (represented avian and swine viruses) (Chan et al., 2015). In November 2002, SARS-CoV was initially identified in China's Guangdong Province and then spread to Hong Kong and to the world (Peiris et al., 2004; Zhao et al., 2003). Within a month of 55 index cases appearing in Hong Kong, Hanoi, and Singapore, 3,000 patients were confirmed worldwide, with 200 new cases each day. The epidemic of SARS prompted a swift and robust public health response coordinated by the WHO, and by July 2003, the global transmission had ended. Despite the efforts, 8,096 probable cases had developed in 29 countries, resulting in 774 fatalities globally (Peiris et al., 2004).

In 2012, the MERS coronavirus developed in Saudi Arabia and twenty-seven countries were affected. As of November 2019, 2,494 cases of MERS illnesses have been reported, with 858 deaths (Azhar et al., 2019; WHO, 2019). MERS-CoV may have infected humans through

dromedary camels, which seem to be a reservoir in multiple Middle Eastern countries, including Bahrain, Iraq, Iran, Palestine, Jordan, Kuwait, Qatar, Saudi Arabia, Syria, the United Arab Emirates, Lebanon, Oman, and Yemen (Alnuqaydan et al., 2021).

In 2019, the new coronavirus (nCoV), later named SARS-CoV-2, was initially reported to spread in the Huanan wholesale seafood market in Wuhan, Hubei province, China (Wang et al., 2020). The isolated agent was eventually identified as the seventh human-infecting species of the coronavirus family (Tang et al., 2020). It is widely believed that the species originated from Rhinolophus affinis (horseshoe bats, 96.0% identical genome with RaTG13 coronavirus) with potential zoonotic spillover in Manis javanica (Malayan pangolins) (Liu et al., 2019).

### 1.2.2. SARS-CoV2

The SARS-CoV-2 is a spherical virus with irregular crown-like protrusions on its surface (Atri et al., 2020). These crowns are surrounded by submerged and projecting functional proteins of various types. It contains a positive-sense single-stranded RNA (+ssRNA) genome of about 30.0 kilobases (Zhao et al., 2020). In terms of size, its diameter ranges from 75.0 to160.0 nm (Feng et al., 2020).

The life cycle of SARS- CoV2 is thought to be analogous to that of SARS-CoV and other coronaviruses. Cell entry proceeds in three steps: binding, cleavage, and fusion. First, the spike protein on the surface of the virion attaches to the angiotensin-converting enzyme 2 (ACE2) receptor protein on host cells (Zhang et al., 2020). The virus is subsequently absorbed through endocytosis, which is mediated by spike protein cleavage by the transmembrane serine protease 2 (Hoffmann et al., 2020). Then, the viral genome is translated by host machinery into a polyprotein that is cleaved by both host and viral proteases; a viral RNA-dependent RNA polymerase amplifies

the genome and finally, virions are formed and discharged via exocytosis (Atri et al., 2020) (see **Figure 1.1**). Notably, the ACE2 receptor has a wide tissue distribution, including the lungs (alveolar epithelial cells), upper airway, heart, gastrointestinal system, kidneys, and vascular endothelial cells in most tissues (H. Xu et al., 2020).

The binding process is guided by the molecular structure of the spike protein, which is structured in three segments: an ectodomain, a transmembrane anchor, and an intracellular tail. The ectodomain forms the crown-like structures on the viral membrane and contains two subdomains known as the S1 and S2 subunits. The S1 (N-terminal) domain forms the head of the crown and contains the receptor binding motif, and the S2 (C-terminal) domain forms the stalk that supports the head. The S1 subunit guides the binding of the virus to the host cell, and the S2 subunit guides the fusion process ( Li et al., 2024)

After the binding of the S1 subunit to an entry point, the spike protein of coronaviruses is often cleaved at the S1/S2 boundary into the S1 and S2 subunits by a host protease. This proteolytic priming is important because it prepares the S protein for fusion. The two subunits remain bound by van der Waals forces, with the S1 subunit stabilizing the S2 subunit throughout the membrane fusion process. Cleavage at a second site within S2 (S2') activates S for fusion by inducing conformational changes. Similar to SARS-CoV-1, SARS-CoV-2 exhibits redundancy in which host proteases can cleave the S protein. Both transmembrane protease serine protease-2 (TMPRSS-2) and cathepsins B/L have been shown to mediate SARS-CoV-2 S protein proteolytic priming, and small molecule inhibition of these enzymes fully inhibited viral entry in vitro. Other proteases known to cleave the S1/S2 boundary in coronaviruses include TMPRSS-4, trypsin, furin, cathepsins, and human airway trypsin-like protease (HAT) (Carvajal et al., 2024).

Unlike in SARS-CoV-1, a second cleavage site featuring a furin-like binding motif is also present near the S1/S2 boundary in SARS-CoV-2. This site is found in HCoV belonging to the A and C lineages of beta coronavirus, including MERS-CoV, but not in the other known members of the B lineage of beta coronavirus that contains SARS-CoV-1 and SARS-CoV-2. It is associated with increased virulence in other viral species and may facilitate membrane fusion of SARS-CoV-2 in the absence of other proteases that prime the S1/S2 site. However, given that proteases such as HAT are likely to be present in targets like the human airway, the extent to which this site has had a real-world effect on the spread of SARS-CoV-2 was initially unclear. Subsequent research has supported this site as an important contributor to pathogenesis: in vitro analyses have reported that it bolsters pathogenicity specifically in cell lines derived from human airway cells (Calu3 cell line) and that furin inhibitors reduced pathogenic effects in VeroE6 cells (Jackson et al., 2022).

Electron microscopy suggests that in some coronaviruses, including SARS-CoV-1 and MERS-CoV, a six-helix bundle separates the two subunits in the postfusion conformation, and the unusual length of this bundle facilitates membrane fusion through the release of additional energy. The viral membrane can then fuse with the endosomal membrane to release the viral genome into the host cytoplasm. Once the virus enters a host cell, the replicase gene is translated and assembled into the viral replicase complex. This complex then synthesizes the double-stranded RNA (dsRNA) genome from the genomic ssRNA (+). The dsRNA genome is transcribed and replicated to create viral mRNAs and new ssRNA (+) genomes. From there, the virus can spread into other cells. In SARS-CoV-2, the insertion of the furin-like binding site near the S1/S2 boundary is also thought to increase cell-cell adhesion, making it possible for the viral genome to spread directly from cell to cell rather than needing to propagate the virion itself. In this way, the genome of SARS-CoV-2 provides insight into the pathogenic behaviour of the virus (Rando et al., 2021). The

virulence of SARS-CoV-2 is increased by non-structural proteins (nsp1) nsp1, which can suppress host gene expression by stalling mRNA translation and inducing endonucleolytic cleavage and mRNA degradation.

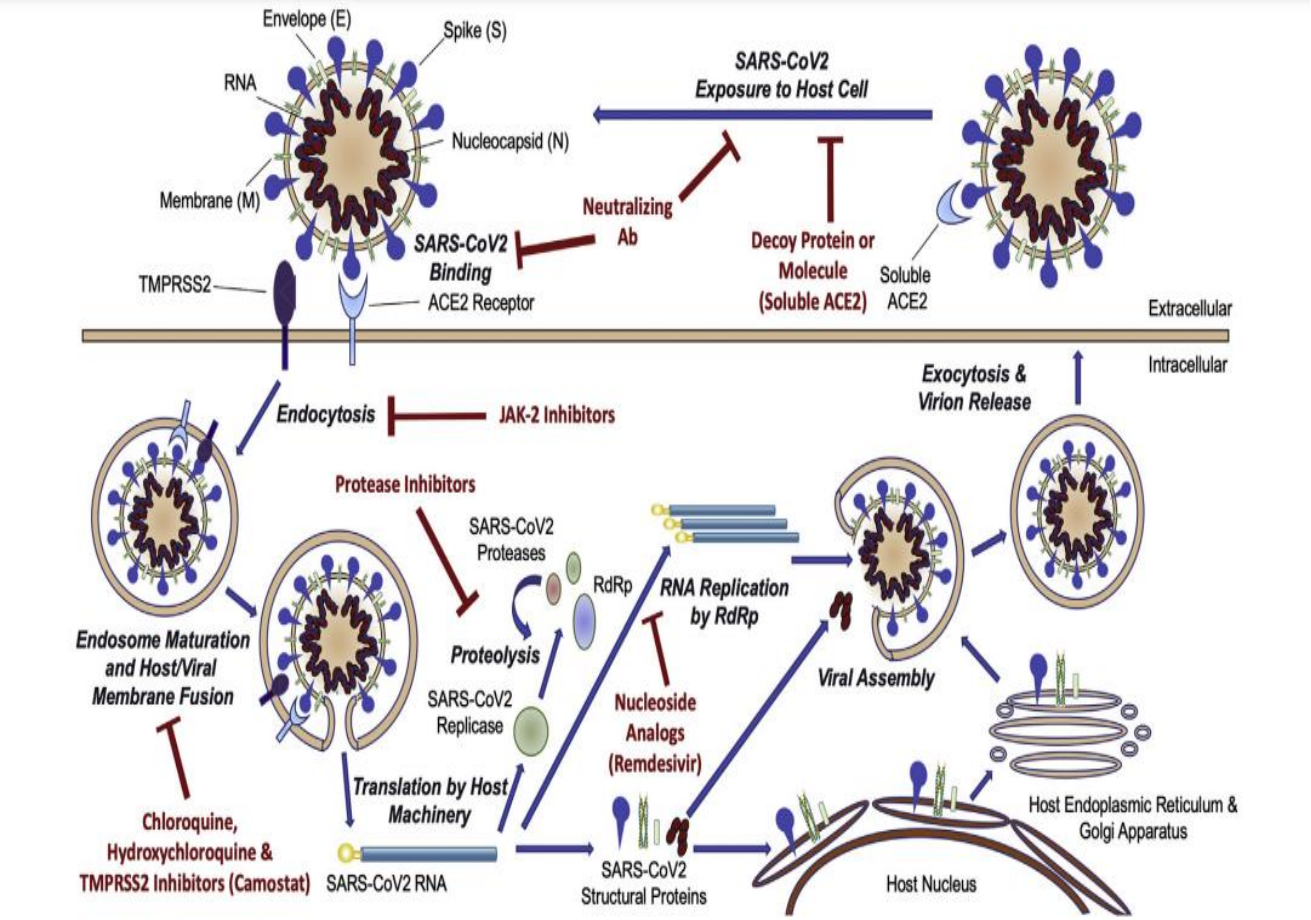


**Figure 1.1** Life cycle SARS- CoV2 (Fung et al., 2021) (Reproduced with permission).

Transmission of SARS- CoV-2 occurs primarily through respiratory droplets from face-to-face contact and, to a lesser extent, via contaminated surfaces. An estimated 48% to 62%of transmission may occur via presymptomatic carriers (Ganyani et al., 2020), and the symptoms often appear 5-6 days after infection (Cascella et al., 2022). Transmission is also linked to SARS-CoV-2 variants,

type and length of exposure, with prolonged close contact in tight, crowded, or poorly ventilated settings posing the greatest risk (Chu et al., 2022).

Following an incubation period ranging from two days to two weeks, SARS-CoV2 initially causes influenza-like symptoms (Vivaldi et al., 2023). The virus can activate both innate and adaptive immune systems. The ensuing inflammation with cytokine generation injures the alveolar sacs (Conti et al., 2020). The disease can then progressively affect the lungs, with patients developing a high fever, dry cough, falling oxygen saturation, and severe acute respiratory distress. SARS-CoV2 has also been observed to enhance clotting, predisposing to pulmonary embolism or large vessel ischemic complications Following an incubation period ranging from two days to three weeks, SARS-CoV2 initially causes influenza-like symptoms (Hu et al., 2021)**.**

Although respiratory failure remains the leading cause of death for COVID-19 patients, SARS-CoV-2 infection can damage many other organ systems including the heart, kidneys, liver, and gastrointestinal tract. As it becomes increasingly clear that SARS-CoV-2 infection can damage multiple organs, the scientific community is pursuing multiple avenues of investigation in order to build consensus about how the virus affects the human body (Shi et al., 2020; Nakayama et al., 2023).

**Comorbidities and risk factors in COVID-19 susceptibility**

There are many risk factors which influence COVID-19 prevalence among individuals and populations. Within the same population, factors such as age, sex, weight, and health status play a major role in the determination of disease severity (high-risk individuals: males, old age, overweight, history of chronic diseases as diabetes, cardiovascular diseases, or asthma). Similarly, other factors determine disease susceptibility among different populations including population

density, percentage of youth in the population, traditional diet/gut microbiota, lifestyle, genetic factors including ethnic differences, and the share of Neanderthals DNA in the genome (Woolf et al., 2021).

SARS-CoV-2 is capable of infecting people of all ages, but older people or people with pre-existing medical conditions showed a predisposition to infection and severe forms of COVID-19. The sensibility of the elderly could actually be explained by the over-expression of ACE2 in the elderly or the high prevalence of co-morbidities. The list of co-morbidities includes obesity, diabetes, hyper- tension, lung, liver, and kidney disease; immune-compromised patients (cancer patients on chemotherapy, transplant recipients), smokers and patients taking steroids chronically (Sanyaolu et al., 2020). The order of importance varied between studies but the major factors seems to be hypertension and cardiovascular problem followed by diabetes and respiratory underlying diseases (Boutin et al., 2021).

Mechanistically, the risk factor hypertension for a severe COVID-19 course, could be linked to the use of angiotensin- converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARBs) to treat people with hypertension. The manipulation of the renin–angiotensin system (RAS) could have an implication on the invasion and replication of SARS-CoV-2 in the cells. Those treatments are known to potentially increase the levels of ACE2 in several tissues which could increase the power of invasion by SARS-CoV-2 (Boutin et al., 2021).

An underlying cardiovascular disease (CVD) is linked to a worst outcome in patient with COVID-19. People with CVD develop severe form of COVID-19 and face more likely fatal outcome. The risk factors due to cardiovascular disease might depend on the same mechanistic as the

hypertension because of the use of ACE inhibitors and ARBs. Furthermore, cardiac damage might occur during infection and treatment (Chatzis et al., 2022).

Metabolic disorders (MDs), such as diabetes and obesity are associated with a pro-inflammatory, and prothrombotic state that can promote atherosclerosis (accumulation of lipids and leucocytes in blood vessels, leading to the formation of plaque) that restricts blood flow and promotes organ dysfunction due to insufficient oxygen supply. Hence, MDs are considered as major risk factor for a critical course of COVID-19. Diabetes, a common comorbidity in people with COVID-19, is a multifaceted metabolic disorder affecting the glucose level in the organism. As a result of an absolute or relative insulin deficiency or resistance to its action, impaired glucose tolerance and hyperglycaemia takes place. A small part of patients treated for diabetes also receive ACE inhibitors and ARBs, which could impact the prevalence of infection (Boutin et al., 2021).

In fact, diabetes is associated with a poorer outcome in COVID-19. This is most probably due to chronic inflammation with pro- moted atherosclerosis that sustains the symptoms in severe COVID-19. However, the underlying reasons for pre- disposing morbidity are complex. In addition to the general impairments in immunity (impaired neutrophil chemotaxis, phagocytosis, T-cell function) by which diabetes predisposes to infectious disease, diabetes might facilitate virus entry and replication. Roca-Ho et al. could show that diabetic mice have increased expression of ACE-2 in renal cortex, liver and pancreas (Roca-Ho et al., 2017). Although the upregulation of the receptor could not be confirmed in lungs this might predispose people with diabetes to infection with SARS-CoV-2. Furthermore, diabetes is associated with an increase in type-1 membrane-bound protease furin. Furin is involved in the entry of coronaviruses into the cell and therefore might facilitate viral entry and replication (Boutin et al., 2021).

obesity is defined by an excess accumulation of adipose tissue to an extent that impairs both physical and psycho- social health and well-being which can affect both children and adults. Obesity is also linked to ACE2, adipose tissue express higher levels of ACE2 which might enhance the viral entry in adipocytes. Therefore, a concern was raised if adipose tissue can serve as a reservoir for the spread of SARS-CoV-2. Furthermore, obesity does not come alone and is often associated with other co- morbidities which are also increasing the risk of COVID-19 such as hypertension, diabetes, cardiovascular diseases and lung function decline. It is closely associated with the development and worsening of T2DM, implicating similar reasons for the reported worsening COVID-19 outcome like diabetes (Boutin et al., 2021).

Briefly, the major reasons for promoting morbidity most probably include chronic inflammation and facilitated thrombosis. Dead and dying adipocytes, mediate infiltration and activation of macrophages, that release high levels of cytokines such as TNF-α, IL-6, and IL-1β. This increased inflammation might con- tribute to alveolar damage or systemic organic dysfunction in critical cases. Additionally, obesity-associated thrombosis obviously displays the metabolic disease as a risk factor for severity in COVID-19 that can be viewed as pro- thrombotic disease and treated in some cases with heparin beneficially. Furthermore, released hormones could be important. Obesity is associated with higher circulating leptin and lower circulating adiponectin. Adiponectin is considered as anti-inflammatory, and adiponectin-deficient mice develop inflammation of the pulmonary vasculature. This might account for facilitating a severe COVID- 19 course. However, some risk groups tend to have lower and some tend to have higher adiponectin levels emphasizing the importance of the sum of factors for disease outcome (Boutin et al., 2021).

Within the high range of chronic respiratory distress, chronic obstructive pulmonary disease (COPD) and asthma were the most associated as comorbidity. COPD and asthma were already

associated with other coronavirus infec- tion, such as SARS-CoV and MERS-CoV. However, in case of COVID-19, data are not clear if COPD really increases the rate of infection, but it is clear that people with COPD are most likely to present severe symptoms. Most COPD patients have a long history of smoking or exposure to other harmful particles or gases, capable of impairing pulmonary defences even years after the absence of exposure. COPD is characterized by persistent respiratory symptoms and airflow limitation due to airway inflammation and/or alveolar abnormalities. COPD patients showed an odds ratio of 2.681 for ICU admission, mechanical ventilation or death, even after adjustment for age and smoking (Boutin et al., 2021).

**COVID 19: relevance of host genetic factors**

While age and co-morbidities largely determine the clinical course of COVID-19, equally host genetic predisposition for life-threatening COVID-19 is being increasingly recognized in world populations. Identification of such host genetic factors associated with different clinical phenotypes help disentangle elements associated with susceptibility, hospitalization, virulence. Clinical outcomes of COVID-19 have been shown to be associated with interindividual, as well as interpopulation, differences. While some African nations and South Asian countries with young populations report low incidence and mortality, genetic predisposition may limit viral infection and modulate COVID-19 immunopathogenesis (Boutin et al., 2021).

For instance, irrespective of age, sex and co-morbidities, individuals with African descent in the UK and United States are associated with susceptibility, hospitalization and mortality (Ajilore & Thames, 2020). Similar observations have been reported in non-Hispanic black, Hispanic, and non-Hispanic American Indian or Alaskan Native populations and among few Asian population with hospitalization and mortality. Both monogenic and polygenic risk variants can predispose to

disease progression. In COVID-19, it is polygenic risk variants, as multiple loci are thought to influence the clinical phenotype. Various genome wide association studies (GWAS) and candidate gene studies have investigated the association of inter- and intra-ethnic genetic variations with COVID-19 clinical phenotypes. Among the well- studied loci of interest are blood group ABO, genes that facilitate SARS-CoV-2 entry into epithelial cells, and genes that modulate innate and adaptive immune responses. In particular, the SNP rs11385942 on chromosome 3, located at 3p21.31 and surrounding the genes SLC6A20, LZTFL1, CCR9, FYCO1, CXCR6, and XCR1, was identified as a risk variant in three independent GWASs. Although there is supporting evidence showing a significant association of SLC6A20, CCR9, CXCR6, and FYCO1 with COVID-19 susceptibility, it is yet unclear on the functional role of these studied variants. In another GWAS study from the UK, the rs13050728 variant of interferon-alpha/beta receptor subunit 2 (IFNAR2), which binds to type 1 interferons and is known to modulate signal transduction, is associated with critical clinical outcome, alongside the rs11085727 variant in tyrosine kinase 2 (TYK2), which is implemental in cytokine signalling and interferon responses (Boutin et al., 2021).

SARS-CoV-2 infects lung alveolar epithelial cells using the primary entry receptor angiotensin-converting enzyme II (ACE2). High ACE2 expression in people with co-morbidities are associated with severe COVID-19. It is not apparent whether high ACE2 expression is a risk for severe disease, as other entry receptors are increasingly recognized. Elevated angiotensin II levels have been shown to have pro-inflammatory and prothrombotic properties, resulting in poor clinical outcomes (Boutin et al., 2021).

### 1.2.3. Diagnosis of COVID-19:

Early diagnosis helps to reduce COVID-19 spread (Hu et al., 2021). Several COVID-19 detection methods have been developed. The two main SARS- CoV-2 diagnostic tests are for viral nucleic acid and for antibodies. COVID-19 detection and immunological response relies on test timing relative to the period of exposure or infection.

COVID-19 is diagnosed by detecting RNA of SARS-CoV-2 using PCR assays, often on nasopharyngeal swabs (Fang et al., 2020). These technologies are based on the amplification and detection of different regions of the SARS-CoV-2 genome (e.g., nucleocapsid gene, envelope gene, spike gene, open reading frame, RNA- dependent RNA polymerase gene) (Udugama et al., 2020). Many researchers claim that 20.0% - >50.0% of people with positive tests may be asymptomatic (Ma et al., 2021; Ra et al., 2021). However, some of these individuals will subsequently develop symptoms because they were tested during the incubation period prior to the onset of symptoms.

According to the most recent epidemiological data, as the illness spread globally, several genetic variations of SARS-CoV-2 appeared quickly, with the World Health Organization (WHO) naming 11 of them. Among these, seven SARS-CoV-2 subtypes have received the most attention. Alpha (B.1.1.7), Beta (B.1.351), Gamma (P.1), Delta (B.1.617.2), and Omicron (B.1.617.2) are now designated as variations of concern (VOC) (B.1.1.529). Lambda (C.37) and Mu are variations of interest (VOI) (B.1.621) (Saberiyan et al., 2022).

**The Alpha variant**

B.1.1.7 variant was renamed as Alpha variant on 18 December 2020. The Alpha variant was found in the earliest documented sample that was found in the United Kingdom in September 2020. It is also noted as lineage B.1.1.7. It is defined by 17 mutations, where 14 mutations are because of the change in amino acids. Three others are deletions of 8 mutations in the spike protein gene that help the virus for viral access to the human cell. Viral functions are potentially affected by at least 3 mutations. The Alpha variant is associated with increased severity of infection regarding hospitalizations and fatality rates, shows no effect on susceptibility when treating with emergency use authorization (EUA) monoclonal antibody, increased transmission (Islam et al., 2022).

The most common symptoms in infected people by this variant were chills, loss of appetite, headache and muscle aches. According to a survey, sore throat, fever, myalgia, fatigue, cough, found common symptoms of B.1.1.7 infection. However, loss of smell or taste was reported as a less common symptom; and a higher prevalence of having at least one of the symptoms (Islam et al., 2022).

**The Beta variant**

The WHO renamed B.1.351 or 20H/501Y.V2 as a Beta variant on 18 December 2020. It was first reported in South Africa. The earliest documented sample was found in May 2020 in South Africa. The WHO enlisted the Beta variant as a variant of concern. There are 3 mutations on the surface named spike region: K417N, E484K, and N501Y. And there are also 5 spike mutations on the surface of the virus that are a matter of less concern. Compared to a preexisting variant, this variant has a faster spreading quality and causes severe illness in young people more frequently (Tegally

et al., 2020). The main characteristics of this variant are increased transmission than the previous variant, to the combination of bamlanivimab and etesevimab.

**The Gamma variant**

The Gamma variant was designated on 11 January 2021 by WHO. The earliest documented sample was found in November 2020 in Brazil. It is also known as lineage P.1. This variant has 17 amino acid substitutions, in which 10 are present on the surface as spike protein. All of them, are of particular concern: N501Y, E484K, and K417T. Also, 2 mutations are found: one in its ORF8 region and one in its N region. In 2020, a study among 180 samples identified the lineage P.2 of this virus, where the samples are taken from Rio de Janeiro. By genome sequencing, this P.2 was first identified in October 2020 but appeared in early July 2020 (Voloch et al., 2021). The P.2 case can be asymptomatic in some cases. It has been found higher than expected reinfections with Gamma variant among the Brazilian (Taylor, 2021). This variant involves household transmissions and can be traveled in a community without travel history. This variant shows good sensitivity when treated with some EUA monoclonal antibodies.

**The Delta variant**

The WHO considers the Delta variant as a VOC. The Delta variant was designated on 4 April 2021, as a VOI and designated on 11 May 2011, as a VOC by the WHO. The earliest documented sample was found in October 2020 in India. It is also recognized as lineage B.1.617.2. In India, it was first acknowledged during an aggressive wave of COVID-19 there in April and May 2021. It is rising so fast than the other variants (Islam et al., 2022).

This variant is 60% more transmissible than the Alpha variant that is already known as highly infectious. It can be said that this variant is somewhat resistant to vaccines; more especially in those subjects who have received just a first dose of vaccine. A first vaccine dose of either AstraZeneca's or BioNTech's vaccine can reduce the risk by 33% for the Delta variant and 50% for the Alpha variant. This Delta variant showed less sensitivity toward neutralizing antibodies inside the body (Planas et al., 2021).

**The Lambda variant**

The Lambda variant was designated on 14 June 2021, by WHO. The WHO considers it to be a VOI that experts suspect it could be more dangerous than the original strain. The earliest documented sample of the Lambda variant was found in December 2020 in Peru. It is also known as lineage C (Kannan et al., 2021). is spreading so fast in South America. mutation of the Lambda variant resembles those found in several other highly contagious or worrisome variants, which means that it is worth studying. The variant contains 8 mutations, where 7 mutations in the gene for the spike protein and are found on the surface of the virus. These mutations may help the variant to be more infectious or to destroy the immune system of the human body (Padilla-Rojas et al., 2021).

**The Omicron variant**

The newly discovered variant "Omicron" of SARS-CoV-2 has heavily mutated to its spike protein, the target of vaccines. The Omicron has raised concerns regarding the transmission of coronavirus, immune system evasion, and vaccine resistance. Many countries have already confirmed the first case of the Omicron variant and the symptoms are mid so far. Several countries have imposed

travel restrictions on South African countries to curb the international spread of the Omicron variant (Saxena et al., 2022).

**Other VOIs**

The WHO designated several variants of SARS-CoV-2 as VOIs including Eta, Lota, and Kappa strains. The first cases of these mutants were found in multiple countries between the last 2 months of 2020. Later WHO designated these variants as VOIs when their transmissibility, disease severity, immune escape, diagnostic or therapeutic escapes, and their epidemiological impacts meet the criteria although these variants are not significantly as severe and fatal than VOCs (Parums, 2021).

Testing accuracy depends on specimen collection, the timing of testing relative to exposure, viral load, and the assay parameters (Wiersinga et al., 2020). Pharyngeal swabs and anterior nares samples are less sensitive than nasopharyngeal swabs. Quick and cheap lateral-flow techniques that detect viral antigens in saliva are less sensitive than nasal swabs but may identify transmissible viruses. Daily saliva testing may increase detection and reduce transmission (De Marinis et al., 2021). In general, techniques target coronavirus immunogenic proteins (namely, Spike (S), Envelope (€), Matrix (M) and Nucleocapsid (N)) and receptor binding domain (RBD) to detect SARS-CoV-2 antibodies (McIntosh etal., 2020; Shoaib et al. 2021). SARS-CoV-2 specific IgG antibodies have been identified after four days of illness, peaking after 2 two weeks.

Laboratory tests are often used to diagnose COVID-19, particularly in hospitalized patients. Multiple anomalies are common in positive individuals and may help measure a patient's improvement or decline. Typical abnormal outcomes include elevated serum C- reactive protein, lactate dehydrogenase, ferritin, procalcitonin, and creatine kinase, and up to 50.0% of hospitalized

patients have abnormal liver enzymes (Akinci, 2022). Lymphocytopenia increases the likelihood of intensive care and acute renal failure. However, many laboratory results are nonspecific and prevalent in pneumonia; thus, their clinical relevance is questionable.

### 1.2.4. Clinical manifestations of COVID- 19

COVID-19 patients can experience a wide range of symptoms affecting various bodily systems, including neurological and gastrointestinal systems. Neurological symptoms include fever, headache, muscle soreness, fatigue, dizziness, ageusia, anosmia, and others. Additionally, gastrointestinal symptoms were prevalent, like diarrhea, vomiting, nausea, anorexia, abdominal pain, constipation, and others were also commonly reported (Luo et al., 2022). Asymptomatic carriers who may transmit the disease generally develop symptoms later (Buitrago-Garcia et al., 2020), although 30-40% of infected individuals may stay asymptomatic (Oran & Topol, 2021). However, people with mild symptoms may develop severe coughing, hypoxia, and Acute Respiratory Distress Syndrome (Berlin et al., 2020). Extrapulmonary symptoms impact most organs (Gupta et al., 2020). Cardiac complications involve thrombosis, myocardial infarction, myocarditis (in around 2% of healthy young people), and arrhythmias. Neurological findings such as myoclonus, seizures, delirium, and encephalitis may appear (Puntmann et al., 2020). Taste and smell loss are neurologically mediated, indicating brain involvement. Around 25% of inpatients have diarrhea (Ng & Tilg, 2020). Approximately one-third of mechanically ventilated patients also need renal dialysis (Casas et al., 2020). Skin lesions include pseudo-chilblains, maculopapular eruptions, urticarial lesions, and blisters. Age (>65 years), chronic respiratory disorders, cardiovascular diseases, hypertension, DM, and obesity have been identified as risk factors associated with the complications of COVID-19 (Fu et al., 2020).

The Chinese Centre for Disease Control and Prevention (CDC) classified COVID-19 severity and reported about 70.0 - 80.0% of people with mild, while 20.0 -30.0% have severe or critical disease **(Table 1.1)**:

**Table 1.1.** Classification of COVID-19 severity (Zayed et al., 2021).

| Mild | Severe | Critical |
|---|---|---|
| • Fever<br>• Respiratory symptoms<br>• Pneumonia on CT | Meets one of the following criteria:<br>• Respiratory distress, RR ≥ 30/min<br>• Resting blood oxygen saturation ≤ 93%<br>• Arterial blood oxygen partial pressure (PaO2)/FiO2 ≤ 300 mmHg | Meets one of the following criteria:<br>• Respiratory failure needing mechanical ventilation<br>• Shock<br>• Development of other organ failures, requiring ICU care (Wu & McGoogan, 2020). |

### 1.2.5. Co-morbidities and COVID-19

Risk factors for life-threatening and severe cases of COVID-19 include age over 65 years and comorbidities, demonstrated for DM, hypertension, obesity, chronic kidney or obstructive pulmonary disease, asthma, immunocompromised conditions, pregnancy, heart failure, and cancer (Zhou et al., 2020; Bajgain et al., 2021). A Chinese meta-analysis by Li et al. (2020) including 1,527 infected people found that hypertension [OR (95% CI): 17.1% (9.9 – 24.4%)], cerebrovascular disorders [OR (95% CI): 16.4% (6.6–26.1)], and DM [OR (95% CI): 9.7% (6.9 – 12.5%)] were the most common comorbidities associated with COVID-19. People with hypertension or DM had double the risk of infection or Intensive Care Unit (ICU) admission with COVID-19; people with cerebrovascular diseases showed triple the disease severity (Li et al., 2020). DM is also associated with several complications that impact the severity of COVID-19 disease (Mcdonald et al., 2014). Pneumonia and influenza are common in older people with T2DM, and high blood glucose and DM have crucial roles in mortality and infection severity in patients infected with viruses such as MERS-CoV, H1N1 (influenza A), and SARS (Schoen et al.,

2019). Elderly people with T2DM are more vulnerable to COVID-19-related mortality, and COVID- 19 infection in people with diabetes has been correlated with elevated CRP levels and advancing age. COVID-19 in people with diabetes has induced excessive stress and increased hyperglycaemia-related hormone release, including catecholamines and glucocorticoids (Zahedi et al., 2023). These hormones cause irregular fluctuations in blood glucose and raise blood glucose levels (Wang et al., 2020; Gerganova et al., 2022)

### 1.2.6. Post-COVID-19 syndrome

Post-COVID-19 syndrome, sometimes also referred to as 'long-COVID', is defined as the persistence of symptoms after viral clearance and the emergence of new symptoms after a few months following recovery from COVID-19 (Shah et al., 2022). Post-COVID-19 syndrome is not a single clinical entity but a conglomeration of symptoms and signs due to multiple biological factors, and more research is needed. One study suggests mast cell activation in the development of chronic symptoms (Afrin et al., 2020). Commonly understood factors include organ damage, persistently dysregulated inflammatory and immune responses, and un-recognized microvascular thrombosis and endotheliitis (Østergaard, 2021).

Various investigations have identified a variety of post-COVID-19 symptoms (Augustin et al., 2021; Mahmud et al., 2021). Their prevalence is more common among those who developed severe disease requiring hospital admission. Even with moderate disease, post-COVID-19 symptoms may occur (Carfì et al., 2020). The most prevalent symptoms described in most studies were fatigue, cough, respiratory discomfort and headache (del Rio et al., 2020; Greenhalgh et al., 2020).

Recently, the University of Cincinnati Medical Centre recommended criteria for COVID-19 sequelae, dividing long COVID-19 syndrome into five categories based on the initial symptoms,

onset time, length of symptoms and period of quiescence (Becker, 2021). Other studies have described long-COVID prevalence and characteristics. For example, in Germany a prospective study of 958 SARS-CoV-2-convalescent patients found 27.8% (123/442) had health consequences after four months, defined by at least one symptom (anosmia, ageusia, fatigue, or shortness of breath) (Augustin et al., 2021). A prospective study in France by Carvalho-Schneider and his colleagues followed 150 people with mild and moderate COVID-19 severity for two months and found continuing dyspnoea and asthenia in 30% and 40% of patients, respectively (Carvalho-schneider et al., 2020). Symptoms were not just reported from Western countries; in Egypt, about 38.8% of post-COVID-19 patients still had mild COVID-19 symptoms after one-and-a-half-months of follow-up beyond recovery (Gamal et al., 2022). In Nepal, after four months 39.3% (of 300) patients in a tertiary hospital had post-COVID-19 symptoms, with fatigue, persistent cough, exertional dyspnoea, and body discomfort or vertigo affecting 28.3%, 2%, 6.7%, and 17.7% of cases, respectively (Shah et al., 2022). In Bangladesh, the incidence of post-COVID-19 syndrome was 46%, with post-viral fatigue being the most common symptom in 70% of cases. Female sex, respiratory distress, lethargy and long disease duration were identified as risk factors for developing post-COVID-19 syndrome (Mahmud et al., 2021). The long-term effects of COVID-19 should not be ignored because they may lead to increased morbidity, increased financial resource consumption and health system burden as affected patients require long-term follow-up even after recovery for observation and management of their post-COVID ailments.

A recent multicentre study revealed that paranoia in post-COVID-19 syndrome was observed more often in people with T2DM than in those without DM (4.0% vs. 1.2%; $p = 0.009$). Long-term mortality was higher in people with rather than without T2DM (33.9% vs. 29.1%; $p = 0.005$) (Abumayyaleh et al., 2023).

### 1.2.7. Epidemiology of SARS-CoV-2 infection and COVID-19 disease

This section aims to provide a timely report on the global distribution of disease and emerging epidemiologic trends of the COVID-19 outbreak. The reportage of cases reveals COVID-19's rapid development from emergence to pandemic status. On 31 December 2019, Wuhan Municipal Health Commission reported several unidentified pneumonia cases connected to Huanan Seafood Wholesale Market; 27 patients were hospitalized, seven in a critical condition (Deng et al., 2020). By 5 February 2020, 59 cases of viral pneumonia with unknown aetiology were detected in Wuhan, including seven severe cases, and "human-to-human" and nosocomial transmission of infection was verified on 20 February 2020 (Chan et al., 2020). By early June 2021, more than 170 million cases of SARS-CoV2 were confirmed worldwide, with about 3.7 million deaths. On 12 November 2021 the WHO declared that COVID-19 had infected more than 251 million individuals and caused the deaths of five million people worldwide (WHO, 2021a). Six weeks later, on 26 December 2021, figures had risen to over 278 million cases and just under 5.4 million deaths globally (see Appendix 1.1).

Within each country and community, the reported incidence and mortality from COVID- 19 has depended on population density, degree of testing, and timing of mitigation strategies such as social distancing. Globally, as of 17 December 2023, there have been over 772 million confirmed cases of COVID-19, including 6,988,679 deaths (WHO, 2023)**.** Most deaths have occurred in the elderly or those with chronic diseases such as DM, hypertension, obesity, chronic kidney disease, cardiovascular disease and cancers (Zhou et al., 2020). This was a specific concern in Middle Eastern areas, where DM prevalence rates are among the highest globally; for example, 22% are affected in Kuwait and 18.3% in Saudi Arabia (Taha, 2022). DM has been reported as responsible for increasing COVID-19-related Acute Respiratory Distress Syndrome mortality (Gupta et al.,

2020), although maintenance of normal blood glucose levels (normoglycaemia) may strengthen the immune system and reduce disease severity (Guan et al., 2020). Impaired glycaemic management might have been anticipated during the pandemic where the lockdowns resulted in enforced inactivity, poor nutrition, and lack of follow up care. Several studies have been conducted on the impact of lockdown measures on people with type 1 diabetes mellitus (T1DM) (Cognigni et al., 2021; Sánchez Conejero et al., 2022; Tornese et al., 2020), yet there is little information about people with T2DM (Önmez et al., 2020).

### 1.2.8. COVID-19 lockdowns

To prevent the spread of COVID-19, governments implemented various lockdown measures as infection control methods (Desvars-Larrive et al., 2020). The lockdown idea was initially applied in Wuhan, China, in January 2020. After the WHO declared COVID-19 a pandemic, most of the world adopted this strategy to restrict virus spread from Asia to Europe and the Americas. Lockdown measures have included voluntary home curfews, travel limitations, and social and public event bans (Ruissen et al., 2021). Other lockdown techniques included official declarations of crises, limiting trips and person-to-person encounters, and avoiding settings with inadequate ventilation (Ruissen et al., 2021). Large-scale events and activities have been cancelled, postponed or scaled down, and elementary, secondary, and high schools closed (Takahara et al., 2022). Government lockdowns have differed in strategy, timing, and length mainly based on countries' mortality rates and have included curfews, limitation of movement of citizens to necessities only, travel limitations, gathering constraints (size limitations or cancellations) and isolation at home (curtailing attendance at work and school) (Usher et al., 2020). Across the world hospitals temporarily locked down, due to lack of personal protective equipment (PPE) and ventilators, and to reduce nosocomial COVID-19 transmission and preserve hospital capacity, (Lee et al., 2021).

Several European countries imposed particularly severe restrictions on people's mobility, including on outdoor physical activities and entry to hospitals and health facilities for regular treatments (Carino et al., 2022). The Italian government imposed a drastic nation-wide lockdown on 10 March when COVID-19 cases exceeded 35,000 and fatalities were above 3000 (Burkle et al., 2021). In Turkey, curfews were applied from 1 December 2020 on weeknights (from 21:00 to 05:00 every day) and weekends (from 21:00 Friday to 05:00 Monday). In contrast, other nations, like Sweden and Japan, encouraged social isolation but did not impose lockdowns.

In the 20 countries and 578 million people of the Middle East and North Africa (MENA) region, governments have restricted individuals' movements to prevent the spread of COVID-19. Many countries closed schools and nurseries and banned large public gatherings, even for religious reasons (Taha, 2022), and some declared a state of national emergency and implemented more drastic containment measures, home-isolation, and curfews. In Jordan, Saudi Arabia and the United Arab Emirates, severe consequences were imposed for non-compliance with the quarantine rules, ranging from fines to imprisonment. They imposed entrance restrictions on foreigners, and flight traffic was halted or drastically restricted, although the borders remained open for the transit of goods and medical equipment. Among Arab countries, the Kingdom of Saudi Arabia had the largest number of confirmed cases, followed by the United Arab Emirates (UAE) and Qatar (Taha, 2022). As of 30 July 2022, the MENA countries had reported 22 649 341 confirmed COVID-19 cases and 345 100 deaths since the start of the pandemic. By 30 July 2022 Jordan had reported the third highest number of deaths, after Iran and Iraq, with around 1,715,296 cases and 14,083 fatalities, according to WHO (2022a) (**Figure 1.2**).

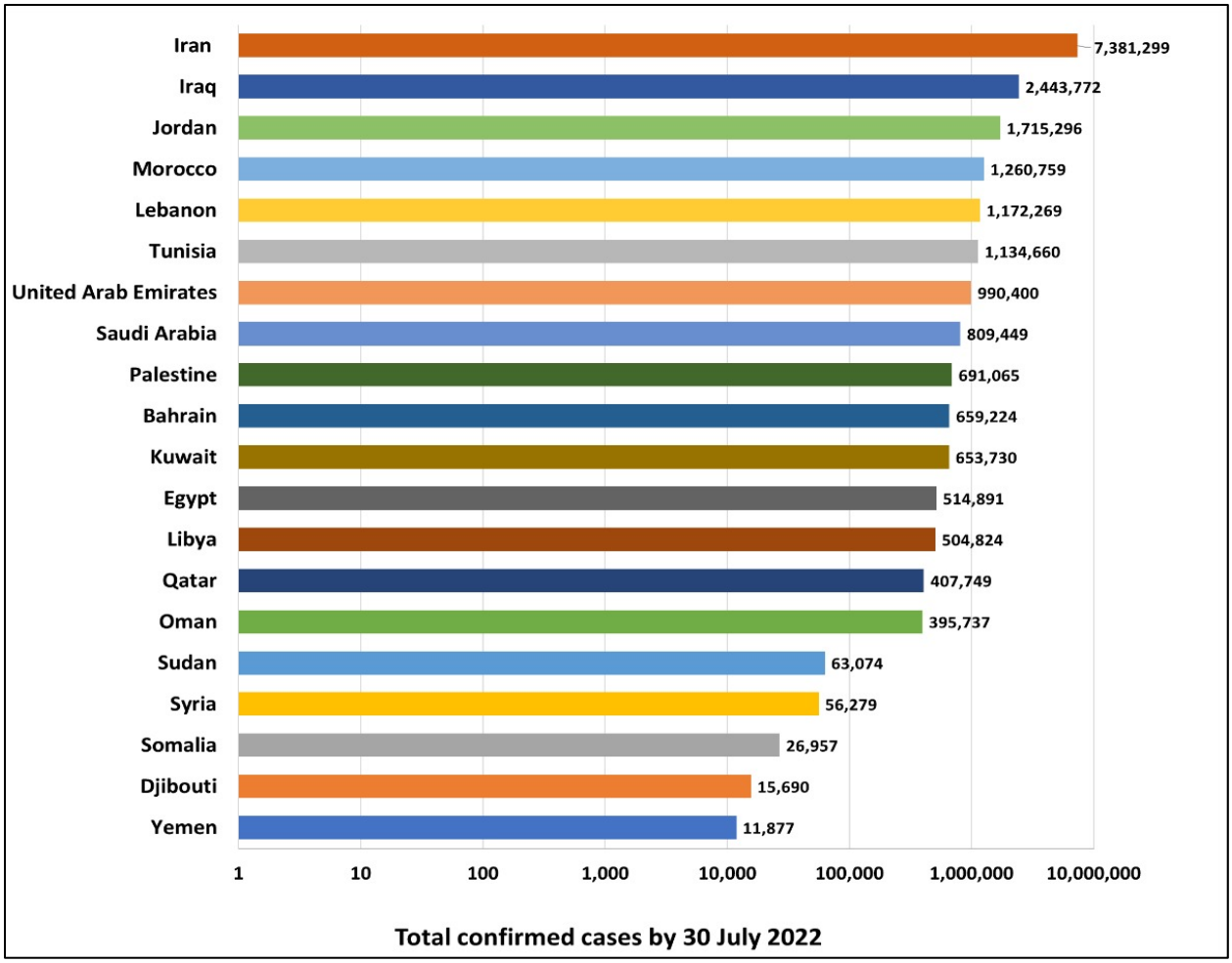


**Figure 1.2** The prevalence of COVID-19 in the MENA region by 30 July 2022 (WHO, 2022a).

Jordan initially banned access to all people from China, South Korea, and Iran (Alqutob et al., 2020). At the Jordanian border and airports, all travellers were rigorously checked, and arrivals were quarantined; all shopping centres and malls were closed. From 16 March to 6 June 2020, the Jordanian government declared a complete quarantine and lockdown, including cessation of public activities, home isolation, suspension of all outpatient clinics, postponement of all elective surgeries, and closure of hospitals for all except emergency cases (Al-Dwairi et al., 2021). By 20 September 2022, Jordan recorded 1,745,032 confirmed cases of COVID-19, with 14,116 deaths since the pandemic began (WHO, 2022a).

The main benefit of a lockdown, when there are no vaccinations or therapies, is the potential of delaying the transmission of infection in a naive population and reducing its mortality (Yang, 2021). Additionally, it provides city or nation authorities time to develop disease-containment policies, particularly if there is no healthcare infrastructure or ability to do surveillance tests (Lytras & Tsiodras, 2021). Other indirect benefits of the worldwide lockdown included a reduction in pollution, an increase in flora and animals, and the rapid development and roll-out of telecommuting and telemedicine (Woc-Colburn & Godinez, 2022).

In contrast, Sweden didn't enforce a mandatory lockdown. Instead, it allowed people a free choice on whether or not to follow the government recommendation to limit contact with others, resulting in a lower reduction of mobility and a substantial increase in mortality. It has been estimated that up to about 4,411 of the 46,554 deaths could have been avoided had Sweden implemented a mandatory lockdown (Ege et al., 2023).

However, the COVID-19 pandemic not only created direct harmful effects but also had a negative impact on individuals with chronic diseases. One of the most significant challenges during this pandemic has been delays in seeking and obtaining follow-up appointments (Wang et al., 2023). According to a cross-sectional survey, a significant number of people (17.1%) delayed seeking medical care during the COVID-19 pandemic. This delay was observed more among individuals with underlying health conditions [AOR (95% CI): 1.62 (1.58, 1.65)], including those with asthma, cancer (past year), chronic heart disease, chronic kidney disease, chronic lung disease, diabetes, and immunosuppressive conditions (Gertz et al., 2022). This is further complicated by differences in the delay of care across different regions, age groups, and demographics.

The lockdown resulting from the COVID-19 pandemic also caused a socio-economic crisis and psychological distress. The quarantine, as well as the constant feed of news about the number of cases and deaths, exposed the general population, and frontline health care workers in particular, to very stressful emotional impacts of COVID-19 (Xiang et al., 2020). Lockdown measures affected the ordinary lives of every person in the world, where daily responsibilities and mundane routines ceased to exist and were sometimes replaced with constraints and boredom. People felt more worried and less in control of their lives due to the pattern shift and isolation (Duan & Zhu, 2020). A great number of psychological disorders, such as acute stress disorders, irritability, insomnia, emotional distress and mood disorders, depression, fear and panic, anxiety and stress, resulted from the isolation and consequent financial concerns, frustrations, uncertainty, boredom, loneliness, lack of resources and ineffective communication that attended the pandemic (Usher et al., 2020). People with pre-existing mental health problems were particularly susceptible (Neelam et al., 2021).

### 1.2.9. Protecting Public Health During Global Health Emergencies

All countries face new challenges due to the mutation of coronavirus but for poor and developing countries, lack of resources present challenges in making proper planning for timely vaccination of whole populations. Public health measures given by WHO to prevent infection and slow transmission require adequately resourced and integrated public health systems for effective delivery. Globally, policymakers should review and revise their structures of public and community health. Countries should make themself ready for further global health crises. No nation was prepared for this deadly situation, but for the future countries must be ready to fight against this kind of emergency. In the meantime, vaccinating populations and maintaining health measures can be the ultimate target world-wide (Islam et al., 2022).

During the pandemic, with vaccination campaigns in COVID-19-affected countries, the emergence of new strains generated global concerns about their potential impact on the severity of disease and antibody sensitivity. Antibody generation is a time-consuming process, meaning that individuals should maintain safety measures even though they have been vaccinated. All the VOC-designated strains are highly transmissible, particularly the Delta and Omicron variants. Gamma and Beta strains escape immunity and generate global public health concerns as they can elevate the rate of mass reinfection. The prevalence of severe disease with Beta, Delta, and Gamma variants was found to be very high although any of the VOC strains have the potential to cause serious disease and, in the worst case, death. COVID-19 affected nations should follow the guidelines provided by WHO. Mass vaccination can be a preventive action and vaccination can help in minimizing severity and transmission. Control of community transmission of viruses and mass vaccination should be carried out at the same time. Systematic guidelines and plans of action are essential, entailing adequate professional workforces and resourcing (Islam et al., 2022). Globally challenging, this is particularly so for developing nations.

### 1.3. Type 2 Diabetes Mellitus (T2DM)

DM is a complex chronic metabolic disorder characterized by chronic hyperglycaemia (ADA, 2022a). Approximately 463 million adults between 20–79 years are diagnosed with diabetes worldwide (IDF, 2019), most of whom live in low and middle-income countries. T2DM is the most common type of DM, accounting for 90–95% of cases. Reported risk factors for T2DM include rising age, body Mass Index (BMI) ≥ 25 kg/m2 and a lack of physical activity. T2DM is caused primarily by a progressive loss of beta-cell insulin secretion due to insulin resistance (IR) (Galicia-Garcia et al., 2020). These alterations result in (1) hyperglycaemia because of impaired peripheral glucose uptake, (2) dyslipidaemia (hypertriglyceridemia and low high-density

lipoprotein [HDL]-cholesterol) because of impaired peripheral fat uptake, (3) impaired amino acid uptake and ATP production into peripheral tissues, like skeletal muscle, because of the impaired nutrient uptake, and (4) elevated glucagon production, which further exacerbates hyperglycaemia and hyperlipidaemia (Okon et al., 2007; Reed et al., 2021). Defects in any of the mechanisms involved in these processes can lead to a metabolic imbalance responsible for the disease development. Therefore, strict lifestyle and dietary adjustments are required, as well as regular self-monitoring of blood glucose levels and compliance to recommended medicines.

### 1.3.1. Pathophysiology of T2DM

Failure of the feedback loops between insulin action and insulin secretion leads to abnormally high glucose levels in the blood (Galicia-Garcia et al., 2020), influenced by genetic and environmental factors (A. Mansour et al., 2023). In the case of β-cell dysfunction, insulin secretion is reduced, reducing the body's ability to maintain physiological glucose levels. On the other hand, IR contributes to increased glucose production in the liver and reduced glucose absorption in the muscle, liver, and adipose tissue. Even if both processes occur early in the pathogenesis and contribute to the development of the disease, β-cell dysfunction is often more severe than IR. However, when both β-cell dysfunction and IR are present, hyperglycaemia worsens, leading to the progression of T2DM (Zheng et al., 2018). Mitochondrial dysfunction, endoplasmic reticulum stress, and inflammation are closely correlated with IR and β-cell dysfunction (Lima et al., 2022).

The key pathophysiological process involved in T2DM is IR, and the understanding of the insulin signalling cascade requires knowledge of normal insulin action. Insulin is an endocrine peptide hormone that binds plasma membrane-bound receptors in target cells to orchestrate an integrated anabolic response to nutrient availability. Under physiological conditions, insulin is secreted by

pancreatic β-cells in response to high blood glucose levels and stimulates glucose uptake and protein synthesis in the muscle. Besides, insulin promotes glucose and amino acid uptake, triglycerides synthesis, and lipolysis inhibition in adipose tissue, increasing glucose utilization and decreasing gluconeogenesis in the liver. In addition, insulin regulates whole-body energy homeostasis and participates in the control of hunger, memory formation and other functions in the brain. On the other hand, when blood glucose levels are low, the glucagon hormone secreted by the pancreatic α-cells stimulates glycogen breakdown (gluconeogenesis) in the liver to release glucose into the circulation (Lima et al., 2022).

Glucose homeostasis occurs in a cascade through the insulin signalling pathway. Initially, insulin binds to insulin receptors in the cell surface and activates its tyrosine-kinase domain, which phosphorylates insulin receptor substrate (IRS) proteins. These proteins serve as an anchoring site for phosphatidylinositol 3-kinases (PI3K) kinase that generates phosphatidylinositol 3,4,5-trisphosphate (PIP3) from phosphatidylinositol 3,4,5-biphosphate (PIP2) and culminates in AKT serine/threonine kinase (AKT) protein activation. PI3K pathway is a critical node in insulin action. Meanwhile, AKT promotes translocation of glucose trans- porter type 4 (GLUT4), facilitating glucose influx into the cell, regulates glycogen storage through inactivation of glycogen synthase kinase-3 (GSK-3), and also controls the transcription of several stress response and antioxidant defence genes through inactivation of fork- head box O (FOXO) proteins. Among its downstream targets, AKT activates mammalian target of rapamycin (mTOR), a protein involved in a myriad of functions, regulating cell growth and proliferation, autophagy, mitochondrial biogenesis, protein synthesis, and others. Besides, mTOR is widely known for its role in aging and age-related diseases, with a major function in the regulation of lifespan in all eukaryotes. Reducing insulin

signalling and mTOR expression has been described as one of the mechanisms by which dietary restriction increases longevity in some organisms (Galicia-Garcia et al., 2020) .

The regulation of insulin signalling is crucial to maintaining metabolic homeostasis. The mechanism of regulation involves the action of antagonists that are normally capable of attenuate the insulin signalling, such as Phosphatase and Tensin Homolog (PTEN) and Src homology 2 (SH2)-containing inositol 5′-phosphatase 2 (SHIP2), which dephosphorylate PIP3 preventing AKT activation; PH Domain Leucine-Rich Repeat Protein Phosphatase (PHLPP) and Protein phosphatase 2A (PP2A) dephosphorylate AKT preventing downstream signalling, while Protein-tyrosine phosphatase 1B (PTP1B) dephosphorylate insulin receptor and IRS proteins. However, high levels of inflammatory cytokines, oxidative stress, mitochondrial dysfunction, ER stress, and hyperinsulinemia can also negatively regulate insulin signalling and trigger insulin resistance.

In this scenario, due to the crucial role of insulin signalling in facilitating glucose entry into cells, the consequence is hyperglycaemia. There is evidence linking oxidative stress and inflammation with impairment in insulin secretion and action. As long as obesity is established and body weight increases with age, the organism suffers a parallel state of chronic inflammation characterized by increased proinflammatory cytokines. In obese individuals, the release of inflammatory cytokines from macrophages and the accumulation of fatty acids, triglycerides and diacylglycerol that activate inflammatory pathways, such as JNK and IKK/NF-κB, impair insulin signalling by reducing IRS protein activation. Additionally, in obese, the high levels of ceramides can disrupt insulin-induced PI3K/AKT pathway by inducing the association of PKCλ/ζ and AKT, therefore impairing AKT activation through PI3K. Alternatively, ceramide can activate PP2A which dephosphorylates AKT (Lima et al., 2022). Oxidative stress is also correlated with high levels of inflammatory cytokines and contributes to reduced activity of IRS proteins. Additionally,

increased ROS can induce GLUT4 degradation, thus reducing glucose uptake. Mitochondrial dysfunction increases ROS production as well, further aggravating the oxidative stress state, which impairs IRS proteins activity. Interestingly, Wang & Wei (2017) demonstrated that dysregulation of intracellular Ca2+ homeostasis could occur as a consequence of mitochondrial dysfunction or compromised function of mitochondria-associated ER membranes, being implicated in insulin sensitivity in T2D patients. Thus, as a whole, insulin signalling can be impaired by several cellular and molecular mechanisms that are mainly mediated by oxidative stress, inflammation, mitochondrial dysfunction, and ER stress. All of them play a crucial role in glucose homeostasis and insulin signalling cascade. Therefore, under the influence of obesity, aging, and several genetic and environmental factors, they constitute the main contributors to the pathophysiology of T2DM (Lima et al., 2022).

Hyperglycaemia is the main metabolic feature of T2DM due to IR and β-cell dysfunction. Among the cellular alterations induced by hyperglycaemia, the overproduction of reactive oxygen species and consequently oxidative stress, accompanied by a reduced antioxidant response and impaired DNA repair pathways, represent essential mechanisms underlying the pathophysiology of T2DM and the development of late complications.

### 1.3.2. Epidemiology of T2DM

The global prevalence of diabetes is estimated to rise to 700 million by 2045 from 463 million in 2019, with an overall prevalence of 9.3%. Additionally, the actual disease burden of T2DM is likely an underrepresentation as it is estimated that 1 in 3 people with diabetes remain undiagnosed, equivalent to 232 million people (IDF, 2019). People with T2DM have a 15% increased risk of all-cause mortality compared with people without diabetes but with cardiovascular disease, the

most significant cause of morbidity and mortality associated with T2DM (Galicia-Garcia et al., 2020).

In 2017, T2DM affected about 462 million people, or 6.3% of the world's population (4.4% of those aged 15–49 years, 15% of those aged 50–69, and 22% of those aged 70 and above), or a prevalence rate of 6,059 cases per 100,000 (M. A. B. Khan et al., 2019). The incidence and prevalence of T2DM continue to increase. By 2035, it is estimated there will be more than 590 million people diagnosed with T2DM (Thompson & Kanamarlapudi, 2013). Generally, the age group with the highest risk of developing T2DM is those aged 40–60 years in developed countries and 60 years and beyond in developing countries (Shaw et al., 2010). The incidence and prevalence of T2DM vary according to geographical region, with more than 80% of people affected living in low-to-middle-income countries, which poses additional challenges to effective treatment. This is thought to be due to developing countries adopting 'western lifestyles' and the subsequent increase in overweight and obesity in their populations (Bhurosy & Jeewon, 2014; Reed et al., 2021). This increase disproportionately impacts low- and middle-income countries and adds a burden of excess morbidity, mortality, and health care costs (Moradi-Lakeh et al., 2017). Specifically, the MENA region had the highest prevalence of DM in 2019 at 12.2% (El-Kebbi et al., 2021) and is forecast to have 96% increase in DM prevalence between 2019 and 2045, second only to the African region with 143% projected rise (Saeedi et al., 2019). The age-adjusted prevalence rates in Saudi Arabia, Kuwait, Qatar, and Jordan were 17.7%, 15.8%, 16.5%, and 11.8%, respectively (IDF, 2017). Furthermore, the actual prevalence will be much higher as 44.7% of people living with T2DM in the MENA region are unaware of their condition.

### 1.3.3. Epidemiology of T2DM in Jordan

Among the countries of the MENA region, Jordan has experienced a rapid spread of T2DM over the past decades (Awad et al., 2020). According to a national population-based epidemiological survey between 1994 and 2017, the prevalence of DM increased from 12.9% in 1994 to 17.4% in 2004, to 20.8% in 2009 and 22.4% in 2017, representing an increase in the crude prevalence of roughly 74.0% between 1994 and 2017 (Ajlouni et al., 2019). The age-adjusted prevalence rate of diabetes showed a similar pattern, increasing from 13.0% in 1994 to 23.7% in 2017. Overall, 13.0% of the total population had diabetes. In Jordan, males showed a much greater increase in the prevalence of diabetes than women (32.4% vs.18.1% in 2017) (Ajlouni et al., 2019). These patients experienced substantial mortality: a retrospective electronic data file study of people with T2DM admitted to a tertiary centre in the north of Jordan between 2014–2018 reported a mortality rate of 10.1% for people with T2DM (Mayyas & Ibrahim, 2021). Key risk factors for mortality associated with T2DM were cardiovascular diseases and chronic kidney disease, indicating that management should focus on optimizing risk factors to prevent diabetes complications and hence deaths (Mayyas & Ibrahim, 2021).

### 1.3.4. Risk Factors associated with T2DM

T2DM is caused by insulin loss and IR (ADA, 2022a). The pathophysiology of T2DM is complicated, as seen by the many risk factors listed in **Table 1.2.** (Zheng et al., 2018). Several studies have focused on examining the pathogenetic role of various T2DM risk factors and identifying susceptible groups for T2DM who can be targeted in clinical practice for prevention interventions and public health initiatives (Zheng et al., 2017; Manios et al., 2018; Weisman et al., 2018).

**Table 1.2** Risk factors implicated in the pathogenesis of T2DM **( Zheng et al., 2017).**

| Risk factors implicated in the pathogenesis of T2DM |
|---|
| ▪ Obesity<br>▪ Other metabolic syndrome components (e.g., hypertriglyceridaemia, low HDL-cholesterol plasma levels, hypertension)<br>▪ Unhealthy eating/dietary habits.<br>▪ Sedentary lifestyle - decreased physical activity<br>▪ Smoking<br>▪ Older age<br>▪ Ethnicity (non-white ethnic background/ancestry)<br>▪ Family history of T2DM<br>▪ Genetic factors<br>▪ Low socioeconomic status, deprivation<br>▪ Stress, anxiety, and depression |

Whilst lifestyle-related risk factors are well-known and established causes, more recently the advancement of genetic research tools has provided support that T2DM may arise from a complex interaction of genetic, lifestyle, and environmental factors (unhealthy diet, lack of exercise, alcohol consumption, smoking, among others) (IDF, 2019). A heritable genetic association has been observed since having one family member with T2DM increases the risk (2.5-fold) of developing T2DM, with the risk being greater as additional family members are affected (Lima et al., 2022).

Additionally, some variants are associated with T2DM complications, such as cardiovascular diseases (SORT1), retinopathy (GJA8 and SLC18A2), neuropathy (NRP2), and nephropathy (UMOD and TENM3) (Vujkovic et al., 2020). Polymorphisms in genes involved in DNA repair mechanisms also contribute to genomic instability and are related to T2DM development. Besides, alterations in the expression levels of mitochondrial genes and genes involved in the insulin

signalling pathway are greater contributors to T2DM development and progression. However, genetic variants seem to explain only a minor percentage of T2DM risk (Lima et al., 2022).

### 1.3.5. Complications of T2DM

The clinical presentations and disease progression seen in people living with T2DM are heterogeneous, which may lead to a delay of diagnosis, multiple pathophysiological abnormalities, and varying susceptibility to complications. Complications from T2DM can be classified as microvascular complications, such as retinopathy, neuropathy and nephropathy, or macrovascular complications, including cardiovascular, cerebrovascular, and peripheral vascular disease (Harding et al., 2019). Although there is a strong inheritance of risk of developing T2DM, less is known about the heritability and genetic component of diabetes complications (Cole & Florez, 2020).

Genome wide association studies (GWAS) have played a major role in identifying susceptibility loci associated with these various categories of diabetes-driven complications. More than 300 genetic loci have been associated with T2DM, which explain >19% of the phenotypic variance in risk for T2DM risk. GWAS studies have identified susceptible loci for diabetic retinopathy *(WDR72, NVL*, and *CCDC146*), diabetic neuropathy (*XIRP2*, and *APOL1*), diabetic nephropathy (*GABRR1*, and *GYPA*), and cardiovascular complications (*PDE4DIP, NAT8, F5, LPA*, and *RPS6KA2*) (A. Mansour et al., 2023). However, a number of the single nucleotide polymorphisms (SNPs) that failed to replicate in multiple populations demonstrate the strong influence of population specificity on genetic variation discrimination and contribution to the phenotype of interest (Wojcik et al., 2019).

**Diabetic Nephropathy**

Diabetic Nephropathy (DN) is the most common cause of end-stage renal disease globally, with 10–20% of people living with diabetes developing this disease. Kidney pathology can result due to nerve and blood vessel damage in this organ caused by the diabetic phenotype. The American Diabetic Association classifies diabetes as having DN when the estimated glomerular filtration rate (GFR) is lowered (eGFR ≤60ml/min/1.73m2) and/or increased albuminuria (≥30mg/g creatinine) is persistent for more than 3 months (Tuttle et al., 2014). The diabetic phenotype also promotes DN by inducing pathology in kidney cells directly involved with glomerular filtration, as, for example, hyperglycemia promotes fibrosis in the kidney via inducing activation of specific intracellular pathways – the mechanisms by which T2DM induces DN are reviewed in detail elsewhere. In addition, urinary tract infections are more common in people with diabetes, which is at least partly thought to be due to increased glucose levels in the urine (Reed et al., 2021).

**Diabetic Retinopathy**

Diabetic Retinopathy (DR) is a most common condition of T2DM characterized by alterations in the vascular permeability in the retina or progressive damage to the retinal lining of the eye due to hyperglycaemia (Ansari et al., 2022). The structural attributes of DR are the formation of new blood vessels on the retina (known as retinal neovascularization), which may swell (macular oedema), bleed (vitreous haemorrhage) or leak, distorting the retina, often yielding severe and permanent loss of vision. Besides the major risk variables like gender, age, diabetes duration, hypertension, and dyslipidaemia, oxidative stress is also considered as a critical player in the development of DR. Due to its rapid glucose absorption and high amount of polyunsaturated fatty acids (PUFAs), the retina is especially more sensitive to oxidative stress. ROS triggers alterations in the retinal vasculature directly or indirectly via some effector molecules. The loss of endothelial

cells and pericytes is caused by the basement membrane thickening caused by the cross-linking of AGEs with collagen. In-vitro study in cultured Muller cells also indicates that accumulation of AGEs in the vitreous favours the progression of DR via inducing the fibroblast growth factor (AI et al., 2013).

The hyperglycaemia and enhanced ROS promote the generation of pro-inflammatory factors like NF-κB, which in response activates the vascular endothelial growth factor (VEGF), VCAM-1 and ICAM-1. Furthermore, upregulation of these proinflammatory cytokines is related to the disruption of the blood-brain barrier (BBB), signifying the earliest visible manifestation of DR, i.e., microaneurysm. In diabetes, high-oxidative stress promotes apoptosis of the retinal cells via impairing the functioning of mitochondria through enhancing matrix metalloproteinases (such as MMP-9 and MMP-2) and inactivating the process of mitophagy by caspases (Frost et al., 2014).

**Diabetic Neuropathy**

Diabetic Neuropathy is the most prevalent form of diabetic complications, caused by the destruction to the autonomous and the peripheral nervous systems (Feldman et al., 2019). There can be different forms of diabetic neuropathy such as small-fibre predominant neuropathy, distal symmetric polyneuropathy (DSPN) and treatment-induced neuropathy; DSPN is the most prevalent form. The lower extremities are commonly affected; the patient may feel numbness, pricking or burning pain and sensory loss, thereby increasing the vulnerability towards infections, feet ulcers and consequently, limb loss. Majorly, it is a progressive complication that begins early and goes on asymptomatically, ultimately leading to late-stage DSPN with a high mortality rate (Tesfaye & Selvarajah, 2012).

**Diabetic cardiomyopathy**

Diabetic patients are more likely to develop cardiomyopathy at later stages (Boudina & Abel, 2010). The structural and functional alterations in the myocardium or heart (independent of other cardiac risk factors such as hypertension, coronary heart disease or valvular disease) as a result of diabetes is termed Diabetic Cardiomyopathy (DCM). The characteristics of DCM include systolic and diastolic dysfunction, fibrosis, and left ventricular (LV) hypertrophy. The pathophysiology of DCM seems very complex; however, some of the factors of T2DM, like hyperglycaemia, hyperlipidaemia and IR, also act as major elements in its pathogenesis. Hyperglycaemia promotes the generation of ROS via the activation of classical oxidative stress pathways (see section hyperglycaemia and ROS), resulting in cardiac injury. The protein oxidation caused due to ROS can result in the constitution of thin and thick filaments associated with impaired contractibility, furthermore, ROS-induced modification of protein titin is related to the stiffness of cardiac muscles. ROS is also involved in the activation of MAPK and MMPs, contributing to hypertrophic responses. Moreover, it is also involved in the initiation of cardiac hypertrophy in diabetes and subsequently its progression to heart failure by activating the angiotensin-II (Bhatti et al., 2022).

### 1.3.6. Management of T2DM

The cornerstone of therapy in T2DM is diet and exercise (Eckstein et al., 2019). Diets low in saturated fat and carbohydrates and high in dietary fibre and monounsaturated fats are recommended (Eckstein et al., 2019). Aerobic exercise for 90 to 150 minutes per week is also beneficial (Eckstein et al., 2019). However, while diet and physical exercise are the first line of treatment for T2DM, many drugs have efficacy in controlling blood sugar if lifestyle modification fails. Metformin is commonly the first-line therapy, with other classes of medications including oral sulfonylureas, dipeptidyl peptidase-4 (DPP-4) inhibitors, glucagon-like peptide-1 (GLP-I)

receptor agonists, sodium-glucose co-transporter-2 (SGLT2) inhibitors, alpha-glucosidase inhibitors, and insulin. Furthermore, it is essential to note that psychological well-being (PWB) has been linked to better glucose control and lower mortality rates in people with T2DM (Massey et al., 2019).

**Lifestyle**

Lifestyle modifications have always been considered the cornerstone of T2DM management and the first step before advancing to pharmacological intervention (Mahgoub et al., 2023). These can be defined as the alteration of eating habits and physical activity on a long-term basis in order to reverse obesity, prevent the occurrence of T2DM and manage T2DM and other cardiovascular diseases. The effects of lifestyle modifications in reducing the incidence of T2DM and/or improving glycaemic management are well-documented. A study conducted on individuals with pre-diabetes showed a 20% reduction in the incidence of T2DM after adopting a healthy lifestyle compared to those with an unhealthy diet and sedentary lifestyle (Tuso, 2014). Another study showed that combining a healthy diet and regular exercise resulted in a 34–69% reduction in T2DM over a period of 6 years (Brunetti & Kalabalik, 2012). In addition, a systematic review and meta-analysis showed that lifestyle modification approach for more than 6 months can be effective in reducing the incidence of T2DM and reducing the incidence of diabetes by 25% compared to metformin (Mousavi et al., 2023).

**Diet**

One of the most challenging elements in the management of T2DM is diet and nutrition. Meal tolerance tests have proven that blood glucose and serum insulin concentrations largely depend on carbohydrate intake, while dietary protein and fat intakes have little effect on these concentrations. Thus, controlling carbohydrate intake has been one of the most important factors for monitoring

postprandial hyperglycaemia (Davies et al., 2022). Several studies of people with T2DM showed that a moderate low-carbohydrate diet over 6 months led to significant reductions in HbA1c levels. However, there is no consensus on the ideal nutritional strategy and percentages of calories, carbohydrates, proteins, and fats for people with T2DM. Therefore, the type of strategy and distribution of macronutrients should be based on an individualized assessment of current eating patterns, preferences, and metabolic goals. However, several references show that Mediterranean diet may bring greater benefits in the long term, with the following recommended dietary prescription: 40–50% carbohydrates; 15–25% proteins; 25–35% fats (<7% saturated, 10% polyunsaturated, and 10% monounsaturated); at least 14 g of fiber for every 1000 kcal consumed; and <2300 mg sodium (Minari et al., 2023).

**Physical Activity**

Physical activity is another essential lifestyle modification that the community in general and diabetic individuals in particular are advised to adopt. Several types of training are known, including resistance training, aerobic training and high-intensity interval training. While each type of exercise can produce different beneficial outcomes in improving glucose levels and enhancing insulin activity and weight reduction, studies are inconclusive as to the ideal type of exercise for improving metabolic abnormalities (Silva et al., 2024).

Diet and exercise improved fasting plasma glucose levels in both obese and non-obese individuals. Indeed, it has been reported that physical exercise activates adenosine-monophosphate-activated protein kinase (AMPK), which plays a role in enhancing glucose uptake in the muscle by stimulating GLUT4 translocation. AMPK also regulates mTOR activities by inhibiting the mammalian/mechanistic target of rapamycin (mTOR). In skeletal muscle, mTOR over-activation

can generate insulin resistance through the degradation of IRS-1 via S6K1, leading to a reduced glucose uptake (O'Neill, 2013).

High-intensity interval training, which consists of four to six repeated intervals of maximal activity interspersed with short periods of rest, recently arose as one of the most practiced exercising modalities (Kirwan et al., 2017). This type of physical activity was found to enhance muscle glycaemic management, oxidative capacity and insulin sensitivity in people with diabetes. In addition, when comparing the effects of aerobic training to high-intensity interval training, the latter produced a more significant improvement in glucose regulation, insulin resistance and weight reduction (Jelleyman et al., 2015)

**Sleep**

Healthy sleep is considered a key lifestyle component in the management of type 2 diabetes, with clinical practice guidelines promoting the importance of sleep hygiene. Sleep disorders are common in T2DM, cause disturbances in the quantity, quality, and timing of sleep and are associated with an increased risk of obesity and impairments in daytime functioning and glucose metabolism (Smyth et al., 2020). Additionally, obstructive sleep apnoea affects over half of people with T2DM, and its severity is associated with blood glucose levels (Fallahi et al., 2019). The quantity of sleep is known to be associated (in a U-shaped manner) with health outcomes (e.g., obesity and $HbA_{1c}$), with both long (>8 h) and short (<6 h) sleep durations having negative impacts. By extending the sleep duration of short sleepers, it is possible to improve insulin sensitivity and reduce energy intake (Sondrup et al., 2022).

**Smoking**

Smoking cessation is an important aspect of diabetes management. Smoking worsens the cardiometabolic parameters of individuals with T2DM, increasing the risk of diabetes-related

complications, such as coronary heart disease, stroke, heart failure, peripheral arterial disease, and even death. Conversely, smoking cessation is associated with better cardiometabolic values and reduced risks of cardiovascular morbidity and mortality (Grech et al., 2024). A retrospective study found that people with diabetes who joined a smoking cessation program showed significant decreases in fasting plasma glucose, HbA1c, blood pressure, and total cholesterol. This indicates that participating in the program led to improvements in glycaemic management and cardiometabolic risk factors, independent of the decrease in smoking amount (Chen et al., 2021).

**Pharmacotherapy**

Several groups of injectable and oral hypoglycaemic agents have been identified for the management of T2DM. Each group has several molecules that share a specific mechanism of action but differ in their pharmacokinetic properties, including the duration of action, excretion, and metabolism (Mahgoub et al., 2023).

Insulin is the mainstay treatment for T1DM and many individuals with T2DM. Although it is rarely used in newly diagnosed people with diabetes, there are several instances in which the use of insulin is considered, such as severe hyperglycaemia, gestational diabetes, the presence of significant weight loss, and ketonuria (Boyle et al., 2018).

The HbA1c target is the main goal for the addition of a new drug to the first line of treatment, which is usually metformin and basal insulin. Moreover, other factors are also considered when selecting an additional anti-diabetic agent, such as the duration of the illness, risk of hypoglycaemia, cardiovascular disease, and life expectancy. The goal of adding insulin to the treatment regimen is to mimic the physiological insulin profile, covering both overnight and postprandial glucose levels. The ADA recommends that long-acting insulin should be incorporated to cover the basal requirement of insulin after the failure of non-insulin agents (ADA, 2022b).

Intensifying basal insulin therapy in people with diabetes may lead to decreased glucose toxicity and improved endogenous insulin release from the pancreas. Consistent with this concept, studies showed that short-term insulin therapy in newly diagnosed people with diabetes significantly improved β-cell function. Although insulin can have a long duration of action, the postprandial increase in glucose is difficult to control. For this reason, bolus insulin injections may be considered by adding meal-time injections of short-acting insulin, a process called insulin intensification (Mahgoub et al., 2023).

Different insulin preparations are classified according to their onset and duration of action, including short-acting, intermediate-acting, and long-acting analogues. Long-acting agents such as glargine and Levemir are mostly administered at bedtime to cover basal insulin requirements and are associated with a lower incidence of hypoglycaemia. Short-acting insulin preparations such as glulisine, apart, and lispro are administered at mealtimes to control postprandial spikes in glucose levels. Insulin regular is another preparation that is used for emergencies (Mahgoub et al., 2023).

Due to the complexity of administration and the frequency of dosing, special training and education are required for patients on insulin therapy. To overcome these difficulties, new insulin preparations, such as inhaled insulin and oral insulin, are being developed (Shahani & Shahani, 2015). In addition, insulin pumps are used in people with high HbA1c levels and a poor compliance history (Mahgoub et al., 2023).

**Oral Hypoglycaemic Agents**

Many drugs have been approved to lower T2DM-associated hyperglycaemia. These agents include, but are not limited to, Metformin, sulfonylureas, thiazolidinediones, GLP-1 agonists,

dipeptidyl peptidase-4 (DPP-4) inhibitors, inhibitors of α-glucosidase, amylin mimetic drugs, bile acid binding resins and sodium–glucose co-transporter (SGLT) inheritors (Mahgoub et al., 2023). Metformin is the most commonly used agent for T2DM and is accepted as a first-line agent. It operates through the activation of AMP-dependent protein kinase (AMPK), which is activated when cellular energy stores are depleted under normal conditions. The activation of AMPK leads to fatty acid oxidation and inhibits gluconeogenesis in the liver. Moreover, metformin can stimulate glucagon-like peptide-1 (GLP-1) secretion, which improves insulin sensitivity by enhancing the expression of insulin receptors and improving tyrosine kinase activity. Furthermore, metformin can also lower plasma lipid levels and reduce the incidence of cardiovascular disease by acting on peroxisome proliferator-activated receptors (PPAR- αs) (LeRoith et al., 2019).

Metformin can be used as a monotherapy and can also be used in combination with other hypoglycaemic agents. Daily dosing varies depending on the formulation (immediate versus extended release), and the length of time on the medication. The side effects caused by metformin mainly involve the gastrointestinal tract, including nausea, vomiting, diarrhea and abdominal discomfort (Marín-Peñalver et al., 2016). Therefore, extended- release forms of metformin were developed to reduce the dosing frequency and eventually reduce these side effects. Moreover, the prolonged use of metformin is associated with folic acid and vitamin B12 deficiencies; as a result, monitoring the levels of both vitamins is needed, especially in the elderly. Metformin should also be administered with caution and in low doses in people with heart failure and renal failure as this category of patients have an increased risk of experiencing lactic acidosis, which is considered the most serious side effect of metformin (Chaudhury et al., 2017).

**Sulfonylureas**

Sulfonylureas (SUs) are classified into first and second-generation agents. Due to their frequent dosing and higher risk of hypoglycaemia, the first-generation drugs tolbutamide and tolzamide are no longer used clinically. The second-generation agents, such as glibenclamide, gliclazide and glimepiride, are still in use, and some are available in extended-release formulations. They exert their effect through the blockade of ATP-sensitive potassium channels found on the pancreatic β-cells, leading to cell depolarization, increasing cellular levels of calcium and enhancing the secretion of insulin, hence the name "insulin secretagogue". In addition, SUs can also reduce the production of fatty acids and decrease insulin clearance. Due to their high efficacy in reducing HbA1c by up to 1–1.5% as and their cost-effectiveness, SUs are considered a second-line therapy and are currently used by 50–80% of diabetic patients worldwide (Patti et al., 2020). However, prolonged use of these agents reduces their effectiveness. This may be due to progressive β-cell failure or an alteration in the drug's metabolism.

The major side effect seen with an SU is a weight gain of 1–3 kg. As a result, metformin is provided to patients on SU to reverse weight gain (Nathan, 2015). Sulfonylurea-induced hypoglycaemia may be caused by decreased renal excretion, hepatic metabolism or displacement from protein-binding sites, which typically occurs in people with renal/hepatic failure or when co-administered with CYP450 enzyme inhibitors such as aspirin and allopurinol (Nathan, 2015).

**Meglitinides**

Meglitinides, including repaglinide and nateglinide, belong to another class of insulin secretagogue agents that exert their action by blocking the ATP-sensitive potassium channels in pancreatic β-cells. Unlike SUs, meglitinides have a rapid onset but a short duration of action. These features

make them suitable for people with inconsistent meal times and those who develop rapid postprandial hyperglycaemia (Guardado-Mendoza et al., 2013).

**Thiazolidinediones**

Two agents from this class are currently used clinically: pioglitazone and rosiglitazone. This pair of agents exerts its hypoglycaemic effect by activating PPARγ receptors. PPARγ receptors are expressed primarily in adipose tissue, with lower expression in skeletal muscle, liver, pancreatic β-cells, the central nervous system (CNS) and vascular endothelial cells. The primary effect of thiazolidinediones (TZDs) is believed to be through the activation of PPARγ receptors in adipose tissue, which promotes the uptake of circulating fatty acids into fat cells, thereby increasing insulin sensitivity (Hurren & Dunham, 2021).

Moreover, activation of this receptor in skeletal muscle and the liver also contribute to TZD action as they increase glucose uptake and reduce glucose production in both organs, respectively. TZD can cause a 0.5–1.4% reduction in HbA1c, and clinical trials showed a 10–15% reduction in plasma triglyceride levels. In fact, this effect on the lipid profile is believed to be mediated through another isoform of PPAR receptors present in the liver, heart and skeletal muscles. Furthermore, TZDs were also found to reduce the levels of inflammatory cytokines, such as tumour necrosis factor alpha, improving the function of pancreatic β-cells and increasing the levels of adiponectin, both of which are believed to contribute to their insulin-sensitizing effects. The common side effects of TZDs include weight gain and oedema. These are believed to occur because of the activation of PPARγ receptors in the CNS, which increases food intake (Mahgoub et al., 2023).

**Glucagon-like Peptide-1 (GLP-1) Agonists**

Glucagon-like peptide-1 (GLP-1) is an incretin secreted from the distal ileum in response to nutrients such as proteins and carbohydrates. Following its release, GLP-1 binds to its receptor,

GLP-1R, which is expressed on the pancreatic β-cells, thereby activating a cascade of intracellular events that increases the release of insulin, inhibits the release of glucagon, reduces food intake by causing satiety, delays food emptying and normalizes both postprandial and fasting insulin secretion (Hinnen, 2017).

People with DM were found to have a significant reduction in the levels of GLP-1, which is believed to occur due to a reduction in the expression of GLP-1 receptors in the pancreas or an enhancement of DPP-4 activity. Due to its potent insulinotropic effects, restoring the activity of GLP-1 arose as a potential target for researchers and pharmaceutical companies. As a result, several GLP-1 agonists have been developed and used clinically in the management of T2DM, including exenatide, liraglutide and dulaglutide. These molecules are administered subcutaneously and have various pharmacokinetic properties accounting for the differences in dosing. The majority of side effects associated with the administration of these compounds involve the GI tract, and this includes diarrhea, nausea and vomiting. In addition, some patients reported abscesses, cellulitis formation and even tissue necrosis at the site of injection. The risk for hypoglycaemia is low unless they are used in combination with insulin or sulfonylureas (Mahgoub et al., 2023).

**Dipeptidyl Peptidase-4 (DPP-4) Inhibitors**

DPP-4 is a serine protease that is expressed on endothelial cells and T-lymphocytes and in a free-circulating form. Its main function is the inactivation of the glucagon-like peptide-1 (GLP-1) and gastric inhibitory peptide (GIP) produced in the intestines. These two hormones are known as incretins, and they play an essential metabolic role in augmenting the secretion of insulin, inhibiting glucagon secretion and reducing the absorption of nutrients. By inhibiting this enzyme, DPP-4 inhibitors are considered oral hypoglycaemic agents that are used widely in the management of T2DM. Several DPP-4 inhibitors are available nowadays, such as sitagliptin,

linagliptin, saxagliptin, vildagliptin and alogliptin. They can be used alone or in combination, and studies have shown a 0.48–0.6% reduction in HbA1c and >95% decrease in the activity of DPP-4 for 12 h. Unlike the previously mentioned antidiabetic agents, DPP-4 inhibitors have no effect on insulin sensitivity or secretion; as a result, weight gain is not an adverse effect of gliptins (Mahgoub et al., 2023).

**α-Glucosidase Inhibitors**

α-glucosidase is an enzyme responsible for the breakdown of oligosaccharides into monosaccharides, and inhibiting it causes a reduction in intestinal glucose absorption by delaying the digestion of carbohydrates. Moreover, these compounds were also reported to augment the release of GLP-1, which also contributes to their HbA1c- lowering activity (0.5–0.8%). The major side effects associated with this class are flatulence, diarrhea and abdominal pain (Mahgoub et al., 2023).

**Bile Acid Binding Resins**

Colesevelam is the only agent in this class of hypoglycaemic agents. Although it does not have a direct effect on insulin secretion and/or sensitivity, the glucose-lowering mechanism of bile acid sequestrants is mostly unknown. It is known, however, that colesevelam can reverse dyslipidaemia, which is recognized as an exacerbating factor in T2DM. In addition, colesevelam alone can produce a 0.5% reduction in HbA1c and a 13–17% reduction in low-density lipoproteins (LDL). A lack of systemic side effects makes this a good adjunct medication for managing T2DM (Ooi & Loke, 2014).

**Sodium–Glucose Co-Transporter (SGLT) Inhibitors**

These molecules exert their action on the renal sodium–glucose co-transporter-2 (SGLT2) molecule, which is responsible for glucose reabsorption in the proximal renal tubules. This novel

agent stimulates glucose excretion and has also been shown to have weight loss effects with minimal hypoglycaemia. In fact, canagliflozin was reported to cause a significant reduction in HbA1c of 0.77–1.03%, and dapagliflozin produced similar results after both short- and long-term treatments. Although SGLT2 is responsible for the reabsorption of 90% of glucose filtered via glomeruli, diabetic people with declining renal function may respond less to SGLT2 inhibitors, making SGLT1 inhibitors a better option for treatment (Xu et al., 2022).

Many people with T2DM have difficulties accessing medications, healthcare, fresh food, and being physically active because of confinement. It is vital that health care workers (predominantly nurses and doctors) be involved in disseminating appropriate and accurate information to facilitate self-care in people with T2DM amid the COVID-19 pandemic. In countries with high prevalence of diabetes, such as India, the COVID-19 pandemic has challenged the physician-centered approach of T2DM care that is primarily based on routine clinic visits (Mukona & Zvinavashe, 2020).

**Management of T2DM in Jordan**

The Jordanian Diabetes Management Practices Study (JDMPS) is a disease registry that focuses on T2DM patients seen by general practitioners, family medicine, internists, diabetologists/endocrinologists who are experienced in diabetes management and insulin therapy (initiation and titration) and working in public institutions in Jordan. Regarding use of anti-diabetic therapies in Jordan, a cross-sectional study showed that over half of all patients with T2DM in public institutions in Jordan are treated with oral glycaemic-lowering drugs (OGLDs), whereas insulin is chronologically and progressively delayed until it becomes the only medication effective to treat these patients. Concomitantly, within the group treated with OGLDs, the percentage of

people with HbA1c below 7.0% decreased in patients with long-standing diabetes (Momani et al., 2020).

In Jordan, there are limited data available on services provided to patients with diabetes and aspects of good quality of care (Al-sahouri et al., 2019). Evaluating the quality of diabetes healthcare services delivered in Jordan is a novel topic that has not been addressed in previous studies. A national study demonstrated that glycaemic management (HbA1c level <7%) was independently and inversely associated with the number of years with diabetes and number of annual visits (Saadeh et al., 2023). Following a specific diet for managing diabetes and medication cessation after feeling better were independently associated with higher odds of on-target glycaemic management (HbA1c level <7%). Many patients in Jordan tend not to visit health facilities unless there is an emergency, their disease is not controlled, or they become ill. However, patients who had been living with diabetes for many years may have developed complications that needed attention, and those diagnosed in more recently had lower levels of awareness about the importance of regular visits. Education is a major contributor to the quality of care provided to patients with diabetes. Hence, many patients with diabetes in Jordan require education about the treatment and management of diabetes, and the complications associated with it, especially those recently diagnosed (Saadeh et al., 2023).

**Psychological -wellbeing and glycaemic management.**

PWB has been widely recognized as a major aspect of health, and evidence has shown that PWB was important for quality of life, better glucose control, lessening burden of disease, improving work productivity, and lower mortality The optimal management of diabetes depends not only on the attempts to mitigate chronic complications and comorbidities, but also on improvement of PWB. PWB consists of positive psychological characteristics, such as autonomy, personal growth,

positive relation with others, self-acceptance, and purpose in life, and can play an important role in health. Impaired PWB can lead to low self-empowerment as an important factor in diabetes management. Generally, substantial numbers of people with T2DM has are reported with clinical depression and distress, which can influence PWB (Theodoropoulou et al., 2020). A previous study on people with T2DM revealed that results of univariate and multivariate analyses showed that the level of adherence to medication had a significant or close-to-significant relationship with PWB score (Mirahmadizadeh et al., 2020). The results of univariate and multivariate analyses also indicated that adherence to diet was significantly associated with PWB score. However, there were no significant differences among PA levels regarding the PWB score. The results showed that glycaemic control was significantly correlated to PWB score (Mirahmadizadeh et al., 2020). Impaired PWB in T2DM might increase community costs and reduce the achievement of optimal diabetes management (Bolge et al., 2016). Thus, it is important for healthcare providers and health policymakers to recognise the factors related to PWB and to prioritise intervention to address this.

### 1.3.7. Role of nursing in patient self-management

Education plays an important role in promoting how people take control of their diabetes and improve their quality of life. Nurses who have correct knowledge about diabetes can contribute significantly to educating diabetic patients with the accurate information they need to manage and care for their condition in healthcare and community settings (De la Fuente Coria et al., 2020)

A diabetes nurse educator plays a crucial role in ensuring people with diabetes achieve competency and are motivated to adhere to self-care long-term (Ahmad et al., 2020). There are three main themes to consider: 1) Effective teaching strategies that emphasize assessing patients' knowledge and education level to provide individualized instructional plans, which need to follow

the latest ministerial guidelines and effective pedagogy; 2) Barriers to providing effective education, including psychological, financial, and lack of familial support, 3) Overcoming barriers through parallel health education and counselling, referring to the medical social worker and other support sources including non-governmental organizations, and inclusion of family members and carers in the plan of care. This study concluded that diabetic nurse educator plays a crucial role to ensure patient with diabetes achieved competency and compliance with long term self-care management. Nurses' need to ensure psychological preparedness and patient literacy assessment when designing individualised health education session. While identifying and addressing key barriers for each patient to ensure effectiveness of management plan and improve quality of life (Ahmad et al., 2020).

Education session based on patients' preferences and individualised teaching plan while maintaining standard content, were found to be more effective. Several teaching strategies and teaching aids were also more helpful in diabetes education such as hands-on demonstration and practical, and provide pictures, leaflets and drawings. Nurses could then help patients visualise, practice and assess competency, particularly on insulin injection, and as a result, increase understanding and ability for self- care and reduce diabetes complications in the long run (Fan & Sidani, 2017).

A recent quasi-experimental study found that nurse-led diabetes self-management education (DSME) significantly improved the self-care knowledge and behaviours of people with T2DM. Implementing DSME in healthcare facilities can improve diabetes self-care management (Tamiru et al., 2023).

Nurse-led Diabetes self-management education (DSME) is a key component of diabetes care (Beck et al., 2018). It offers ways to achieve good glycaemic and metabolic control, which is

essential for preventing long-term complications, especially in low-resource settings where it is known to have positive effects on knowledge of diabetes, glycaemic control, and behavioral outcomes. Nurse-led DSME plays an important role in diabetes treatment because it enhances diabetic self-care knowledge and practice which in turns improves clinical and psychological outcomes and quality of life. In addition to medical care, the American Diabetes Association recommends that all patients with DM receive DSME at diagnosis and as needed thereafter (American Diabetes Association, 2018).

Facilitating appropriate diabetes self-management and improving clinical outcomes, health status, and quality of life are key goals of nurse-led DSME to be measured and monitored as part of routine care. These goals could be achieved by providing patients with DSME from diabetic educators, nurses, physicians, and pharmacists collaboratively, and diabetes self-management support from lay health coaches, navigators, or community health workers when available. To demonstrate the benefits of nurse-led DSME, it is important for DSME providers to track relevant evidence-based DSME outcomes, such as its effect on self-care knowledge and self-care (Beck et al., 2017).

Nurses are more likely to encounter patients with diabetes as the number of associated hospital admissions rises. Further, they are in unique position to improve the outcomes for patients with diabetes due to the length of time they spend with patients. The holistic nature of the nursing profession requires nurses to be informal nutrition advisors and ensure that patients in hospital receive an appropriate diet. They assist patients at mealtimes, during which patients may seek dietary advice. Thus, nurses should be aware of the guidelines for the nutritional management of diabetes. Poor knowledge of health care providers of dietary requirements of patients with diabetes can lead to a poor glycemic control and increase the risk of diabetes-associated complications

(Mogre et al., 2015). Nurses' negative attitudes can affect their practice on nutritional management of diabetes. Other factors include time, nutrition education, organizational support, and resource availability(Hulbert et al., 2021).

A cross-sectional study of nurses in Iran demonstrated a moderate level of knowledge and practice in relation to the nutritional management of diabetes mellitus, although their attitude toward this aspect of patient care was positive (Farzaei et al., 2023). Being a male nurse, having a preference for blended learning, having opportunities to get involved in providing education to diabetes patients during work, hospital where employed, and perceive competency in the nutritional management of diabetes affected nurses' knowledge, attitudes, and practice. Given the growing trend of diabetes worldwide and the role of nutrition in diabetes management, it is necessary to improve the knowledge, attitudes, and practice of nurses about the nutritional management of diabetes. The educational curriculums should be examined for adequate education of nurses about diabetes care (Farzaei et al., 2023).

The demands of COVID-19 led to a high additional burden on hospital care and among physicians in general. COVID-related stress and burn-out were also reported among primary care providers such as general practitioners (GPs) – which was associated with practice and staffing changes and concerns about exposure to COVID-19 (Seda-Gombau et al., 2021). Given the vulnerability of people with type 2 diabetes in the COVID-19 era, the declined delivery of diabetes care might pose specific burdens on healthcare providers. Insight into the impact of COVID-19 on the work-related stress and well-being of primary diabetes healthcare providers is lacking. In response to these risks of disease deterioration, the use of tele-medicine and remote facilities such as telephone consultations and SMS messages increased sharply (Peek et al., 2020). Teleconsultation refers to communication that happens between a physician and a patient or between a physician and a

physician for the purpose of providing diagnostic or therapeutic advice through electronic means. Video consultation is a form of telemedicine with direct interaction between physician and patient, using synchronous video and sound facilities. The use of video consultation rose steeply, although evidence on the clinical advantages of video consulting is mixed. Nevertheless, a study among Norwegian GPs found that compared to face-to-face consultations, video consultations were rated at least equally suitable, or even better – for example, to assess the main reason for contact, follow-up treatment for new health problems and mental problems, such as anxiety, life stress, and depression (Car et al., 2020).

A previous study revealed that less diabetes care was delivered and a negative impact on people with diabetes was observed by healthcare providers. Despite healthcare providers feeling overloaded, mental wellbeing seemed unaffected. Video consultations were seen as potentially useful. Given the ongoing COVID-19 risks, and the desire for proactive management of people with diabetes, these findings urge further exploration of incorporation of video consultation in diabetes care (Van Grondelle et al., 2023).

On the other hand, the COVID-19 pandemic has impacted all sectors, including nursing education. As the crises escalated, many governments closed schools, colleges and universities to ensure the safety of students, teachers and communities. With the onset of the pandemic, globally, face-to-face classes, clinical skills laboratories and the clinical placements of students were either suspended or restricted, particularly in countries that were critically affected by the outbreak, in order to maintain and safeguard the health of students and faculty as a whole (Jackson et al., 2020). The impact of COVID-19 on nursing education across the world has shown that if adequate measures are put in place by way of disaster preparedness and preplanned mitigation strategies, future crises like COVID-19 will have less impact on nursing education. Therefore, health

policymakers and nursing regulatory bodies in the developing countries should put policies in place that will help in responding, coping and recovering quickly from future occurrences (Agu et al., 2021).

A recent narrative review revealed Nurses closely work with people with diabetes to educate, set self-management goals, and also adopt approaches to assist positive self-management behaviours in the areas of active participation, glucose self-monitoring, medication administration, healthy eating, and physical activity for effective coping and to identify DM complications. Additionally, nursing interventions can result in improved patient outcomes such as QoL, glycaemic control, self-management behaviours, and diabetes knowledge. Therefore, the necessity for continuous nursing interventions in DM management and indicate that more studies are required to establish evidence-based and the most effective interventions (Dailah, 2024).

### 1.4. T2DM and COVID-19

In 2019, DM was the ninth largest cause of mortality, with approximately 1.8 million deaths directly attributed to hyperglycaemia (Corrao et al., 2021; WHO, 2021b). Further, people with diabetes are at increased risk for bacterial, fungal, parasitic, and viral infections. Since 2019 and by January 2021, the COVID- 19 pandemic had already exceeded global DM mortality with over 2 million fatalities, and diabetes was a significant risk factor for death or severe COVID-19 infection (Selvin & Juraschek, 2020).

In people with COVID-19, the prevalence of DM has varied from 5% to 36% (Corrao et al., 2021); the incidence of T2DM in COVID-19-affected people has varied based on age, disease severity, the study population and region, and the testing method (Corrao et al., 2021). T2DM prevalence is around 13.5% (95% CI: 12.4%-14.7%) in residents over 60 years old (Wei et al., 2021). Additionally, COVID-19 is linked to high blood sugar levels, especially in people with T2DM

(Verma et al., 2021). Consequently, T2DM is one of the main comorbidities encountered in COVID-19 patients and an understanding of the relationships between the two disorders is essential to enable the scientific and clinical community to handle the pandemic effectively.

As individuals living with T2DM contract COVID-19, they are at a heightened risk of experiencing COVID-19-related complications, such as requiring ICU admission or dying from the disease. In Greece, among the 354 hospitalized people with T2DM during the third wave of the COVID-19 pandemic, 63 (18.6%) died during hospitalization, and 16.4% required ICU admission (Akinosoglou et al., 2023). Further, diabetes affected 8.2% of 1,590 patients from China with COVID-19, but the incidence of diabetes was elevated to 34.6% in patients who complained of severe COVID-19 symptoms (Guan et al., 2020). Similarly, 35.3% of ICU patients in Wuhan had T2DM (Du et al., 2020). Supporting these findings, a large COVID-19-related whole-population study in England revealed that 23,698 COVID-19 patients died in hospitals through from 1 March to 11 May 2020. A third of these deaths (n7,434; 31·4%) occurred in people with T2DM, and 61.5% were men, with a mean age of 78.6 years (Barron et al., 2020). More recent results showed a T2DM prevalence of 18.3% in English people with severe COVID-19 needing critical care (high dependency unit or ICU) (Dennis et al., 2021). In Italy, 17% of patients admitted to ICUs with severe COVID-19 had T2DM (Grasselli et al., 2020).

On the whole, diabetes has been linked with a significant increase in mortality (OR: 3.62, 95%CI: 2.11–6.2; $p < 0.0001$) and has emerged as an independent predictor after adjusting for age, race/ethnicity, sex, BMI, and hypertension (Crouse et al., 2021). Often accompanying T2DM, obesity increases the incidence of hypoventilation syndrome in ICU patients and may lead to respiratory failure in the presence of Acute Respiratory Distress Syndrome (Simonnet et al., 2020). The mechanisms that likely underlie these effects are poorly known, but mechanical and

inflammatory factors may be involved. According to Crouse et al., (2021), 74% of people with T2DM were obese, which may have increased the risk found in this population. Given the previously described epidemiological link, the presence of both disorders might be considered a "cumulative" risk factor for illness severity.

### 1.4.1. T2DM as a risk factor for worse COVID-19 outcomes

T2DM is related to low-grade chronic inflammation generated by increased visceral fat. This inflammation impacts glucose homeostasis regulation and insulin sensitivity. Chronic hyperglycaemia and inflammation may affect immune function (Iacobellis, 2020). People with DM infected with COVID-19 are more likely to exhibit severe hypercoagulability and uncontrolled inflammatory responses, which may lead to worse results (Guo et al., 2020). A further study showed that 74.46% of people with T2DM had inadequate glycaemic management (Tao et al., 2020), which is similar to the rate of 74.0% reported in people with COVID-19 and pre-existing T2DM (Zhu et al., 2020). In 2019, a study of 1512 people with T2DM in Hunan Province found that the compliance rates for e fasting blood glucose (FBG) values, 2-h postprandial blood glucose (2hPBG), and glycosylated haemoglobin were 25.5%, 22.7% and 19.5%, respectively (Dong et al., 2019).

Recent research with 132 people with T2DM revealed a negative linear association between SaO2 and HbA1c, and a significant linear association between serum ferritin, C-Reactive Protein, Fibrinogen, and Erythrocyte Sedimentation Rate levels and HbA1c, particularly when HbA1c exceeded 7.5% (Wang et al., 2020). Developing evidence suggests that people with diabetes who contract COVID-19 had more severe involvement of the lung compared to people without diabetes, and it was found to be statistically significant ($p = 0.024$) (Bashir et al., 2023). Univariate analysis of 191 COVID-19 patients showed that DM was associated with in-hospital death (OR:

2.85, 95%CI: 1.35-6.05; $p < 0.001$) (Zhou et al., 2020). However, the correlation between DM and death was no longer statistically significant after a multivariate regression analysis revealed an independent and positive association between age, Sequential Organ Failure Assessment score, and D-dimer levels.

In 174 hospitalized COVID-19 patients, compared to people without diabetes, people with DM exhibited no significant differences regarding sex or age, but less fever (59.5% vs. 83.2%), greater nausea and vomiting (16.7% vs. 0%) and increased mortality (16.7% vs. 0%). Neutrophil counts and inflammation-related indicators, such as IL-6, serum ferritin, C-Reactive Protein, Erythrocyte Sedimentation Rate and D-dimer, were greater in individuals with DM compared to those without DM. In addition, the DM group had considerably lower absolute counts of lymphocytes, red blood cells and haemoglobin, and higher levels of enzymes such as Lactate Dehydrogenase (LDH), a-hydroxybutyrate-dehydrogenase, Alanine Transaminase (ALT), and Gamma-glutamyl Transferase (GGT), which indicate damage to the heart, kidney and liver. These findings demonstrate that organ damage was much more severe in the group with rather than without diabetes (Guo et al., 2020). Similarly, individuals with diabetes exhibited more severe pathological alterations on lung C.T imaging, indicating that the people with diabetes had worse pneumonia than people without diabetes (Guo et al., 2020)

### 1.4.2. COVID-19 with T2DM in the Middle East

Countries of the Middle East vary widely in income, healthcare system strength, and population density, with nations ranging from less than 2 million to over 100 million people. In a retrospective study conducted in Kuwait with a total of 417 COVID-19 patients who were admitted to Jaber Al-Ahmad Hospital between 24/2/2020 and 24/5/2020, the mean age of the patients was 54.2 ± 11.09 years, the case fatality rate among them was 14.4%. Males accounted for 90% of all deaths, while

diabetes was diagnosed in 40 % of the deceased (Abdullah et al., 2020). Similarly, Hafidh et al. (2020) found that among the 250 COVID-19 cases presenting to a tertiary care centre in the Emirate of Dubai, UAE, during the months of March to May 2020, 166 (66.4%) had diabetes.

As of 20 September 2022, global statistics showed 609,848,852 confirmed cases of COVID-19, including 6,507,002 deaths according to WHO Coronavirus (COVID-19) Dashboard 2022. Jordan is one of the hardest-hit countries by the pandemic (Kofahi et al., 2022) as of June 3, 2022, placing the country among the top 50 in the world regarding the number of confirmed cases (World Health Organization, 2022).

### 1.4.3. Impact of COVID-19 lockdown on T2DM

Given the global expansion of the COVID-19 outbreak, home isolation was considered an efficient method for containing the virus (Matias et al., 2020); only necessary activities were permitted, and movement was restricted for most people, including individuals with T2DM, to procuring food and medicine, and online activities were encouraged. This limited physical activity, often accompanied by excess caloric intake during the quarantine, made it challenging to maintain a healthy diet, leading to weight gain which could have consequences for glycaemic management and insulin sensitivity (Banerjee et al., 2020; Takahara et al., 2022). Further, most out-patient clinics were closed except for remote and emergency visits, while hospitals handled a substantial influx of COVID-19 patients (Fernández et al., 2020). Hence, many people with diabetes were apprehensive because they could not undertake regular checkups or change their medication (Peric & Stulnig, 2020). In Jeddah, Saudi Arabia, Al Shareef et al. reported reduced levels of compliance with medications, healthy diets, and physical exercise after the COVID-19 lockdown in people living with T2DM (Alshareef et al., 2020). A study in China revealed that 321 patients (27.7 %) selected low-intensity exercises, like walking and housework, so falling short of the recommended

weekly volume and intensity of exercise (Tao et al., 2020). All of these factors could reduce the effectiveness of glycaemic management and may, in turn, lead to acute and chronic complications following the COVID-19 pandemic. The stresses reported to accompany COVID-19 lockdowns may be at least partly responsible for the associated variable glucose control levels.

Lockdown has been linked to a range of diabetes-related adverse effects. For example, it resulted in increased HBA1C in people with T2DM both in India (Khare & Jindal, 2021) and in Turkey (Ojo et al., 2022). The COVID-19 lockdown in Turkey was linked to increased body weight and triglyceride levels in patients living with T2DM (Karatas et al., 2021). According to a review and meta-analysis, COVID-19 lockdown was associated with a substantial increase in glycated haemoglobin, fasting blood sugar, and BMI in people with T2DM in Italy, Morocco and Japan (Ojo et al., 2022). However, the impact of the lockdown on lipid parameters, such as total cholesterol, triglycerides, LDL and HDL cholesterol, has been inconsistent (Ojo et al., 2022). In Italy the COVID 19 lockdown did not appear to negatively affect glycaemic control in people with T2DM, from which it may be assumed that the impact of lifestyle modifications during lockdown was negligible (D'Onofrio et al., 2021; Falcetta et al., 2021). In the Netherlands, for people with relatively well-controlled T1DM and T2DM, while the COVID-19 pandemic and lockdown measures reduced physical exercise and led to weight gain during a short observational period, there was no change in glycaemic management (Ruissen et al., 2021).

On the other hand, the lockdown seemed to benefit some people with T1DM since it was linked to improved glycaemic management in studies from Italy, Spain and the UK, all badly affected countries. This was attributed to lower stress levels away from work environments and better compliance in the young age population, and to better self-care and digital diabetes control related to staying at home (Dalmazi et al., 2020; Fernández et al., 2020; Pla et al., 2020). In contrast,

lockdown could also lead to short-term deterioration of glycaemic indices in people with T2DM (Eberle & Stichling, 2021). The disparity in outcomes between studies may be attributable not just to differing lockdown characteristics but also varying criteria for blood sugar management, variable use of telemedicine during a lockdown and inconsistent uptake of improved technology to enable people with diabetes keep in contact with their physicians (Tao et al., 2020).

In Jordan, the lockdown imposed in early March 2020 was likely to have greatly affected individual lives from physical and psychological well-being standpoints, especially people living with T2DM. Physical activity at the Jordanian population level has been described as predominantly related to going to and from work, visiting relatives and friends, and outdoor physical activities such as football, etc (Madanat & Merrill, 2006). People living with T2DM were stripped of these activities with the curfew forcing them to stay home, work remotely, and only contact relatives and friends through social media. Physical inactivity and boredom also often breed unhealthy eating habits, such as ordering fast food rich in refined carbohydrates and saturated fats (Moynihan et al., 2015). Furthermore, many patients in Jordan depend on governmental health institutions for follow-up and medications, which were restricted during the lockdown to decrease contact between potential cases and healthy populations, and as resources were diverted to combat the pandemic.

Lockdown duration is also an important consideration, directly linked to the deterioration of glycaemic management and diabetes-related comorbidities (Belkhadir, 2020). A study in India showed that glycaemic management worsened in 143 people with T2DM after 3 weeks of lockdown, mainly because of changes in diet and less physical activity occurring during the lockdown (Khare & Jindal, 2021). Another study in Turkey of 101 people with T2DM showed that HbA1C values rose from 7.67 ± 1.76 pre-lockdown to 8.11 ± 2.48 post-lockdown, and fasting

glucose from 157.9 (83-645) mg/dl pre-lockdown to 163.2 (84-550) mg/dl post-lockdown although these increases were not statistically significant ($p = 0.253$ and 0.079, respectively) (Önmez et al., 2020).

A case-controlled study in Turkey found that the prolonged COVID-19 lockdown had a negative impact on metabolic control in T2DM and showed that people with rather than without diabetes experienced a significant increase in HbA1c levels from before to after the sixth month of lockdown ($\Delta$ 0.7 ± 1.4 vs. 0.02 ± 0.2%, $p = 0.002$). Additionally, the duration of diabetes was identified as an independent predictor of the change in HbA1c [OR (95% CI): 1.2 (1.1–1.8), $p = 0.032$] (Karatas et al., 2021). In India, a retrospective study of out people with T2DM aged 30 years or above revealed a significant increase in mean HbA1c levels by 1.1% ($p < 0.000$), FBG by 21.9 mg/dL ($p < 0.001$), and PPBG by 28.0 mg/dL ($p < 0.001$), from pre- to post-lockdown visit suggesting a negative impact of lockdown on glycaemic management in people with diabetes (Kumar & Nachankar, 2022). In China, retrospective study reported that people with HbA1c ≥6.5% were more likely to develop secondary respiratory infections ((25, 89.0)% vs. (33, 67%), $p = 0.032$) and ARDS ((17, 61%) vs. (14, 29%), $p = 0.006$) than people with HbA1c < 6.5%, with increased risk of hospital admission (Liu et al., 2021). Hyperglycaemia is considered an independent factor which increases the risk of death and worsens the prognosis (Liu et al., 2021). Poor glucose control in people living with diabetes could promote glycosylation of ACE 2, the gateway for SARS-CoV-2 in the host (Brufsky, 2020).

In Jordan, people living with T2DM may have experienced deterioration in glycaemic management during lockdown and hence increased risk of diabetes complications, but little data are available on this topic. This is an important gap in knowledge, which will hinder healthcare professionals and policy-makers from establishing evidence-based strategies for better health of

people with T2DM during a time of pandemic. With the SARS-CoV2 pandemic far from over, and future pandemics from other novel viruses likely, this gap needs to be addressed.

### 1.4.4. Pathogenic pathways in people with T2DM and COVID-19

There are a number of factors and processes through which diabetes predisposes to infections in general and may enhance susceptibility, risk and severity of COVID-19 infection. Possible mechanisms that may increase vulnerability include hyperglycaemia, high-affinity cellular binding, more effective virus entry, poor viral clearance, lower T cell function, increased sensitivity to hyper-inflammation, cytokine storm syndrome, and cardiovascular disease (Muniyappa & Gubbi, 2020). Infection with SARS-CoV-2 **(Figure 1.3)** may lead to elevated levels of inflammatory mediators in the blood, such as lipopolysaccharides, inflammatory cytokines and toxic metabolites. Modification (raised or reduced) of natural killer cell activity and IFNγ secretion may enhance the interstitial and/or vascular permeability for pro-inflammatory products. In addition, SARS-CoV-2 infection causes an increase in reactive oxygen species generation. These actions cause lung fibrosis, acute lung injury, and Acute Respiratory Distress Syndrome (Tang et al., 2020). Reactive oxygen species generation and viral activation of the renin-angiotensin-aldosterone system (through increased angiotensin II expression) produce IR, hyperglycaemia, and vascular endothelial destruction, contributing to cardiovascular events, thromboembolism, and disseminated intravascular coagulation. Also, infection increases blood viscosity, vascular endothelial damage, thromboembolism, and disseminated intravascular coagulation via increasing fibrinogen and D- dimer levels (Lim et al., 2020).

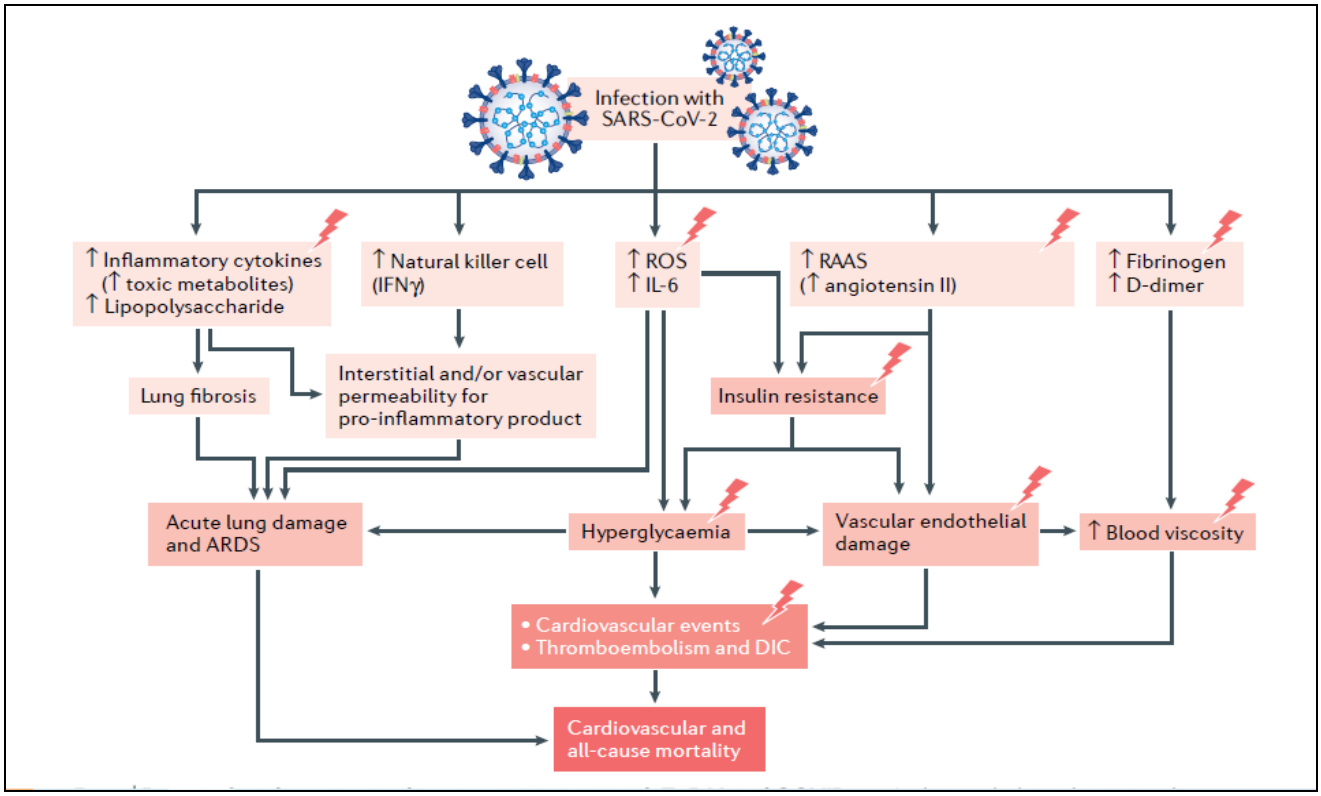


**Figure 1.3.** Potential pathogenic pathways in people with T2DM and COVID-19 (Lim et al., 2020) (Reproduced with permission).

### 1.4.5. Ethnicity and Family History

T2DM incidence and prevalence vary greatly depending on ethnicity and geographical region (Galicia-Garcia et al., 2020). In the USA, race/ethnicity is associated with many other risk factors for T2DM, including being overweight/obese, diet, and socioeconomic status.

Genetic predisposition plays an integral part in the risk of developing T2DM (Fuchsberger et al., 2016). To date, genome-wide association studies (GWAS) have pointed out over 500 genomic variants and susceptibility genes (TCF7L2, PPARG, CDKAL1, CDKN2A/B, IGFBP2, KCNJ, CAPN10, FTO, and others) associated with an increased risk of T2DM (Vujkovic et al., 2020). A recent meta-analysis also reported that, for people in the MENA area, 71 single nucleotide polymorphisms in 32 genes increased the risk of T2DM by 24%-69% (Abuhendi et al., 2019).

Polymorphisms in genes involved in DNA repair mechanisms also contribute to genomic instability and are related to T2DM development (Das et al., 2018).

Jordan represents a unique case of different ethnic populations genetically isolated and living in the same environment. The Jordanian population consists of multiple ethnic constituents: Arabs, the original inhabitants of Jordan, and two other culturally and demographically important ethnicities. Circassians originally from the Caucasus, and Chechens, originally from Chechnya, share the same environmental factors, dietary habits, and lifestyle as the Jordanians of Arab ethnicity (Abudahab et al., 2023). They are ethnically and genetically isolated, mainly due to endogamous marriages and preservation of traditions and language (L. AL-Eitan et al., 2020).

A genome wide association study in 2017 identified two unique loci determinants for T2DM in Circassians and Chechens in Jordan (Dajani et al., 2017). They determined a novel T2D locus at chr20p12.2 at genome-wide significance (rs6134031) and replicated the results in the Wellcome Trust Case Control Consortium (WTCCC) dataset. Another locus at chr12q24.31 is associated with T2DM at a suggestive significance level (top SNP rs4758690), and it is a robust expression quantitative trait loci (eQTL) for the gene MLXIP and is significantly associated with methylation level in MLXIP, the functions of which involve cellular glucose response (Dajani et al., 2017).

Another study has found several SNPs and copy number variations (CNV) associated with T2DM in Circassians and Chechens, including a CNV region in protein tyrosine phosphatase receptor type D and other 16 CNV regions associated with T2DM, which overlapped with gene exons, suggesting a distinct genetic factor for type-2 diabetes in the two populations (Dajani et al., 2015).

In addition, a comparative study between diabetes patients of Arab descent and diabetes patients of Circassian/Chechen descent showed differences in the disease manifestations; Jordanian-Arabs with T2DM were proportionately more likely to have hypertension as a diabetes comorbidity than

Circassians/Chechens. Arab peoples living with diabetes had higher levels of HbA1c and fasting blood sugar, and were more likely to have unsatisfactory glycaemic management (60.6%) than Circassian/Chechen peoples living with diabetes (38.2%) (HbA1c ≥7.0%), suggesting a role for genetic factors (Al-Eitan et al., 2017).

The Src homology 2 B adapter protein 1 (SH2B1) gene and its polymorphisms have a major role in developing T2DM. The SH2B1 gene is located on chromosome 16p 11.2 and encoded SH2B adapter protein 1 in humans acts as an adapter protein for many ligands, such as insulin, leptin, platelet-derived growth factor (PDGF), Glial cell-derived Neurotrophic Factor (GDNF), Insulin-like Growth Factor 1 (IGF1), Nerve Growth Factor (NGF), fibroblast growth factor and prolactin that activate either receptor tyrosine kinases or cytokine receptors associated with Janus kinases (JAK) (Al-Eitan et al., 2020). Two novel variations were present in the SH2B1 gene in Jordanian people with T2DM: c.827C>G and c.2026G>A, and previously reported five SNPs: rs146946750, rs565131715, rs370302573, rs143212778, rs200470848. Also, a strong genetic association was seen of rs565131715 SNP polymorphism within the SH2B1 gene in people with diabetes. Additionally, rs143212778 SNP presented a genetic correlation with people with diabetes compared to control individuals. The GTACG haplotype of SH2B1 has a highly significant association with responders. Thus, these findings indicated a strong association between the rs565131715 poly-morphism and the risk of T2DM among the Jordanian population (Al-Eitan et al., 2020).

Furthermore, the E23K (rs5219) polymorphism in the potassium channel inward-rectifying subfamily of the J member 11 (KCNJ11) gene has been implicated with T2DM (Al-Khalayfa et al., 2023).The E23K (rs5219) polymorphism was associated with T2DM susceptibility in Jordanians. The risk of developing T2DM was greater among the K allele carriers compared to the

E allele carriers. Furthermore, T2DM was more common among those with the KK genotype than those with the EE genotype after adjusting for gender, age, and body mass index. Based on the dominant model, both KK and EK genotypes showed an increased risk of T2DM than the EE genotype after adjusting for gender, age, and body mass index, suggesting polymorphism E23K (rs5219) is associated with susceptibility to T2DM in Jordanians (Al-Khalayfa et al., 2023).

Tumor necrosis factor-alpha (TNF-α) polymorphisms have also been associated with insulin resistance and diabetes development and complications. TNF-a G-308A polymorphism in promoter sequence might influence glycaemic management among Jordanian people with diabetes. Poor glycaemic management in patients who have the − 308GG genotype might be due to insulin resistance, which is subsequently developed by the high circulating levels of TNF-a protein (S. I. Al-Azzam et al., 2014)

The rs13266634 is a missense SNP in the last exon of the SLC30A8 gene, where a change between the two nucleotides C/T occurs, leading to an alteration between the amino acids arginine (R) and tryptophan (W) at position 325 (R325W). The risk C allele that encodes for arginine has shown an association with lower early insulin response to glucose and increased susceptibility to developing T2DM disease (Mashal et al., 2021).

Several genome-wide association studies (GWAS) have identified SNP rs13266634 in the Solute carrier family 30 member 8 (SLC30A8) gene as a risk factor for T2DM (Thirunavukkarasu et al., 2019). Mashal et al. demonstrated a significant association between the C/T rs13266634 SNP and T2DM among the Jordanian population. A significant difference was found between the cases and controls regarding the allelic (P = 0.003) distribution. Compared to people having a T allele, those with a C allele had a higher risk of T2DM (OR = 1.47; 95% CI: 1.14 – 1.89; P = 0.003). Having a CC genotype versus TT genotype was significantly associated with an increased risk of T2DM

(OR = 2.44; 95% CI: 1.16 – 5.12; P = 0.019) after adjusting for age, gender, and BMI (Mashal et al., 2021).

A more recent study revealed statistically significant correlations were detected between the AA genotype at the rs206833 variant related to the xanthine dehydrogenase (XDH) gene and reduced control over T2DM, as well as the CT genotype at the rs16890979 variant in the Solute carrier family 2 member 9 (SLC2A9) gene. Notably, the rs206833 variant had an association between allele frequency level and T2DM regulation; genetic variants (rs16890979 and rs206833) may influence T2DM control and could be associated with an elevated risk of impaired glucose homeostasis in people with T2DM (N. Al-Azzam et al., 2024). Besides the genetic predisposition, various other factors such as obesity-related physical inactivity, poor nutritional habits, and urbanization are also involved in the rising trend of diabetes prevalence in the Middle East (Akhlaghipour et al., 2022).

### 1.4.6. Obesity and diet

The main risk factor is obesity, as being obese can increase the risk of T2DM 90-fold, and most people living with T2DM are overweight or obese. T2DM risk is positively associated with increasing BMI, which rises exponentially with increasing BMI ≥30 kg/m2 (Bellou et al., 2018). In Western countries, around 50% of people with T2DM have a BMI of >30kg/$m^2$, and 30–40% have a BMI of 25–30kg/$m^2$ (Kyrou et al., 2020). Whilst in some Asian countries approximately 50% of patients are not overweight, a significant rise in diabetes prevalence is expected in Jordan due to alarming rates of obesity accompanying economic growth and nutrition transition (Khawaja et al., 2018). The overall prevalence of obesity among Jordanians was 28.1% in 2016 (21.0% of males and 35.6% of females (World Health organization, 2016). According to WHO (2018) estimates, the highest levels of overweight and obesity in 16 countries in the Eastern Mediterranean

Region occurred in Egypt, Bahrain, Jordan, Kuwait, Saudi Arabia, and United Arab Emirates. The prevalence of overweight and obesity in these countries ranged from 69.0 to 77.0% in men and 74.0 to 86.0% in women (WHO, 2018).

Excessive calorie intake leads to the accumulation of triglycerides in the adipose tissue, promoting hypertrophic enlargement of adipocytes and rapid expansion of the tissue (Lima et al., 2022). This cellular derangement induces the release of proinflammatory cytokines by hypertrophied adipocytes and macrophages residing within the adipose tissue. Consequently, the proinflammatory cytokines attract and promote immune cell infiltration, leading to chronic low-grade inflammation (Hotamisligil, 2017). In addition, adipocyte triglycerides undergo lipolysis and release free fatty acids into circulation, further stimulating macrophages to secrete more proinflammatory cytokines. Remarkably, weight loss through diets, exercise, and bariatric surgery reduces inflammatory markers and improves insulin sensitivity (Hernandez et al., 2021).

### 1.4.7. Physical activity

Several trials have shown physical exercise can reduce the incidence and severity of T2DM. According to the Canadian Diabetes Association Clinical Practice Guidelines Expert Committee, In people with impaired glucose tolerance followed for 20 years, six years of leading an active life combined with a healthy diet can lower the occurrence of T2DM by 43.0% (Sigal et al., 2013). Another meta-analysis found that exercise training decreases HbA1c in people with T2DM by 0.66%, a percentage that significantly reduces the consequences of T2DM (Li et al., 2008). Not surprisingly, one of the most important modifiable risk factors in the Arab world is a sedentary lifestyle, particularly when comparing the prevalence of highly active persons in the Arab world to global data (Boulé et al., 2001). Globally, more than a quarter of adults (27.5%, 95% UI 25.0% –32.2%) were insufficiently physically active in 2016 (Guthold et al., 2018). The Emirates had the

greatest proportion of physically active adolescents (23.9%), whilst Egypt had the lowest (9.2%), with an overall prevalence of 19.0% of adolescents that are physically active using PA core questions in the 2003 to 2008 version of the Global school-based student health survey (GSHS) in the Eastern Mediterranean countries (Al Subhi et al., 2015).

A sedentary lifestyle is a similar risk factor for T2DM, as shown by the Women's Health Study and the Kuipio Ischemic Heart Disease Risk Factor Study, which showed 34.0% and 56.0% reductions in development of T2DM in participants walking 2–3 h per week or at least 40 min per day, respectively. Physical activity has three primary benefits on the delay of T2DM onset. First, the contraction of skeletal muscle cells increases blood flow into the muscle, enhancing glucose uptake from plasma. Second, physical activity reduces the notorious intra-abdominal fat, a known risk factor that promotes IR (Galicia-Garcia et al., 2020). Finally, a moderate-intensity aerobic exercise-training program can improve glucose uptake by 40.0%. Physical activity enhances glucose uptake and insulin sensitivity, and can also improve or reverse inflammation and oxidative stress, which are T2DM predisposing factors (Venkatasamy et al., 2013). The American Diabetes Association recommends at least 150 min/week of physical activity to prevent, delay and/or enhance management of T2DM, and this is important, especially for individuals with prediabetes (Colberg et al., 2016).

### 1.4.8. Hyperglycaemia and COVID-19

Previous evidence identifies angiotensin-converting enzyme 2 receptors (ACE2r) as the SARS-CoV-2 internalisation receptor inducing COVID-19, in conjunction with the host's TMPRSS2 membrane protease, which primes the spike S protein of the virus to promote its cell entrance (Hoffmann et al., 2020). Potential explanations for the association between hyperglycaemia and ACE2r levels in the severity of COVID- 19 infection may be possible alterations in glycosylation

of the ACE2r and glycosylation of the viral spike protein. Both may be caused by uncontrolled hyperglycaemia and may affect viral spike protein binding to ACE2r and immunological response to virus (Brufsky, 2020).

In uncontrolled hyperglycaemia, elevated and aberrantly glycosylated ACE2r in the lung, nasal airways, tongue, and oropharynx could serve as increased SARS-CoV-2 viral binding sites, leading to COVID-19 infection and a more severe form of the disease (Brufsky, 2020). Bhandari et al. (2020) found that COVID-19-related symptoms among adults with uncontrolled T2DM (defined in their article as HbA1c > 8% or 64 mmol/mol) were significantly worse compared to those with controlled T2DM. In addition, adults with uncontrolled T2DM hospitalized due to COVID-19 were significantly more likely to require ventilation, to have longer hospital stays, and had higher mortality than those with controlled T2DM (Bhandari et al., 2020). This outcome is not surprising given the poorer results seen for people with stress hyperglycaemia in a systematic review and meta-analysis (Gerganova et al., 2022; Huang et al., 2020). Stress hyperglycaemia was seen as prognostic for poor outcomes related to increased respiratory failure and mortality in SARS- CoV-2 patients, flagging the importance of achieving and maintaining normoglycaemia (Lim et al., 2020).

### 1.4.9. Management of people with T2DM during COVID-19

The top priority for people with DM is to maintain their blood glucose levels as close to normal values as possible. It has been shown that in the case of COVID-19, uncontrolled blood sugar levels may lead to increase vulnerability to COVID-19, hospitalization and death (Selvin & Juraschek, 2020).

For T2DM, metformin is considered the first-line treatment option in the pandemic situation. It typically activates the AMP-activated protein kinase in the liver which phosphorylates ACE2

receptors to induce functional alterations. Such modification may alter the binding of coronavirus with its ACE2 receptors. It has been demonstrated that this virus enters the host cell through ACE2 receptors and disrupts the renin-angiotensin pathway; metformin limits this situation by activating ACE2 through AMPK signalling pathways (Sharma et al., 2020).

Insulin produces anti-inflammatory effects in humans and decreases inflammation biomarkers in critically ill hospitalized patients. Pro-inflammatory states are considered to have a worse prognosis for COVID-19. Thus, this type of drug is considered to be supportive therapy for COVID-19 (Carboni et al., 2020). However, it is essential to maintain a reasonable level of glycaemic management in these patients and, in a sample of 59 patients, insulin infusion was shown to be advantageous for achieving glycaemic targets and improving outcomes in people with COVID-19 (Sardu et al., 2020).

Corticosteroids have a role in controlling ARDS and sepsis, and are regarded as anti-inflammatory management strategies for COVID-19 (Reshad et al., 2021). Methylprednisolone (1–2 mg/kg/day) can be used to suppress cytokine storm (Qin et al., 2020). Corticosteroids are often associated with the onset of hyperglycaemia or DM (Fathallah et al., 2015) and higher dosages (dexamethasone > 4 mg, hydrocortisone > 50 mg, prednisolone > 20 mg) have the potential to induce severe adverse effects (Suh & Park, 2017). They may increase blood glucose by 80 % in people with DM with COVID-19 infection, and to lower levels in those without diabetes. This can lead to an increase in COVID-19 patient-related mortality (Yang et al., 2021). In circumstances when corticosteroids are required, blood glucose monitoring is essential to maintain near euglycemia and optimize pulmonary and immunologic functioning (Alhazzani et al., 2020; Ugwueze et al., 2020). Also, in order to minimize their adverse effects, new medications such as tocilizumab (a monoclonal antibody for rheumatoid arthritis) may be used to suppress the cytokine storm (Deng et al., 2021).

### 1.4.10. COVID-19 Vaccination in People with T2DM

The SARS-CoV-2 vaccine program has reduced the incidence of serious outcomes caused by COVID-19 (Bergwerk et al., 2021). Nonetheless, viral spread is still significant in many nations, most likely owing to a combination of factors reducing the vaccine's effectiveness against outbreak infections. The inability of vaccinations to provide 100 % protection against illness, the influence of time in declining antibody titres, and the generation of viral variations evading vaccine-induced immunity are likely the main causes of vaccination failures (Stefan, 2022). However, patient factors may also impact the frequency of breakthrough infection, as shown for people with various comorbidities including T2DM (Agrawal et al., 2021). According to a systematic review, immunogenicity of the vaccines has mostly been reported to be lower among people with DM compared to healthy controls (Boroumand et al., 2022).

The advancements in rapid vaccine development have saved the situation. Several vaccines for SARS-CoV-2 have been developed and approved by the FDA's Emergency Use Authorization, including the vaccine manufactured by Pfizer BioNTech, Moderna, and Johnson & Johnson. Later, Pfizer BioNTech received full FDA approval (Krause & Gruber, 2020).

Even though vaccines have proven efficacy against many transmitted diseases as one of the most effective available medical interventions that save millions of lives yearly, Vaccine hesitancy and refusal remain limiting factors for achieving optimal herd immunity against some diseases. Moreover, vaccine refusal has been proven to increase the risk of contracting the target disease (Phadke et al., 2016). Many factors usually affect people's general perception and attitudes toward vaccinations, including their experience with vaccines, level of education and knowledge, risk perception and trust, and perceived importance of vaccination (Dubé et al., 2013). In the case of

COVID-19 vaccines, additional factors have also played a role, including the speed at which the vaccines were developed in less than a year which raised some public concerns about their safety, and the uncertainty regarding the durability of the immune response gained with vaccination (Dror et al., 2020). Moreover, differences in efficacy and adverse effects may cause varying trust in COVID-19 vaccines. This may subsequently affect the willingness to vaccinate, particularly when people are not given a choice of vaccine they wish to receive (as has been the case in Jordan until the mid of 2021) (Alnatour et al., 2023) .

The Jordanian government started the vaccination campaign in January 2021. Since then and until the beginning of this study in August 2021, the percentage of Jordanians who were fully vaccinated did not exceed 25% of the total population. Hence, it was crucial to explore the population's beliefs and perceptions toward the COVID-19 vaccines, which stand behind their attitudes and willingness to receive the vaccine. Current statistics from Jordan (October 2022) reveal an increasing percentage of the fully vaccinated population to 44.56 % of the total population. A previous study included a total of 398 participants were included in the study, with the majority (around 81.0%) received at least one dose of any of COVID-19 vaccines approved for use in Jordan. Most non-vaccinated participants (67.4%) were either unwilling to receive the COVID-19 vaccine or unsure. The main reasons for receiving the vaccine were: family protection, self-protection, global efforts to fight the virus and local restrictions, with some variability between vaccinated and non-vaccinated. The major reasons for fear of COVID-19 vaccines were limited research, vaccine effectiveness, and vaccine side effects. Pfizer-BioNTech vaccine was the most trusted vaccine by vaccinated and non-vaccinated participants (47.8% and 57.9%, respectively), and Oxford-AstraZeneca was the most feared by them (42.2% and 57.9%, respectively). Internet websites (>85.0%), social media platforms (>70.0%), relatives and friends (>69.0%), and news applications

(>60.0%) were the major sources of information about the COVID-19 vaccines among participants (Alnatour et al., 2023).

Another study found that the public's knowledge of vaccines in Jordan has improved. This is due to the efforts of experts, healthcare professionals, national authorities, and the media who provided reliable information about COVID-19 vaccines through various channels. These efforts have increased vaccination rates and improved the sense of security among those vaccinated or considering vaccination, as they have been assured of the vaccines' safety (Alnatour et al., 2023).

### 1.4.11. Effect of COVID-19 on healthcare services

The increase in diabetes-related problems has placed extra strain on already overcrowded healthcare systems and led to a rise in COVID-19 infections among individuals with uncontrolled glycaemia (Khunti et al., 2022). People with COVID-19 and diabetes comorbidity have twice the risk of being admitted to ICU (Roncon et al., 2020). It was estimated that people with COVID-19 and diabetes contributed 22.2% - 58.0% of ICU admissions due to septic shock and Acute Respiratory Distress Syndrome as result of blood glucose variability and elevated blood pressure, with a mortality rate of 7.3% - 7.6% (Wang et al., 2020). Another study in Kuwait observed that COVID-19 people with diabetes had higher ICU admission and mortality rates compared to non-diabetic patients (20.1% vs. 16.8%, $p < 0.001$ and (16.7% vs. 12.1%, $p < 0.001$) respectively). They also revealed that every 1 mmol/L increase in fasting blood glucose in COVID-19 patients is associated with 1.52 times the odds of dying from COVID-19 (Alshukry et al., 2021). This underlined the need for greater infrastructure in the form of rapid development of innovative redeployment and training strategies for patient care and infection control (Juan et al., 2022).

Redeployment planning is intended to reduce training needs and increase the use of redeployed healthcare workers' (HCWs') previous knowledge by putting HCWs in positions where they can readily transfer their existing skills (Juan et al., 2022). Redeployment to meet surge needs has differed across nations and health systems based on institution design, geography and population context, and pandemic stage (England, 2020). Most locations, however, redeployed HCWs using volunteers internal or external to the health system (e.g., migrant nurses) to places with greater COVID-19 burden (Panda et al., 2021). Another effective strategy was a tiered staffing model where critical care trained doctors or nurses oversaw non- ICU professionals (Vranas et al., 2021). For example, experienced renal doctors and trainee radiologists established line insertion teams (Shipchandler et al., 2020), and physiotherapists assisted with prone positioning (Doyle et al., 2020). Benefits included fewer workers for procedures, less viral aerosolization, faster process times, and minimum or no additional training for helpers.

Some of the training development and delivery was performed by HCWs who were recently retired, elderly clinicians, or those at risk for severe COVID-19 infection, contributing to the pandemic response by leading simulation-based education sessions using a variety of formats and media (Dedeilia et al., 2023). Online learning formats allowed HCWs to access material at their own pace and check their understanding, but practical follow-up sessions were needed to consolidate the learning (Alshwiah, 2023).

People living with T2DM required proper self-management of their blood sugar control throughout the pandemic period of home isolation. Online or tele-consultation with healthcare practitioners was recommended, including to check medication taking, requiring rapid adoption of new protocols, systems and technologies. Endocrinologists could also use smartphone apps (such as WeChat, WhatsApp, Line) to communicate and exchange resources (Olausson et al., 2023). It was

also important to ensure that all people with diabetes had adequate medication stocks and to prescribe enough medication because of limited access to clinics during the pandemic (Wicaksana et al., 2020). The effectiveness of telehealth was shown in a recent review of 46 studies on telemedicine used with people with T1DM (n = 2052) and T2DM (n = 24,000), which showed significant reduction in HbA1c values (-0.12% to -0.86% and -0.01 to -1.13%, respectively) (Timpel et al., 2020).

One study used a mixed-method approach in Jordan to collect data from 300 people with diabetes and chronic renal disease. Almost 99.0% of participants faced barriers to accessing healthcare services during COVID-19, while more than half perceived low to moderate quality of healthcare services. Four themes and nine sub-themes related to barriers and facilitators were identified. The study showed that healthcare services for people with diabetes and renal disease were impacted during COVID-19, and the findings could be useful in developing health programs and revising policies for improvement (Al-Bataineh et al., 2023).

### 1.5. COVID-19 in Jordan

Jordan, located in the MENA region, has an estimated population of about 10.6 million people, 52.9% male and 47.1% female, and occupies a total area of 89,342 square kilometers (Jordan Department of Statistics, 2020). Jordan borders Iraq, Israel, the occupied Palestinian territory, Saudi Arabia, and Syria. The World Bank categorizes Jordan as an upper middle-income country, with a per capita Gross National Income (GNI) of $9,430 per individual in 2019. Since the beginning of the COVID-19 epidemic, the Jordanian government has adhered to the WHO guidelines and updates.

Jordan is a tourist country and the central connection point for many regional flights and trips. Due to the increase in COVID-19 cases globally, the government implemented strict rules and measures relating to travel, education, religious and social events, and working in various industries. The first step in preventing and controlling the spread of COVID-19 in Jordan started at the country's entry ports through temperature screening of incoming travellers and quarantining individuals from high COVID-19 spread nations. The Jordanian government began locking down the kingdom on 18 March, suspending classes in schools and colleges, stopping prayer in mosques and churches, closing borders and suspending all arriving and departing aircraft. In addition, as a precaution, all inbound passengers from the country's primary international airport were quarantined for 14 days in hotels (Al-zoubi et al., 2020).

Three weeks after the first case in the country, on 20 March 2020, a countrywide curfew with harsh mobility limits and severe penalties was proclaimed (Prime Ministry of Jordan., 2020). A national lockdown was triggered for three days between 22 to 24 March 2020 (Jordanian Ministry of Health., 2020). With numbers stabilising, the lockdown was reduced from 2 August 2020, but only for one month as numbers subsequently increased exponentially. The government continued a policy to increase the capacity of the health system by allocating additional hospitals, wards, and intensive care unit beds to treat COVID-19 patients while also investing in building field hospitals to handle the outbreak (Alshoubaki & Harris, 2021).

### 1.5.1. Epidemiology of COVID-19 in Jordan

The first confirmed case of COVID-19 in Jordan was a young Jordanian man traveling to Italy on 2 March 2020. Upon confirming the first case, the national measures were scaled up to limit the spread of COVID-19. By 17 March 2020, there were 56 cases (CNN, 2020). Three weeks after the first case there were 98 cases in the country, but by 2 August 2020 only 77 new cases had been

detected, bringing the total number of cases to 1,213 and 11 fatalities (Jordanian Ministry of Health., 2020), indicating some success with the procedures to enforce the curfew. One month after reducing the lockdown (from 2 August 2020), the number of cases substantially doubled to 2,161 but in the following month reached 13,650 cases (Jordanian Ministry of Health., 2020) and continued to expand as a result of illegal public gatherings on Election Day (10 November 2020), where compliance with protective measures was non-existent. This marked a turning point in the country's epidemiological situation as the first pandemic wave occurred around the period from 1 September 2020 to 26 January 2021.

By the end of November and early December 2020 numbers had begun to stabilize with total cases reaching 250,219 and 3,206 deaths. By 4 January 2021, infection rates had decreased to reach 298,208 cases, 3,903 deaths, and 278,929 recovered patients (Alqutob et al., 2020).

A second pandemic wave hit Jordan starting around 27 January 2021 and the COVID-19 morbidity and mortality rates rose again (Al-Tammemi et al., 2021). By 4 April 2021, Jordan had reported 683,466 COVID-19 cases and 8,178 fatalities; the occupancy rate of ICU beds due to COVID-19 was about 73% and 77% in north and major regions, respectively (The National News, 2021). This pandemic wave posed a significant burden on healthcare institutions with high occupancy rates of isolation beds, ventilators, and ICU beds, especially in northern and central Jordan. In total, from 3 January 2020 to 23 September 2022, there were 1,745,032 confirmed cases of COVID-19 with 14,116 deaths, reported to WHO (2022).

### 1.5.2. Effect of COVID-19 on healthcare services in Jordan

The pandemic-related lockdown imposed in Jordan from March to June 2020 had many implications and effects for health services. Despite the many governmental and private hospitals all over Jordan, the Jordanian health authorities, in collaboration with the National Center for

Security and Crisis Management, decided to admit all COVID-19 patients to two hospitals only: King Abdullah University Hospital (KAUH) in the North and Prince Hamza Hospital in the capital, Amman. These hospitals maintained basic services and terminated elective operations and treatments including outpatient clinics (Mazahreh et al., 2020). The goal was to prioritize care for COVID-19 patients, provide better compliance with infection control policies, and protect non-infected patients and HCW (Alorjani et al., 2021).

Internationally adopted safety measures and local staff protection guidelines were applied in the two hospitals, including strategies to limit the burden and prioritise duties for best usage of resources. HCWs with diabetes, hypertension, and chronic respiratory disorders, as well as pregnant women, were excluded from work during this period (Al-zoubi et al., 2020). Ensuring HCWs' health and safety in the workplace and community was recognized as critical as they were recognised as at a higher risk of developing infectious diseases because of their high level of occupational contact (Jones and Carver, 2020). Therefore, before the outbreak of this pandemic in Jordan the local infection control committee began to train HCWs about care for COVID-19 patients including hand washing, wearing and removing PPE (gloves, N95 masks, face and eye protection including face shields and goggles, gowns, aprons, head and shoe coverings) (Al-zoubi et al., 2020).

Particularly during the early phases of the pandemic, supplies of medicine were interrupted. For example, insulin, a common medicine used by people with diabetes, must be refrigerated but during the COVID-19 pandemic, the cold chain transit of insulin was halted, causing a shortage in supply. A study in a Northern Jordan hospital found that COVID-19 has impacted healthcare quality for people with DM and chronic respiratory disease. More than half of the participants reported low to moderate levels of quality of chronic disease services, such as staff unavailability

and medication unavailability, as significant barriers to healthcare accessibility and quality (Al-Bataineh et al., 2023). Therefore, pharmacists at the Jordan University Hospital (JUH) worked together with other healthcare providers to coordinate efforts, and quickly adapted to make changes in pharmacy practice. During the quarantine, a total of 5,994 prescriptions, including 28,494 medications, were delivered to 4,853 patients (Hammour et al., 2022). The pharmacy department expanded its capabilities creatively using health technologies to ensure a coordinated, systematic program for the delivery of medications and staff safety. Nonetheless, the pandemic severely disrupted routine diabetes self-management because of changes in diet due to the unavailability of certain food products and difficulty in maintaining physical exercise due to the lockdown.

Further, surgical practice encountered several challenges due to the COVID-19 pandemic, such as the risk of viral transmission and cross-infection, staffing shortages, prioritization of surgical procedures, and a lack of beds due to hospitals and ICUs being occupied by COVID-19 patients (Al-Jabir et al., 2020). A survey in Jordan showed a significant reduction in elective and emergency procedures performed during October 2020, reduced to 48.5% of the average monthly rate in 2019. Sixty percent of the surveyed surgeons said they had to cancel elective surgeries due to COVID-19-related reasons, and they also provided the reasons for cancellation. Additionally, 38.3% of the surveyed surgeons faced difficulties admitting emergency cases due to the overwhelming number of patients and the shortage of beds. Based on the results, it can be concluded that COVID-19 had a moderate to significant impact on surgical practice in Jordan during October 2020 (Ennab & Ibdah, 2021).

Training and Education: The pandemic has presented unprecedented challenges to the healthcare sector, necessitating the development of effective management strategies to address the surge in

patient volume and resource constraints. Of all specialties, teaching is a compulsory component of medical training. To continue providing training sessions to trainees at variable stages, numerous online tools have been used. This has proved to be more realistic, versatile, and instructional. Conferences, workshops, seminars, and other types of remote training are made possible by mobile technologies. Hospital rounds were filmed by webcams; Zoom classrooms, interactive simulators, 3D images replaced cadavers, webcasting, video chat rooms, interactive dissection, interactive virtual reality E-anatomy have now been taking place (Naseri et al., 2020).

Telemedicine and healthcare infrastructure have been identified as critical resources with a significant moderating effect on healthcare management performance during this crisis. Telemedicine, as a technology-related resource, enables remote healthcare delivery, virtual consultations, and monitoring, which have become crucial during the pandemic (Alsabi et al., 2023).

**The effect of COVID-19 on Nursing**

With the heavy nursing workload due to the COVID-19 pandemic, long working hours and large numbers of severe cases, nurses are required to manage and reprioritize their work (Aquila et al., 2020). Nurses during COVID-19 have to provide a lot of complex tasks for a large number of patients, which increases the opportunity of a defect or deficiency in the provision of nursing care (Abu Mansour & Abu Shosha, 2022). Missed Nursing Care (MNC) was defined as the inability to carry out all nursing tasks (Assaye et al., 2022).

The study shows that different personal and organizational factors in Jordan may lead to an increase in MNC. More experienced nurses, dissatisfaction with the income and intention to leave the current job may result in higher chances towards an increase in the incidence of MNC. Moreover, increased workload by increasing the patient: nurse ratio above 6 patients, which was

aggravated by the COVID-19 pandemic may also lead to increased MNC levels. Increasing the organizational support to nurses to perform their jobs may result in a reduction in MNC, thus increasing the overall quality of care provided to patients (Khrais et al., 2023). Healthcare organizations should be committed to creating a supportive environment that enables nurses to meet their needs and achieve their goals. Nursing management in the different healthcare settings needs to investigate the impact of the factors discussed in the current study and their impact on MNC. Moreover, they are also invited to work on enhancing the nurses' perception of accountability and the perception of organizational support in order to reduce the levels of missed nursing care. They may need to create a blame-free environment and establish a system to follow and control the MNC. It is highly suggested to review the adopted nursing care delivery model at the practice setting and how the COVID-19 pandemic may change it in a way that it may affect the occurrence rates of MNC and thus the quality of care provided (Khrais et al., 2023).

In a previous study, the obstacles faced by Jordanian nurses during the emergence of COVID-19 were examined. There was a statistically significant link between nurses' knowledge and their years of experience ($r = 0.15$, $p = 0.03$), their experience with COVID-19 infection ($r = 0.83$, $p = 0.01$), and having a first-degree relative who had COVID-19 ($r = 0.17$, $p = 0.02$) (Aryan & Ahmad, 2022).. Also, nurses knew a fair amount about COVID-19. There was a statistically significant link between how nurses felt and how they were trained to care for COVID-19 patients ($r = 0.15$, $p = 0.034$), nurses who had COVID-19 infection ($r = 0.30$, $p = 0.001$), and having a first-degree relative who had COVID-19 infection ($r = 0.18$, $p = 0.014$) (Aryan & Ahmad, 2022).

The Jordanian nurses' understanding of COVID-19 disease is categorized as average because the majority of their responses ranged between 56 % and 86 %. The nurses' knowledge was related to their length of experience in the field, and their perceptions were related to how they had been

trained to care for COVID-19 patients. Nurses also admitted to having a variety of views on the use of personal protective equipment (PPE). Patients suffered because of the nurses' inexperience and lack of competence in reading electrocardiograms and arterial blood gases (Aryan & Ahmad, 2022).

A descriptive cross-sectional study of nursing and midwifery students from academic faculties of nursing of both governmental and private Jordanian revealed that the lockdown had a negative impact on nursing and midwifery students' self-confidence and competency in performing nursing procedures. The academic year of the students was a significant independent predictor of their self-confidence and competency levels in performing nursing procedures. The study concluded that nursing and midwifery students were dissatisfied with their clinical education during the COVID-19 pandemic, which led to poor self-confidence in performing nursing procedures. The study group recommended repeating the clinical practicum, incorporating extensive laboratory and hospital courses, and implementing a one-year internship for newly graduated nurses and midwives to address the training gap and enhance self-confidence in clinical procedures (Alnjadat et al., 2024).

A cross-sectional study explored the knowledge, attitudes, and willingness of Jordanian nurses to provide care for patients with COVID-19. The findings revealed that 56% of the nurses reported prior experience in treating or caring for confirmed or suspected COVID-19 cases, with 71.8% expressing their willingness to do so. However, only 55% of the nurses indicated completion of a COVID-19 training program. The nurses' job title, type of hospital, and previous experience in managing COVID-19 patients were identified as factors influencing their willingness to provide care (Hamdan et al., 2022)

The study also highlighted that Jordanian nurse identified knowledge gaps, particularly in the proper use of personal protective equipment, and they expressed concerns about transmitting the

disease to their family members. Additionally, the nurses reported a moderately positive attitude towards hand hygiene and the use of personal protective equipment, despite most of them expressing willingness to provide care for COVID-19 patients (Hamdan et al., 2022)

### 1.5.3. COVID-19 and T2DM in Jordan

In Jordan, people with T2DM experienced a higher prevalence of COVID-19 infection compared to the general population without diabetes: 32.3% were infected, with 3.0% COVID-19-related mortality. Of those with T2DM who contracted COVID-19, 22% required hospitalization and 6.8% were admitted to the ICU. Additionally, 19.1% of COVID-19-infected people with diabetes developed lung fibrosis (Farah et al., 2023). The prevalence of chronic non-communicable diseases in Jordan is considered high. For example, 38% of deaths pre-COVID were attributed to cardiovascular diseases (Mokdad, 2016). A recent study from Jordan revealed that the prevalence of diabetes in men and women aged ≥ 25 years was 32.4% and 18.1%, respectively (Ajlouni et al., 2019). The overall prevalence of dyslipidaemia among people living with T2DM was 95.4% and the combination of high triglyceride and low HDL-c is the commonest lipid abnormality detected in people with T2DM (Hyassat et al., 2022).

The COVID-19 pandemic has impacted the mental health of the general population in Jordan (Khatatbeh et al., 2021; Suleiman et al., 2022). Jordanian people with T2DM also had a high occurrence of depression due to overlapping symptoms, with a significant correlation between depression severity and glycaemic management (Khassawneh et al., 2021). The COVID-19 pandemic negatively impacted the quality of health and treatment satisfaction of many people with T2DM in Jordan (Al-Bataineh et al., 2023).

### 1.6. Summary and study aims

From the start of the spread of COVID-19 outside China in January 2020, by 31 December 2021 worldwide recorded fatalities owing to COVID-19 had reached 5.94 million, while the estimated number of excess deaths was about 3.1-times (95% UI 2.9–3.3) larger, reaching 18.2 million (17.1–19.6) ( Wang et al., 2022). In Jordan, from 3 January 2020 to 23 September 2022, there have been 1,745,032 confirmed cases of COVID-19 with 14,116 deaths, reported to WHO (2022).

In the face of this rapidly spreading pandemic disease, to reduce the spread of COVID-19, many countries including Jordan imposed lockdowns with movement restrictions, social distancing, and home confinement (Eberle & Stichling, 2021). While this undoubtedly had great benefits for people with diabetes, considered among the most vulnerable groups to COVID-19 (Kaddar et al., 2022), lockdowns also caused negative effects which impacted on diabetes self-management. However, little evidence is available to demonstrate how COVID lockdowns affected diabetes self-management, particularly in Jordan. This is an important gap in knowledge as a deeper understanding of patients' responses to infection prevention and control policies, resource utilization and clinical outcomes in a major clinical population such as people living with T2DM could improve the planning and organization of healthcare facilities to ensure better preparation and optimization of delivery of care during times of pandemic crisis. Patient education, self-care training and the management of derived complications are great challenges for nurses, and also pose opportunities for practice and service improvement during times of crisis.

Therefore, the aims of this study were:

1. To synthesize the current evidence about glycaemic control and associated factors in people with T2DM in the Middle East and North Africa.

2. To determine measurements indicative of glycaemic control in people with T2DM in Jordan and identify whether glycaemic control differed in people with T2DM before and after the first COVID-19 lockdown in Jordan.
3. To determine factors predictive of the level of glycaemic control during the pandemic (before and after lockdown).
4. To create a consensus of expert opinions regarding the recommendations to be drawn from the findings of this study for nursing education and practice preparation for any future pandemic.

To address these aims, this work was undertaken, structured as follows.

This thesis is presented as a thesis by compilation with the findings supported by four publications. One paper is in print (a systematic review; Appendix 3.1) and three papers are in development (the 1) quantitative and 2) qualitative findings and 3) the Delphi study.

**Chapter 1** described the problem of the study (the unknown effects of lockdown as a COVID-19 pandemic public health strategy on the self-management of their diabetes in people with T2DM in Jordan) and the importance of this gap in knowledge for future planning including of nursing education and curricula for better management of future pandemics. It included an outline of the main structure and argument of the thesis.

**Chapter 2** provides an outline of the research design, methodology, methods and plan for the study. The methodology used was a mixed methods study conducted in three phases. Phase I aimed to determine any change in routinely recorded glycaemic data in people with T2DM, comparing test values recorded before and after the first lockdown in Jordan. Phase II aimed to measure and assess characteristics that might be affected by the COVID-19 pandemic and its management,

including lockdown, and which might, in turn, influence glycaemic management in people with T2DM. Phase III entailed an electronic modified Delphi consultation to develop consensus statements based on participants' expert opinion of study findings and their implications, with recommendations for nursing education and practice.

**Chapter 3** addresses the first aim of the study by providing a systematic review of the literature regarding glycaemic control and its associated factors in people with type 2 diabetes in the MENA region.

**Chapter 4** provides the findings that address the second and third aims of the study. The first section presents phase I findings which are quantitative findings that address the second aim of the study. The second section presents phase II findings which are qualitative findings that address the third aim of the study.

**Chapter 5** provides the findings that address the fourth aim of the study. It presents phase III findings which are the recommendations derived from the modified Delphi consultation.

**Chapter 6** provides a discussion of the findings in relation to demographic factors, clinical characteristics, behavioural and lifestyle factors, mental health issues and diabetes self-management.

**Chapter 7** provides the conclusion of the study and considers its implications and recommendations for nursing policy and practice, education, and research, and for the wider health care services of Jordan to optimize self-management and glycaemic management of people with diabetes in preparation for any future pandemic.

# 2. CHAPTER 2 STUDY METHODS

This chapter outlines the research methodology and methods of this thesis, including the design, sampling and selection methods, eligibility criteria, ethical considerations, data collection, management and analysis for all three phases of the study.

## 2.1. Study research questions and aims

### 2.1.1. Research Questions

1. What is known about glycaemic control and associated factors in people with type 2 diabetes in the Middle East and North Africa?
2. What was the glycaemic control of people with T2DM in Jordan before and after the Covid-19 lockdown?
3. What factors predicted the level of glycaemic control during the pandemic (before and after lockdown)?
4. What recommendations can be drawn from the experiences of the COVID-19 pandemic in relation to supporting glycaemic control of people with T2DM and for nursing education and training for future pandemic preparedness?

### 2.1.2. Study aims

1. To synthesize the current evidence about glycaemic control and associated factors in people with T2DM in the Middle East and North Africa.
2. To determine measurements indicative of glycaemic control in people with T2DM and identify whether glycaemic control differed in people with T2DM before and after the first COVID-19 lockdown in Jordan.

3. To determine factors predictive of the level of glycaemic control during the pandemic (before and after lockdown) in Jordan.
4. To create a consensus of expert opinions regarding the recommendations to be drawn from the findings of this study for nursing education and practice preparation for any future pandemic.

## 2.2. Study design

The study as a whole was performed as a mixed methods design, which is defined by Morgan as *"a type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e. g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration"* (Morgan, 2017). This design is used to elaborate, enhance, and illustrate the results from one method with the results from another method. Moreover, researchers have also applied this design to use the results from one method to help develop or inform the other method, where development is broadly construed to include sampling and implementation, as well as measurement decisions (Schoonenboom & Johnson, 2017). The overall objective for use of this research methodology was to achieve breadth and depth of data and analysis, and to draw out the practice implications and recommendations that derive from this. Thus, the study makes both a valuable contribution to the published literature and direction for future nursing clinical improvement.

In this study, the mixed methods design was used to provide a solid background for a quantitative research approach supported by qualitative perspectives in order to achieve a holistic view of the pre-and post-lockdown situations of patients living with diabetes in terms of glycaemic control

and the risk factors associated with this, and the implications for future pandemic planning in relation to educating nurses to best support patients' self-care for their diabetes.

The methods employed in this study include retrospective audit/ secondary data analysis (phase 1) and a survey with quantitative and qualitative data elements (phase 2) followed by a Delphi consultation to determine expert consensus recommendations from study findings for nursing education and practice (phase 3).

This study was conducted in three phases as set out in the study phases diagram (**Figure 2.1**).

**Phase I:**

This study phase aimed to determine changes in glycaemic management indicators among people with T2DM and identify whether glycaemic management differed in people with T2DM after compared to before the first COVID-19 lockdown in Jordan (research question 2). A retrospective study design was employed in this phase using healthcare data collected before and after the lockdown period, which was between 21/03/2020 and 06/06/2020. This period was chosen as it entailed a full lockdown, which could particularly affect patients requiring regular monitoring. Electronic medical records of patients who visited the diabetes clinic of the public health facilities were reviewed before and after this period, considering that HbA1c measurements reflect the glycaemic management of the previous approximately 12 weeks. The hospital sites of this study were Al Karak Public Hospital, Al Bashir Hospital, and Ma'an Government Hospital, Jordan.

**Phase II:**

The purpose of this component was to measure and assess characteristics which might be affected by the COVID-19 pandemic and its management, including lockdown, and which might, in turn, influence glycaemic management in people with T2DM (research question 3).

Qualitative designs play a crucial role in discovering reasons for observed patterns, particularly those that are invisible or surprising. This is because certain research questions cannot be answered through quantitative methods alone. Therefore, incorporating qualitative designs into research methodology is essential to gain a better understanding of complex phenomena and uncover new insights that are not easily obtainable through quantitative data analysis. Using qualitative methods can also help shed light on the "softer" side of medical treatment (Busetto et al., 2020).

In this phase of the study, cross-sectional interviews were carried out with eligible patients (recruited as in Phase 1), involving the use of a structured questionnaire that incorporated open-ended questions to investigate and uncover novel issues, problems and associations between glycaemic management and potential explanatory factors impacted by the COVID-19 pandemic and its management, for example, such as physical activity, self-management, anxiety, and depression.

**Phase III:**

The Delphi technique, originally named after the famous Greek oracle, was developed by Dalkey and Helmer in 1963 for the RAND Corporation. Initially intended for military forecasting, it is now utilized across various domains like computer science, education, psychology, retail, and healthcare. The technique involves gaining consensus on a particular topic through the use of rounds of questioning by experts in the field. It has three characteristics that make it distinct from other group interaction methods, including anonymous group interactions and responses, multiple

rounds of questioning, and the provision of feedback to the group between each round (Chalmers & Armour, 2018).

This phase entailed a modified electronic Delphi consultation. The purpose of this phase was to develop consensus statements based on expert opinion of study findings and their implications, with recommendations for nursing education and practice to optimise self-management and glycaemic management of people with diabetes in preparation for any future pandemic (research question 4).

The classic Delphi process was modified for this study to enable the findings of phases I and II of the study to be presented by the researcher to the Delphi panel through email. The Delphi consultation process was then conducted in three rounds via email. In light of the phase 1 and 2 findings that they were shown, the panel was asked for their recommendations on how to strengthen nurse education and practice in order to optimize self-management and meet glycaemic targets of people with diabetes. Recommendations were sought through an iterative process, reviewing and revising participants' contributions until consensus was achieved.

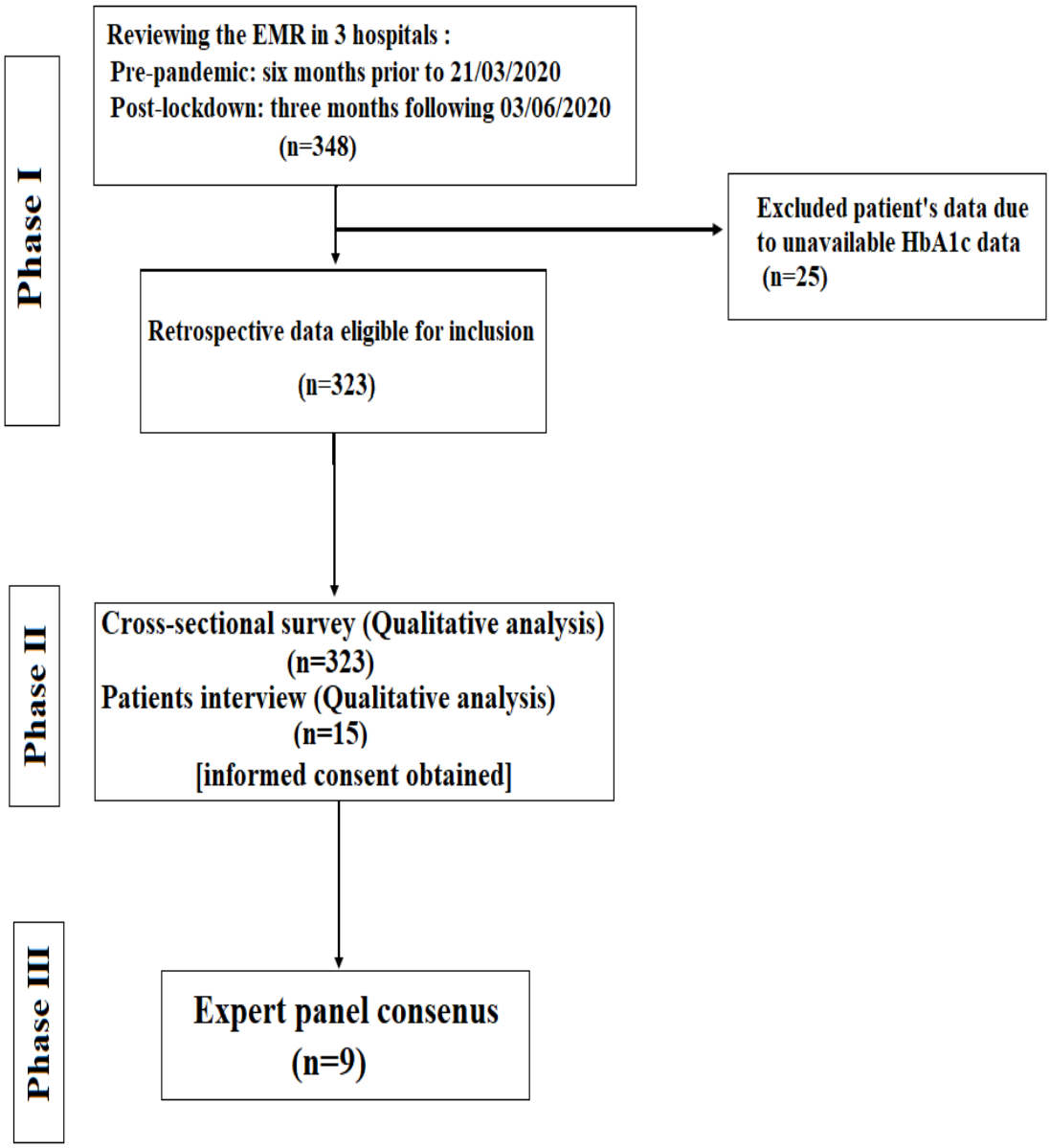


**Figure 2.1. Study phases diagram.**

## 2.3. Sampling strategies and sample size

### 2.3.1. Phase I and II sampling strategies and sample size

For phase I, the healthcare records were selected retrospectively using purposive sampling of 323 people with T2DM from electronic medical records at the Al Karak Public Hospital, Al Bashir Hospital, and Ma'an Hospital in Jordan during the two study sampling periods: pre-pandemic during the six months before 21/03/2020 and post-lockdown during the three months following 03/06/2020. Purposive selection criteria are listed at section 2.4.1.

For phase II, an internet-based survey consisting of four sections was sent to the patients whose data had been collected in Phase I. All patients were invited to a face-to-face interview of which 15 patients accepted the invitation. The data of these respondents were used for qualitative analysis.

Participants for Phases I and II were patients diagnosed with T2DM. The required sample size was estimated using Epi-Info Software (CDC, USA), assuming that the proportion of people with diabetes with inadequate glycaemic management was 30%. This percentage (30%) was based on the mean proportion of people with diabetes reported to have inadequate glycaemic management in the referenced studies (Al Dossari et al., 2019; Albasheer et al., 2018; Baltaci et al., 2015; Samancioğlu et al., 2017). The level of significance (α) was determined at 0.05, with a design effect of 1.0, and 5% error limits. The estimated sample size calculated for the given prevalence at a 95% confidence interval (CI) was 323.

$$n = \frac{z^2 \times \hat{p}(1-\hat{p})}{\varepsilon^2}$$

### 2.3.2. Phase III sampling strategies and sample size

Purposive and snowball sampling was used to choose Delphi participants (Patton, 1990). Firstly, panel members were purposively sampled with the following inclusion criteria:

- They were recognized as experts in nursing and midwifery workforce management and/ or education by their peers.
- They currently worked in Jordan in the field of nursing and midwifery and were recognised as knowledgeable and experienced in this field using the local knowledge of research team members and their networks to compile this.

The research team members prepared an initial list of key nursing and midwifery experts in Jordon. Chief Nursing Officers (CNO), managers, and directors of the selected health facilities were contacted via email and invited to participate or to suggest an appropriate representative from their or other health facilities. Next, using a snowball sampling approach, potential participants were invited to suggest other suitably qualified and experienced potential participants. The experts were selected based on the local knowledge of research team members and their networks, supplemented by the contacts and networks of the initial expert contacts.

For the sample for Phase III, the Delphi consultation, a panel of twelve expert nurses in the field was recruited, to ensure that the established accepted minimum of eight participants remained in the final round after allowing for drop-outs (Hallowell & Gambatese, 2010).

### 2.4. Participant selection

#### 2.4.1. Phase I and phase II participant selection

Phase I participants' data were sampled following the sequence of the date of their last pre-pandemic clinic attendance, from the list of patients meeting the following inclusion, and not meeting the following exclusion criteria.

Patients were included if they were:

1. Adult (18 years or above) at the time of inclusion
2. Medically diagnosed with T2DM
3. Resident in Jordan during the period immediately pre, during and post the first COVID-19 lockdown.
4. Had any of the following combinations of blood results recorded:
    - Two recorded measurements of HbA1c: one before the pandemic and one immediately post the lockdown.
    - Two recorded measurements of fasting blood glucose (FBG): one pre the pandemic and one immediately post the lockdown, in addition to one recorded measurement of HbA1c immediately post the lockdown.
    - Three recorded measurements of FBG: one pre the pandemic, one during the lockdown, and one immediately post the lockdown.

Patients were excluded if they:

1. Had been diagnosed with T2DM for less than six months.
2. Had been diagnosed with any form of diabetes other than T2DM.
3. Were pregnant, as this would have entailed additional medical attention unavailable to non-pregnant population (ACOG, 2015).

4. Had been diagnosed with COVID-19 or had experienced symptoms such as fever, cough, or respiratory difficulty during the lockdown period based on patients self-reporting, as these may be indicative of COVID-19.

Patients whose data were eligible for Phase I were invited to take part in the cross-sectional survey and interview which were conducted in Phase II.

### 2.4.2. Phase III participant selection

Panellists for this Phase were selected if they were:

1. Recognized as experts with more than 10 years of experience in nursing and midwifery workforce management and/ or education by their peers.
2. Working in Jordan in the field of nursing and midwifery and were generally regarded as knowledgeable and experienced in this field.

The research team members prepared an initial list of key nursing and midwifery expert in Jordon. Chief nursing officers (CNO), managers, and directors of the selected heath facilities were contacted via email and invited to participate or to suggest an appropriate representative from their or other health facilities, and to suggest other suitably qualified and experienced potential participants.

## 2.5. Data collection

### 2.5.1. Phase I:

Data were collected from the English-language electronic database of the three study site hospitals (Al Karak Public Hospital, Al Bashir Hospital, and Ma'an Government Hospital, Jordan), from records of attendances at out-patient diabetes clinics during the two study sampling periods:

**Pre-pandemic**: during the six months prior to 21/03/2020.

**Post-lockdown**: during the three months following 03/06/2020.

**Demographic, anthropometric and clinical data**:

Demographic data included age, gender, marital status, education level, income, and smoking status, while anthropometric data included height, weight and BMI. Definitions of demographic, anthropometric and clinical data measurements are set out in **Table 2.1**.

BMI is calculated as weight in kilograms divided by the height in metres squared. According to the WHO, BMI categorized as underweight is defined as a BMI of < 18.5 kg/m², normal weight is defined as a BMI of 18.5–24.9 kg/m², overweight as 25.0 -29.9 kg/m², while a BMI ≥ 30 kg/m² is defined as obesity (WHO, 2010). Clinical data extracted included diabetes duration and diabetes-related data (medications and administration methods) and detail of co-morbidities (diabetes-related and others). Laboratory results were extracted, including fasting blood glucose and HbA1c values recorded during the period before lockdown and the description of each measurement. After lockdown, HbA1c values for all patients were recorded as an indicator of mean glycaemia and risks for complications in people with T2DM (Little & Rohlfing, 2013)**.** Notably, FBG levels are indicative of short-term control (Abera et al., 2022). To accurately represent a patient's glycaemic management status, HbA1c is the gold standard test for measuring long-term glycaemic management over the previous 2-3 months (Sherwani et al., 2016). In line with the criteria

proposed by the American Diabetes Association, patients were divided into two groups based on their HbA1c levels: those with HbA1c levels < 7% were designated with adequate glycaemic management and those with HbA1c levels ≥ 7% were considered to indicate inadequate glycaemic management (American Diabetes Association, 2018; Almogati & Ahmed, 2019).

**Table 2.1** Definitions of demographic, anthropometric and clinical data measurements.

| Variable | Unit | Definition |
|---|---|---|
| Age | Years | Patient age at index (pre-lockdown) clinic attendance |
| Diabetes duration | Years | Patient diabetes duration at index (pre-lockdown) clinic attendance |
| Height | cm | Patient height at index (pre-lockdown) clinic attendance |
| Weight | Kg | Patient Weight at index (pre-lockdown) clinic attendance |
| BMI | $Kg/m^2$ | Patient BMI at index (pre-lockdown) clinic attendance |
| FBG | mg/dl | Patient FBG at index (pre-lockdown) clinic attendance |
| HbA1c | % | Patient HbA1c before the lockdown (6m before) and after the lockdown (3m after).<br>Patients were divided into two groups based on their HbA1c levels: those with HbA1c levels > 7% and those with HbA1c levels ≥7% were considered as indicating uncontrolled hyperglycaemia because the US ADA recognizes this level as indicating inadequate diabetes control (American Diabetes Association, 2018; Almogati & Ahmed, 2019). |
| Marital Status | - | Patient civil marital status at clinic attendance |
| Education level | - | Patient highest education level at index (pre-lockdown) clinic attendance [Primary, Secondary/High school, Vocational training, Bachelor degree, Master/Doctoral degree] |
| Domicile | - | Patient domestic status at index (pre-lockdown) clinic attendance [Living alone, Living with parents/guardians/relatives/ friends, Living with spouse] |
| Occupation | - | Patient occupational status at index (pre-lockdown) clinic attendance [Unemployed, Employed, Studying full time, Retired] |
| Income | US$ | Patient income level at index (pre-lockdown) clinic attendance |
| Diabetes medications | - | Types of diabetes medications that the patients received at index (pre-lockdown) clinic attendance |
| Comorbidities | - | The presence of one or more chronic conditions in the same person with diabetes (CVA, Gastric/Peptic ulcer, HTN, COPD/Asthma, CHF, CKD) at index (pre-lockdown) clinic attendance. |

### 2.5.2. Phase II:

Data were collected through a survey consisting of four sections which was accessed via a web-link sent to the participants via WhatsApp for self-completion at a time of their choosing or completed during a face-to-face interview when they attended the clinic for a routine out-patient attendance. The interview questions were: 'What was it like for you to manage your diabetes during the lockdown?' and 'How did you feel during the lockdown period in relation to your glycaemic control, compared to your usual control before the lockdown?' Demographic data and the two interview questions were prepared in English and then translated into Arabic (the local language) (**see Appendix 2.1)**. Validated Arabic translated versions of the questionnaire instruments were used. The Qualtrics Software platform was used to build the questionnaires. The survey and interviews were conducted in Arabic, translated by the researcher who is fluent in both languages and the translations were verified by Bernard Saliba. Bernard Saliba is an academic researcher and lecturer in the School of Public Health, (Faculty of Health, University of Technology Sydney) who is fluent in both Arabic and English and experienced in research in Arab-speaking communities.

Consenting patients were offered their choice of up to two ways to complete the survey:

- Complete the survey as a self-report questionnaire accessed via a web-link embedded in the invitation letter which was sent to them via WhatsApp.
- Complete the survey in a face-to-face interview conducted in a room at the clinic when they next attended for an outpatient clinic appointment.

Interviews were conducted in adherence to COVID-19 safety protocols and regulations in effect at the time. To ensure compliance and maintain both participant safety and data integrity, several adjustments were made to the interview methods. These adjustments were continuously refinconsed to remain compliant with the evolving COVID-19 guidelines throughout the interview period. The measures included:

1. **Interview Setting:** Where personal contact was permitted, interviews were held in well-ventilated spaces to facilitate social distancing. Seating arrangements were modified to ensure a minimum distance of at least 1.5 meters between participants and interviewers.
2. **Personal Protective Equipment:** Both the interviewer and participants wore masks throughout the interview to minimize the risk of transmission. Hand hygiene protocols were strictly observed, including the use of hand sanitizers before and after each interview.
3. **Health Screening:** Prior to scheduling interviews, Both the interviewer and participants were screened for COVID-19 symptoms and potential exposure risks. Interviews were rescheduled if participants exhibited any symptoms or had recent exposure.
4. **Documentation and Data Handling:** All physical documentation was minimized, and electronic methods were used to collect and store data. Any physical materials used were sanitized before and after each interview.

**Interview Guide:**

1. **Introduction:**
    - Greet the participant and explain the purpose of the interview.
    - Reiterate COVID-19 safety protocols being followed.
    - Obtain verbal consent to proceed with the interview.
2. **Demographic Questions:**
    - Age
    - Gender
    - Duration of diabetes management
3. **Open-Ended Questions:**
    - *What was it like for you to manage your diabetes during the lockdown?*
    - *How did you feel during the lockdown period in relation to your glycaemic control, compared to your usual control before the lockdown?*
4. **Conclusion:**
    - Ask if the participant has any additional comments or insights they would like to share.
    - Thank the participant for their time and contribution.

- Provide information on how the data will be used and the steps taken to ensure confidentiality.

In Phase II, the interview recruitment response rate was only 15 of 323 participants who agreed to participate in the interviews, which was less than expected. This could be due to the ongoing presence of COVID-19 cases in the country, which may have led to hesitancy among participants due to concerns about their health and safety. Despite the data collection being conducted post-lockdown, the fear of infection might have still been prevalent, influencing their decision to avoid further participation. Additionally, this highlights the continued impact of the pandemic on individuals' willingness to engage in research activities, even within a post-lockdown context.

**Participants were asked to complete a 4-section questionnaire:**

**1- Demographic data:**

This incorporated age, gender, marital status, education level, income, smoking status (see **Appendix 2.1**).

**2- Physical activity:**

Physical activity (PA) was obtained for the previous 7 days using the short, self-administered version of the International Physical Activity Questionnaire (Craig et al., 2003) (see **Appendix 2.1**). This questionnaire provided a common instrument that can be used to obtain internationally comparable data on health–related physical activity. It is available free of charge and can be found on the IPAQ website (https://sites.google.com/site/theipaq/home). Patients were asked about their work and sport physical activity, including type, pattern, duration and intensity, using the validated Arabic version of the short-form (A-IPAQ; Al-Hazzaa, 2007) (see **Appendix 2.1**). A-IPAQ provides specific details on PA in these four domains and differentiates between usual sitting time on a week-day and a weekend day. The questionnaire considers vigorous-intensity, moderate-intensity, and walking activities, in addition to the time spent sitting to assess a sedentary lifestyle. Based on their responses to PA, the participants were categorized into 1) Low, which is the lowest level of physical activity. Those individuals who do not meet criteria for categories 2 or 3 are considered low/inactive; 2) Moderate, which represents any one of the following three criteria: 3 or more days of vigorous activity for at least 20 minutes per day OR 5 or more days of moderate-intensity activity or walking for at least 30 minutes per day OR 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 600 MET-min/week; 3) High, which represents any one of the following two criteria: vigorous-

intensity activity on at least 3 days and accumulating at least 1500 MET-minutes/ week OR 7 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week) (Ipaq Research Committee, 2005).

The reliability and validity of the IPAQ has been tested in adult populations (Craig et al., 2003; Lee et al., 2011). The A-IPAQ showed a high internal consistency reliability with Cronbach's alpha ranging from 0.769-1.00 ($p < 0.001$) and intraclass correlation coefficient (ICC) ranging from 0.625-0.999 ($p < 0.001$) (Helou et al., 2018)**.**

**3- Diabetes self-management:**

The Summary of Diabetes Self-care Activities scale, used to evaluate participants' self-management practices, was initially developed by Toobert & Glasgow (1994) and Toobert et al. (2000), and translated from English to Arabic and validated for Arabic-speaking populations (Aljohani et al., 2016) **(See Appendix 2.1)**. Following the recommendation of the WHO, the modified Arabic version of the instrument was back-translated into English. The back-translated version was remarkably similar to the original instrument, with the exception that the phrase "seven days" in the final Arabic version was converted to "one week." As the original English version of the instrument used the phrase "seven days," this was retained in the final version, the Summary of Diabetes Self-care Activities- Arabic (SDSCA-Arabic).

The SDSCA-Arabic is an 11-item instrument comprising five subscales: diet (four items: general and food), exercise (two items), blood glucose testing (two items), foot care (two items), and smoking subscales (one item). The item on smoking habits was not included. Each item on the other four subscales was scored on an 8-point Likert scale ranging from 0 to 7 points. Mean item scores for the diet, exercise, blood sugar testing and foot care subscales were obtained as averages of all relevant items combined. Mean item scores for overall self-care activities were computed as

the average of diet, exercise, blood sugar testing and foot care. The smoking item was not included in the calculation of overall self-care activities. Higher scores indicated better self-care.

The reliability and validity scores of the SDSCA-A were as follows: test-retest, $r = 0.912$ and $p < 0.001$; split-half = 0.9; and Cronbach's alpha ($\alpha$) = 0.76 (Aljohani et al., 2016)**.**

**4- The Depression, Anxiety and Stress Scale:**

The Depression, Anxiety and Stress Scale (DASS) is a 21-item self-report measure in which participants rate the frequency and severity of experiencing the three related negative emotional states of depression, anxiety, and tension/stress over the previous week **(Appendix 2.1)** (Lovibond, 1995; Lovibond and Lovibond 1995)**.** This scale was designed to assess participants' current state or change in state over time and can be administered in groups or individually. Each item is answered according to the presence and intensity of each symptom in the last week on a 4-point Likert response scale, the limits of which range from 'nothing' to 'most of the time'. Each scale has seven items and its total score is calculated with the sum of the items belonging to that scale. Scores on the DASS-21 are multiplied by 2 to calculate the final score. The DASS sub-scale severity ratings are shown in **Appendix 2.1** (Lovibond, 1995; Lovibond and Lovibond 1995).

Ng and colleagues supported the validity of this tool as a routine clinical outcome measure in private in-patient and out-patient settings (Ng et al., 2007). The Cronbach alpha for each scale showed subscales values of 0.81, 0.89, and 0.78 for depression, anxiety, and stress respectively. Moreover, previous studies showed that the validity of each subscale was $r = 0.701$, $r = 0.650$, and $r = 0.658$ for depression, anxiety, and stress, all $p < 0.001$ (Coker et al., 2018). The Cronbach alpha for internal consistency test was done to study the reliability of DASS, exhibiting good reliability with Cronbach's alpha = 0.88.

This scale was translated into Arabic and estimates of internal consistency for the translated version were adequate (coefficient alpha = 0.88, 0.81, 0.76, and 0.67 for the four subscales) ( Ali et al., 2017). The Arabic version of DASS21 is used by health professionals and social work practitioners working in the health field. It is a dimensional instrument as the emotional syndromes assessed are themselves dimensional. It usually produces a smooth distribution of scores with most people in the low–medium range and fewer and fewer people at the higher (more severe) end of the dimension. Intensive clinical and social work intervention can be directed to fewer people at the higher (more severe) end of the dimension whereas non-intensive and non-clinical and social work intervention is more commonly oriented to many people in the low–medium range of the dimension. The validated Arabic Version of the Depression Anxiety Stress Scales (DASS) was used **(See Appendix 2.1)** (Moussa et al., 2017). The translated version of the DASS-21 is available on the official DASS website (http://www2.psy.unsw.edu.au/groups/DASS/) (Medvedev, 2023).

**5- Open questions**

Two open-ended questions were added to the questionnaire to be answered during the face-to-face interview. However, both questions were optional. The two qualitative questions were:

1- What was it like for you to manage your diabetes during the lockdown?
2- How did you feel during the lockdown period in relation to your glycaemic control, during the lockdown compared to your normal or usual control before the lockdown?

The two open-ended questions were added to give the participant the opportunity for unrestrained or free responses to discuss their experience during the lockdown, which may result in the identification and description of factors not covered by other questionnaire items.

### 2.5.3. Phase III:

A modified electronic Delphi consultation (Niederberger & Spranger, 2020) was used to generate, assess and achieve consensus among expert opinions and recommendations regarding the implications and recommendations for nurse education and practice arising as a consequence of the study findings.

The aim was to use a three-round modified Delphi study to establish consensus recommendations for nurse education and practice to optimize self-management and glycaemic control of people with T2DM (based on the findings of phases 1 and 2 of this study) in preparation for any future pandemic.

Initially, the expert panel was provided the findings of phases I and II of this study through a video recorded presentation, a Power Point slide pack and a written report via email. This recorded video was about 15 minutes long and presented by the researcher, accompanied by the Power Point slides that were presented and a brief written report of the same content. Participants were able to email any questions to the researcher, and responses were circulated to all participants.

**Round 1**: Following receipt of the above presentation of findings, Delphi participants were asked their opinions regarding the findings of this study, based on their responses to these questions.

- What are the implications of these findings for nursing practice?
- What are the implications of these findings for nursing and health service policy development or change?
- What are the implications of these findings for nursing education?
- What recommendations could be made to develop nursing practice to better manage care and support for people with T2DM during any future pandemic?

- What recommendations could be made to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic?
- What recommendations could be made to develop nursing education to better prepare nurses to support people with T2DM during any future pandemic?

Responses to these questions were sought via free-text email responses, with responses sent on the 'reply' option to the study researcher. The participants' responses to round 1 were collated, and duplicates were removed, but the number of times any one point had been made was retained. Each suggestion and recommendation were numbered consecutively.

**Round 2:** A confidential questionnaire was prepared that included all numbered responses; this was distributed to all experts individually via email. The questionnaire items asked participants to report their agreement or disagreement with each recommendation, and to justify their agreement or disagreement. Recommendations agreed upon by a minimum of eighty percent of experts were accepted and entered into round 3, while recommendations disagreed by a minimum of eighty percent of experts were rejected (Diamond et al., 2014).

**Round 3**: All the consensus recommendations that advanced to round 3 were sent to each expert individually, who were then requested to score each for importance and feasibility.

To ensure a comprehensive evaluation, a Likert scale ranging from 0 (lower) to 5 (higher) was employed in scoring each recommendation. This scale provided a clear framework for the experts to express their opinions on the importance and feasibility of the consensus recommendations. The Likert scale categories encompassed a spectrum of responses, ranging from: 0; Not at all important/not at all feasible, 1; Slightly important/slightly feasible, 2; Somewhat important/somewhat feasible, 3; Quite important/quite feasible, 4; Important/feasible, and 5; Very important/very feasible).

This dual assessment approach enabled a thorough evaluation of the recommendations from different perspectives, enhancing the reliability and robustness of the data collected. By capturing both the importance and feasibility aspects separately, a more nuanced understanding of the recommendations was obtained, considering their potential impact and practicality.

## 2.6. Data analysis

### 2.6.1. Phase I and phase II statistical considerations

All data analyses were performed using the Statistical Package for the Social Science (SPSS) Windows version 28.

**Descriptive statistics:**

Initially, Kolmogorov-Smirnov tests were used to check the normality of continuous data. According to the Kolmogorov-Smirnov Test of normality, the HbA1c variables in the 6 months pre-lockdown and the 3 months post-lockdown were not normally distributed with p values $< 0.05$. Continuous variables were presented as mean with standard deviation (SD) for normally distributed data and as median with inter-quartile range (IQR) for non-normally distributed data. Categorical data were presented as frequencies (n) and percentages (%).

**Quantitative data analyses:**

Glycaemic values during the pre-and post-lockdown periods were analysed using HbA1c and FBG. A comparison of glycaemic values during the pre-and post-lockdown periods was done using paired-t-tests for normally distributed numeric data. If the data were not normally distributed, the Wilcoxon signed-rank test was used.

Separate analyses were used to compare participants whose glycaemic values approximated to adequately-controlled and inadequately-controlled blood glucose using the well-accepted HbA1c cutoff values of the American Diabetes Association (Abera et al., 2022; American Diabetes

Association, 2021; Edwards, 2021). Those with HbA1c < 7% (FBG < 6.5 mmol/dL) were considered well controlled and those with HbA1c ≥ 7% (> 6.5mmol/dL) poorly controlled.

Comparison of people with adequately versus poorly controlled glycaemic values was done using independent samples-t test for normally distributed numeric variables after testing for the homogeneity of variance. Mann-Whitney U-test was utilized to compare the two groups when data were non-normally distributed and there were significant outliers in one or both groups. The Wilcoxon signed-rank test was used to study the difference between HbA1c values before and after the lockdown (paired data).

Categorical variables underwent a test of association using the Chi-square test for paired data or Fisher's exact test as appropriate. McNemar's test was used to study if there was a change in the glycaemic management status after compared to before the lockdown as these data were dichotomous.

A univariate binary logistic regression analysis was applied to evaluate the association between independent factors and the outcome of well-controlled versus inadequately-controlled glycemia pre and post lockdown. The independent factors included demographic factors (age, BMI, gender, marital status, education level, domicile, occupation and income), clinical characteristics (diabetes duration, smoking, the type of regular diabetes treatment, and co-morbidities, which were quantified by number per patient). These factors were first identified from the literature. Demographic factors such as age, BMI, gender, marital status, education level, domicile, occupation, and income can all influence the prevalence and management of diabetes. Also, older age and higher BMI are risk factor for T2DM. Social support from a spouse or family can play a role in managing diabetes, and education can impact health literacy, understanding of diabetes management, and compliance with treatment plans. Geographic location may influence access to

healthcare resources, lifestyle, and environmental factors that can affect diabetes management, while socioeconomic status, reflected in occupation and income, can impact access to healthcare, ability to afford medications, and overall health outcomes. Clinical characteristics such as diabetes duration, smoking, type of regular diabetes treatment, and comorbidities can also influence diabetes management. Longer durations of diabetes may be associated with a higher risk of complications, while smoking is a modifiable risk factor that can exacerbate diabetes complications. Understanding the prevalence of these factors in a population can guide public health interventions. Different treatment modalities (e.g., oral medications, insulin, lifestyle modifications) can impact glycaemic management and overall health outcomes, while presence of other health conditions alongside diabetes can complicate its management and influence overall health. Common comorbidities include cardiovascular disease, hypertension, and kidney disease (Pinchevsky et al., 2020). A comprehensive evaluation of factors influencing glycaemic management post-lockdown was also conducted using univariate binary logistic regression analysis, which included DASS-21, SDSCA, and IPAQ-A. Additionally, Cronbach's alpha coefficient for the Depression Anxiety Stress Scales (DASS-21), the Summary of Diabetes Self-Care Activities (SDSCA), and the International Physical Activity Questionnaire (IPAQ-A) in this study were calculated as a standard practice to ensure internal validity.

Next, multiple logistic regression was used to study the factors associated with inadequate glycaemic management while controlling for other factors pre and post lockdown. During multiple logistic regression modelling, the critical assumptions taken into account included independence, no multicollinearity, linearity, and absence of extreme outliers.

Firstly, the independence assumption was observed, ensuring that all observations were independent of each other. Secondly, multicollinearity was evaluated using correlation coefficients

and tolerance/variance inflation factors (VIF), seeking VIF values < 3 among the independent variables. Thirdly, linearity, the relationship between the independent variables and the dependent variable, was assessed through estimates of the normal Probability Plot (P-P) of the Regression Standardised Residuals, examining a standardized residual plot, correlation coefficients and scatter plots to ensure that the model's predictions were reliable. Finally, a test for extreme outliers in the data was conducted by checking skewness, kurtosis, and Mahalanobis Distance. All mean and median values and their measures of variability were formatted to two decimal places. All percentages were rounded to one decimal place. The significance level accepted was two-sided, with a type 1 error of 5%. The confidence interval (CI) was used at the level of 95%, and a p-value of 0.05 for outcome measures was considered statistically significant.

### 2.6.2. Qualitative data analyses

In this study, qualitative descriptive methods were employed as the qualitative research approach, supported by an adapted version of the Bruan and Clarke (2013) framework of thematic analysis. As suggested by Sandelowski (1995) the components of qualitative analysis overlap with data collection, analysis and interpretation, becoming part of the iterative approach of analysis and synthesis, as distinct from the linear approach of quantitative methods. The data analysis process was systematically guided by the six phases of thematic analysis as articulated by Braun and Clarke (2013).

Initially, phase one involved an in-depth familiarization with the data, where repeated readings were undertaken to ensure a comprehensive understanding of the content. In phase two, initial codes were generated, capturing significant features of the data relevant to the research questions. Excel was utilized as the data management system, facilitating the organization and coding of data efficiently. During phase three, patterns and themes began to emerge as these codes were organized

and reviewed to identify broader thematic constructs. In phase four, these preliminary themes were carefully refined and reviewed to ensure coherence and alignment with the data. The fifth phase involved further analysis and detailed description of the refined themes, ensuring that they accurately reflected the underlying patterns within the data. Finally, in phase six, the themes were interpreted, contextualized, and synthesized to construct a coherent narrative, culminating in the writing of the report. The entire process was underpinned by thematic analysis as the theoretical framework, following the guidelines established by Braun and Clarke (2013).

### 2.6.3. Analysis of Phase III data

In the first round, a panel of experts was consulted and provided a series of recommendations which were then synthesized and organized into a preliminary framework. Subsequently, these recommendations were carefully formatted into a confidential questionnaire for the second round of review.

In round two, the experts were asked to agree or disagree about these implications and recommendations.

During the third round, recommendations with a consensus agreement of 80.0% or more were accepted, whereas those with little to no agreement (< 20.0%) were rejected. Afterwards, the experts proceeded to rank these implications and recommendations based on their importance and feasibility, assigning scores ranging from 1 to 5, with 5 representing the highest degree of agreement. Mean (SD) scores were generated for the importance and feasibility of each item and topic, and a combined summary score of importance multiplied by feasibility scores was similarly calculated (Boyatzis, 1998). Processes to support implementation were ranked in order of the mean summary scores and then re-arranged according to the overall number from the highest to the lowest, reflecting the degree of agreement.

### 2.7. Storage and archiving of study documents

Data for this project were managed and stored in accordance with UTS data management policy, as appropriate to the classification of the data. A data management plan was created in Stash, and the audit data were extracted and initially stored on a secure drive of the hospital's network. Data were later uploaded to UTS OneDrive through a personalized link for data collectors and transferred onto password-protected UTS OneDrive with access limited to researchers on this application.

In terms of the web-based questionnaire, the received responses were downloaded in the form of an Excel sheet and added to the same folder of password-protected UTS OneDrive. The interview records and consent forms were also uploaded to the OneDrive folder, and another copy was stored at the secured device in the hospital.

Data kept on external hard drives were encrypted, and all laptops and external hard drives were password protected and kept in a locked cabinet in the researcher’s office. Supervisors also had copies of keys and passwords to access data in the event of misadventure. Data will be stored on the eResearch Store for 5 years.

At the end of the retention period, the data manager will review the data to confirm whether it is still in use. If the data is no longer required and there are no specific requirements for extended retention, the data will be securely destroyed in compliance with UTS and NHMRC guidelines. This process will involve secure deletion methods, including an electronic search to permanently delete any copies of the data. If the data is still needed, an additional retention period may be set.

## 2.8. Ethical Considerations

Study methods were developed to reflect standards of good clinical practice in research and to be compliant with the National Health and Medical Research Council guidelines (NHMRC, 2018).

### 2.8.1. Research Ethics

In phase I, demographic, clinical and biochemistry data of the eligible patients were collected from the healthcare record repositories of three hospitals; Al Karak Public Hospital, Al-Bashir Hospital, and Ma'an Government, with local Ethics Research and Ethics Committee approval from the Jordanian Ministry of Health (MOH; See **Appendix 2.2).** The data collection process for this phase was considered in Jordan to be a local audit, and therefore, the consent of the local management was required but individual consent from each patient participant was not required. Accordingly, the researcher sought and received appropriate approvals from all study site hospitals to provide access to patients' medical records for research purposes under the supervision of the responsible department for regulating clinical research protocols issued by the Jordanian MOH. This approach was taken because, whilst consent to access data stored in hospital records was sought and obtained for Phase I participants at the same time as their consent to participate in Phase II, the research team needed to know the identities of Phase I participants as inclusion in Phase I was a criterion for recruitment to Phase II.

Approval for the study to proceed was granted by the University of Technology Sydney Health and Medical Research Ethics Committee for Phase I and Phase II (ETH22-6925 and ETH216333) (See **Appendix 2.2).** This was in addition to the approval from the Jordanian Ministry of Health Scientific Research Ethics Committee.

For Phase III, UTS Ethics Approval (ETH22-7224) was obtained, as evidenced by the documentation provided in **Appendix (2.2)**.

### 2.8.2. Informed Consent

Due to the retrospective nature of the Phase I, a waiver of consent was obtained by the Medical Research Ethics Committee at UTS. In Phase II, the contact details (phone and email) needed to invite participation in this Phase were stored in the databases of the hospitals. At each clinical centre, a research collaborator who was clinically entitled to access the local database and the records of people with diabetes generated a list of eligible people with their contact details.

The listed patients received an invitation to participate in the study from these healthcare personnel (study site HCPs), sent to the email address held on file for them. In the invitation letter, the patients were invited to provide consent to participate in the study via allowing access to their health records, including their biochemistry results (Phase I), and completion of a survey (Phase II, including optional qualitative questions).

Phase I involved the analysis of data from eligible participants' medical records and these data were subsequently analyzed alongside phase II data. Accordingly, patient data for individuals who did not agree to participate in both Phases I and II of the study were excluded from the original download of Phase I data. Data were extracted to MS Excel and stored on a secure online data collection platform (UTS OneDrive). The Research Data Management Plan (RDMP) is shown **Appendix 2.2.**

All patients participated voluntarily in this study and were informed of all procedures as per study protocol, including the topic of the research and what types of questions they would be asked. This enabled them to decide if they wanted to participate. In addition, they were assured they had the right to withdraw at any stage while completing the relevant surveys without having to give a

reason. During the interview, the participants had the right not to answer any question and to terminate the interview without having to give a reason. The UTS Consent Matters Subject certificate is shown in **Appendix 2.2.**

### 2.8.3. Confidentiality

Individual interview locations were selected to ensure privacy and confidentiality and ensure the participant's view was heard. The researcher delivered the survey verbally, audio recorded participants' responses and took field notes (Cartagena et al., 2022). To maintain confidentiality, participants' identifiable personal information, such as names, medical identifiers, etc., was protected by allocation of a unique code number to each participant; use of participants' names was avoided, or any other details that could identify them, which were maintained separately in a coding sheet. Participant coding sheets, digital recordings, and interview transcripts were securely stored in a locked filing cabinet at a secured location. At the end of the research, all documents and records except the transcripts will be destroyed. Permanently de-identified interview transcripts will be kept in a secure place for five years and then will be destroyed. Only members of the research team have access to permanently de-identified interview transcripts. No personal information, such as names, was or will be included in any documentation or publication, and confidentiality will be maintained in all communication of findings to ensure the privacy of our participants.

During phase III, survey responses were collated confidentially using a unique identifying number known only to the participant and the lead investigator. All responses were kept strictly confidential, and the identities of the participants were not disclosed. Direct quotes from free-text answers were used as part of the Delphi iterations, but these quotes are not traceable back to individual participants. The survey responses were collected online using a personalized link for

data collectors and downloaded onto a password-protected UTS OneDrive with access limited to researchers on this application to allow analysis by the research team.

### 2.9. Safety

Phase II: Ensuring the physical and psychological safety of research participants was at the heart of the research project. Consideration of the participant's ethical values (e.g., autonomy, privacy, dignity, and integrity) and protection from physical, psychological, social, or spiritual distress were factored into the research process.

The risk of stress, discomfort or distress was anticipated to be low with no more than minor discomfort potentially arising as a result of recall of the events of the pandemic. In case of distress however, the following protocol was agreed in advance for face to face interviews.

In the event of any stress, discomfort or distress, the interview would be stopped, and the researcher would offer immediate support to the participants. The participant's wellbeing would be checked; if the participant felt able to continue the interview, it could continue; if not, the researcher would encourage the participant to contact their GP or mental health provider, or the researcher would contact the healthcare team after obtaining consent from the participant.

Given the context of the Jordanian healthcare system, where access to healthcare, including General Practitioners (GPs) and mental health services, can be influenced by factors such as cost and geographic location, alternative support options were considered. As a result, participants were provided with information about free or low-cost mental health services and support hotlines available in Jordan. These options were included to ensure that participants had access to the necessary support regardless of their financial situation or proximity to healthcare providers. All participants opted to conduct the interviews face-to-face during their routine outpatient clinic

attendance, which took place at the hospital site. This setting was particularly beneficial as it provided immediate access to medical and psychological support if needed, ensuring that any stress or discomfort experienced by participants could be promptly addressed. Phase III: No harms were anticipated for Phase III participants.

Awareness and alertness to the potential for distress were maintained by being attuned to nonverbal cues, changes in body language, and subtle signs of discomfort that participants might display, especially during face-to-face interviews given the sensitivity of the nature of the questions and topics discussed. Participants were also informed of their right to decline to answer any question or discuss any topic that might make them uncomfortable. This approach aimed to foster an environment that encouraged participants to feel respected and in control, thus able to voice their concerns freely. If any participant showed signs of distress or requested a pause, researchers were fully prepared to stop the interview immediately.

No participant expressed or communicated any indication of stress, discomfort or distress during Phase II or Phase III data collection.

Following the interview, participants were given the option of debriefing or additional support while ensuring the utmost confidentiality of their answers. Ethical considerations regarding the confidentiality of participants' responses were strictly taken into account, with the assurance that any distress expressed during the interview would be handled with the utmost care.

At all times the researcher and participants met the local requirements for COVID-Safe interviewing, e.g., wearing a face mask, use of alcohol hand sanitizer, maintaining the recommended distancing, checking for any symptoms suggestive of COVID-19, temperature checking on entry and conducting the interview outdoors if possible and acceptable to the participant.

## 2.10. Rigor of the study

Ensuring the rigor of this study was paramount across all phases, with specific methods employed to guarantee the validity and reliability of the data collected.

**1. Phase 1 and Phase 2 Quantitative Components:**

**Phase 1: Data Collection from Health Records**

In Phase 1, data were meticulously collected from the English-language electronic databases of the three study site hospitals. A standardized protocol was developed and adhered to, incorporating specific inclusion and exclusion criteria as detailed in section 2.4.1. This protocol ensured the consistency and relevance of the data extracted, minimizing the risk of bias and enhancing the reliability of the data set.

**Phase 2: Surveys and Questionnaire Validation**

In Phase 2, validated Arabic versions of widely recognized questionnaires were utilized to assess physical activity, diabetes self-management, and psychological health among participants:

a. Physical Activity Questionnaire: The Arabic version of the International Physical Activity Questionnaire (A-IPAQ) was used to measure participants' physical activity levels. The reliability and validity of the IPAQ have been established in adult populations, with Cronbach's alpha ranging from 0.769 to 1.00 and an intraclass correlation coefficient (ICC) from 0.625 to 0.999, both with significant p-values (Helou et al., 2018). These metrics confirm the A-IPAQ as a reliable tool for this study.

b. Diabetes Self-Management Questionnaire: The Arabic version of the Summary of Diabetes Self-care Activities (SDSCA-Arabic) was employed to assess participants' diabetes self-management behaviors. The SDSCA-A has demonstrated strong reliability and validity, with a test-retest correlation of $r = 0.912$, a split-half reliability score of 0.9,

and a Cronbach's alpha of 0.76 (Aljohani et al., 2016), making it a robust measure for this study.

c. Depression, Anxiety, and Stress Questionnaire: The Arabic version of the Depression Anxiety Stress Scales (DASS) was used to evaluate the psychological state of participants. This tool has shown good reliability and validity, with Cronbach alpha values of 0.81, 0.89, and 0.78 for depression, anxiety, and stress subscales, respectively, and validity correlations of $r = 0.701$, $r = 0.650$, and $r = 0.658$ for each subscale, all with $p < 0.001$ (Ng et al., 2007; Coker et al., 2018). The overall reliability of the DASS was confirmed with a Cronbach's alpha of 0.88.

These rigorous measures ensured that the data collected in Phase 1 and Phase 2 were both valid and reliable, providing a solid foundation for the study's findings.

**2. Phase 3 and Phase 2 Qualitative Components**

**Phase 2: Qualitative Data Collection and Analysis**

In Phase 2, qualitative data were collected through interviews with patients whose data were eligible from Phase 1. A qualitative descriptive approach was adopted, guided by an adapted version of Braun and Clarke's (2013) framework for thematic analysis. To ensure the rigor of the qualitative component, the demographic data and interview questions were initially prepared in English and then translated into Arabic, the local language, by the researcher, who is fluent in both languages. The translations were verified by Bernard Saliba, an academic researcher and lecturer fluent in both Arabic and English, with extensive experience in research involving Arab-speaking communities. This process of translation and verification ensured the cultural and linguistic accuracy of the data collection instruments, thereby enhancing the validity and reliability of the qualitative data.

**Phase 3: Delphi Consultation Process**

In Phase 3, the Delphi consultation was conducted with a purposively sampled panel of experts recognized for their knowledge and experience in nursing and midwifery workforce management and education. The inclusion criteria for the panel members, as outlined in section 2.3.2, ensured that only individuals with substantial expertise in the relevant fields participated in the consultation. The use of local knowledge from research team members and their networks to identify suitable panel members further ensured that the Delphi process was grounded in the contextual realities of nursing and midwifery in Jordan. This careful selection process contributed to the reliability and validity of the consensus reached through the Delphi method.

By employing these comprehensive and methodologically sound approaches across both the quantitative and qualitative components of the study, the research maintained a high level of rigor, ensuring the credibility and reliability of its findings.

## 2.11. The role of the researcher

As the researcher of this study, my background in healthcare has played a significant role in shaping my motivation and approach. I began my career as a Registered Nurse, working directly with patients and gaining firsthand experience in clinical settings. Following this, I transitioned to the role of a Clinical Instructor, where I was responsible for educating and guiding nursing students. This combination of practical and educational experience has deeply informed my understanding of patient care, and the challenges faced by healthcare professionals.

My motivation for conducting this study stems from a desire to contribute to the field of diabetes management, particularly in the context of the COVID-19 pandemic. My previous experience as a Registered Nurse at one of the study sites, though limited to a nine-month period in 2014, provided me with valuable insights into the complexities of patient care in such environments.

However, I do not have any current links or affiliations with the study sites or participants, ensuring that my past connections do not influence the study's outcomes.

To manage any potential biases arising from my background, I engaged in regular discussions and debriefing sessions with my supervisors throughout the research process. These sessions, along with the ethical approvals obtained from my university in Australia and the study sites in Jordan, were instrumental in maintaining the objectivity and integrity of the study. Additionally, I remained vigilant about any personal biases that could affect my reporting, ensuring that they were acknowledged and addressed as part of the research process.

Regarding the ethical considerations of power dynamics, it is important to clarify that none of the patient participants were aware of my previous clinical or professional roles. They regarded me solely as a student researcher, as described in the Information Statement provided to them. This distinction was carefully maintained to prevent any potential power imbalances and to ensure that participants felt comfortable and uninfluenced by my professional background.

# 3. CHAPTER 3 LITERATURE REVIEW

This chapter presents a systematic review and meta-analysis of glycaemic control and its associated factors in patients with type 2 diabetes in the Middle East and North Africa (MENA) regions. This study addressed the first research question of this thesis:" What is known about glycaemic management and associated factors in patients with type 2 diabetes in the Middle East and North Africa?".

This chapter is based on an article published in the Journal of Advanced Nursing and available in **Appendix 3.1**. It is cited as follows:

Al-Ma'aitah, O., Demant, D., Jakimowicz, S., Perry, L. (2022) Glycaemic control and its associated factors in patients with type 2 diabetes in the Middle East and North Africa: An updated systematic review and meta-analysis. Journal of Advanced Nursing 78, 2257-76 https://doi.org/10.1111/jan.15255

**Abstract**

**Aims:** To examine the patient-related factors that have been linked to glycaemic control in people living with type 2 diabetes mellitus in Middle Eastern countries.

**Design:** A systematic review and meta-analysis.

**Data sources:** A computerized search was conducted using the databases MEDLINE (via PubMed and Ovid), EMBASE, Scopus and CINAHL to identify peer-reviewed articles published in English between 1 January 2010 and 21 May 2020. On 28 June 2021, the search was updated with the same keywords and databases; however, no further relevant studies were identified.

**Review methods:** Extracted data were analysed using Review Manager 5.4.

**Results:** The final sample consisted of 54 articles with a total of 41,079 participants. Pooled data showed an increased risk of inadequate glycaemic control in smokers [OR = 1.26, 95% confidence interval (CI): 1.05, 1.52; p = .010], obese patients (OR = 1.30, 95% CI: 1.10, 1.54; p = .002), patients with elevated waist to hip ratio (OR = 1.62, 95% CI: 1.16, 2.26; p = .004) and longer disease duration (OR = 2.01, 95% CI: 1.64, 2.48; p < .001). A lower risk of inadequate control was associated with physical activity (OR = 0.40, 95% CI: 0.24, 0.67; p < .001) and self-management (OR = 0.49, 95% CI: 0.29, 0.82; p = .006).

**Conclusion:** These findings highlight the opportunity to address factors to improve glycaemic control. Further longitudinal studies are required to better understand these variations, to assess all predictors of glycaemic control in participants with type 2 diabetes, and to provide a strong basis for future measures to optimize glycaemic control.

### 3.1. Introduction

Diabetes is a major public health issue with an increasing burden globally (Johar et al., 2019). The latest data show that in 2019, 463 million adults were living with diabetes. It has been estimated that, without action to reduce the rising prevalence, by 2030, 578 million people will live with diabetes (Duke et al., 2019). One of the most affected areas is the Middle Eastern and North African (MENA) region, where approximately 54.8 million adults aged 20-79 were living with diabetes in 2019 (Duke et al., 2019). It was estimated that the number of patients with diabetes in the MENA region will reach 76 million by 2030 (Duke et al., 2019). Effective management of diabetes is, therefore, a priority for the countries of this region.

If not properly controlled, diabetes and its complications can result in frequent hospital admissions and premature death. Glycaemic control is a fundamental determinant of the prognosis of diabetes

(Mamo et al., 2019). As a result, it is targeted by physicians to prevent diabetes-related complications and mortality (Khattab et al., 2010). A wide variety of factors are associated with glycaemic control among participants with Type 2 Diabetes Mellitus (T2DM); these include demographic factors such as age, gender, marital status, and education (Abdullah et al., 2020; Aghili et al., 2016). Lifestyle parameters have also been linked with T2DM, such as smoking, obesity, and physical inactivity (Al Slamah et al., 2020). In addition, correlations have also been noted between psychological status (e.g., depression and anxiety) and glycaemic status (Ahmadian et al., 2018; Al Hayek et al., 2014). Many of these factors have the potential to be influenced by the local context and cultural considerations. However, little information is available to inform priorities for the MENA region and clinical guidelines to direct healthcare professionals on how this information may be used to improve health and prevent or delay the onset of the complications of diabetes.

## 3.2. Review methods

### 3.2.1. Aims

Given the high and rising prevalence of T2DM in the MENA region, and to minimize cultural and geographic heterogeneity, this systematic review and meta-analysis was conducted to examine the patient-related factors that have been linked to glycaemic control in people living with T2DM in the MENA region, in order to make recommendations for locally appropriate diabetes care.

### 3.2.2. Design

This systematic review and meta-analysis followed the Preferred Reporting Items of Systematic Reviews and Meta-analysis (Moher et al., 2016). Review methods and analyses were conducted in accordance with international recommendations (Agency for Healthcare Research and Quality,

2014; Welch, 2019). The protocol of this study has been registered in PROSPERO (https://www.crd.york.ac.uk/prospero/; ID:CRD42021227250).

### 3.2.3. Search methods

A search strategy was developed based on the format of PEO: P (population), E (exposure, in this review interpreted as characteristics) and O (outcome). The search strategy was structured as follows:

P: Participants with T2DM living in Middle Eastern countries (Jordan, the United Arab of Emirates, Bahrain, Iraq, Saudi Arabia, Kuwait, Yemen, Iran, Syria, Israel, Oman, Palestine, Qatar, Lebanon, Egypt, and Turkey (TeachMideast, 2020).

E: Exposure (or characteristics) included demographic details (age, gender, race or ethnicity, education, marital and employment status); clinical characteristics (insulin use, duration of diabetes, body mass index, and waist-hip ratio); behavioural variables (smoking, diet, and physical activity); and mental and physical wellbeing characteristics such as anxiety and depression. Characteristics were chosen where they were examined in included studies, where there was a recognised rationale for a potential link to glycaemic control.

O: Outcomes sought were glycaemic control.

A computerized search was conducted using databases MEDLINE (via PubMed and Ovid), EMBASE, Scopus, and CINAHL identify peer-reviewed articles published in English between January 1, 2010 and May 21, 2020. On June 28, 2021, the search was updated with the same search strategy and databases; however, no further relevant studies were identified. Additionally, all reference lists of included and any review articles were checked for potentially relevant studies.

MESH terms were applied, and synonyms identified and used as keywords, linked with Boolian operands, as follows:

LINE 1: (“Non-insulin-dependent diabetes”, “Diabetes Mellitus, Type 2”, “Type II diabetes”, “Type 2 diabetes”, “NIDDM”)

AND

LINE 2: ("Middle East" OR "Jordan" OR "UAE" OR "Bahrain" OR "Iraq" OR "Saudi Arabia" OR "Kuwait" OR "Yemen" OR "Iran" OR "Syria" OR "Israel" OR "Oman" OR "Palestine" OR "Qatar" OR "Lebanon" OR "Egypt" OR "Turkey")

AND

LINE 3: (“Glycaemic control”, “Glycaemic Control”, “Blood Glucose”, “Hemoglobin A1c”, “HBA1c”)

NOT

LINE 4: (child* or kid* or adolescen*)

### 3.2.4. Eligibility criteria

To be included in the review, studies had to meet the criteria set out in the PEO framework. Studies were also required to be observational in design (case-control, cohort, or cross-sectional studies). Studies that were not available in English; animal studies; case-reports or not full reports of primary research (e.g. conference abstracts, and review articles) were excluded.

### 3.2.5. Search outcomes

Citations were downloaded into EndNote x9, and duplicate studies were removed using the "Remove duplication" function. Two independent reviewers (OA and SJ) screened the retrieved articles in two steps. First, only the titles and abstracts were independently screened to remove papers not meeting eligibility criteria. Then, the full-texts of the remaining papers were retrieved for full-text screening of their eligibility for inclusion. Full-text screening focused predominantly on the methods and results sections to confirm the eligibility of the study and provision of relevant data. Any discrepancies between reviewers' decisions were addressed in discussion of the eligibility criteria with the third reviewer (LP).

### 3.2.6. Data abstraction

A standardized extraction form was prepared using MS Excel (Microsoft, Redmond, Washington, USA), including the domains shown in **Table 3.1**. Data extraction was done independently by two investigators (OA and SJ), with any discrepancies resolved in discussion with a third reviewer (LP). Missing odds ratios were calculated with Review Manager 5.3 using the required data (event and total of experiment and control groups). Missing standard deviations (SD) were calculated from the standard error (SE) with the following formula:

$$SD=SE \times \sqrt{N}$$

and from the confidence interval (CI) using this formula:

$$SD= \sqrt{N}\times(\text{upper limit-lower limit})/3.92$$

The Newcastle-Ottawa Scale (NOS) for observational studies (Case-control, Cohort, and Cross-sectional studies) was used (Wells et al., 2014) to critically appraise all included studies **(Appendix 3.2).**

### 3.2.7. Synthesis

Data were analyzed in three forms based on our objectives:

1) We performed a generic inverse variance analysis using the logarithmic odds ratio and standard error (LogOR and SE) to identify the association between glycaemic control and characteristics reported as associated with glycaemic control in bivariate analyses, such as age, gender, marital status, education, mental status, physical activity, smoking, obesity, and self-monitoring.

2) We used the Inverse Variance (I-V) model to calculate the mean difference (MD) between adequate (HbA1c less than 7) and inadequate (HbA1c equal to or more than 7) levels of glycaemic control according to participants' characteristics such as age, Body mass index, and duration of diagnosis (ADA, 2021).

3) Moreover, we used the I-V model to calculate the MD of HBA1c according to the studied groups (male vs female, current smokers vs non-smokers, older (≥50 years) vs younger aged (<50 years), obese (BMI ≥30 kg/m2) vs non-obese (BMI <30 kg/m2)) (World Health Organization, 2020).

Data analysis was performed using Review Manager Version 5.3 for windows.

### 3.2.8. Sensitivity analysis and publication bias

According to Egger and Smith (1998), publication bias assessment is reliable where ≥10 studies are pooled. Therefore, we assessed the publication bias using funnel plots and the Egger test. We

performed a sensitivity analysis to ensure that none of the included studies affected the results and whether the overall effect size was statistically robust. We excluded one study in each scenario to determine the effect of each study on the overall effect size (Agency for Healthcare Research and Quality, 2014).

## 3.3. Results

### 3.3.1. Study selection

The literature search of databases yielded 3,345 records. Following the title/abstract and full-text screening, 54 articles with a total of 41,079 participants were retained for inclusion in the systematic review. Of these, 32 articles reported adequate and relevant data for inclusion in the meta-analysis. The flow of the study selection process is shown in **Figure 3.1.**

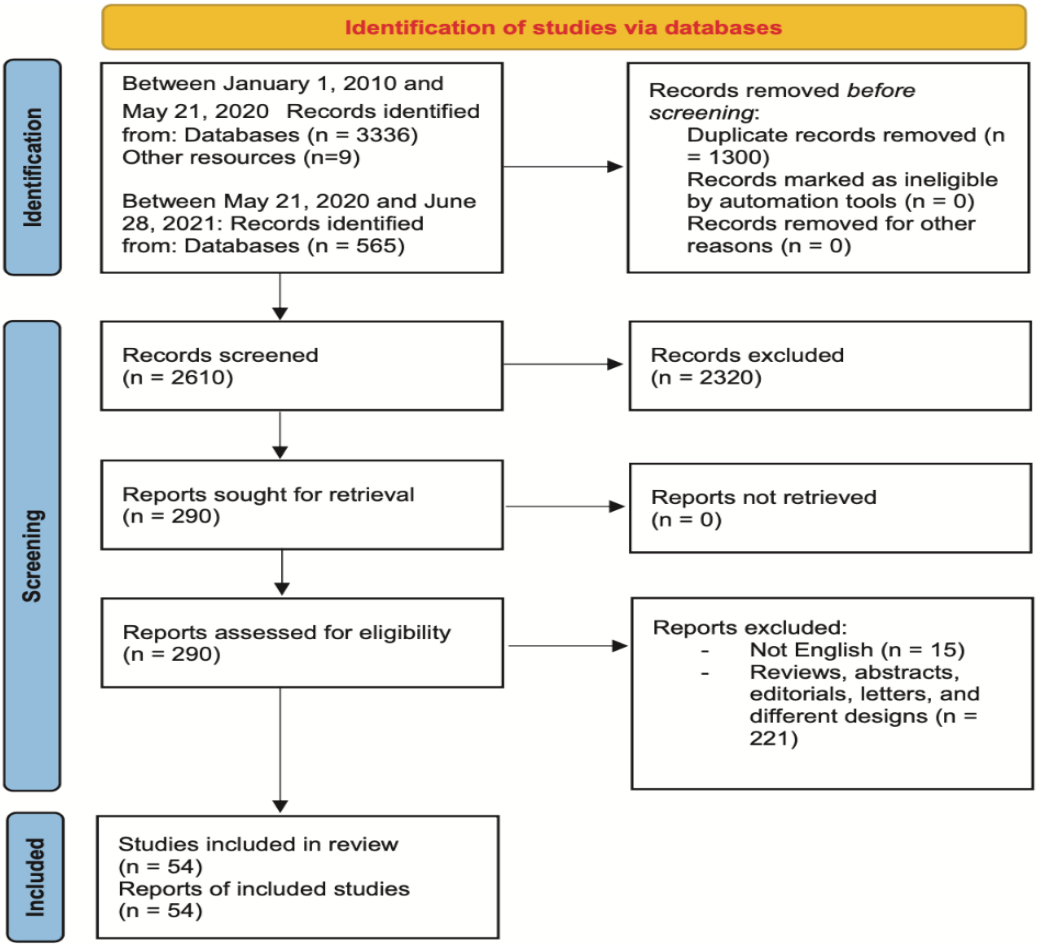


**Figure 3.1 PRISMA Flow diagram of included studies.**

### 3.3.2. Study characteristics.

Of the included studies, 17 articles were conducted in Saudi Arabia, seven each in Turkey and Iran, six in Jordan, three each in Iraq and Palestine, two each in Egypt, Bahrain, Kuwait and Oman, and one each in Lebanon, United Arab Emirates, and Yemen. Forty-nine studies were cross-sectional, and five were cohort studies. Both genders were represented equally in the majority of the included studies. A total of 34 studies reported participants' level of education, with an average of 79.6% being university-level educated. Insulin therapy was reported in 33 studies, on average

used by 38.8% of participants. Obesity was reported in 47.6% of the participant population, and 25.5% were smokers. Uncontrolled diabetes (HbA1c >7%) was reported in 63% of the participants. Appendix 3.3 shows the baseline characteristics of the included studies and participants.

### 3.3.3. Quality of included studies.

The quality of included studies, assessed using the NOS tool, ranged from good to very good for cross-sectional studies, and was deemed very good for all included cohort studies (**Table 3.2**).

**Table 3.1. Quality assessments of included cross-sectional studies.**

| Cross-Sectional Studies | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Study ID** | **Selection** | | | | **Comparability** | **Outcome** | | **Quality Score** |
| | Ascertainment of the exposure (risk factor) | Non-respondents | Sample size | Representativeness of the sample | The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled. | Assessment of the outcome | Statistical test | |
| Abdullah et al.(2020) | ** | * | * | * | ** | ** | * | 10 |
| Abuhegazy(2017) | ** | | | * | ** | ** | * | 8 |
| Adham et al.(2010) | ** | * | * | * | ** | ** | * | 10 |
| Aghili et al.(2016) | ** | * | | * | ** | ** | * | 9 |
| Ahmadian et al. (2018) | ** | | | | ** | ** | * | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Al-Hayek et al. (2012) | ** | | | * | ** | ** | * | 8 |
| Al Saweer (2015) | ** | | | * | ** | ** | * | 8 |
| Al Slamah et al. (2020) | ** | * | * | * | ** | * | * | 10 |
| ALAboudi et al. (2016) | ** | * | | * | * | ** | * | 8 |
| Al Balushi et al. (2014) | ** | * | | * | ** | ** | * | 9 |
| Albasheer et al. (2018) | ** | * | * | * | * | ** | * | 9 |
| Al Dossari et al. (2019) | ** | * | * | * | * | ** | * | 9 |
| AL-Eitan et al. (2016) | ** | | | * | * | ** | * | 8 |
| Al Hayek et al. (2014) | ** | | | * | ** | ** | * | 8 |
| Ali et al. (2013) | ** | | | | ** | ** | * | 7 |
| Al-Lawati et al. (2012) | ** | | * | * | * | ** | * | 8 |
| Almetwazi et al. (2019) | ** | | | * | * | ** | * | 7 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Al-Mukhtar et al. (2012) | ** | | | * | * | ** | * | 7 |
| Awwad Al qahtani et al. (2015) | ** | | | * | * | ** | * | 7 |
| Alqudah et al. (2019) | ** | | * | * | * | ** | * | 8 |
| Alramadan et al. (2018b) | ** | | * | * | * | ** | * | 8 |
| Al-Rasheedi (2014) | ** | | * | * | ** | ** | * | 9 |
| Alromaihi (2019) | ** | | | * | * | ** | * | 7 |
| Al-Shahrani et al. (2012) | ** | | | * | * | * | * | 6 |
| Azadi et al. (2020) | ** | * | * | * | * | ** | * | 9 |
| Baltaci et al. (2012) | ** | | | * | ** | ** | * | 8 |
| Baltaci et al. (2015a) | ** | | | * | ** | ** | * | 8 |
| Channanath et al. (2018) | ** | | | * | * | ** | * | 7 |
| Cosansu & Erdogan (2013) | ** | | | * | ** | ** | * | 8 |
| Greenberger et al. (2014) | ** | | | | * | ** | * | 6 |
| Gucuk (2015) | ** | | | * | ** | ** | * | 8 |
| Habib (2013) | ** | | | * | * | ** | * | 7 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Jahanlou & Alishan (2011) | ** | | | * | * | ** | * | 7 |
| Khattab et al. (2010) | ** | | | * | * | ** | * | 7 |
| Maddah & Attarpour (2016) | ** | | | * | * | ** | * | 7 |
| Megahed & Farg (2020) | ** | | | * | * | ** | * | 7 |
| Mirahmadizadeh et al. (2020) | ** | * | * | * | ** | ** | * | 10 |
| Mosleh et al. (2017) | ** | | * | * | ** | ** | * | 9 |
| Nemeh A et al. (2011) | ** | | * | * | ** | ** | * | 9 |
| Noureddine et al . (2014) | ** | | | * | ** | ** | * | 8 |
| Al Nozha (2014) | ** | | * | * | ** | ** | * | 9 |
| Qteishat & Ghananim (2016) | ** | | | * | ** | ** | * | 8 |
| Radwan et al.(2017) | ** | | * | * | ** | ** | * | 9 |
| Saad et al. (2018) | ** | | | * | ** | ** | * | 8 |
| Saghir et al. (2019) | ** | | * | * | ** | ** | * | 9 |
| Samancioglu et al.(2017) | ** | | * | * | ** | ** | * | 9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Samara et al.(2017) | ** | | * | * | ** | ** | * | 9 |
| Sürücü et al.(2017) | ** | | * | * | * | ** | * | 8 |
| Tol et al. (2012) | ** | | | * | * | ** | * | 7 |
| Yacoub et al. (2011) | ** | | | * | * | ** | * | 7 |

**Table 3.2. Quality assessments of included cohort studies.**

| Cohort Studies | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Study ID** | **Selection** | | | | **Comparability** | **Outcome** | | | **Quality Score** |
| | Representativeness of the exposed cohort | Selection of the non-exposed cohort | Ascertainment of exposure | Demonstration that outcome of interest was not present at start of study | Comparability of cohorts on the basis of the design or analysis controlled for confounders | Assessment of the outcome | Was follow-up long enough for outcomes to occur | Adequacy of follow-up of cohorts | |
| Akin (2019) | * | | | * | ** | * | * | * | 7 |
| Almutairi & Alkharfy, (2013) | * | | * | * | ** | * | * | * | 8 |
| Alzaheb & Altemani (2018) | * | * | * | * | ** | * | * | * | 9 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Alzahrani et al. (2019) | * | * | * | * | ** | * | * | * | 9 |
| Mansour et al. (2020) | * | | * | * | ** | * | * | * | 8 |

**Each (*) mean 1 on the score of NOS, and the final column count the total of these stars to give a final decision.**

### 3.3.4. Characteristics of the participants linked to glycaemic control.

**Older age (>50 years):** Overall effect estimates of 17 studies showed no significant association between risk of inadequate glycaemic control and older age (>50 years) (OR= 0.97, 95% CI: 0.90, 1.05; p = 0.49) (**Figure 3.2)**. Overall pooled data were heterogenous (I2= 73%, p< 0.0001). A subgroup analysis showed no significant association between risk of inadequate glycaemic control and older age in Saudi Arabia (OR= 0.84, 95% CI: 0.69, 1.01; p = 0.06) and Jordan (OR= 1.43, 95% CI: 0.89, 2.29; p = 0.14). In studies conducted in Palestine, older participants were associated with a lower risk of inadequate glycaemic control (OR= 0.97, 95% CI: 0.94, 1.00; p = 0.02). Pooled data in the subgroup analysis were homogenous (I2= 0%, p = 0.62),. Moreover, participants with adequate glycaemic control were older than those with inadequate glycaemic control (MD= 0.70 years, 95% CI: 0.11, 1.29; p = 0.02), and the pooled data were homogenous (I2= 28%, p = 0.18).

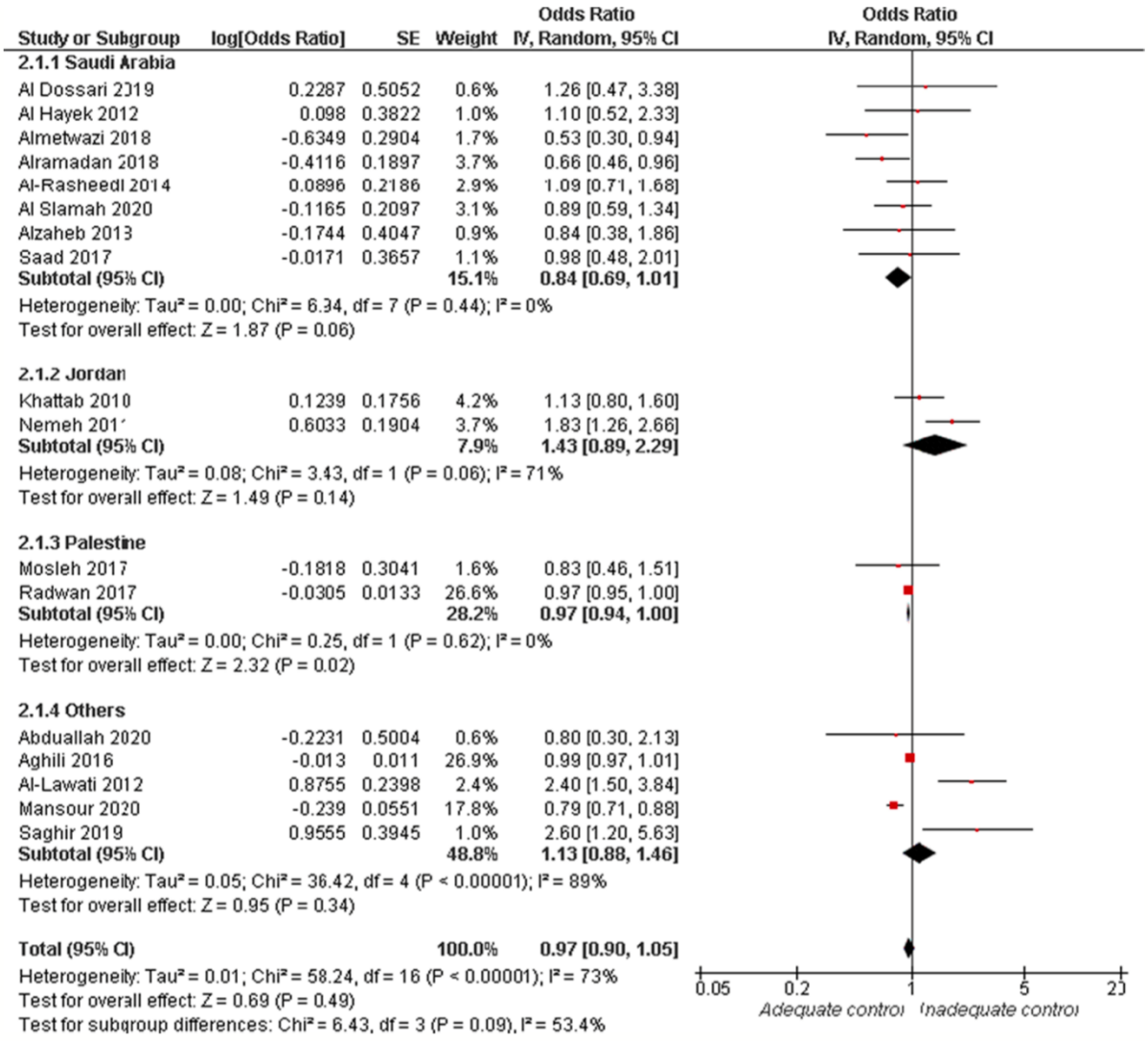


**Figure 3.2. Forest plot of the Odds Ratio of age (>50 years) in relation to adequate glycaemic control**

**Female gender:** Overall random-effect estimates of 22 studies showed no significant association between risk of inadequate glycaemic control for female compared to male participants (OR= 1.12, 95% CI: 0.97, 1.30; p = 0.13). Overall pooled data were heterogenous ($I^2$= 78%, p< 0.0001). Subgroup analysis showed no significant association between risk of inadequate glycaemic control in female compared to male participants in Saudi Arabia (OR= 1.06, 95% CI: 0.90, 1.25; p = 0.48), Jordan (OR=

0.74, 95% CI: 0.40, 1.37; p = 0.33), Kuwait (OR= 1.20, 95% CI: 0.57, 2.55; p = 0.63), and Iran (OR= 1.21, 95% CI: 0.94, 1.56; p = 0.14). For Palestine and other countries, female gender was associated with higher risk of inadequate glycaemic control (OR= 1.57, 95% CI: 1.07, 2.30; p = 0.02 and OR= 1.36, 95% CI: 1.07, 1.74; p = 0.01), respectively. Pooled data from Palestine were homogenous ($I^2$= 0%, p = 0.92). The heterogeneity in the other subgroup was resolved by excluding the data from Noureddine et al. (2014) ($I^2$= 0%, p = 0.65), with an effect estimate of (OR= 1.48, 95% CI: 1.34, 1.62; p< 0.0001), see **Figure 3.3.**

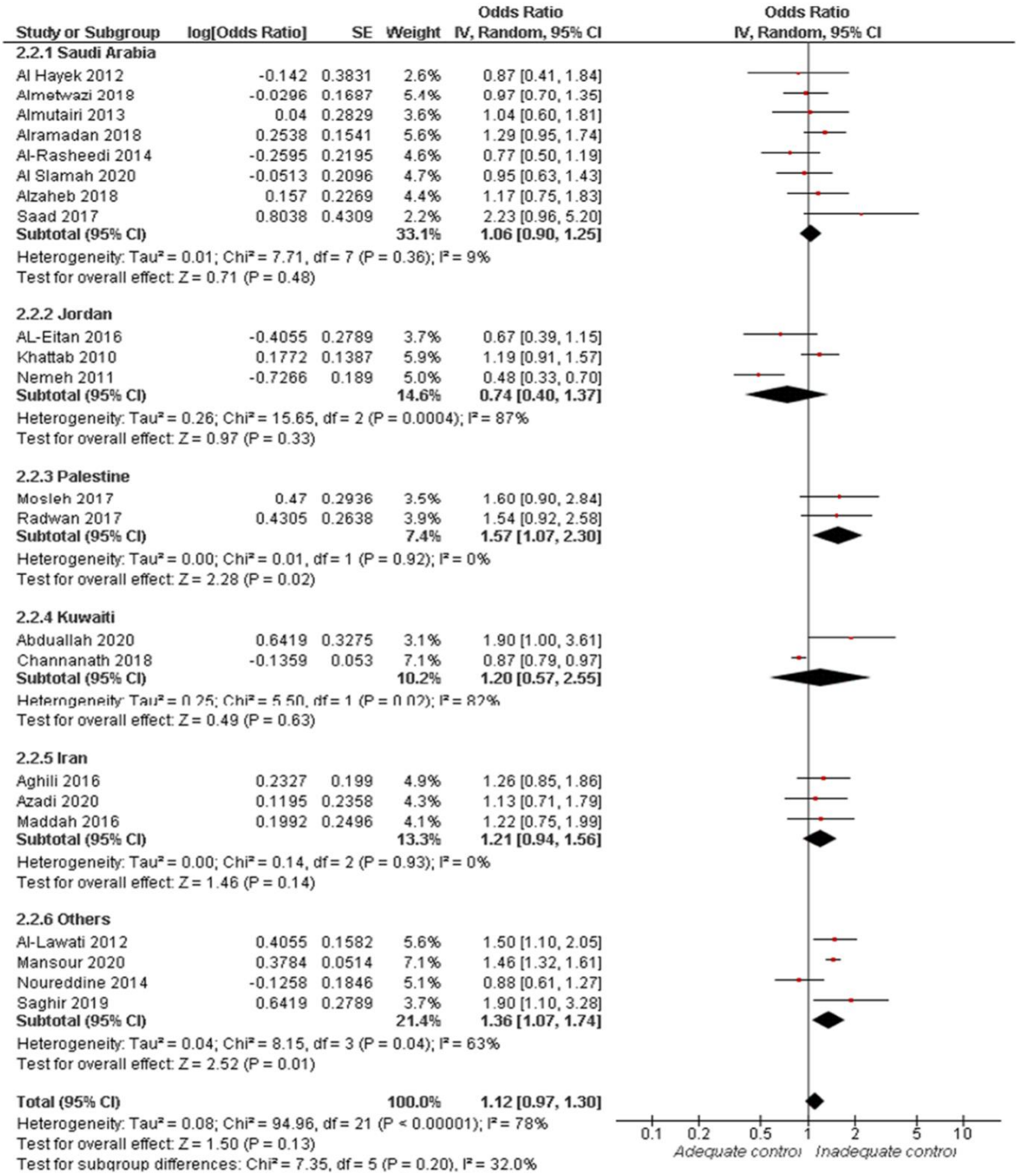


**Figure 3.3 Forest plot of the Odds Ratio of inadequate glycaemic control by gender**

**Elevated waist to hip ratio:** Pooled data of two studies demonstrated a significant elevation of the risk of inadequate glycaemic control in patients with elevated waist to hip ratio (WHR) (OR= 1.62, 95% CI: 1.16, 2.26; p = 0.004). Pooled data were homogenous ($I^2$= 0%, p = 0.69), **Figure 3.4.**

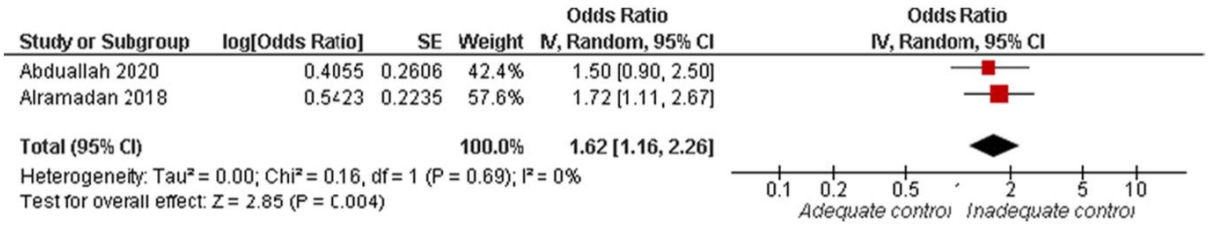


**Figure 3.4 Forest plot of the Odds Ratio for inadequate glycaemic control in relation to elevated WHR**

**Obesity:** Overall random effect estimates of 16 studies showed a significantly increased risk of inadequate glycaemic control in obese patients (BMI >30kg/$m^2$) (OR= 1.30, 95% CI: 1.10, 1.54; p = 0.002) (Figure 3.5). Overall pooled data were heterogenous ($I^2$= 81%, p< 0.0001). Subgroup analyses showed a significant elevation in the risk of inadequate glycaemic control in obese participants in Saudi Arabia (OR= 1.58, 95% CI: 1.04, 2.39; p = 0.03), Jordan (OR= 1.48, 95% CI: 1.03, 2.13; p = 0.03), and Kuwait (OR= 1.50, 95% CI: 1.34, 1.67; p< 0.00001), see Figure 3.5. Moreover, participants with adequate glycaemic control had lower BMI compared to those with inadequate glycaemic control (MD= -1.16 Kg/$m^2$, 95% CI: -1.85, -0.47; p = 0.001), and the pooled data were heterogenous ($I^2$= 73%, p < 0.0001). The heterogeneity was managed by excluding the data from Channanath et al. (2018) ($I^2$= 47%, p = 0.06). Furthermore, there was an association between glycaemic control and BMI, with lower HbA1c levels more likely in participants with lower BMI (< 30 kg/$m^2$) than participants with BMI > 30 (MD= -0.32, 95% CI: -0.52, -0.12; p = 0.002). Pooled data were homogenous ($I^2$ = 5%, p = 0.35).

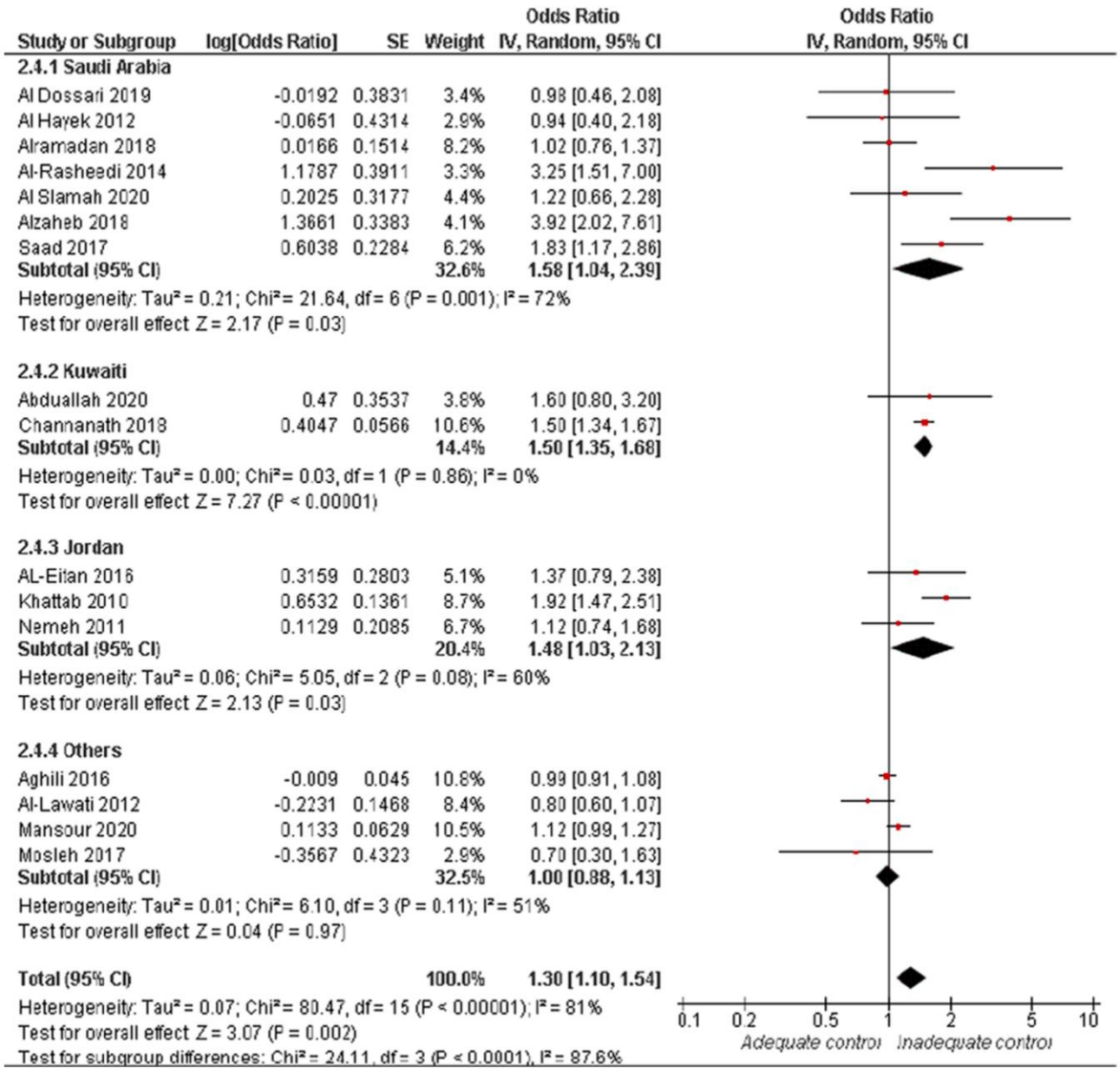


**Figure 3.5 Forest plot of the Odds Ratio of inadequate glycaemic control in relation to obesity (BMI >30kg/m2)**

**Smoking:** Overall random-effect estimates of 10 studies showed that the risk of inadequate glycaemic control was significantly elevated in smokers (OR= 1.26, 95% CI: 1.05, 1.52; p = 0.01). Overall pooled data were homogenous ($I^2$= 0%, p =1.00), see Figure 3.6.

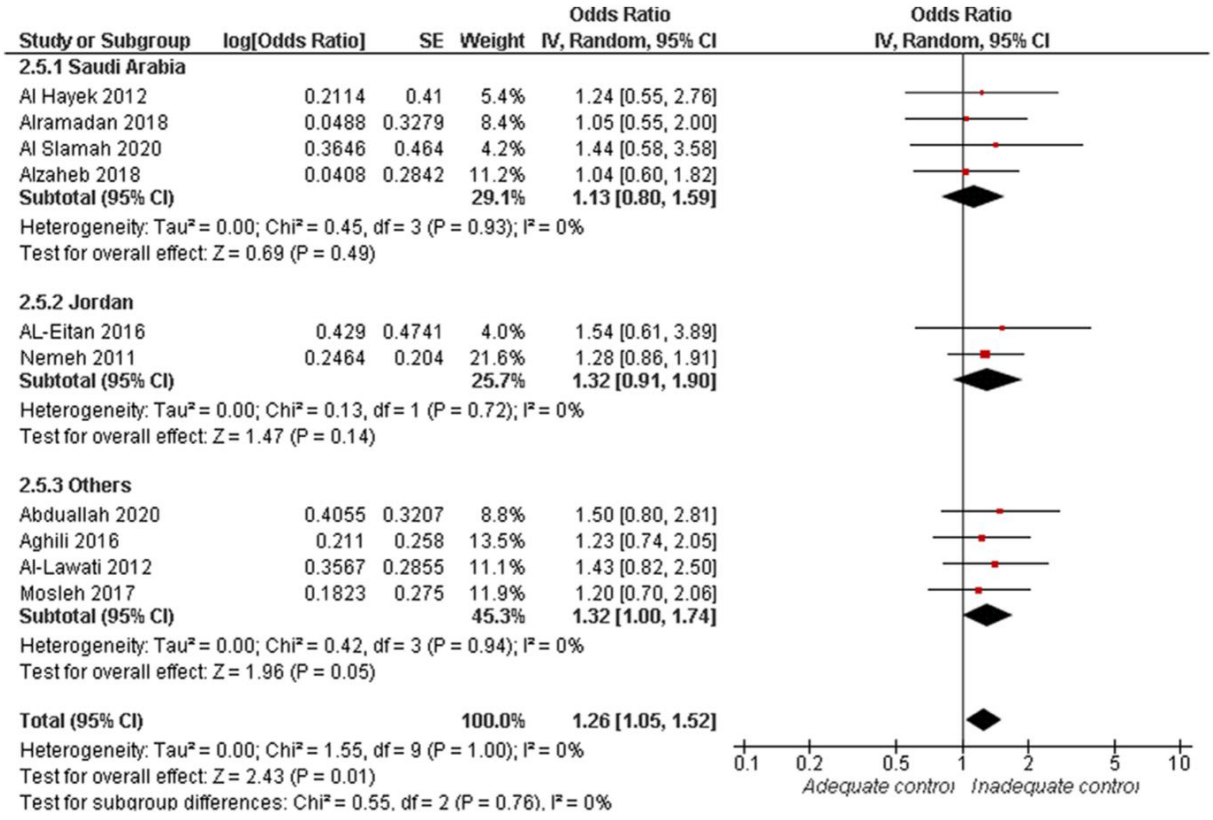


**Figure 3.6 Forest plot of the Odds Ratio of inadequate glycaemic control by smoking status.**

**Duration of diabetes (>10 years):** Overall, random-effect estimates of 13 studies showed an increased risk of inadequate glycaemic control in patients with longer duration of diabetes (OR= 2.01, 95% CI: 1.64, 2.48; p < 0.001). Overall pooled data were heterogeneous ($I^2$= 98%, p < 0.001), see Figure 3.7. The heterogeneity could not be resolved by sensitivity analysis. Subgroup analysis demonstrated that in the Saudi population, the risk of inadequate glycaemic control was tripled in participants who had diabetes for more than 10 years compared with those who experienced the disease for a shorter duration (< 10 years; OR= 3.02, 95% CI: 2.34, 3.91; p< 0.0001). Subgroup pooled

data were homogenous ($I^2$= 0%, p = 0.51). Moreover, participants with adequate glycaemic control tended to report shorter duration of diabetes (MD= -1.86, 95% CI: -3.55, -0.16; p = 0.03)**.**

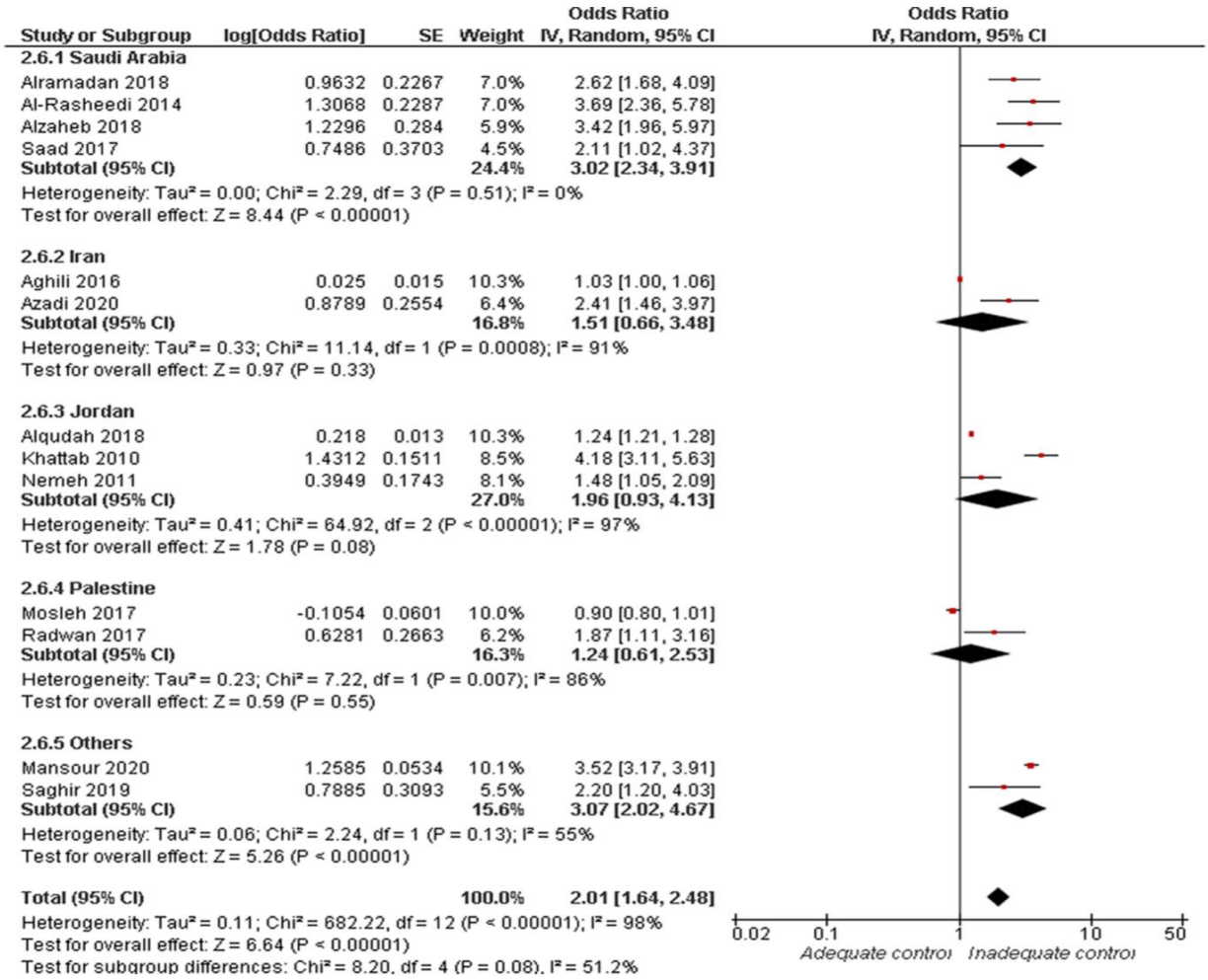


**Figure 3.7 Forest plot of the Odds Ratio of inadequate glycaemic control in relation to extended duration of diabetes (>10 years).**

**Self-Management:** Pooled analysis of seven studies showed a significant association between lower risk of inadequate glycaemic control and self-management (OR= 0.49, 95% CI: 0.29, 0.82; p = 0.006). Overall pooled data were heterogenous ($I^2$= 94%, p < 0.001), see Figure 3.8 Heterogeneity was best resolved by excluding the data from (Aghili et al., 2016; Al-Hayek et al., 2012; Khattab et al., 2010) ($I^2$= 31%, p = 0.23), with the overall effect estimate still significant (OR= 0.65, 95% CI: 0.47, 0.89; p = 0.007).

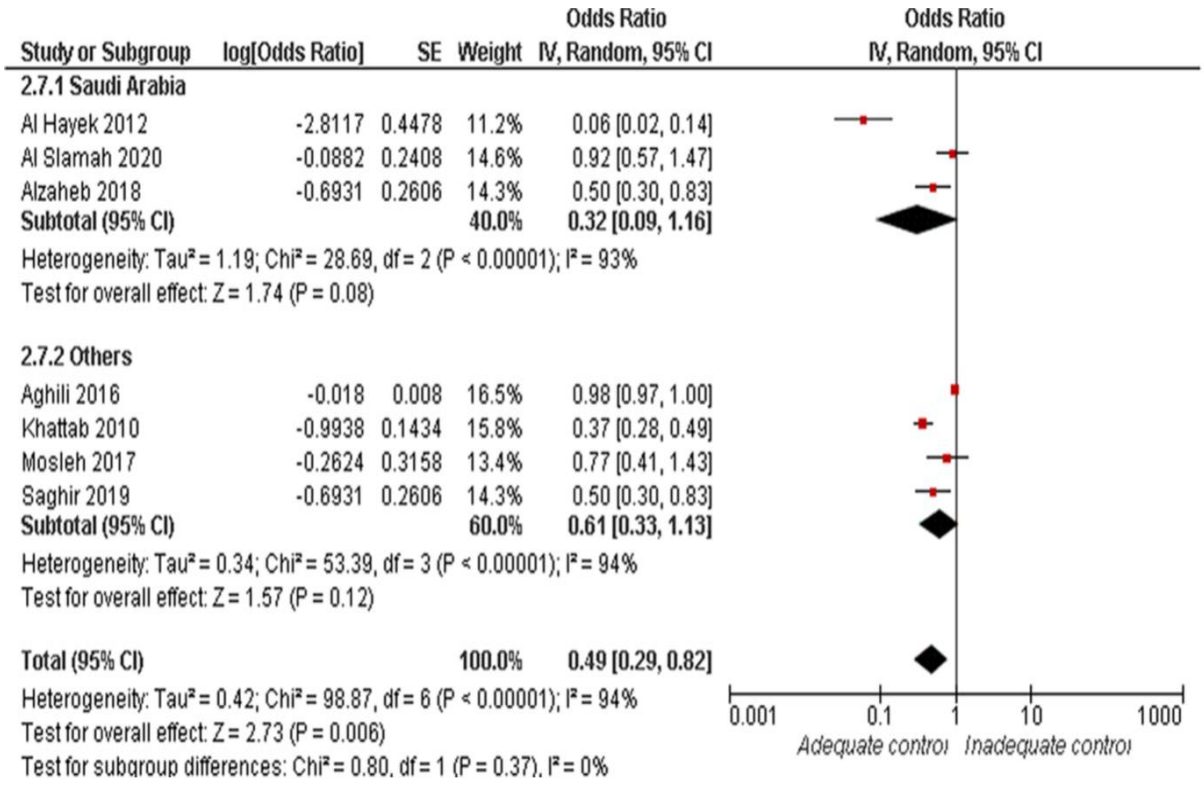


**Figure 3.8 Forest plot of the Odds Ratio of inadequate glycaemic management in relation to self-management.**

**Physical Activity:** Overall random-effect estimates of eight studies showed a significant association between the lower risk of inadequate glycaemic control and physical activity (OR= 0.40, 95% CI: 0.24, 0.67; p = 0.0005). Overall pooled data were heterogenous ($I^2$= 80%, p< 0.0001), see Figure **3.9.** Heterogeneity was best resolved by excluding the data from (L. N. AL-Eitan et al., 2016; Alramadan et al., 2018a; Mosleh et al., 2017) ($I^2$= 49%, p = 0.10), with the overall effect estimate still significant (OR= 0.25, 95% CI: 0.15, 0.40; p< 0.0001).

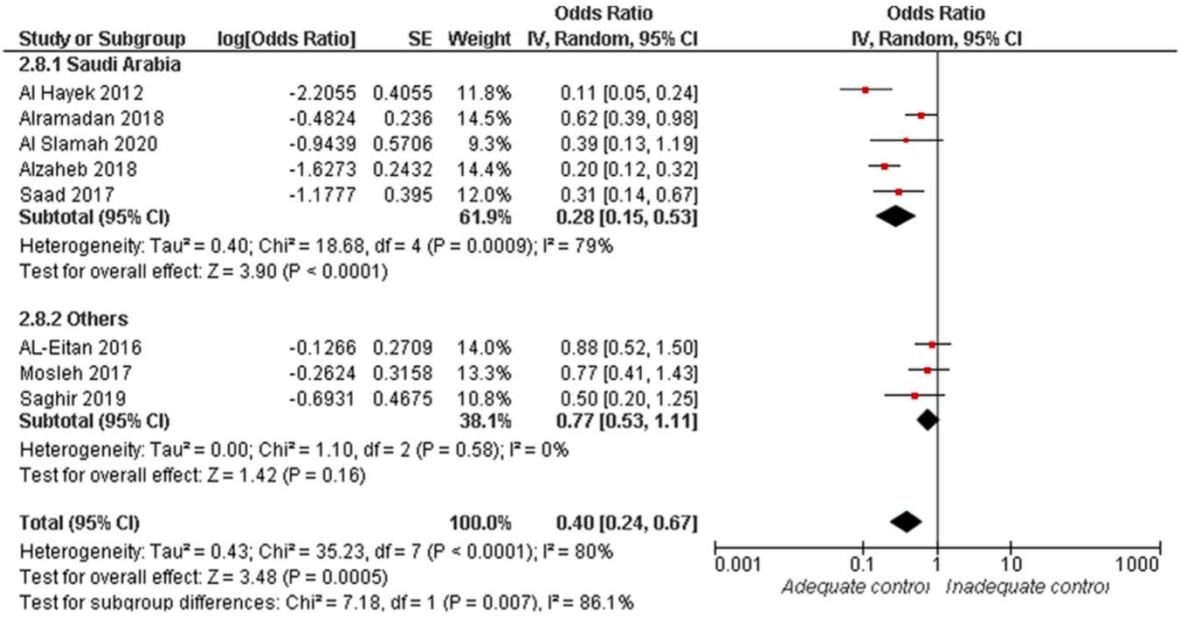


**Figure 3.9 Forest plot of the Odds Ratio of inadequate glycaemic control in relation to physical activity.**

**Diabetes Knowledge:** The pooled analysis of four studies showed no significant association between diabetes knowledge and glycaemic control (OR= 0.67, 95% CI: 0.39, 1.16; p = 0.15). Overall pooled analysis was heterogenous ($I^2$= 81%, p = 0.001). Subgroup analysis showed no significant association in Saudi Arabia (OR= 0.55, 95% CI: 0.28, 1.07; p = 0.08) and other countries (OR= 0.89, 95% CI: 0.55, 1.42; p = 0.62), **Appendix 3.4a.**

**Depression:** Pooled analysis of three studies demonstrated no significant difference between depressed and non-depressed participants in terms of glycaemic control (OR= 0.98, 95% CI: 0.93, 1.03; p = 0.42). Overall pooled data were homogenous ($I^2$= 0%, p = 0.89). Subgroup analysis showed no significant association in Saudi Arabia (OR= 1.07, 95% CI: 0.74, 1.55; p = 0.73) and Iran (OR= 0.98, 95% CI: 0.93, 1.03; p = 0.39), see **Appendix 3.4b.**

**Anxiety:** Data from three studies indicated no significant association between anxiety and glycaemic control (OR= 1.01, 95% CI: 0.99, 1.03; p = 0.53). Overall pooled data were homogenous ($I^2$= 5%, p = 0.35). Subgroup analysis showed no significant association in Saudi Arabia (OR= 1.25, 95% CI: 0.89, 1.76; p = 0.20) and Iran (OR= 1.01, 95% CI: 0.98, 1.03; p = 0.59), see **Appendix 3.4c.**

**Employment:** The overall fixed-effect showed no significant association between employment and glycaemic status (OR= 1.03, 95% CI: 0.85, 1.24; p = 0.75). Overall pooled data were homogenous ($I^2$=19%, p = 0.28). Subgroup analysis showed no significant association in Saudi Arabia (OR= 0.95, 95% CI: 0.75, 1.19; p = 0.63) and other countries (OR= 1.23, 95% CI: 0.89, 1.72; p = 0.21), see **Appendix 3.4.d**

**Marital status:** The overall random-effect estimate demonstrated no significant association between marital status and glycaemic control (OR= 1.07, 95% CI: 0.85, 1.35; p = 0.55). Overall pooled data showed minor heterogeneity ($I^2$=38%, p = 0.09). Subgroup analysis showed no significant association

in Saudi Arabia (OR= 1.06, 95% CI: 0.68, 1.67; p = 0.79), Iran (OR= 0.96, 95% CI: 0.72, 1.27; p = 0.76), Jordan (OR= 1.30, 95% CI: 0.92, 1.84; p = 0.14), and Palestine (OR= 0.84, 95% CI: 0.24, 2.96; p = 0.79), see **Appendix 3.4e.**

## 3.4. Discussion

Previous meta-analyses focused on the relationship between individual factors and the development of diabetes (Lustman et al., 2000; Rodríguez-Gutiérrez & Montori, 2016); however, this review is the first to examine a broad spectrum of elements regarding their possible influence on glycaemic control in participants with established T2DM in the MENA region .

This systematic review and meta-analysis found no significant association between glycaemic control and age, gender, diabetes knowledge, depression, anxiety, employment or marital status. However, in Palestine, older participants and females had a lower risk of inadequate glycaemic control. Overall, a greater risk of inadequate glycaemic control was seen in participants with obesity, higher WHR, smokers and those who had lived with diabetes for a longer duration (>10 years). Studies from Saudi Arabia demonstrated those with obesity and longer duration with diabetes at greater risk of inadequate control, as were participants from Jordan and Kuwait with obesity. Moreover, those with better self-management and greater physical activity had a lower risk of inadequate glycaemic control.

Regarding the effect of demographic factors on the development of inadequate glycaemic control, our findings demonstrated a significant difference in age between participants with adequate and inadequate glycaemic control [MD= 0.70 years, p = 0.020]). A cross-sectional analysis of 1,438 participants by Berkowitz et al., reported that young age patients were significantly associated with inadequate glycaemic control (p < 0.001) (Berkowitz et al., 2013). Similarly, a nationwide cross-sectional study of 697 American patients with T2DM showed that adequate glycaemic control was

prevalent among older patients. Moreover, these authors suggested that young patients undergo HbA1c assessments at least annually (Comellas et al., 2019). One suggested explanation for these observations is that older age is associated with a reduction in the lifespan of the red blood corpuscles, reducing their exposure to circulating glucose, thereby lowering blood levels of HbA1c (Dubowitz et al., 2014; Shperling & Danon, 1990). However, the overall odds ratio in our study showed no association between these variables. Similarly, Wiener and Roberts found no significant correlation in 399 participants between age and HbA1c levels (Wiener & Roberts, 1999). The lack of significance was ascribed to the exclusion of participants who had impaired glucose tolerance yet were eligible for inclusion in the normoglycaemic group based on a fasting plasma glucose value less than 6.4 mmol/l, a criterion that does not completely rule out diabetes in all participants, particularly non-insulin-independent diabetes.

Subgroup analysis surprisingly showed a significant inverse relationship between age and HbA1c amongst Palestinian participants. This relationship can perhaps be attributed to differences in attitudes among young participants compared to their elders. Younger individuals are often regarded or observed to be more negligent of the hazards of diabetes and the necessary self-management activities to control their glucose levels; conversely, older participants tend to be more careful and adherent to their treatment regimen (Toh, 2011). Radwan et al. (2017) found a significant association between old age and adequate glycaemic control (OR= 0.97; 95% CI: 0.945, 0.995). Their results contradict previous findings because of differences in the demographics of the studied populations, especially in terms of the age distribution (Radwan et al., 2018). Higher percentages of participants were of older age in the Palestinian samples than in other study groups, with 34% of participants >61 years (Radwan et al., 2018) and more than 50% $\geq$58 years (Mosleh et al., 2017)]. However, studies from Aldossari et al. (2019), Nemeh et al. (2011), and Saghir et al. (2019) providing data from Saudi Arabia, Jordan,

and other locations, respectively, did not show a significant inverse correlation between age and HbA1c. This could be attributed to the lower proportion of people >60 years in these studies (10.5% in Aldossari et al. (2019), 26% in Nemeh et al. (2011), and 25% in Saghir et al. (2019)).

The second demographic aspect examined was gender. No significant correlation was seen between gender and the risk of inadequate glycaemic control. This finding is inconsistent with a previous patient-level pooled analysis of six RCTs, totalling 2,600 participants with diabetes, which found women more prone to hypoglycaemia and high HbA1c levels (Kautzky-Willer et al., 2015). Another systematic review and meta-analysis from 2015 found that the risk of inadequate glycaemic control was higher in women; however, three of their included studies were deemed unreliable due to the high risk of bias (Sobers-Grannum et al., 2015). Various explanations have been put forward for these observations. It has been proposed that women show lower levels of adherence to medications, to which they more frequently report side effects (Thunander Sundbom & Bingefors, 2012). Differences in lifestyles (e.g., exercise) as well as in psychosocial perceptions might also play a role in gender-based differences in glycaemic control (Walker et al., 2006). Socio-economic differences might also play a part; however, these were not considered in any study. Differences in physiology have also been suggested to underlie any sex-based differences in HbA1c levels; however, further investigation is required of any sex-based differences in efficacy/treatment response, as current evidence for factors such as dissimilarities in body composition is unlikely to provide sufficient explanation for such observations (Radwan et al., 2018). In Lebanon, Noureddine et al. (2014) found no association between gender and the risk of T2DM within the Lebanese population (Noureddine et al., 2014). Similarly, in Saudi Arabia, Al-Rasheedi (2014) failed to demonstrate a significant connection between the two factors (Al-Rasheedi, 2014). However, though insignificant, both studies showed that the

percentage of males within the inadequate glycaemic control group was higher than in the adequate glycaemic control group.

With regard to the anthropometric measures, this review found a significant association between increased WHR and high HbA1c levels ($p< 0.05$). Such results are congruent with the findings from (Vazquez et al., 2007), where 32 different populations from 29 studies were analyzed. In that study, WHR was found to correlate well with the incidence of diabetes. WHR is considered by some a reliable measure of visceral fat (Gadekar et al., 2020). An elevated WHR indicates greater accumulation of visceral fat stores, a feature that negatively influences the metabolism of hormones such as insulin through free fatty acid secretion, which hinders insulin uptake by the liver leading to hyperinsulinemia and subsequent IR (Despres et al., 1995; Kahn & Flier, 2000). Nevertheless, reports have questioned the reliability of WHR for accurately reflecting changes in visceral fat (Van Der Kooy et al., 1993). This suggests that more sensitive measures should be used in order to properly explore the relationship between fat mass and glycaemic control.

Obesity, signified by BMI >30kg/$m^2$, was significantly associated with an increased risk of inadequate glycaemic control. This observation supports the findings of Abdullah et al. (2010). Moreover, a significant association was detected between BMI and HbA1c levels. As mentioned above, obesity (represented by both high WHR and BMI) is usually accompanied by IR and insensitivity due to the effect of visceral fat on insulin secretion and clearance. Accordingly, this sheds some light on a possible association between IR itself and HbA1c. Saha & Schwarz (2017) found HbA1c a reliable tool for predicting IR and inadequate glycaemic control among 3578 normoglycaemic and hyperglycaemic individuals (Saha and Schwarz, 2017).

The third category of factors related to glycaemic control is that of lifestyle. This includes physical activity, smoking, and psychological and social patterns. This review indicated a significant association between smoking and inadequate glycaemic control. Other meta-analyses have found significant associations between smoking (whether active or passive) and the risk of developing T2DM (Pan et al., 2015; Soulimane et al., 2014; Wang et al., 2013). With the exception of Alzaheb and Altemani (2018), all the included studies that analysed smoking used HbA1c as an index for glycaemic control, and reported significant positive correlations between smoking and HbA1c. Numerous explanations have been put forward to explain the relationship between smoking and glycaemic control. One theory proposed that smoking raises HbA1c levels by altering the erythrocytic membrane permeability to glucose, consequently increasing haemoglobin glycation (T. Higgins et al., 2009). Moreover, smoking lowers oxygen saturation in the blood, which leads to higher levels of deoxyhemoglobin, which is more readily glycated than oxyhemoglobin, accelerating HbA1c formation. Other possible explanations pertain to the amplifying effect exerted by smoking on the levels of 2,3-diphosphoglycerate, an intermediate of glycolysis that correlates with high levels of HbA1c. Furthermore, one of the components of tobacco smoke, carbon monoxide, increases the lifespan of circulating erythrocytes, increasing their blood glucose exposure (Beutler, 1975; Smith et al., 1982). The strong association between smoking and T2DM may offer a new approach for avoiding a rise in HbA1c levels, and therefore reducing the incidence of the disease. For example, awareness campaigns could educate people living with diabetes regarding the particular seriousness of smoking and its harmful influence on their glycaemic status.

Regarding physical activity, this review found that increased physical effort led to a significant reduction in the risk of inadequate glycaemic control ($p < 0.001$). Similarly, Aune et al. (2015) presented a meta-analysis of 87 studies (including three RCTs and 84 cohorts) demonstrating an

inverse relationship between total physical activity (i.e., leisure-time, occupational, and transport) and the risk of inadequate glycaemic control (Aune et al., 2015). The consequential reduction in body adiposity, a major contributing factor to the development of diabetes, can explain this response to sustained, regular physical activity (Mozaffarian et al., 2011; Rana et al., 2007). Alternatively, Aune et al. (2015) pointed out that physical exercise involves concentric contractions of the body's skeletal muscles, which take up glucose from the circulation (Aune et al., 2015). This process is mediated through the GLUT4 glucose transporter located on the membranes of striated muscle cells. Studies have reported that physical activity enhances GLUT4 translocation on the myocytic membrane, thereby increasing the rate of glucose uptake by muscles and improving glucose homeostasis (Colberg et al., 2010; Perseghin et al., 1996; Röckl et al., 2008). On sensitivity analysis, three records were excluded to resolve the observed heterogeneity (L. N. AL-Eitan et al., 2016; Alramadan et al., 2018a; Mosleh et al., 2017). The first two of these observed no significant association between physical exercise and glycaemic control, which Al-Eitan et al. (2016) ascribed to possible selective information sharing by the participants during their interviews, commonly known as reporting bias, resulting in the inconsistent findings of studies in this review (L. N. AL-Eitan et al., 2016).

Another factor frequently included in lifestyle-modification interventions is self-management (M. Ali et al., 2012; Muchiri et al., 2016; Zheng et al., 2019). In the analysis by Garcia-Molina et al., 16 studies introduced self-management as part of their intervention. These observations emphasize the importance of implementing lifestyle changes in order to achieve better glycaemic control. García-Molina et al., (2020) found, analyzing the findings of 28 studies, that lifestyle interventions were more efficient than standard care in reducing the risk of inadequate glycaemic control (García-Molina et al., 2020). Heterogeneity in this analysis was best resolved by excluding (Aghili et al., 2016; Al-Hayek et al., 2012; Khattab et al., 2010). Aghili et al., noted a negative relation between self-care

practices and HbA1c levels, ascribed to the strong association between self-management and diabetes-related distress (Aghili et al., 2016). The latter has been associated with negative responses (e.g., increasing depressive symptoms linked to reducing adherence to medication), directly and indirectly leading to uncontrolled glucose levels (Aikens, 2012; Gonzalez et al., 2008). Khattab et al. (2010) and Al Hayek et al. (2012) used self-report to collect data concerning participants' medication adherence, glucose self-monitoring, and dietary-intake (i.e., self-management practices), which risked recall bias, a type of error that might have led to exaggerated findings (Al-Hayek et al., 2012; Khattab et al., 2010).

Lastly, a highly significant link was demonstrated between longer disease duration and inadequate glycaemic control. By contrast, a UK-based cross-sectional study found an inverse relation between the two variables. This finding may be attributed to the different healthcare systems of developing and developed countries. Abubakari et al. (2016) hypothesized that longer disease duration allows participants to better understand their condition's nature, consequences, and responsibilities, which assists in the management of negative emotions that might affect their response, allowing them to better control their disease (Abubakari et al., 2016).

### 3.5 Strengths and limitations

There are several limitations to this meta-analysis. First, most included studies used self-report to collect outcome data, potentially leading to recall bias, which might either exaggerate or underestimate the true effect size. Second, in terms of the anthropometric markers, only two measures were observed, WHR and BMI. These measurements have been reported as less informative measures of obesity than other measurements such as waist circumference and the waist-to-height ratio (Rajput et al., 2014; Vazquez et al., 2007). Third, the high heterogeneity observed between studies was not always resolvable, potentially indicating diversity in the methodology or baseline criteria of the included studies. Greater consistency in design among studies is recommended for the future. Fourth, we only included English language studies, and peer-reviewed published articles to ensure the quality of the included studies' methodologies.

The strengths of this review include the relatively large number of included studies, adding to the strength of association between the predictors of glycaemic control.

In conclusion, the current evidence suggests an increased risk of inadequate glycaemic control in patients with elevated waist to hip ratio, longer disease duration, obesity, and smokers, with lower risk of inadequate control associated with physical activity and self-management. Further longitudinal studies are required to better understand these variations and to assess all predictors of glycaemic control in participants with T2DM, and to further provide a strong basis for future recommendations to optimize glycaemic control.

## 3.6 Recommendations

Review findings illustrated some variability in variables which exert significant impact across the countries of the Middle East and North Africa. Irrespective of whether they are middle-income or high-income, countries should use national and regional data to inform the development of strategies sensitive to local and global influences. Broadly, however, policymakers and clinicians should pay attention to spreading awareness campaigns to educate people living with diabetes regarding the seriousness and implications of obesity and smoking for glycaemic status. Regular exercise is essential, especially in people with living with diabetes for long periods, who should be encouraged to follow a balanced physical program to improve their glycaemic status. Diabetes education and self-care management should be integral to the management of all people living with diabetes regardless of their medication and management pathways.

## 3.7 Summary:

This review aimed to examine the patient-related factors that have been linked to glycaemic control in people living with T2DM in the MENA region, in order to make recommendations for locally appropriate diabetes care. From the findings of this systematic review and meta-analysis, no significant association was shown between glycaemic control and age, gender, diabetes knowledge, depression, anxiety, employment or marital status. However, findings demonstrated a significant difference in age between participants with adequate and inadequate glycaemic control. Also, obesity, signified by BMI >30kg/$m^2$, was significantly associated with an increased risk of inadequate glycaemic control. Further, this review indicated a significant association between smoking and inadequate glycaemic control. Lastly, a highly significant link was demonstrated between longer disease duration and inadequate glycaemic control.

This chapter evaluated the various patient-related factors that may be associated with glycaemic control in individuals diagnosed with type 2 diabetes in the MENA region. The purpose was to inform development of recommendations for diabetes care that are tailored to the specific needs of the population in this region. Some of the factors that emerged as significant contributors were age, obesity (as indicated by a BMI >30kg/m2), smoking, longer disease duration, and inadequate glycaemic control. To expand upon this research, the following chapters collect and examine current evidence and measurements that point to glycaemic control in patients diagnosed with type 2 diabetes in Jordan before and after the first COVID-19 lockdown, identifying factors that may predict the levels of glycaemic control before and after a lockdown instituted for pandemic control. Finally, expert opinions were gathered to develop recommendations for nursing education and practice preparation and implementation, to inform response to potential future pandemics.

# 4. CHAPTER 4 PHASE I &II RESULTS

## 4.1. Introduction

This chapter provides results from Phase I and II to answer quantitatively and qualitatively the second and third research questions: "What was the glycaemic control of people with T2DM in Jordan before and after the COVID-19 lockdown?" and " What factors predicted the level of glycaemic control during the pandemic (before and after lockdown)?".

The first section of this chapter provides results from Phase I to answer the second research question: "What was the glycaemic control of people with T2DM in Jordan before and after the COVID-19 lockdown?" using a retrospective audit of healthcare records for people with T2DM during the periods before and after the COVID-19 lockdown.

## 4.2. Phase I findings

### 4.2.1. Phase 1 participants' demographic characteristics

A total of 323 patient records were accessed in this phase of the study, of whom 165 (51.1%) were females and 158 (48.9%) were males. Their mean age was 57.8 ± 11.7 years, and their mean duration post-diabetes diagnosis was 19.1 ± 10.81 years **(Table 4.1).**

As shown in **Table 4.1**, most participants (n=230, 71.2%) were married and living with their spouse (n=230, 71.4%). Almost half of the participants had completed secondary education (n=149, 46.3%), followed by primary education (n=104, 32.3%) and a smaller number had a bachelor's degree (n=68, 21.1%).

Regarding occupational status, approximately one-third of participants reported being unemployed (n=126, 39.0%), followed by those who described themselves as retired (n=112, 34.7%). Additionally, 84 participants were employed (26.0%), while only one reported being a full-time student (0.3%). Most participants (n=232, 71.8%) had an income equating to less than US$3,000 per year, while 90 participants (27.9%) had incomes equivalent to between US$3,000 and US$7,000 per year. Only one participant (0.3%) had an income between US$7,000 and US$10,000 per year.

As shown in **Table 4.1**, there was no statistically significant difference between males and females regarding age, diabetes duration, or educational level. There was a significantly higher proportion of participants who reported being married (n=124, 78.5%) and living with their spouse (n=123, 77.8%) among males compared to females ($p = 0.005$ and $p < 0.001$). Regarding occupational status, a significantly higher proportion of male participants reported being retired (n=90, 57.0%) compared to females (n=22, 13.3%) ($p < 0.001$). Also, there were significantly fewer male participants who had income less than US$3,000 per year (n=98, 62.0%) than females (n=134, 81.2%) ($p < 0.001$) **(Table 4.1)**.

**Table 4.1.** Demographic characteristics of the phase I participants pre-lockdown.

| | Total (N=323) | Male (N=158) | Female (N=165) | t/ χ2/ FET | df | p-value |
|---|---|---|---|---|---|---|
| **Age (years) Mean ± SD (Range)** | 57.8 ±11.7 (22-92) | 57.7 ±11.9 (22-89) | 57.8 ±11.5 (25-92) | 0.077 | 321 | 0.939 |
| **Diabetes duration (years) Mean ± SD (Range)** | 19.1 ±10.8 (2-65) | 19.1 ±10.4 (2-60) | 18.9 ±11.3 (65-165) | -0.234 | 320 | 0.815 |
| **Marital Status** | | | | | | |
| **Not currently married** | 93 (28.8%) | 34 (21.5%) | 59 (35.8%) | 7.981 | 1 | 0.005* |
| **Married** | 230 (71.2%) | 124 (78.5%) | 106 (64.2%) | | | |
| **Highest education level** | | | | | | |
| **Primary** | 104 (32.3%) | 46 (29.1%) | 58 (35.2%) | 2.661 | 3 | 0.447 |
| **Secondary/High school** | 149 (46.3%) | 78 (49.4%) | 71 (43.0%) | | | |
| **Vocational training** | 1 (0.3%) | 1 (0.6%) | 0 (0.0%) | | | |
| **Bachelor degree** | 68 (21.1%) | 33 (20.9%) | 35 (21.2%) | | | |
| **Master/Doctoral degree** | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | | | |
| **Domicile** | | | | | | |
| **Living alone** | 36 (11.2%) | 25 (15.8%) | 11 (6.7%) | 32.164 | 2 | **< 0.001*** |
| **Living with parents/guardians/relatives/ friends** | 56 (17.4%) | 9 (5.7%) | 47 (28.5%) | | | |
| **Living with spouse** | 230 (71.4%) | 123 (77.8%) | 107 (64.8%) | | | |
| **Occupation** | | | | | | |
| **Unemployed** | 126 (39.0%) | 19 (12.0%) | 107 (64.8%) | 105.977 | 3 | < 0.001* |
| **Employed** | 84 (26.0%) | 49 (31.0%) | 35 (21.2%) | | | |
| **Studying full time** | 1 (0.3%) | 0 (0.0%) | 1 (0.6%) | | | |
| **Retired** | 112 (34.7%) | 90 (57.0%) | 22 (13.3%) | | | |
| **Income, US$ /year** | | | | | | |
| **Less than 3,000** | 232 (71.8%) | 98 (62.0%) | 134 (81.2%) | 16.442 | 2 | < 0.001* |
| **3,000-7,000** | 90(27.9%) | 60 (38.0%) | 30 (18.2%) | | | |
| **7,000-10,000** | 1 (0.3%) | 0 (0.0%) | 1 (0.6%) | | | |

**Data are presented as n (%) for categorical variables and mean±SD for continuous variables.**
**SD: standard deviation, df: degrees of freedom.**
**t: Independent samples t test. χ2: chi-square, FET: Fisher's exact test was used.**
***: Statistically significant at p-value < 0.05.**

### 4.2.2. Phase 1 participants' clinical characteristics

Of the total, 155 participants (48.0%) were smokers, while 168 (52.0%) were non-smokers, as shown in **Table 4.2**. Almost half the participants (n=151, 46.7%) had been diagnosed with hypertension (HTN). Other comorbidities were uncommon, with only four patients having Coronary Artery Disease (CAD) and Chronic Kidney Disease (CKD) (1.2%). Three patients had Chronic Obstructive Pulmonary Disease (COPD)/Asthma, Chronic Heart Failure (CHF) and Prostate Cancer (0.9%), while one patient had experienced a Gastric/Peptic ulcer and Acute Myocardial Infarction (AMI) (0.3%).

Regarding the type of regular diabetes treatment, more than half the participants (n=193, 59.9%) controlled their diabetes with oral agents and diet only, while the remainder used oral agents and insulin as well as diet (n=129, 40.1%). In terms of medication type, almost all participants (n=314, 97.2%) used Metformin, followed by insulin (n=97, 30.0%), Glimepiride (n=63, 19.5%), and Gliclazide (n=27, 8.4%).

The median fasting blood glucose level was 210.0 mg/dl, with IQR of 90 mg/dl, with the majority of participants (n=316, 97.8%) displaying inadequate control with a value exceeding 130 mg/dl.

There was a significantly higher proportion of smokers amongst male rather than female participants. Regarding the type of regular diabetes treatment and medication type, no statistically significant difference was detected between males and females, except for Glimepiride usage, where fewer males used Glimepiride (n=23, 14.6%) compared to females (n=40, 24.2%). Also, no statistically significant difference was found between males and females regarding comorbidities, including for hypertension (HTN), CAD, CKD, Gastric/Peptic ulcer, AMI, COPD/Asthma, CHF, and Prostate Cancer. There was no significant gender-based difference in the median values for fasting blood glucose and the proportions with adequately and poorly controlled diabetes.

**Table 4.2.** Clinical characteristics of the phase I participants pre-lockdown.

| | Total (N=323) | Male (N=158) | Female (N=165) | χ2/ FET/U | df/ z-score | p-value |
|---|---|---|---|---|---|---|
| **Current smoking** | | | | | | |
| **Yes** | 155 (48.0%) | 114(72.2%) | 41 (24.8%) | 72.358 | 1 | < 0.001* |
| **No** | 168 (52.0%) | 44 (27.8%) | 124 (75.2%) | | | |
| **Type of regular diabetes treatment** | | | | | | |
| **Oral agents and diet only** | 193 (59.9%) | 94 (59.5%) | 99 (60.0%) | 0.025 | 1 | 0.873 |
| **Oral agents and insulin as well as diet** | 129 (40.1%) | 64 (40.5%) | 65 (39.4%) | | | |
| **Diabetes medications** | | | | | | |
| **Metformin** | 314 (97.2%) | 153 (96.8%) | 161 (97.6%) | 0.163 | 1 | 0.686 |
| **Insulin** | 97 (30.0%) | 48 (30.4%) | 49 (29.7%) | 0.018 | 1 | 0.894 |
| **Glimepiride** | 63 (19.5%) | 23 (14.6%) | 40 (24.2%) | 4.822 | 1 | 0.028* |
| **Gliclazide** | 27 (8.4%) | 15 (9.5%) | 12 (7.3%) | 0.520 | 1 | 0.471 |
| **Comorbidities** | | | | | | |
| **HTN** | 151 (46.7%) | 75(47.5%) | 76(46.1%) | 0.064 | 1 | 0.800 |
| **CAD** | 4 (1.2%) | 3(1.9%) | 1(0.6%) | 1.103 | 1 | 0.294 |
| **CKD** | 4 (1.2%) | 3(1.9%) | 1(0.6%) | 1.103 | 1 | 0.294 |
| **Gastric/Peptic ulcer** | 1 (0.3%) | 1(0.6%) | 0 (0.0%) | 1.048 | 1 | 0.306 |
| **AMI** | 1 (0.3%) | 0 (0.0%) | 1(0.6%) | 0.961 | 1 | 0.327 |
| **COPD/Asthma** | 3 (0.9%) | 1 (0.6%) | 2 (1.2%) | 0.294 | 1 | 0.587 |
| **CHF** | 3 (0.9%) | 3(1.9%) | 0 (0.0%) | 3.162 | 1 | 0.075 |
| **Prostate Cancer** | 3 (0.9%) | 3(1.9%) | 0 (0.0%) | 3.162 | 1 | 0.075 |
| **Fasting blood glucose (mg/dl)** | 210.0 (90) (110.0-410.0) | 210.0 (86.2) (115.0-410.0) | 213.0 (93.00) (110.0-389.0) | 12508.5 | -0.628 | 0.530 |
| **Adequate control (<130 mg/dl)** | 7 (2.2%) | 3 (1.9%) | 4 (2.4%) | 0.105 | 1 | 0.746 |
| **Inadequate control (>130 mg/dl)** | 316 (97.8%) | 155 (98.1%) | 161 (97.6%) | | | |

**Data are presented as n (%) for categorical variables and Median (IQR) and Range for continuous variables.**
**IQR: Interquartile range.**
**Test of significance: U: Mann-Whitney U, χ2: Chi-square test, FET: Fisher's exact test was used**
**z-score = standardized test statistic, df: degrees of freedom.**
***: Statistically significant at p-value< 0.05.**
**CAD: Cardiovascular disease. HTN: Hypertension, AMI: Acute myocardial infarction,**
**COPD: Chronic obstructive pulmonary disease, CKD: Chronic kidney disease,**
**CHF: Congestive Heart Failure**

### 4.2.3. Phase 1 participants' anthropometric measurements

As shown in **Table 4.3**, the median and IQR values for weight, height, and BMI were 80.0 (20) kg, 165.0 (10) cm, and 30.2 (8) kg/m2, respectively. Additionally, half of the participants were obese (n=169, 52.3%).

For males, the median weight, height and BMI were 84.5 (IQR: 21) kg, 167.0 (IQR: 11) cm, and 30.5 (IQR: 9) kg/m2, respectively. For women, the median values of the same variables were 80.0 (IQR: 19) kg, 161.0 (IQR: 8) cm, and 30.1 (IQR7) kg/m2, respectively (**Table 4.3**). Mann-Whitney U test showed that males had a statistically significantly higher median weight than females ($p < 0.001$). However, there was no significant difference in height, BMI and its categorization between males and females.

**Table 4.3.** Anthropometric measurements for males and females.

| | **Total (N=323)** | **Male (N=158)** | **Female (N=165)** | **U/ FET** | **Z score/ df** | **p-value** |
|---|---|---|---|---|---|---|
| **Weight (kg)** | 80.0 (20) (50-128) | 84.5 (21) (50-128) | 80 (19) (50-115) | 11480.0 | -1.855 | < 0.001* |
| **Height (cm)** | 165.0 (10) (140-190) | 167 (11) (140-190) | 161 (8) (145-186) | 8436.0 | -5.493 | 0.064 |
| **Body mass Index (kg/m2)** | 30.2 (8) (19-46) | 30.5 (9) (19-46) | 30.1 (7) (20-44) | 12622.5 | -0.492 | 0.623 |
| **Underweight (<18.5 kg/m2)** | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 3.390 | 2 | 0.184 |
| **Normal weight (18.5-24.9 kg/m2 )** | 63 (19.5%) | 37 (23.4%) | 26 (15.8%) | | | |
| **Overweight (25.0-29.9 kg/m2)** | 91 (28.2%) | 40 (25.3%) | 51 (30.9%) | | | |
| **Obesity (≥30.0 kg/m2)** | 169 (52.3) | 81 (51.3%) | 88 (53.3%) | | | |

**Data are presented as n (%) for categorical variables and Median (IQR) and Range for continuous variables.**
**IQR: Interquartile range.**
**z-score = standardized test statistic, df: degrees of freedom.**
**Test of significance: Mann-Whitney U, FET: Fisher's exact test was used**
***: Statistically significant at p-value< 0.05.**

### 4.2.4. Research question 2: Glycaemic management pre and post lockdown

According to the Kolmogorov-Smirnov Test of normality, HbA1c at 6 months pre-lockdown and 3 months post-lockdown did not demonstrate normal distributions, with p values < 0.001. The Wilcoxon signed-rank test revealed a statistically significant increase in the HbA1c values between 3m post-lockdown (median (IQR): 8 (2.4) %) and 6m pre-lockdown (median (IQR): 7.7 (1.7) %) (p < 0.001), as presented in **Table 4.4**.

**Table 4.4.** Comparison between HbA1c in the 6 months before and 3 months after the lockdown.

| HbA1c (%) | Median (25, 75 quartiles) | Range | Z score | Test of significance | p-value |
|---|---|---|---|---|---|
| **6m pre-lockdown** | 7.7 (1.7) | 4.0-13.3 | -8.164 | 37428.5 | < 0.001* |
| **3m post-lockdown** | 8 (2.4) | 4.8-15.3 | | | |

**Data are presented as Median (IQR) and Range.**

**IQR = interquartile range**

**z score = standardized test statistic, Test of significance: Wilcoxon signed rank.**

***: Statistically significant at p-value< 0.05**

As per ADA guidelines, 102 patients (31.6%) had adequate glycaemic management, and 221 (68.4%) had inadequate glycaemic management at 6m pre-lockdown. At 3m post-lockdown, 69 patients (21.4%) had adequate glycaemic management, while 254 had inadequate glycaemic management (78.6%). The McNemar's test showed that the proportion of patients who have inadequate glycaemic management is statistically significantly increased at 3m post-lockdown as compared to 6m pre-lockdown (p = 0.002), as reported in **Table 4.5**.

**Table 4.5.** Change in glycaemic management status pre versus post lockdown.

| | | | **After lockdown** | | **Total** | **χ2 McNemar** | **df** | **p-value** |
|---|---|---|---|---|---|---|---|---|
| | | | Adequate control (n=69) | Inadequate control (n=254) | | | | |
| **Before lockdown** | Adequate control | N | 33 | 69 | 102 | 10.4 | 1 | 0.002* |
| | | % | 32.4% | 67.6% | 31.6% | | | |
| | Inadequate control | N | 36 | 185 | 221 | | | |
| | | % | 16.3% | 83.7% | 68.4% | | | |
| **Total** | | N | 69 | 254 | 323 | | | |
| | | % | 21.4% | 78.6% | 100.0% | | | |

**Data are presented as n (%)**
**χ2: McNemar test.**
***: statistically significant at p-value< 0.05**

In addressing research question two, " What was the glycaemic control of people with T2DM in Jordan before and after the COVID-19 lockdown?" Wilcoxon signed rank findings demonstrated a significant increase in median HbA1c from 7.7% at 6m pre-lockdown to 8.0 % at 3m post-lockdown (p < 0.001). Additionally, McNemar's test revealed a statistically significant increase in the proportion of participants with inadequate glycaemic management 3m post-lockdown as compared to 6m pre-lockdown ((n =254, 78.6%) vs. (n =221, 68.4%)) (p = 0.002).

### 4.2.5. Research question 3: Factors associated with adequacy of glycaemic management pre and post lockdown.

In order to address research question 3, the following variables were considered: demographic factors: age, BMI, gender, marital status, education level, domicile, occupation and income, and

clinical characteristics: diabetes duration, smoking, the type of regular diabetes treatment, and comorbidities, physical activity (measured using the IPAQ-A) (Ipaq Research Committee, 2005), mental health issues (measured using the DASS-21) (Lovibond, 1995; Lovibond and Lovibond 1995) and diabetes self-management (assessed using the SDSCA-Arabic) (Toobert & Glasgow, 1994;Toobert et al., 2000).

First, these variables were described and explored for bivariate associations with participants with adequate versus inadequate glycaemic management pre-lockdown.

#### 4.2.5.1 Associations between demographic and clinical factors with adequacy of glycaemic management pre-lockdown

Before the lockdown, an independent t-test revealed no significant differences by age and BMI between people with adequate and inadequate glycaemic management ($p = 0.988$ and 0.979, respectively) **(Table 4.6)**. Mann-Whitney test showed a slightly greater median diabetes duration between people with inadequate glycaemic management (19.0 years) compared to those with adequate glycaemic management (16.50 years); however, the difference did not reach statistical significance ($p = 0.056$). A Chi-square test revealed no significant association between socio-demographic data, including gender, marital status, highest education level, domicile, occupation, income, and inadequacy of glycaemic management pre-lockdown (all p values > 0.05).

**Table 4.6.** Associations between baseline demographic characteristics with adequacy of glycaemic management pre-lockdown.

| | | HbA1c pre-lockdown | | t / U / $\chi^2$ | df/ Z | p-value |
|---|---|---|---|---|---|---|
| | | **Adequate control (n=102)** | **Inadequate control (n=221)** | | | |
| **Age (years)** | Mean ±SD<br>Range | 57.8 ±11.4<br>(27-87) | 57.7±11.9<br>(22-92) | 0.016 | 321 | 0.988 |
| **Body Mass Index (kg/m2)** | Mean ±SD<br>Range | 30.3 ±5.1<br>(20-43) | 30.3 ±5.7<br>(19-46) | 0.027 | 321 | 0.979 |
| **Diabetes duration (years)** | Median (IQR)<br>Range | 16.50 (14)<br>(3-45) | 19.0 (16)<br>(2-65) | 9739 | -1.91 | 0.056 |
| **Gender** | Male | 54 (34.2%) | 104 (65.8%) | 0.966 | 1 | 0.326 |
| | Female | 48 (29.1%) | 117 (70.9%) | | | |
| **Marital status** | Not currently married | 22 (23.7%) | 71 (76.3%) | 3.794 | 1 | 0.051 |
| | Currently married | 80 (34.8%) | 150 (65.2%) | | | |
| **Highest education level** | Primary | 27 (26.0%) | 77 (74.0%) | 2.893 | 3 | 0.430 |
| | Secondary/High school | 51 (34.2%) | 98 (65.8%) | | | |
| | Vocational training | 0 (0.0%) | 1 (100.0%) | | | |
| | Bachelor degree | 24 (35.3%) | 44 (64.7%) | | | |
| **Domicile** | Living alone | 11 (30.6%) | 25 (69.4%) | 4.793 | 2 | 0.091 |
| | Living with parents/guardians/relatives/ friends | 11 (19.6%) | 45 (80.4%) | | | |
| | Living with spouse | 80 (34.8%) | 150 (65.2%) | | | |
| **Occupation** | Unemployed | 38 (30.2%) | 88 (69.8%) | 1.914 | 3 | 0.660 |
| | Employed | 31 (36.9%) | 53 (63.1%) | | | |
| | Studying full time | 0 (0.0%) | 1 (100.0%) | | | |
| | Retired | 33 (29.5%) | 79 (70.5%) | | | |
| **Income, US$ /year** | Less than $3,000 | 73 (31.5%) | 159 (68.5%) | 0.480 | 2 | > 0.999 |
| | $3,000-$7,000 | 29 (32.2%) | 61 (67.8%) | | | |
| | $7,000-$10,000 | 0 (0.0%) | 1 (100.0%) | | | |

**Data are presented as n (%) for categorical variables and Mean ±SD or Median (IQR) and Range for continuous variables.**
**IQR: Interquartile range, SD: standard deviation. df: degrees of freedom,**
**t: Independent samples t test. U: Mann-Whitney U test. FET: Fisher's exact test was used.**
***: statistically significant at p-value < 0.05**

A Chi-square test revealed no significant association between smoking and inadequacy of glycaemic management before the lockdown ($p = 0.236$) **(Table 4.7)**. However, a Chi-square test showed a significant association between the type of regular diabetes treatment and inadequacy of glycaemic management; people with oral agents and insulin as well as diet were more likely to have inadequate glycaemic management than those who received oral agents and diet only ($p < 0.001$).

Considering types of medication used, Chi-square tests showed a significant association between usage of insulin and inadequacy of glycaemic management before the lockdown; patients who used insulin were more likely to have inadequate glycaemic management than those who did not use insulin ($p < 0.001$). However, there was no significant association between other medication types, including Metformin, Glimepiride, and Gliclazide, and inadequacy of glycaemic management ($p > 0.05$ for all).

A Chi-square test revealed no significant association between comorbidities and inadequate glycaemic management before the lockdown, except that patients who had HTN were significantly more likely to have inadequate glycaemic management compared to those without HTN ($p < 0.001$).

In summary, those who used insulin (compared to those who did not use insulin, whether considered in isolation or in combination with oral agents) as their regular diabetes treatment and those with HTN (compared to those with no diagnosis of HTN) were more likely to have inadequate glycaemic management before the lockdown (all p values $< 0.001$).

**Table 4.7.** Associations between clinical variables with the adequacy of glycaemic management pre-lockdown.

| | | HbA1c pre-lockdown | | FET / $\chi^2$ | Z | p-value |
|---|---|---|---|---|---|---|
| | | Adequate control (n=102) | Inadequate control (n=221) | | | |
| **Smoking** | Yes | 44 (28.4%) | 111 (71.6%) | 1.405 | 1 | 0.236 |
| | No | 58 (34.5%) | 110 (65.5%) | | | |
| **Type of regular diabetes treatment** | Oral agents and diet only | 85 (44.0%) | 108 (56.0%) | 35.951 | 1 | < 0.001* |
| | Oral agents and insulin as well as diet | 16 (12.4%) | 113 (87.6%) | | | |
| **Diabetes medications** | | | | | | |
| **Metformin** | No | 1 (11.1%) | 8 (88.9%) | 1.795 | 1 | 0.282 |
| | Yes | 101 (32.2%) | 213 (67.8%) | | | |
| **Insulin** | No | 96 (42.5%) | 130 (57.5%) | 41.373 | 1 | < 0.001* |
| | Yes | 6 (6.2%) | 91 (93.8%) | | | |
| **Glimepiride** | No | 84 (32.3%) | 176 (67.7%) | 0.328 | 1 | 0.567 |
| | Yes | 18 (28.6%) | 45 (71.4%) | | | |
| **Gliclazide** | No | 89 (30.1%) | 207 (69.9%) | 3.744 | 1 | 0.053 |
| | Yes | 13 (48.1%) | 14 (51.9%) | | | |
| **Comorbidities** | | | | | | |
| **CAD** | No | 101 (31.7%) | 218 (68.3%) | 0.081 | 1 | > 0.999 |
| | Yes | 1 (25.0%) | 3 (75.0%) | | | |
| **Gastric/Peptic ulcer** | No | 102 (31.7%) | 220 (68.3%) | 0.463 | 1 | > 0.999 |
| | Yes | 0 (0.0%) | 1 (100.0%) | | | |
| **HTN** | No | 69 (40.1%) | 103 (59.9%) | 12.411 | 1 | < 0.001* |
| | Yes | 33 (21.9%) | 118 (78.1%) | | | |
| **MI** | No | 102 (31.7%) | 220 (68.3%) | 0.463 | 1 | > 0.999 |
| | Yes | 0 (0.0%) | 1 (100.0%) | | | |
| **COPD/Asthma** | No | 102 (931.9%) | 218 (68.1%) | 1.398 | 1 | 0.554 |
| | Yes | 0 (0.0%) | 3 (100%) | | | |
| **CHF** | No | 102 (31.9%) | 218 (68.1%) | 1.398 | 1 | 0.554 |
| | Yes | 0 (0.0%) | 3 (100%) | | | |
| **Prostate Cancer** | No | 102 (31.9%) | 218 (68.1%) | 1.398 | 1 | 0.703 |
| | Yes | 0 (0.0%) | 3 (100%) | | | |
| **CKD** | No | 102 (32.0%) | 217 (68.0%) | 1.869 | 1 | 0.312 |
| | Yes | 0 (0.0%) | 4 (100.0%) | | | |

**Data are presented as n (%)**
**FET: Fisher's exact test was used.**
***: statistically significant at p-value < 0.05**
**HTN: Hypertension, MI: myocardial infarction, COPD: Chronic obstructive pulmonary disease, CKD: Chronic kidney disease, CHF: Congestive Heart Failure**

#### 4.2.5.2 Predicting adequacy of glycaemic management pre-lockdown.

Multiple logistic regression modelling was used to identify variables that were independently predictive of adequacy of glycaemic management pre-lockdown. The model contained three independent variables (entering type of regular diabetes treatment, insulin use, and HTN). The full model containing all predictors was statistically significant, $\chi 2$ (3, N = 323) = 58.021, $p < 0.001$ and -2 Log likelihood =342.547, indicating that it was capable of distinguishing between respondents who had inadequate glycaemic management from those with adequate glycaemic management pre-lockdown.

As shown in **Table 4.8**, two of the independent variables (using insulin and having a diagnosis of HTN) made statistically significant contributions to the model. Use of insulin (OR: 6.6, 95% CI: 2.2-19.7, p = 0.001) and having a diagnosis of HTN (OR: 2%, 95% CI: 1.2-3.3, p = 0.013) were found to be significantly predictive of inadequate glycaemic management before the lockdown.

**Table 4.8.** Modelling factors potentially predictive of adequacy of glycaemic management pre-lockdown.

| | SE | df | Wald | OR | p-value | 95% CI for OR |
|---|---|---|---|---|---|---|
| **Type of regular diabetes treatment** | | | | | | |
| **Oral agents and diet only** | | | | R | | |
| **Oral agents and insulin plus diet** | 0.402 | 1 | 1.701 | 1.7 | 0.192 | 0.8-3.7 |
| **Insulin** | | | | | | |
| **No** | | | | R | | |
| **Yes** | 0.557 | 1 | 11.581 | 6.6 | 0.001* | 2.2-19.7 |
| **HTN** | | | | | | |
| **No** | | | | R | | |
| **Yes** | 0.269 | 1 | 6.220 | 2 | 0.013* | 1.2-3.3 |

**SE: Stander error. df : degrees of freedom. OR: Odds ratio. R: Reference category.**
***: statistically significant at p-value < 0.05.**

#### 4.2.5.3 Associations between demographic and clinical factors with adequacy of glycaemic management post-lockdown

**Table 4.9** illustrates the association of demographic data, including age, BMI, diabetes duration, gender, marital status, highest education level, domicile, occupation, and income, with the adequacy of glycaemic management post-lockdown. Post-lockdown, an independent t-test revealed a significantly higher mean age among people with inadequate glycaemic management than those with adequate glycaemic management ($p = 0.003$). Also, Mann-Whitney tests demonstrated higher median BMI and diabetes duration in people with inadequate compared to those with adequate glycaemic management ($p < 0.001$ for each).

A Chi-square test revealed significant associations between education, occupation and income, with inadequacy of glycaemic management post-lockdown (p values < 0.001 and 0.003, respectively).

Those with education only to primary school level, those who were retired, and those with incomes less than $3,000/year had a higher likelihood of inadequate glycaemic management post-lockdown compared to those with higher levels of education, those who were unemployed, employed, studying full time, or had an income exceeding $3,000/year. However, a Chi-square test showed no significant association between gender, marital status, and domicile with adequacy of glycaemic management post-lockdown (all p values > 0.05).

**Table 4.9.** Associations between demographic characteristics with adequacy of glycaemic management post-lockdown.

| | | HbA1c post-lockdown | | t / U / $\chi^2$/ FET | df/ Z | p-value |
|---|---|---|---|---|---|---|
| | | **Adequate control (n= 69)** | **Inadequate control (n=254)** | | | |
| **Age (years)** | Mean ±SD<br>Range | 54.1±12.7<br>(27-84) | 58.8±11.2<br>(22-92) | -3.031 | 321 | 0.003* |
| **Body Mass Index (kg/m2)** | Median (IQR)<br>Range | 26.8 (9)<br>(20-42) | 31.2 (7)<br>(19-46) | 5546.5 | -4.68 | < 0.001* |
| **Diabetes duration (years)** | Median (IQR)<br>Range | 14 (13)<br>(3-45) | 19 (13)<br>(2-65) | 6242.0 | -3.63 | < 0.001* |
| **Gender** | Male | 32 (20.3%) | 126 (79.7%) | 0.226 | 1 | 0.634 |
| | Female | 37 (22.4%) | 128 (77.6%) | | | |
| **Marital Status** | Not currently married | 18 (19.4%) | 75 (80.6%) | 0.313 | 1 | 0.576 |
| | Currently married | 51 (22.2%) | 179 (77.8%) | | | |
| **Highest education level** | Primary | 16 (15.4%) | 88 (84.6%) | 17.422 | 3 | < 0.001* |
| | Secondary/High school | 26 (17.4%) | 123 (82.6%) | | | |
| | Vocational training | 0 (0.0%) | 1 (100.0%) | | | |
| | Bachelor degree | 27 (39.7%) | 41 (60.3%) | | | |
| **Domicile** | Living alone | 7 (19.4%) | 29 (80.6%) | 0.266 | 2 | 0.875 |
| | Living with parents/guardians/relatives/ friends | 11 (19.6%) | 45 (80.4%) | | | |
| | Living with spouse | 51 (22.2%) | 179 (77.8%) | | | |
| **Occupation** | Unemployed | 21 (16.7%) | 105 (83.3%) | 26.635 | 3 | < 0.001* |
| | Employed | 33 (39.3%) | 51 (60.7%) | | | |
| | Studying full time | 1 (100.0%) | 0 (0.0%) | | | |
| | Retired | 14 (12.5%) | 98 (87.5%) | | | |
| **Income** | Less than $3,000 | 40 (17.2%) | 192 (82.8%) | 11.118 | 2 | 0.003* |
| | $3,000-$7,000 | 28 (31.1%) | 62 (68.9%) | | | |
| | $7,000-$10,000 | 1 (100.0%) | 0 (0.0%) | | | |

**Data are presented as n (%) for categorical variables and Mean ±SD or Median (IQR) and Range for continuous variables.**
**IQR: Interquartile range, SD: standard deviation, df: degrees of freedom.**
**t: Independent samples t test. U: Mann-Whitney U test. FET: Fisher's exact test was used.**
***: statistically significant at p-value < 0.05**

Post-lockdown, a Chi-square test showed that there was a significant association between smoking and adequacy of glycaemic management; those who smoked were more likely to exhibit inadequate glycaemic management compared to those who did not smoke ($p < 0.001$) **(Table 4.10)**. Chi-square tests also showed significant associations between the type of regular diabetes treatment and adequacy of glycaemic management post-lockdown; patients using oral agents and insulin as well as diet were more likely to have inadequate glycaemic management than those who used oral agents and diet only ($p < 0.001$).

Considering types of medication used, Chi-square tests showed significant associations between usage of insulin and Glimepiride and adequacy of glycaemic management; patients who used insulin and Glimepiride were more likely to have inadequate glycaemic management than those who do not use these medications ($p < 0.001$and 0.027). However, there was no significant association between other medication types, including Metformin and Gliclazide, with adequacy of glycaemic management ($p > 0.05$ for all). A Chi-square test demonstrated a significant association between HTN and adequacy of glycaemic management; people with HTN were significantly more likely to have inadequate glycaemic management than those without HTN ($p = 0.005$).

**Table 4.10.** Associations between clinical variables with adequacy of glycaemic management post-lockdown.

| | | HbA1c post-lockdown | | $\chi^2$/ FET | df | p-value |
|---|---|---|---|---|---|---|
| | | Adequate control (n= 69) | Inadequate control (n=254) | | | |
| **Smoking** | Yes | 20 (12.9%) | 135 (87.1%) | 12.694 | 1 | < 0.001* |
| | No | 49 (29.2%) | 119 (70.8%) | | | |
| **Type of regular diabetes treatment** | Oral agents and diet only | 57 (29.5%) | 136 (70.5%) | 18.797 | 1 | < 0.001* |
| | Oral agents and insulin as well as diet | 12 (9.3%) | 117 (90.7%) | | | |
| **Diabetes medications** | | | | | | |
| **Metformin** | No | 1 (11.1%) | 8 (88.9%) | 0.579 | 1 | 0.690 |
| | Yes | 68 (21.7%) | 246 (78.3%) | | | |
| **Insulin** | No | 63 (27.9%) | 163(72.1%) | 19.008 | 1 | < 0.001* |
| | Yes | 6 (6.2%) | 91(93.8%) | | | |
| **Glimepiride** | No | 62 (23.8%) | 198 (76.2%) | 4.896 | 1 | 0.027* |
| | Yes | 7 (11.1%) | 56 (88.9%) | | | |
| **Gliclazide** | No | 65 (22.0%) | 231 (78.0%) | 0.752 | 1 | 0.386 |
| | Yes | 4 (14.8%) | 23 (85.2%) | | | |
| **Comorbidities** | | | | | | |
| **CAD** | No | 69 (21.6%) | 250 (78.4%) | 1.100 | 1 | 0.582 |
| | Yes | 0 (0.0%) | 4 (100.0%) | | | |
| **Gastric/Peptic ulcer** | No | 69 (21.4%) | 253 (78.6%) | 0.272 | 1 | 0.999 |
| | Yes | 0 (0.0%) | 1 (100.0%) | | | |
| **HTN** | No | 47 (27.3%) | 125 (72.7%) | 7.789 | 1 | 0.005* |
| | Yes | 22 (14.6%) | 129 (85.4%) | | | |
| **MI** | No | 69 (21.4%) | 253 (78.6%) | 0.272 | 1 | > 0.999 |
| | Yes | 0 (0.0%) | 1 (100.0%) | | | |
| **COPD/Asthma** | No | 68 (21.3%) | 252 (78.8%) | 0.258 | 1 | > 0.999 |
| | Yes | 1 (33.3%) | 2 (66.7%) | | | |
| **CHF** | No | 69(21.6%) | 251 (78.4%) | 0.823 | 1 | 0.602 |
| | Yes | 0 (0.0%) | 3 (100.0%) | | | |
| **Prostate Cancer** | No | 68 (21.3%) | 252 (78.8%) | 0.258 | 1 | > 0.999 |
| | Yes | 1 (33.3%) | 2 (66.7%) | | | |
| **CKD** | No | 69 (21.6%) | 250 (78.4%) | 1.100 | 1 | 0.582 |
| | Yes | 0 (0.0%) | 4 (100.0%) | | | |

**Data are presented as n (%).**
**FET: Fisher's exact test was used.**
**df: degrees of freedom.**
***: statistically significant at p-value< 0.05**
**HTN: Hypertension, MI: myocardial infarction, COPD: Chronic obstructive pulmonary disease, CKD: Chronic kidney disease, CHF: Congestive Heart Failure**

#### 4.2.5.4 Associations between physical activity and adequacy of glycaemic management

First, the reliability of the A-IPAQ (Al-Hazzaa, 2007) was tested with this sample, obtaining a Cronbach's Alpha value of 0.544.

The results of the A-IPAQ (Al-Hazzaa, 2007) showed that the majority of participants (n=314, 97.2%) had low physical activity; nine participants (2.8%) had moderate levels of physical activity, but none had high physical activity. Participants reporting vigorous physical activities undertook this for a median of 0 days per week, ranging between 0 and 4 days per week. Vigorous physical activities were undertaken for a median of 0 min per week, ranging between 0 and 60 mins per week. Vigorous physical activities were undertaken at a median of MET-min per week, ranging between 0 and 480 MET-min per week. Participants reporting moderate physical activities undertook this for a median of 0 days per week, ranging between 0 and 4 days per week. Moderate physical activities were undertaken for a median of 0 min per week, ranging between 0 and 120 mins/week. Moderate physical activities were undertaken at a median of 0 MET-min per week, ranging between 0 and 480 MET-min per week.

Participants reported walking for a median of 1 day per week, ranging between 0 and 4 days per week. Walking was undertaken for a median of 30 min per week, ranging between 0 and 120 mins per week. Walking was undertaken at a median of 99 MET-min per week, ranging between 0 and 480 MET-min per week.

Overall, participants were only physically active for 1 day per week, ranging between 0 and 7 days per week. Physical activity was undertaken for a median of 30 min per week, ranging between 0 and 300 mins per week. Physical activity was undertaken at a median of 99 MET-min per week, ranging between 0 and 1356 MET-min per week **(Table 4.11).**

Chi-square test showed no significant association between A-IPAQ categorization and adequacy of glycaemic management post-lockdown ($p = 0.116$), as shown in **Table 4.12.** Mann-Whitney test revealed no significant difference in vigorous and moderate physical activities, walking, and total physical activity scores between participants with adequate control and those with inadequate glycaemic management ($p > 0.05$ for all) post lockdown.

**Table 4.11.** Physical activity measured using A-IPAQ (N=323).

| **Physical activity** | | |
|---|---|---|
| | | **N (%)** |
| | Low activity | 314 (97.2%) |
| | Moderate activity | 9 (2.8%) |
| | High activity | 0 (0.0%) |
| **IPAQ Scores** | | |
| | **Median (Q1, Q3)** | **Range** |
| **Vigorous physical activities** | | |
| **Days/week** | 0 (0.0, 0.0) | (0 - 4) |
| **Min/week** | 0 (0.0, 0.0) | (0-60) |
| **MET-min/week** | 0 (0.0, 0.0) | (0-480) |
| **Moderate physical activities** | | |
| **Days/week** | 0 (0.0, 1) | (0 - 4) |
| **Min/week** | 0 (0.0, 30) | (0 - 120) |
| **MET-min/week** | 0 (0.0, 120) | (0- 480) |
| **Walking** | | |
| **Days/week** | 1 (1, 2) | (0 - 4) |
| **Min/week** | 30 (15, 30) | (0-120) |
| **MET-min/week** | 99 (49.5, 99) | (0 - 396) |
| **Total physical activity** | | |
| **Days/week** | 1 (1, 2) | (0 - 7) |
| **Min/week** | 30 (15, 60) | (0 - 300) |
| **MET-min/week** | 99 (49.5, 219) | (0- 1356) |

**Q1: 25th percentile**, **Q3: 75th percentile**

**Table 4.12.** Associations between A-IPAQ scores and adequacy of glycaemic management.

| | HbA1c post-lockdown | | U /$\chi^2$ | Z/df | P-value |
|---|---|---|---|---|---|
| | **Adequate control (n= 69)** | **Inadequate control (n=254)** | | | |
| **IPAQ Scores** | | | | | |
| **Low activity** | 65 (94.2%) | 249 (98.0%) | 2.469 | 1 | 0.116 |
| **Moderate activity** | 4 (5.8%) | 5(2.0%) | | | |
| **High activity** | 0 (0.0%) | 0 (0.0%) | | | |
| **Vigorous physical activities** | | | | | |
| **Days/week** | 1(1,2) (0.0-2) | 1(1,2) (0.0-4) | 1291.5 | -0.917 | 0.359 |
| **Min/week** | 30(30, 60) (0.0-60) | 30(30, 60) (0.0-60) | 1291.5 | -0.917 | 0.359 |
| **MET-min/week** | 240(240,480) (0.0-480) | 240(240,480) (0.0-480) | 1291.5 | -0.917 | 0.359 |
| **Moderate physical activities** | | | | | |
| **Days/week** | 1(1,2) (0.0-3) | 1(1.5,2) (0.0-4) | 1351.5 | -0.264 | 0.792 |
| **Min/week** | 30(30, 60) (0.0-90) | 30(30, 60) (0.0-120) | 1333.5 | -0.341 | 0.733 |
| **MET-min/week** | 120(120, 240) (0.0-360) | 120(120, 240) (0.0-480) | 1333.5 | -0.341 | 0.733 |
| **Walking** | | | | | |
| **Days/week** | 1(1,2) (0.0-4) | 2(1, 2.75) (0.0-4) | 1023.5 | -1.618 | 0.106 |
| **Min/week** | 30(30, 60) (0.0-120) | 30(30, 60) (0.0-120) | 1171.5 | -0.923 | 0.356 |
| **MET-min/week** | 99(99, 198) (0.0-396) | 99(99, 198) (0.0-396) | 1171.5 | -0.923 | 0.356 |
| **Total physical activity** | | | | | |
| **Days/week** | 3(3, 6) (0.0-7) | 5(3, 5) (0.0-10) | 1201.5 | -0.804 | 0.422 |
| **Min/week** | 90(90, 180) (0.0-10) | 150(90, 180) (0.0-300) | 1289.5 | -0.456 | 0.648 |
| **MET-min/week** | 459(459, 918) (0.0-918) | 657(459, 918) (0.0-1356) | 1329.5 | -0.307 | 0.759 |

**Data are presented as n (%) for categorical variables and Median (IQR) and Range for continuous variables.**
**U: Mann-Whitney U test. χ2: Chi-square test.**
***: statistically significant at p-value< 0.05**

#### 4.2.5.5 Associations between mental and emotional states and adequacy of glycaemic management post-lockdown

The Depression, Anxiety, and Stress Scale-21 Items (DASS-21) were used to measure the mental and emotional states of depression, anxiety, and stress in the participants. The obtained Cronbach's Alpha value of 0.877 indicates good reliability of the scale with these participants.

With Kolmogorov-Smirnov tests demonstrating that the DASS-21 subscales exhibited non-normal distribution ($p < 0.001$), the median (IQR) depression and anxiety scores were 2 (4), ranging 0-16, and the median stress score was 6 (6), ranging 0-24. These scores indicate overall 'normal' symptom levels (**Table 4.13**.).

The DASS scores demonstrated most participants reported depression, anxiety and stress scores within the "normal" range (n=298, 92.3%; n=294, 91.0%; n=317, 98.1%, respectively). Small numbers of participants reported mild to moderate levels of depression, anxiety and stress, with only one participant reported severe levels of anxiety symptoms (0.3%), and no-one reported extremely severe symptom load.

**Table 4.14** illustrates the relationship between DASS-21 scores and the adequacy of glycaemic management post the lockdown period. Mann-Whitney tests revealed significantly higher scores for depression, anxiety, and stress among participants who had inadequate control compared to those with adequate control post-lockdown ($p = 0.001$, 0.007 and $< 0.001$, respectively). However, the Chi-square test showed that there was no significant association between DASS-21 categories and adequacy of glycaemic management post-lockdown.

**Table 4.13.** Depression, Anxiety and Stress Scale scores for the DASS-21 (N=323).

| | | Depression | Anxiety | Stress |
|---|---|---|---|---|
| **Median (IQR)** | | 2 (4.0) | 2 (4.0) | 6 (6.0) |
| **Range** | | 0.0-16.0 | 0.0-16.0 | 0.0-24.0 |
| **Categories, N (%)** | Normal | 298 (92.3%) | 294 (91.0%) | 317 (98.1%) |
| | Mild | 23(7.01%) | 15(4.6%) | 5 (1.5%) |
| | Moderate | 2 (0.6%) | 13(4.0%) | 1 (0.3%) |
| | Severe | 0.0 (0.0%) | 1 (0.3%) | 0.0 (0.0%) |
| | Extremely severe | 0.0 (0.0%) | 0.0 (0.0%) | 0.0 (0.0%) |

**Table 4.14.** Associations between DASS-21 scores/ categories and adequacy of glycaemic management.

| | HbA1c post-lockdown | | U /$\chi^2$ | Z/df | p-value |
|---|---|---|---|---|---|
| | **Adequate control (n= 69)** | **Inadequate control (n=254)** | | | |
| **Depression score** | 0 (4) (0.0-12) | 2 (4) (0.0 -16) | 6517.5 | -3.387 | 0.001* |
| Normal | 64(92.8%) | 234(92.1%) | 0.122 | 1 | 0.727 |
| Mild | 5(7.2%) | 18(7.1%) | | | |
| Moderate | 0 (0.0%) | 0 (0.0%) | | | |
| Severe | 0 (0.0%) | 0 (0.0%) | | | |
| Extremely severe | 0 (0.0%) | 0 (0.0%) | | | |
| **Anxiety score** | 0 (4) (0.0-10) | 2 (4) (0.0-16) | 6988.0 | -2.684 | 0.007* |
| Normal | 64(92.8%) | 230(90.6%) | 0.980 | 1 | 0.322 |
| Mild | 4(5.8%) | 11(4.3%) | | | |
| Moderate | 1(1.4%) | 12(4.7%) | | | |
| Severe | 0 (0.0%) | 1(0.4%) | | | |
| Extremely severe | 0 (0.0%) | 0 (0.0%) | | | |
| **Stress score** | 0 (7) (0-18) | 6 (4) (0-24) | 5485.0 | -4.847 | < 0.001* |
| Normal | 68(98.6%) | 249(98) | 0.165 | 1 | 0.685 |
| Mild | 1(1.4%) | 4(1.6) | | | |
| Moderate | 0 (0.0%) | 1(0.4) | | | |
| Severe | 0 (0.0%) | 0 (0.0%) | | | |
| Extremely severe | 0 (0.0%) | 0 (0.0%) | | | |

**Data are presented as n (%) for categorical variables and Median (IQR) and Range for continuous variables.**
**U: Mann-Whitney U test. $\chi^2$: Chi-square test.**
***: statistically significant at p-value< 0.05**

#### 4.2.5.6 Associations between diabetes self-management and adequacy of glycaemic management post-lockdown

The SDSCA-A was used to assess four aspects of diabetes self-management: diet, exercise, glucose testing, and foot care. The reliability of the instrument was first assessed, demonstrating a high level of reliability with a Cronbach's Alpha of 0.840.

According to the Kolmogorov-Smirnov normality test, the data were not normally distributed ($p < 0.001$). The median diet compliance was low, reported at about 1 day per week and ranging from 0.0 to 5 days /week, as presented in **Table 4.15**. Participants also reported low compliance with exercise and foot care, with exercise and foot care reported at a median of 1 day per week, ranging from 0.0 to 4 days /week. The only subscale with a higher reported compliance was the blood sugar testing domain, undertaken on a median of 3.0 days per week (range 0.5-5 days/week).

**Table 4.15** Summary of Diabetes Self-care Activities – Arabic version scores (N=323).

| | **Median (Q1, Q3)** | **Range** |
|---|---|---|
| **Diet (days/week)** | 1.0 (1.0) | 0.0-5 |
| **Exercise (days/week)** | 1.0 (0.5) | 0.0-4 |
| **Blood Sugar Testing (days/week)** | 3.0 (1.0) | 0.5-5 |
| **Foot care (days/week)** | 1.0 (0.0) | 0.0-5 |
| **Q1: 25th percentile, Q3: 75th percentile** | | |

As shown in **Table 4.16**, the Mann-Whitney U test showed a significantly lower adherence with diet, exercise, blood sugar testing, and foot care behaviours in participants with inadequate glycaemic management compared to those with adequate control post-lockdown (p = 0.006, < 0.001, 0.009 and 0.006, respectively).

**Table 4.16.** Associations between SDSCA-A scores and adequacy of glycaemic management.

| | HbA1c post-lockdown | | U | Z | p-value |
|---|---|---|---|---|---|
| | **Adequate control (n= 69)** | **Inadequate control (n=254)** | | | |
| **Diet (days/week)** | 2(1) (0.0-5) | 1(1) (0.0-5) | 7020.5 | -2.749 | 0.006* |
| **Exercise (days/week)** | 1(1) (0.0-4) | 0.5(0.5) (0.0-3.5) | 4934.0 | -5.861 | < 0.001* |
| **Blood Sugar Testing (days/week)** | 3(2.5, 3.5) (2- 5) | 3(2, 3) (0.5-5) | 7079.0 | -2.603 | 0.009* |
| **Foot care (days/week)** | 1(1, 1.5) (0.0-5) | 1(1,1) (0.0-5) | 7389.0 | -2.758 | 0.006* |

**Continuous Data are presented as Median (IQR) and Range for continuous variables.**
**U: Mann-Whitney U test.**
***: statistically significant at p-value< 0.05**

#### 4.2.5.7 Predicting adequacy of glycaemic management post-lockdown.

Multivariate logistic regression was used to identify variables that were independently predictive of the adequacy of glycaemic management post-lockdown. A total of 15 independent variables (age, diabetes duration, BMI, use of insulin and Glimepiride, type of regular diabetes treatment, HTN, DASS-21 depression, anxiety and stress sub-scale scores, and SDSCA-A including diet, exercise, blood sugar testing and footcare sub-scale scores) were entered into the model. It should be noted that the IPAQ-A was disregarded due to the low activity reported and the lack of significance among the chosen measures of bivariate association. As a result, only the exercise subscale of SDSCA-A and measure mental and emotional states DASS-21 items were the only measures used. The full model

containing all predictors was statistically significant, $\chi 2$ (15, N = 323) = 72.793, $p < 0.001$ and -2 Log likelihood = 261.333, indicating that it was capable of distinguishing between respondents with inadequate and adequate glycaemic management post-lockdown.

As shown in **Table 4.17**, four independent variables (using insulin, using Glimepiride, BMI and current smoking) made statistically significant contributions to the model.

The strongest predictors of adequacy of glycaemic management after the lockdown were use of insulin (OR: 5.9, 95% CI: 1.6-22.4, p = 0.009), followed by use of Glimepiride (OR:4, 95% CI: 1.6-10.3, p = 0.004), then greater BMI (OR:1.1, 95% CI: 1.1-1.2, p = 0.001). Current smoking less strongly but still significantly predicted adequacy of glycaemic management after the lockdown (OR: 0.4, 95% CI: 0.2-0.8, p = 0.012). Participants who used insulin or Glimepiride, had higher BMI and did not currently smoke were more likely to have inadequate glycaemic management.

**Table 4.17.** Modelling factors potentially predictive of adequacy of glycaemic management post-lockdown.

| | S E | df | Wald | p-value | OR | 95% CI for OR |
|---|---|---|---|---|---|---|
| **Age (years)** | 0.017 | 1 | 1.108 | 0.293 | 1.0 | 1-1.1 |
| **Diabetes duration (years)** | 0.022 | 1 | 0.219 | 0.640 | 1.0 | 1-1.1 |
| **Body Mass Index (kg/m2)** | 0.034 | 1 | 11.550 | 0.001* | 1.1 | 1.1-1.2 |
| **Current smoker** | | | | | | |
| No | | | | | R | |
| Yes | 0.332 | 1 | 6.375 | 0.012* | 0.4 | 0.2-0.8 |
| **Insulin use** | | | | | | |
| No | | | | | R | |
| Yes | 0.681 | 1 | 6.807 | 0.009* | 5.9 | 1.6-22.4 |
| **Glimepiride use** | | | | | | |
| No | | | | | R | |
| Yes | 0.480 | 1 | 8.432 | 0.004* | 4.0 | 1.6-10.3 |
| **Type of regular diabetes treatment** | | | | | | |
| Oral agents and diet only | | | | | R | |
| Oral agents and insulin plus diet | 0.543 | 1 | 0.084 | 0.772 | 0.9 | 0.3-2.5 |
| **HTN** | | | | | | |
| No | | | | | R | |
| Yes | 0.344 | 1 | 0.964 | 0.326 | 1.4 | 0.7-2.7 |
| **Anxiety score** | 0.081 | 1 | 0.022 | 0.881 | 1 | 0.8-1.2 |
| **Depression score** | 0.083 | 1 | 1.507 | 0.220 | 1.1 | 0.9-1.3 |
| **Stress score** | 0.065 | 1 | .239 | 0.625 | 1 | 0.9-1.1 |
| **Diet score** | 0.253 | 1 | 0.625 | 0.429 | 1.2 | 0.7-2.0 |
| **Exercise score** | 0.289 | 1 | 1.585 | 0.208 | 0.7 | 0.4-1.2 |
| **Blood sugar Testing score** | 0.234 | 1 | 0.268 | 0.605 | 1.1 | 0.7-1.8 |
| **Footcare score** | 0.298 | 1 | 0.445 | 0.505 | 0.8 | 0.5-1.5 |

**SE: Stander error. df: degrees of freedom. OR: Odds ratio. R: Reference category.**
***: Statistically significant at p-value< 0.05**

### 4.2.6. Summary:

A total of 323 participants with T2DM participated in this study, of whom 51.4% were female; the sample group was aged mean ± SD 57.8 ± 11.7 years and had lived with diabetes for 19.1 ±10.8 years. The sample group median HbA1c level rose significantly from 7.7% during the six months pre-lockdown to 8.0% within the three months post-lockdown, with an increase in the proportion of participants who had inadequate glycaemic management post-lockdown (n=254, 78.6%) compared to pre-lockdown (n=221, 68.4%).

Pre-lockdown, the only variables that conveyed an increased risk of inadequate glycaemic management were use of insulin and a diagnosis of HTN. However, post-lockdown, a greater number of variables were significantly associated with an increased risk of inadequate glycaemic management, particularly use of insulin or Glimepiride but also greater BMI. Conversely, current smoking was linked to better glycaemic management. In this generally inactive sample, no significant correlation with the adequacy of glycaemic management post-lockdown was demonstrated with A-IPAQ scores, whether vigorous/ moderate physical activities, walking or total physical activity. Participants who reported inadequate management after lockdown demonstrated significantly higher scores for depression, anxiety, and stress compared to those with adequate management. Furthermore, there was also a significant association with lower compliance with diet, exercise, blood sugar testing, and foot care behaviours after the lockdown.

Based on the results of multivariate logistic regression analysis, the factors that were found to be significantly predictive of adequacy of glycaemic management after lockdown were the use of insulin and Glimepiride, higher BMI, and current smoking.

## 4.3. PHASE II QUALITATIVE RESULTS

### 4.3.1. Introduction

The results of phase II were based on responses to the two open-ended questions that allowed the participants to have unrestrained or free responses to discuss their experience during the lockdown.

The two questions asked were:

1- What was it like for you to manage your diabetes during the lockdown?

2- How did you feel during the lockdown period in relation to your glycaemic control, during the lockdown compared to your normal or usual control before the lockdown?

### 4.3.2. Demographic characteristics

In total, 15 survey participants completed the semi-structured interview questions. Of these 15 participants, 9 (60.0%) were female. Their mean age was 58.5 years, and their mean duration post diabetes diagnosis was 18.1 years (see **Table 4.18**). They all used diet and oral medications to management their diabetes, and two (13.3%) participants also used insulin. To preserve the confidentiality of their identities, participants have been identified by code identifiers only (**Table 4.19**).

**Table 4.18. Participants' demographic details.**

| | | N (%) | Mean ±SD |
|---|---|---|---|
| **Age (Years)** | | | 58.5 ±9.1 |
| **Gender** | Male | 6(40.0%) | |
| | Female | 9(60.0%) | |
| **Diabetes duration (Years)** | | | 18.1 ±8.2 |
| **Marital status** | Not currently married | 1(6.7%) | |
| | Married | 14(93.3%) | |
| **Highest education level** | Primary | 4(26.7%) | |
| | Secondary/High school | 10(66.7%) | |
| | Bachelor's degree | 1(6.7%) | |
| **Housing** | Living with parents/guardians/relatives/ friends | 1(6.7%) | |
| | Living with spouse | 14(93.3%) | |
| **Occupation** | Unemployed | 10(66.7%) | |
| | Employed | 3(20.0%) | |
| | Retired | 2(13.3%) | |
| **Income in US$** | Less than 3,000 | 8(53.3%) | |
| | 3,000-7,000 | 746.7%) | |

**Data are presented as n (%) for categorical variables and mean±SD for continuous variables.**

**Table 4.19. Participants' clinical details.**

| | | N (%) | Mean ±SD |
|---|---|---|---|
| **Smoking** | Yes | 5(33.3%) | |
| | No | 10(66.7%) | |
| **Type of regular diabetes treatment** | Oral agents and diet only | 13(96.7%) | |
| | Oral agents, diet and insulin | 2(13.3%) | |
| **Diabetes medications** | | | |
| **Metformin** | Yes | 15(100.0%) | |
| **Insulin** | No | 2(13.3%) | |
| **Co-morbidities** | | | |
| **Stroke** | No | 15(100.0%) | |
| **Gastric/Peptic ulcer** | No | 15(100.0%) | |
| **HTN** | No | 3(20.0%) | |
| | Yes | 12(80.0%) | |
| **MI** | No | 15(100.0%) | |
| **COPD/Asthma** | No | 15(100.0%) | |
| **CHF** | No | 15(100.0%) | |
| **Prostate Cancer** | No | 15(100.0%) | |
| **CKD** | No | 15(100.0%) | |
| | | | |
| **HbA1c (%)6m before lockdown** | | | 7.6±1.1 |
| **HbA1c (%) 3m after lockdown** | | | 8.9±2.1 |
| **Perceived diabetes control Before lockdown** | Good control | 6(40.0%) | |
| | Poor control | 9(60.0%) | |
| **Perceived diabetes control after lockdown** | Good control | 4(26.7%) | |
| | Poor control | 11(73.3%) | |

**Data are presented as n (%) for categorical variables and mean±SD for continuous variables.**

**HTN: Hypertension, MI: Myocardial infarction, COPD: Chronic obstructive pulmonary disease, CHF: Congestive Heart Failure, CKD: Chronic kidney disease.**

The mean height, weight, and BMI for men were 167.33±8.96cm82.83±15.56 Kg and 29.33±3.09 Kg/m2, respectively. For women, the mean of the same variables was 162.44±9.03cm, 80.22±10.76Kg, and 30.41±3.50Kg/m2, respectively **(Table 4.20).**

**Table 4.20.** Anthropometric measurements for both males and females.

| | **Male (N=6)** | **Female (N=9)** |
|---|---|---|
| **Height (cm)** | 167.33±8.96<br>(153-176) | 162.44±9.03<br>(145-170) |
| **Weight (Kg)** | 82.83±15.56<br>(63-102) | 80.22±10.76<br>(60-92) |
| **Body mass Index (Kg/m2)** | 29.33±3.09<br>(25.39-34.08) | 30.41±3.50<br>(24.51-36.15) |
| **Data are presented as mean±SD and Range** | | |

The qualitative analysis of the interviews revealed several key themes reflecting participants' experiences during the pandemic and lockdown. These themes align with the participants' narratives concerning their diabetes management both pre- and during the lockdown. The emergent themes encompass fear and faith, impact of isolation; challenge of control; and barriers and facilitators to diabetes management.

### 4.3.3. Fear and faith

Participants' responses to the pandemic varied. Fear was the predominant response, reported by two-thirds (n=10, 66.7%) and almost half the participants (n=7, 46.7%) reported, specifically, being terrified of being infected with COVID-19. However, other participants reported that their faith in God was a significant help to them to pass these difficult times. Almost half (46.7%) of the participants reported they did not know what they should do during the lockdown, which made them stressed and anxious.

Bad news was said to be everywhere, and one participant reported a fear of being forced to take the vaccine. One elderly female said,

> "I was excessively scared of hearing terrible news regarding the coronavirus and about the possibility of being forced to take the vaccine even though they had not proved that it was safe." (P5).

About two-thirds of the participants mentioned that media and social media were the main cause of the fear of COVID-19. A male participant said,

> "I will be honest with you. I was so nervous because all the news about the coronavirus had increased my stress level." (P3).

Another participant said,

> "I was nervous due to the news about the risks of the virus that was posted on Facebook and all other social media platforms." (P9).

In addition to reports of verified infection rates and deaths, the news conveyed by various media could also be distorted and have a scare-mongering effect:

> "Anyone with a chronic disease who tested positive for the virus would go straight to the grave with no other option." (P6).

Fear of COVID-19 was evident and for many it was seen as a reason for their poor diabetes management. Everyone around them was afraid of the virus, as one female participant said,

> "I was so afraid during the lockdown period because everyone was afraid and was talking about the coronavirus." (P1).

They knew of people who had been infected, and were aware that their diabetes conveyed additional vulnerability:

> "One of my relatives (with diabetes) died after three days of being infected with COVID-19. As I had diabetes, I was afraid of being infected and having the same thing happen to me" (P11).

Another female participant was worried about the lack of availability of any curative drugs for COVID-19.

> "I swear to God that I was scared, because we heard that people were dying quickly, and there is no cure if you get infected. I mean that we lived in terror during the lockdown." (P2). Another participant reported poor blood glucose management because his focus and priority were protecting himself from the coronavirus.
>
> "Getting complications of my diabetes are better than dying from the virus. As a result, my blood glucose readings were high during the lockdown period" (P2).

A lack of resources (particularly diabetes drugs) was reported by seven participants (46.7%) to cause fear. The lack of resources included lack of money due to dismissal from their occupation or the deterioration of the economic situation generally, a lack of food due to the closure of shops, as well as the lack of diabetes drugs. All of these shortages contributed to increase their stress, compounded their fear of COVID-19, and reduced their ability to manage their diabetes. One man, the head of a family, explained:

> "I was depressed and lost hope as I work as a casual and do not have a government job. During the lockdown, I lost my job and did not have an income, so my financial state was terrible, and I could not manage my blood glucose readings. For me, I would rather die with my children due to the virus than die from hunger." (P15).

The lack of resources in terms of access to healthcare providers was highlighted by one participant who reported that she could not reach physicians or nurses by phone during the lockdown, making her more anxious and compounding her situation.

> "My blood glucose readings were high during the lockdown as I could not manage my diabetes. When I needed answers about some problems, I faced due to the high readings, I would be terrified as there was no phone number for the clinic that I could call to contact a doctor or a nurse. At least my worries would have been gone through answering my questions, but this was not available for us. I was scared to get infected with the virus. If I were to get infected, my state would deteriorate entirely, so I would instead remain at home as it was easier for me" (P11).

#### 4.3.4. Impact of isolation

There were various responses to the isolation of lockdown. One man reported feeling boredom because he was normally a very sociable man:

> "I'm a social person and love to be around people. As a result, I was not happy as I would spend the whole-time watching TV, sitting at home, and eating" (P14).

Another man explained that it was not so much the lockdown as the circumstances that it imposed on him that posed the problems for him. He stated that:

> "During the lockdown, I lost my job and did not have an income, so my financial state was terrible, and I could not manage my blood glucose readings. For me, I would rather die with my children due to the virus than die from hunger." (P15).

One participant likened remaining at home during the lockdown as if there was an ongoing war outside.

> "It was a harrowing experience as it was my first time staying at home for an extended period. We were terrified to stay at home as we were suffering from an ongoing war; at the same time, I was also worried about leaving my house, and my blood glucose readings were higher than before the lockdown" (P6).

### 4.3.5. Challenge of control

Asked about their diabetes management before the start of the pandemic, six (40.0%) participants described this as good, and nine (60.0%) described it as poor. After the lockdown, only four (26.7%) participants described the management of their diabetes as good, and 11 (73.3%) deemed it as poor. This pattern of overall deterioration was born out by the HbA1c values recorded in the health records for these participants, where the mean ± SD had risen from 7.6% ±1.1% in the six months before the lockdown to 8.9% ± 2.1% in the three months after the lockdown. For most participants, keeping their diabetes under management during the lockdown was a tremendous challenge. Whilst the majority of participants (n=11, 73.3%) reported their management of their diabetes during this period as poor, a minority managed to keep their diabetes stable.

#### 4.3.5.1 Stable management

Four participants (26.7%) maintained stable blood glucose levels throughout the pandemic and reported they were able to do this by actively managing their glycaemic index. They explained that they achieved this by focusing on taking their diabetes medicines on time and linked their success with this to their ability to maintain their blood glucose at the same level as before the lockdown. Whilst some indicated no change in managing their diabetes during the lockdown period compared to before the lockdown, their rationales for this differed. The first explained:

> "Honestly, the situation was not ideal for everyone; for me, I tried to take my medicine on time, and I would pray to God to help us and get us out of this situation. Also, I would exercise at home and eat less. Thank God, there was no change to my blood glucose levels compared to before the lockdown" (P9).

Another participant, who also mentioned that there were no changes in their blood glucose levels during the lockdown compared to before the lockdown, described the strategies to which they attributed this success.

> "I managed my diabetes by staying away from the news as it would overwhelm people, and I would listen to and read the Quran to release my stress. I also followed the recommended diabetes diet and Alhamdulillah (Thank God). The blood glucose readings did not increase during the lockdown and were very close to the readings before" (P13).

One of these four participants indicated they had not noted any variation in blood glucose levels during the lockdown compared to before the lockdown occurred.

> "It was a different experience because I had worked most of the time before the lockdown and only went home to sleep. However, my diabetes management was better during the lockdown period, but the blood glucose readings were the same as before the lockdown" (P4).

One participant reported better glycaemic index readings during the lockdown because he could meet his needs regarding healthy food, exercise, and medicines.

> "The lockdown was an excellent experience for me as I had all my necessities met regarding healthy food and medicine. I also had time to exercise, and my blood glucose readings were better during the lockdown" (P7).

#### 4.3.5.2 Deteriorating glycaemic management

However, the majority (eleven (73.3%) participants) reported they had inadequate blood glucose management during the lockdown because they were unable to manage their diabetes, although, as one of these participants noted, there was more to it than that. They reported a wide variety of issues which they blamed for their poor diabetes management. The reasons they gave included fear of COVID-19, lack of resources, and a multitude of associated mental and physical health problems, incorporating previous themes of fear and impact of isolation.

One participant reported that it was a bad period for him as he could not stick to a proper diabetes diet due to only having the food that was available at home. As all the shops and clinics were closed, they were anxious about the shortage of everyday necessities and medicine.

Family was another resource that could be missed. An older woman reported that it was difficult for her to manage her diabetes without the help of her daughters.

> "(Normally) my daughters visited me daily to prepare food and give me my medicines. But during the lockdown period, everyone was afraid and could not get out of their houses, so every week, just one of my daughters came to help me instead of every day. My blood glucose readings were high during the lockdown" (P5).

### Barriers and facilitators to diabetes management

**Previous themes describe some barriers and facilitators such as the impact of isolation, and fear. Other barriers and facilitators also impacted participants' management of their diabetes, including physical inactivity.** Six (40.0%) participants reported physical inactivity during the lockdown period. This was a change from their normal lifestyle and consequently affected their diabetes management. One participant explained:

> "I used to walk every day for an hour outside the house, but it was like I was in prison during the lockdown period" (P1).

Another participant stated:

> "It was a bad period for me as I could not … do any exercise, and because of the closing of markets, I only ate what was available at my home without considering the (recommended) diet" (P12).

A third respondent also indicated that he could not manage his diabetes well during the lockdown compared to how he managed before the lockdown.

> "Because I was not eating, sleeping, or resting as before the lockdown period. Because everything had changed. And my blood glucose readings were high during the lockdown period" (P3).

**Mental health problems also were a barrier to diabetes management.** Eight (53.0%) participants reported mental health problems, including anxiety, stress, depression, and a sense of isolation. The enforced isolation meant that people were cut off from members of their family other than those in the same household, and this lack of family contact was a source of major stress. Family and the support they provided each other were important factors in getting through the pandemic, which was highlighted by one participant:

> "I was suffering from severe depression as I could not visit my mother and the rest of the family as home visits were banned, and I was afraid they would get infected" (P8).
>
> "My blood sugar readings were high during the lockdown period because it was difficult for me to manage it from my fear and lack of capability" (P1).

In addition, some participants reported that their stress, fear and anxiety led to a marked increase in eating, which negatively affected their ability to manage their diabetes. One respondent emphasised how this impacted them:

> "I would feel boredom as I would follow the same routine daily of staying at home. This led me to eat more; as a result, I was unable to manage my blood glucose readings during the lockdown compared to before, when you would socialise with people. Staying at home, you would eat and eat" (P10).

Alternatively, four participants reported **positive experiences which they felt allowed them to manage their diabetes effectively**.

Where people had adequate resources, e.g., money, to manage their household expenses whilst they were either without work or able to continue working from home, the lockdown provided these people with additional time. One participant stated:

> "I was the happiest person on the planet because I couldn't get to work during the lockdown. What I mean is that it was the first time I felt this feeling because I desperately needed to rest and stay away from people. Additionally, I did not feel any difference in my blood glucose level during the lockdown period compared to before the lockdown." (P4)

Where they were able to enjoy this as a period of rest and family time (that is, had adequate resources and were not overcome with fear of COVID-19 or associated mental health problems) and this allowed them more time to exercise, to cook and eat home-prepared meals and to enjoy being with their children, the lockdown period was regarded positively. This was explained by one participant:

> "I was glad that I didn't work and had more time to spend with my wife and the kids. I was able to manage my blood glucose readings during the lockdown as I was exercising at home and would eat homemade meals. Before the lockdown, I didn't have time to exercise or spend enough time with the kids. My situation depended on eating from restaurants due to the nature of my work." (P7).

In these circumstances, their control of their diabetes was no worse during the lockdown than before it.

### 4.3.6. Summary

A total of 15 survey participants with T2DM completed the semi-structured interview questions. Due to the exceptional nature of the situation and the stress, worry, and changes in their daily lives during the COVID-19 lockdown, most participants (n=11, 73.3%) reported a deterioration in management of their diabetes during the lockdown period compared to before the pandemic (n=9, 60.0%). This was supported by their blood results, showing that these participants' mean blood glucose level had risen from 7.6% ±1.1% six months before the lockdown to 8.9% ± 2.1% three months after the lockdown - a clinically significant change.

Themes including fear and faith, impact of isolation; challenge of control; barriers and facilitators to diabetes management were found to describe the participants' experiences of managing their diabetes during Covid-19 lockdown. Besides their difficulties managing the disease, they described their fear of contracting the virus and how their lifestyles had been affected by the lockdown, resulting in low levels of physical exercise and greatly reduced ability to adhere to eating only healthy food. They had suffered a wide variety of physical and mental effects which they saw as resulting from the pandemic and its management, and resulting in, for the most part, worsened diabetes management. However, a minority managed well, which they attributed predominantly to having adequate resources to manage without paid employment, and not being overcome with fear of COVID-19 or associated mental health problems.

In the planning and management of future pandemics, these results will be important for how they can help guide the design of information and self-care strategies and explore new ways of empowering people without access to healthcare personnel to manage emergent psychological issues, promote healthy lifestyles, and maintain compliance with diabetes self-management behaviours to management the disease until a more normal situation can be achieved.

# 5. CHAPTER 5 PHASE III: DELPHI CONSULTATION RESULTS

## 5.1. Introduction

This chapter outlines the findings of Phase III in response to the fourth research question: "What recommendations can be drawn from the experiences of the COVID-19 pandemic in relation to supporting glycaemic control of people with T2DM and for nursing education and training for future pandemic preparedness?"

This phase involved a modified Delphi consultation to establish consensus recommendations for nurse education and practice to optimize self-management and glycaemic management of people with T2DM in any future pandemic, based on the findings of phases I and II of this study. This Delphi study was conducted in the form of a survey and consultation exercise, which was delivered three times by email. As is usual for a Delphi study, this was referred to as "three rounds" of consultation, as detailed in Chapter 2, section 6. The component elements of this modified Delphi are presented in **Table 5.1.**

**Table 5.1.** Questions for the modified electronic Delphi consultation.

| |
|---|
| Q1. What are the implications of findings from phase 1 and 2 of this study for nursing practice? |
| Q2. What recommendations could be made to develop nursing practice to better manage care and support for people with T2DM during any future pandemic? |
| Q3. What are the implications of findings from phase 1 and 2 for nursing and health service policy development or change? |
| Q4. What recommendations could be made to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic? |
| Q5. What are the implications of findings from phase 1 and 2 for nursing education? |
| Q6. What recommendations could be made to develop nursing education to better prepare nurses to support people with T2DM during any future pandemic? |

The classic approach of a Delphi study, entailing a number of consultation 'rounds' with an expert panel, was modified by the addition of an initial stage which entailed a presentation to the panel by the researcher of a PowerPoint slide pack of key findings of phases 1 and 2 of this study as set out in chapter 5, sections 5.1 and 5.2 of this thesis. In order to enable the expert panel to review and revisit these findings as desired, to support their deliberations during the Delphi 'rounds', a video was also made of this slide presentation by the researcher, and findings were also condensed into a brief written report, both made available to panel members**; see Appendix 5.1.**

## 5.2. Delphi participants and the recruitment response rate

A panel of twelve expert nurses/midwives were invited to participate in this Delphi consultation via email. Twelve participants were invited as this number was recommended as able to provide sufficient breadth of expertise and experience without the panel becoming so large that consensus became difficult to achieve (Hallowell & Gambatese, 2010).

With nine of twelve invitees responding in round one, the response rate for round one was 75%. All nine respondents to round one also responded in rounds two and three.

The key characteristics of the panellists and their demographic details were summarised in **Table 5.2.** All participating panellists were members of the Jordanian Nurses and Midwives Council and had more than a decade of experience as registered nurses (RNs) in Jordan's public hospitals.

**Table 5.2.** Details of the expert panel members.

| No. | Role | Years of Experience as RN | Workplace |
|---|---|---|---|
| 1 | Intensive Care Unit Nurse Manager | More than 15 years | Public Hospital in Jordan |
| 2 | Medical-Surgical in charge RN | More than 11 years | Public Hospital in Jordan |
| 3 | Healthcare Quality Coordinator | More than 12 years | Public Hospital in Jordan |
| 4 | Infection Control Practitioner | More than 28 years | Public Hospital in Jordan |
| 5 | Nurse Manager of Diabetic Foot and Wound Management Clinic | More than 11 years | Public Hospital in Jordan |
| 6 | Nurse Educator in the Education and Training Department | More than 15 years | Public Hospital in Jordan |
| 7 | Clinical Risk Manager | More than 12 years | Public Hospital in Jordan |
| 8 | Emergency in charge Registered Nurse | More than 14 years | Public Hospital in Jordan |
| 9 | Intensive Care Unit in charge Registered Nurse | More than 11 years | Public Hospital in Jordan |

Results of the responses for each round from respondents are presented initially in a text summary format and then more detail is provided in tables referenced against each question, including the percentage concordance as relevant.

### 5.3. Delphi round one.

In round one of the Delphi consultations, nine participants made a total of 54 proposed recommendations; two were excluded as duplicates and 52 were entered into round two. Below are the results from round one presented by Panellists against each question posed **(Table 5.3.a-f)**:

**Q1.** ***When considering the implications of findings from phase 1 and 2 of this study for nursing practice,*** the respondents offered nine responses that included: novel patient-centred diabetes management/monitoring technology; lack of multi-disciplinary teams; limitations in access to care; methods of delivering diabetes health education; home-based physical activity programs; nursing workload demands; lack of appropriate individualised management plans; decentralised health systems; and lack of easy access to out of hours support. These implications are outlined in **Table 5.3.a.**

**Table 5.3.a.** Proposed implications of findings from phases 1 and 2 of this study for nursing practice obtained in Delphi round one.

| **Q1- What are the implications of these findings for nursing practice?** |
|---|
| **1.** Findings flag the need to develop novel patient centred diabetes management/monitoring technology such as remote monitoring for BGL. |
| 2. Services lack a multidisciplinary well-trained rapid access mobile diabetes team to be deployed during any future pandemic. |
| 3. Limitations in patient access to care might be addressed by telehealth services, which may consequently reduce presentations to hospitals during any future pandemic. |
| 4. There is a need to improve the methods of delivering diabetes health education such as by digital diabetes education programs and mobile applications. |
| 5. Home-based physical activity programs could be used to support diabetes self-management. |
| 6. The increasing nursing workload demands increased resources to be fully prepared for the future pandemics. |
| **7. Patients lack appropriate individualised management plans and feedback.** |
| 8. Decentralized health systems can make it difficult to access patient information support and advice. |
| 9. Patients lack easy access to out of hours nursing support, which might be provided online. |
| **BGL: Blood glucose levels** |

**Q2.** ***When considering the recommendations of findings from phases 1 and 2 of this study to develop a nursing practice to better manage care and support for people with T2DM during future pandemics,*** Delphi participants offered eight recommendations that included: implement metrics to measure whether a facility has the plans, procedures, and human resources; involve diabetes nurses in emergency preparedness drills; enhance hospital managers' awareness and adoption of crisis standards of care; provide free education and counselling to people with T2DM to improve their mental well-being; provide up-dated technology for blood glucose remote monitoring and telehealth; organize mental health sessions for nurses; encourage physical activity

and home-based exercise programs and consider patients' individual health needs. These recommendations are outlined in **Table 5.3.b.**

**Table 5.3.b.** Proposed recommendations to develop the nursing practice to better manage care and support for people with T2DM during any future pandemic obtained in Delphi round one.

| **Q2- What recommendations could be made to develop nursing practice to better manage care and support for people with T2DM during any future pandemic?** |
|---|
| 1. Healthcare accreditors should implement metrics that measure whether a facility has the plans, procedures, and human resources needed to surge the diabetes nursing workforce to better manage care and support for people with T2DM during a pandemic. |
| 2. Hospitals should conduct and include diabetes nurses in emergency preparedness drills and exercises for future pandemic response. |
| 3. Hospital managers enhance awareness and adoption of crisis standards of care. |
| 4. To deal with any future pandemic, people with T2DM should receive free education and counselling to help improve their mental well-being. |
| 5. Hospitals and the government should study the feasibility of providing up-dated technology for blood glucose monitoring (remote monitoring and telehealth) in preparedness of future pandemics. |
| 6. Counselling services and mental health sessions should be available for nurses to help improve their mental well-being and mitigate the fear and anxiety of any future pandemic. |
| 7. Nurses should encourage physical activity and home-based exercise programs as essential tools for preventing and managing diabetes and improving mental well-being during quarantine and future pandemics. |
| 8. Nurses should consider patients' individual health needs, their capacity for self-management and any potential barriers they face daily. |

**Q3.** ***When considering the implications of findings from phases 1 and 2 of this study for nursing and health service policy development or change,*** the respondents offered nine responses that included: the role of diabetes education in addressing fear among people living with T2DM; invest more funding for diabetes management and education; new national disaster planning system; provide telehealth systems; role of psychiatrists in reducing pandemic-related stress and anxiety among people with diabetes; the lack of specific policies to manage fear and anxiety; new policies on monitoring and managing diabetes in community settings; mental health access for vulnerable groups; and review policies concerned with nurse management programs and home visiting. These implications are outlined in **Table 5.3.c.**

**Table 5.3.c.** Proposed implications for nursing and health service policy development or change obtained in Delphi round one.

| **Q3- What are the implications of these findings for nursing and health service policy development or change?** |
|---|
| 1. Findings highlight the role of diabetes education as a critical component in addressing fear among people living with T2DM during a pandemic. |
| 2. Findings highlight the need to invest more funding for diabetes management and education. |
| 3. Findings highlight the need to develop a new national disaster planning system to help healthcare providers and diabetes patients maintain diabetes control even during a pandemic. |
| 4. Telehealth systems might provide support and ensure the safety of healthcare providers and patients. |
| 5. Findings highlight the role of psychiatrists in reducing pandemic-related stress and anxiety among people with diabetes, especially those on insulin and with other comorbidities such as hypertension. |
| 6. Findings flag the lack of specific policies to manage fear and anxiety if access to health services is reduced during a pandemic. |
| 7. Findings highlight the need to develop new policies on monitoring and managing diabetes in community settings. |
| 8. Policymakers must include mental health access for vulnerable groups during a pandemic. |
| 9. Findings flag the need to review policies concerned with nurse management programs and home visiting during a pandemic. It is an essential nursing role to encourage patients to engage in self-management of their condition by using patient-centred customized interventions considering individual circumstances and patients' characteristics, which could have made a huge difference during the pandemic. |

**Q4.** ***When considering the recommendations of findings from phases 1 and 2 of this study to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic,*** Delphi respondents offered nine recommendations that included: fund through Human Resources and Services Administration for development of the diabetes nursing workforce; establish crisis leadership skills among nurse administrators, managers, and executives; identify local capacity for advancing emergency preparedness; convene a national workshop of interdisciplinary subject matter experts; incorporate pandemic education as an essential component for nurses and other healthcare professionals; design and make available a mobile application for managing diabetes; create a Jordanian Diabetes Registry; develop new diabetes management policies; and increase funding for diabetes clinics. These recommendations are outlined in **Table 5.3.d.**

**Table 5.3.d.** Proposed recommendations to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic obtained in Delphi round one.

| **Q4- What recommendations could be made to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic?** |
|---|
| 1. The Human Resources and Services Administration should fund diabetes nursing workforce development for public health emergency preparedness and response. |
| 2. Hospital managers should endeavour to establish and maintain crisis leadership skills in nurse administrators, managers, and executives who can help foster and champion nurse preparedness and response at the highest levels. |
| 3. Key stakeholder groups should identify local capacity for advancing emergency preparedness and the response knowledge base of the diabetes nursing workforce and integrate this information into their subsequent strategic plans. |
| 4. Health policymakers should convene a national workshop of interdisciplinary subject matter experts to explore the lessons learned from the national diabetes nurse response to COVID-19 and ways to take forward any subsequent recommendations in preparation for any future pandemic. |
| 5. Incorporate pandemic education as an essential component for nurses and other healthcare professionals to better manage care and support for people with T2DM during any future pandemics. |
| 6. Decision makers should design and make available a mobile application to assist in diabetes management by allowing the patient to set reminders for medications, track physical activity, record blood glucose levels, and plan daily meals and should also be linked to the patient's medical record to make a follow-up with specialists easier and more effective. |
| 7. A Jordanian Diabetes Registry should be created to track and improve the quality of care and outcomes of people with T2DM through the collection of data on key performance measures that drive change in diabetes care, such as HbA1c, dietary intake counselling, physical activity counselling, diabetes foot examinations, diabetes medication adherence, etc. This will help solve problems and reduce gaps in diabetes care to promote health equity. |
| 8. Policymakers should develop new diabetes management policies to help nurses during any future pandemic. |
| 9. The government should increase funding for diabetes clinics to enable them to be fully prepared for any future pandemics. |

***Q5. When considering the implications of findings from phases 1 and 2 of this study for nursing education*****,** the respondents offered nine responses that included: train nurses in use of telehealth; the importance of good nursing documentation practice; case management system; nursing staff need education about COVID-19 challenges; flexible and adaptive nursing education systems; new ways to educate patients on self-management of diabetes; pre-planning nursing education programs; emphasize challenges faced by people with T2DM; and impact of individual differences between patients. These implications are outlined in **Table 5.3.e.**

**Table 5.3.e.** Proposed implications of these findings for nursing education obtained in Delphi round one.

| **Q5- What are the implications of these findings for nursing education?** |
|---|
| 1. Nurses need to be trained in use of telehealth and in managing patients' disease processes remotely. |
| 2. Findings highlight the importance of good nursing documentation practice to help healthcare providers take decisions for their patients and recognise who needs to go to a health care facility and who can be managed remotely. |
| 3. Findings flag the need to improve the case management system in which nurses help patients focus on controlling combined risk factors to provide good diabetes care. |
| 4. Findings highlight that nursing staff need education about COVID-19 challenges, such as those presented by routine diabetes management. Real-case presentations can be used to present information about the best ways to deal with each case. |
| 5. Nursing education systems must be flexible and adaptive in order to respond or recover more quickly from crises. |
| 6. Nursing education needs to develop new ways to educate patients in diabetes self-management that will remain usable during a pandemic. |
| 7. Nursing education must now include pre-planning on how to cope with diabetes and illnesses during pandemics. |
| 8. Nursing education could benefit from emphasizing the challenges faced by people with T2DM, as this should be the core of nursing care and patient education from the early stages. This should support acceptance of the disease, adherence to treatment, and early identification and management of complications. |
| 9. Nursing education should highlight the impact of individual differences between patients and be resourceful in introducing and explaining self-management interventions that match patients' ages, personalities, genders, backgrounds, and educational levels. |

***Q6. When considering the recommendations of findings from phases 1 and 2 of this study to develop nursing education to better prepare nurses to support people with T2DM during any future pandemic***, the experts offered eight responses that included: healthcare accredited education and training for diabetes nurses; update nursing education curricula; develop robust metrics; revised curricula for schools and universities; formulate a proactive response to the changing infectious disease by academic nursing; prepare a T2DM pandemic resources information and action plan; pre-planning and regular education of nursing staff; and provide education and training, career development, and network opportunities. These recommendations are outlined in **Table 5.3.f.**

**Table 5.3.f.** Proposed recommendations to develop nursing education obtained in Delphi round one.

| **Q6- What recommendations could be made to develop nursing education to better prepare nurses to support people with T2DM during any future pandemic?** |
|---|
| 1. Healthcare accreditors should include education and training for diabetes nurses on pandemic preparedness as a specific requirement beyond the current all-hazards approach, to better evaluate a healthcare organization's emergency preparedness. |
| 2. The nursing education curricula should be updated with the new information and experience acquired from the COVID-19 pandemic in order to train nurses in effective clinical practice for diabetes during pandemics. |
| 3. Schools of nursing should develop robust metrics for evaluating nurse preparedness, which should be implemented across academic and life-long learning programming. |
| 4. Revised curricula are essential for schools and universities to facilitate the inclusion of emergency preparedness and response content across all baccalaureate and graduate academic programs. |
| 5. Academic nursing should formulate a proactive response to the changing infectious disease landscape by offering certificates and digital badges in emergency preparedness and response. |
| 6. Set up a T2DM pandemic resources information and action plan to be activated during future pandemics. |
| 7. Pre-planning and regular education of nursing staff about diabetes and guidelines will help to prepare for future pandemics. |
| 8. Healthcare accreditors should provide education and training, career development, and network opportunities to early career nurse scientists and nursing students. |

### 5.4. Delphi round two.

In the second Delphi round, 43 recommendations were received with >80% response agreement with each statement and these were entered into round three. Nine recommendations obtained >80% disagreement and were therefore eliminated (**Table 5.4a-f**).

***Q1.*** **When asked about the implications of phase 1 and 2 findings for nursing practice,** 100% of respondents agreed that novel patient-centred diabetes management/monitoring technology; lack of multi-disciplinary teams; limitations in access to care; methods of delivering diabetes health education; home-based physical activity programs; and decentralised health systems.

However, 88.89% of respondents disagreed about nursing workload demands; lack of appropriate individualised management plans; and lack of easy access to out of hours support **(Table 5.4.a)**.

**Table 5.4.a.** Proposed implications of findings from phases 1 and 2 of this study for nursing practice obtained in Delphi round two.

| **Statement** | **Agreement/ Disagreement** | **Percentage concordance** |
|---|---|---|
| 1. Findings flag the need to develop a novel patient centred diabetes management/monitoring technology such as remote monitoring for BGL. | Agree | 100% |
| 2. Services lack a multidisciplinary well-trained rapid access mobile diabetes team to be deployed during any future pandemic. | Agree | 100% |
| 3. Limitations in patient access to care might be addressed by telehealth services, which may consequently reduce presentations to hospitals during any future pandemic. | Agree | 100% |
| 4. There is a need to improve the methods of delivering diabetes health education such as by digital diabetes education programs and mobile applications. | Agree | 100% |
| 5. Home-based physical activity programs could be used to support diabetes self-management. | Agree | 100% |
| 6. The increasing nursing workload demands increased resources to be fully prepared for the future pandemics. | **Disagree** | **88.89%** |
| 7. Patients lack appropriate individualised management plans and feedback. | **Disagree** | **88.89%** |
| 8. Decentralized health systems can make it difficult to access patient information support and advice. | Agree | 100% |
| 9. Patients lack easy access to out of hours nursing support, which might be provided online. | **Disagree** | **88.89%** |
| **Statements that received > 80% concordance on disagreement were highlighted in bold font and were excluded from round three.** | | |

***Q2.*** **When asked about the recommendations for developing the nursing practice to better manage care and support for people with T2DM during future pandemics,** 88.89% of respondents agreed with implementing metrics to measure whether a facility has the plans, procedures, and human resources. In addition, 100% of respondents agreed with involving diabetes nurses in emergency preparedness drills; enhancing hospital managers' awareness and adoption of crisis standards of care; to provide free education and counselling to people with T2DM to improve their mental well-being; provide up-dated technology for blood glucose remote monitoring and telehealth; organize mental health sessions for nurses; encourage physical activity and home-based exercise programs and consider patients' individual health needs **(Table 5.4.b).**

**Table 5.4.b.** Proposed recommendations to develop the nursing practice to better manage care and support for people with T2DM during any future pandemic obtained in Delphi round two.

| **Statement** | **Agreement/ Disagreement** | **Percentage concordance** |
|---|---|---|
| 1. Healthcare accreditors should implement metrics that measure whether a facility has the plans, procedures, and human resources needed to surge the diabetes nursing workforce to better manage care and support for people with T2DM during a pandemic. | Agree | 88.89% |
| 2. Hospitals should conduct and include diabetes nurses in emergency preparedness drills and exercises for future pandemic response. | Agree | 100% |
| 3. Hospital managers should enhance awareness and adoption of crisis standards of care. | Agree | 100% |
| 4. To deal with any future pandemic, people with T2DM should receive free education and counselling to help improve their mental well-being. | Agree | 100% |
| 5. Hospitals and the government should study the feasibility of providing up-dated technology for blood glucose monitoring (remote monitoring and telehealth) in preparedness of future pandemics. | Agree | 100% |
| 6. Counselling services and mental health sessions should be available for nurses to help improve their mental well-being and mitigate the fear and anxiety of any future pandemic. | Agree | 100% |
| 7. Nurses should encourage physical activity and home-based exercise programs as essential tools for preventing and managing diabetes and improving mental well-being during quarantine and future pandemics. | Agree | 100% |
| 8. Nurses should consider patients' individual health needs, their capacity for self-management and any potential barriers they face daily. | Agree | 100% |

**Q3. When asked about the implications for nursing and health service policy development or change,** 100.0% of respondents supported: the role of diabetes education in addressing fear among people living with T2DM; invest more funding for diabetes management and education; a new national disaster planning system; providing telehealth systems; the role of psychiatrists in reducing pandemic-related stress and anxiety among people with diabetes; and new policies on monitoring and managing diabetes in community settings. However, 88.89% of respondents disagreed about the lack of specific policies to manage fear and anxiety, mental health access for vulnerable groups; and to review policies concerned with nurse management programs and home visiting **(Table 5.4.c).**

**Table 5.4.c.** Proposed implications for nursing and health service policy development or change obtained in Delphi round two.

| Statement | Agreement/ Disagreement | Percentage concordance |
|---|---|---|
| 1. Findings highlight the role of diabetes education as a critical component in addressing fear among people living with T2DM during a pandemic. | Agree | 100% |
| 2. Findings highlight the need to invest more funding for diabetes management and education. | Agree | 100% |
| 3. Findings highlight the need to develop a new national disaster planning system to help healthcare providers and diabetes patients maintain diabetes control even during a pandemic. | Agree | 100% |
| 4. Telehealth systems might provide support and ensure the safety of healthcare providers and patients. | Agree | 100% |
| 5. Findings highlight the role of psychiatrists in reducing pandemic-related stress and anxiety among people with diabetes, especially those on insulin and with other comorbidities such as hypertension. | Agree | 100% |
| 6. Findings flag the lack of specific policies to manage fear and anxiety if access to health services is reduced during a pandemic. | **Disagree** | **88.89%** |
| 7. Findings highlight the need to develop new policies on monitoring and managing diabetes in community settings. | Agree | 100% |
| 8. Policymakers must include mental health access for vulnerable groups during a pandemic. | **Disagree** | **88.89%** |
| 9. Findings flag the need to review policies concerned with nurse management programs and home visiting during a pandemic. It is an essential nursing role to encourage patients to engage in self-management of their condition by using patient-centred customized interventions considering individual circumstances and patients' characteristics, which could have made a huge difference during the pandemic. | **Disagree** | **88.89%** |
| **Statements that received > 80% concordance on disagreement were highlighted in bold font and were excluded from round three.** | | |

**Q4. When asked about the recommendations to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic,** 100% of participants supported: funds via Human Resources and Services Administration for development of a diabetes nursing workforce, establishing crisis leadership skills among nurse administrators, managers and executives; convening a national workshop of interdisciplinary subject matter experts; incorporating pandemic education as an essential component for nurses and other healthcare professionals; to design and make available a mobile application for managing diabetes; create a Jordanian Diabetes Registry; and increase funding for diabetes clinics.

However, 88.89% of respondents disagreed with identifying local capacity for advancing emergency preparedness; and developing new diabetes management policies **(Table 5.4.d).**

**Table 5.4.d.** Proposed recommendations to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic obtained in Delphi round two.

| **Statement** | **Agreement/ Disagreement** | **Percentage concordance** |
|---|---|---|
| 1. The Human Resources and Services Administration should fund diabetes nursing workforce development for public health emergency preparedness and response. | Agree | 100% |
| 2. Hospital managers should endeavour to establish and maintain crisis leadership skills in nurse administrators, managers, and executives who can help foster and champion nurse preparedness and response at the highest levels. | Agree | 100% |
| 3. Key stakeholder groups should identify local capacity for advancing emergency preparedness and the response knowledge base of the diabetes nursing workforce and integrate this information into their subsequent strategic plans. | **Disagree** | **88.89%** |
| 4. Health policymakers should convene a national workshop of interdisciplinary subject matter experts to explore the lessons learned from the national diabetes nurse response to COVID-19 and ways to take forward any subsequent recommendations in preparation for any future pandemic. | Agree | 100% |
| 5. Incorporate pandemic education as an essential component for nurses and other healthcare professionals to better manage care and support for people with T2DM during any future pandemics. | Agree | 100% |
| 6. Decision makers should design and make available a mobile application to assist in diabetes management by allowing the patient to set reminders for medications, track physical activity, record blood glucose levels, and plan daily meals and should also be linked to the patient's medical record to make a follow-up with specialists easier and more effective. | Agree | 100% |

| | | |
|---|---|---|
| 7. A Jordanian Diabetes Registry should be created to track and improve the quality of care and outcomes of people with T2DM through the collection of data on key performance measures that drive change in diabetes care, such as HbA1c, dietary intake counselling, physical activity counselling, diabetes foot examinations, diabetes medication adherence, etc. This will help solve problems and reduce gaps in diabetes care to promote health equity. | Agree | 100% |
| 8. Policymakers should develop new diabetes management policies to help nurses during any future pandemic. | **Disagree** | **88.89%** |
| 9. The government should increase funding for diabetes clinics to enable them to be fully prepared for any future pandemics. | Agree | 100% |
| **Statements that received > 80% concordance on disagreement were highlighted in bold font and were excluded from round three.** | | |

***Q5.*** **When asked about the implications for nursing education,** 100% of experts agreed about training nurses in use of telehealth; the importance of good nursing documentation practice; case management systems; nursing staff need education about COVID-19 challenges; flexible and adaptive nursing education systems; new ways to educate patients on self-management of diabetes; pre-planning nursing education programs; emphasizing challenges faced by people with T2DM; and the impact of individual differences between patients (**Table 5.4.e**).

**Table 5.4.e.** Proposed implications of these findings for nursing education obtained in Delphi round two.

| **Statement** | **Agreement/ Disagreement** | **Percentage concordance** |
|---|---|---|
| 1. Nurses need to be trained in use of telehealth and in managing patients' disease processes remotely. | Agree | 100% |
| 2. Findings highlight the importance of good nursing documentation practice to help healthcare providers take decisions for their patients and recognise who needs to go to a health care facility and who can be managed remotely. | Agree | 100% |
| 3. Findings flag the need to improve the case management system in which nurses help patients focus on controlling combined risk factors to provide good diabetes care. | Agree | 100% |
| 4. Findings highlight that nursing staff need education about COVID-19 challenges, such as those presented by routine diabetes management. Real-case presentations can be used to present information about the best ways to deal with each case. | Agree | 100% |
| 5. Nursing education systems must be flexible and adaptive in order to respond or recover more quickly from crises. | Agree | 100% |
| 6. Nursing education needs to develop new ways to educate patients in diabetes self-management that will remain usable during a pandemic. | Agree | 100% |
| 7. Nursing education must now include pre-planning on how to cope with diabetes and illnesses during pandemics. | Agree | 100% |
| 8. Nursing education could benefit from emphasizing the challenges faced by people with T2DM, as this should be the core of nursing care and patient education from the early stages. This should support acceptance of the disease, adherence to treatment, and early identification and management of complications. | Agree | 100% |
| 9. Nursing education should highlight the impact of individual differences between patients and be resourceful in introducing and explaining self-management interventions that match patients' ages, personalities, genders, backgrounds, and educational levels. | Agree | 100% |

**Q6. When asked about the recommendations to develop nursing education,** 100% of respondents agreed with healthcare accredited education and training for diabetes nurses; updating nursing education curricula; developing robust metrics; revised curricula for schools and universities; preparing a T2DM pandemic resources information and action plan; pre-planning and regular education of nursing staff; and providing education and training, career development, and networking opportunities.

In contrast, 88.89% of respondents disagreed with formulation of a proactive response to the changing patterns of infectious disease by academic nursing (**Table 5.4.f**).

**Table 5.4.f.** Proposed recommendations to develop nursing education obtained in Delphi round two.

| Statement | Agreement/ Disagreement | Percentage concordance |
|---|---|---|
| 1. Healthcare accreditors should include education and training for diabetes nurses on pandemic preparedness as a specific requirement beyond the current all-hazards approach, to better evaluate a healthcare organization's emergency preparedness. | Agree | 100% |
| 2. The nursing education curricula should be updated with the new information and experience acquired from the COVID-19 pandemic in order to train nurses in effective clinical practice for diabetes during pandemics. | Agree | 100% |
| 3. Schools of nursing should develop robust metrics for evaluating nurse preparedness, which should be implemented across academic and life-long learning programming. | Agree | 100% |
| 4. Revised curricula are essential for schools and universities to facilitate the inclusion of emergency preparedness and response content across all baccalaureate and graduate academic programs. | Agree | 100% |
| 5. Academic nursing should formulate a proactive response to the changing infectious disease landscape by offering certificates and digital badges in emergency preparedness and response. | **Disagree** | **88.89%** |
| 6. Set up a T2DM pandemic resources information and action plan to be activated during future pandemics. | Agree | 100% |
| 7. Pre-planning and regular education of nursing staff about diabetes and guidelines will help to prepare for future pandemics. | Agree | 100% |
| 8. Healthcare accreditors should provide education and training, career development, and network opportunities to early career nurse scientists and nursing students. | Agree | 100% |
| **Statements that received > 80% concordance on disagreement were highlighted in bold font and were excluded from round three.** | | |

### 5.5. Delphi round three.

In the third Delphi Round, 43 proposed recommendations were sent to each expert individually and they were asked to score each for importance and feasibility. **Table 5.5a-f** shows the mean scores for importance and feasibility separately and the calculated combined mean scores as reported by the expert panellists.

**Q1. When asked about the importance and feasibility of the implications for nursing practice,** all experts highly prioritized novel patient-centred diabetes management/monitoring technology, with a mean summary score of 25.93. The experts also identified methods of delivering diabetes health education, limitations in access to care, and lack of multi-disciplinary teams as important areas for improvement, with mean scores of 23.30, 23.28, and 20.70, respectively. However, decentralized health systems and home-based physical activity programs received lower priority (mean summary scores of 18.67 and 15.48, respectively).

**Table 5.5.a.** Expert panellists' scored and ranked implications of findings from phases 1 and 2 of this study for nursing practice obtained in Delphi round three.

| | **Importance (mean score)** | **Feasibility (mean score)** | **Summary score (importance x feasibility)** |
|---|---|---|---|
| 1. Findings flag the need to develop a novel patient centred diabetes management/monitoring technology such as remote monitoring for BGL. | 5.56 | 4.67 | 25.93 |
| 2. There is a need to improve the methods of delivering diabetes health education such as by digital diabetes education programs and mobile applications. | 5.67 | 4.11 | 23.30 |
| 3. Limitations in patient access to care might be addressed by telehealth services, which may consequently reduce presentations to hospitals during any future pandemic. | 5.11 | 4.56 | 23.28 |
| 4. Services lack a multidisciplinary well-trained rapid access mobile diabetes team to be deployed during any future pandemic. | 4.78 | 4.33 | 20.70 |
| 5. Decentralized health systems can make it difficult to access patient information support and advice. | 4.67 | 4.00 | 18.67 |
| 6. Home-based physical activity programs could be used to support diabetes self-management. | 4.22 | 3.67 | 15.48 |

***Q2. When asked about recommendations to develop the nursing practice,*** all experts highly prioritized encouraging physical activity and home-based exercise programs, with a mean score of 25.93, followed by organizing mental health sessions for nurses (mean score of 24.37). In addition, up-dated technology for blood glucose remote monitoring and telehealth and provision of free education and counselling to people with T2DM to improve their mental well-being were also identified as important areas for improvement, with mean scores of 22.72 and 21.01, respectively. However, diabetes nurses taking part in emergency preparedness drills, implementing metrics to measure whether a facility has the plans, procedures and human resources needed, considering patients' individual health needs and enhancing hospital managers' awareness and adoption of crisis standards of care received less priority among all recommendations (mean score of 18.73, 14.16, 13.01 and 10.33) **(Table 5.5.b).**

**Table 5.5.b.** Expert panellists' scored and ranked recommendations to develop the nursing practice to better manage care and support for people with T2DM during any future pandemic obtained in Delphi round three.

| | **Importance (mean score)** | **Feasibility (mean score)** | **Summary score (importance x feasibility)** |
|---|---|---|---|
| 1. Nurses should encourage physical activity and home-based exercise programs as essential tools for preventing and managing diabetes and improving mental well-being during quarantine and future pandemics. | 5.56 | 4.67 | 25.93 |
| 2. Counselling services and mental health sessions should be available for nurses to help improve their mental well-being and mitigate the fear and anxiety of any future pandemic. | 5.22 | 4.67 | 24.37 |
| 3. Hospitals and the government should study the feasibility of providing up-dated technology for blood glucose monitoring (remote monitoring and telehealth) in preparedness of future pandemics. | 5.11 | 4.44 | 22.72 |
| 4. To deal with any future pandemic, people with T2DM should receive free education and counselling to help improve their mental well-being. | 5.11 | 4.11 | 21.01 |
| 5. Hospitals should conduct and include diabetes nurses in emergency preparedness drills and exercises for future pandemic response. | 4.56 | 4.11 | 18.73 |
| 6.Healthcare accreditors should implement metrics that measure whether a facility has the plans, procedures, and human resources needed to surge the diabetes nursing workforce to better manage care and support for people with T2DM during a pandemic. | 4.11 | 3.44 | 14.16 |

| | | | |
|---|---|---|---|
| 7. Nurses should consider patients' individual health needs, their capacity for self-management and any potential barriers they face daily. | 3.78 | 3.44 | 13.01 |
| 8. Hospital managers should enhance awareness and adoption of crisis standards of care. | 3.44 | 3.00 | 10.33 |

**Q3. When asked about the implications for nursing and health service policy development or change,** providing telehealth systems was highly prioritized (mean score of 26.01), followed by the role of psychiatrists in reducing pandemic-related stress and anxiety among people with diabetes (mean score of 24.07). Additionally, investing more funding for diabetes management and education, and new policies on monitoring and managing diabetes in community settings were prioritised (mean scores of 22.78 and 18.67). However, a new national disaster planning system and the role of diabetes education in addressing fear among people living with T2DM were mentioned as lesser priority, with mean scores of 17.38 and 17.28, respectively (**Table 5.5.c).**

**Table 5.5.c.** Expert panellists' scored and ranked implications for nursing and health service policy development or change obtained in Delphi round three.

| | **Importance (mean score)** | **Feasibility (mean score)** | **Summary score (importance x feasibility)** |
|---|---|---|---|
| 1. Telehealth systems might provide support and ensure the safety of healthcare providers and patients. | 5.44 | 4.78 | 26.01 |
| 2. Findings highlight the role of psychiatrists in reducing pandemic-related stress and anxiety among people with diabetes, especially those on insulin and with other comorbidities such as hypertension. | 5.56 | 4.33 | 24.07 |
| 3. Findings highlight the need to invest more funding for diabetes management and education. | 5.00 | 4.56 | 22.78 |
| 4. Findings highlight the need to develop new policies on monitoring and managing diabetes in community settings. | 4.67 | 4.00 | 18.67 |
| 5. Findings highlight the need to develop a new national disaster planning system to help healthcare providers and diabetes patients maintain diabetes control even during a pandemic. | 4.89 | 3.56 | 17.38 |
| 6. Findings highlight the role of diabetes education as a critical component in addressing fear among people living with T2DM during a pandemic. | 4.44 | 3.89 | 17.28 |

**Q4. When asked about the recommendations to develop nursing and health service policies,** all participants highly prioritized convening a national workshop of interdisciplinary subject matter experts and creating a Jordanian Diabetes Registry, both receiving a mean score of 28.43. Additionally, establishing crisis leadership skills among nurse administrators, managers, and executives, increasing funding for diabetes clinics, and investing funds via the Human Resources and Services Administration for the development of a diabetes nursing workforce were accorded importance (mean scores of 25.93, 23.70, and 21.11, respectively). Incorporating pandemic education as an essential component for nurses and other healthcare professionals and designing and making available a mobile application for managing diabetes received lower priorities among the panellists, with mean scores of 20.10 and 16.79, respectively) **(Table 5. 5.d).**

**Table 5.5.d.** Expert panellists' scored and ranked recommendations to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic obtained in Delphi round three.

| | **Importance (mean score)** | **Feasibility (mean score)** | **Summary score (importance x feasibility)** |
|---|---|---|---|
| 1. Health policymakers should convene a national workshop of interdisciplinary subject matter experts to explore the lessons learned from the national diabetes nurse response to COVID-19 and ways to take forward any subsequent recommendations in preparation for any future pandemic. | 5.44 | 5.22 | 28.43 |
| 2. A Jordanian Diabetes Registry should be created to track and improve the quality of care and outcomes of people with T2DM through the collection of data on key performance measures that drive change in diabetes care, such as HbA1c, dietary intake counselling, physical activity counselling, diabetes foot examinations, diabetes medication adherence, etc. This will help solve problems and reduce gaps in diabetes care to promote health equity. | 5.44 | 5.22 | 28.43 |
| 3. Hospital managers should endeavour to establish and maintain crisis leadership skills in nurse administrators, managers, and executives who can help foster and champion nurse preparedness and response at the highest levels. | 5.56 | 4.67 | 25.93 |
| 4. The government should increase funding for diabetes clinics to enable them to be fully prepared for any future pandemics. | 5.33 | 4.44 | 23.70 |
| 5. The Human Resources and Services Administration should fund diabetes nursing workforce development for public health emergency preparedness and response. | 5.00 | 4.22 | 21.11 |

| | | | |
|---|---|---|---|
| 6. Incorporate pandemic education as an essential component for nurses and other healthcare professionals to better manage care and support for people with T2DM during any future pandemics. | 4.89 | 4.11 | 20.10 |
| 7. Decision makers should design and make available a mobile application to assist in diabetes management by allowing the patient to set reminders for medications, track physical activity, record blood glucose levels, and plan daily meals and should also be linked to the patient's medical record to make a follow-up with specialists easier and more effective. | 4.44 | 3.78 | 16.79 |

***Q5.*** **When asked about the implications for nursing education,** all experts highly prioritized flexible and adaptive nursing education systems (mean score 30.86), followed by training nurses in the use of telehealth (mean scores of 29.63). Furthermore, new ways to educate patients on self-management of diabetes, emphasizing challenges faced by people with T2DM, and the needs of nursing staff for education about COVID-19 challenges also received importance (mean scores = 24.37, 24.30, and 24.20, respectively). The impact of individual differences between patients, the importance of good nursing documentation practice, and pre-planning nursing education programs received summary scores of 23.33, 22.63, and 22.22, respectively. The case management system received low priority, with a mean score of 12.96 **(Table 5.5.e).**

**Table 5.5.e.** Expert panellists' scored and ranked implications of these findings for nursing education obtained in Delphi round three.

| | **Importance (mean score)** | **Feasibility (mean score)** | **Summary score (importance x feasibility)** |
|---|---|---|---|
| 1. Nursing education systems must be flexible and adaptive in order to respond or recover more quickly from crises. | 5.56 | 5.56 | 30.86 |
| 2. Nurses need to be trained in use of telehealth and in managing patients' disease processes remotely. | 5.56 | 5.33 | 29.63 |
| 3. Nursing education needs to develop new ways to educate patients in diabetes self-management that will remain usable during a pandemic. | 5.22 | 4.67 | 24.37 |
| 4. Nursing education could benefit from emphasizing the challenges faced by people with T2DM, as this should be the core of nursing care and patient education from the early stages. This should support acceptance of the disease, adherence to treatment, and early identification and management of complications. | 5.33 | 4.56 | 24.30 |
| 5. Findings highlight that nursing staff need education about COVID-19 challenges, such as those presented by routine diabetes management. Real-case presentations can be used to present information about the best ways to deal with each case. | 5.44 | 4.44 | 24.20 |
| 6. Nursing education should highlight the impact of individual differences between patients and be resourceful in introducing and explaining self-management interventions that match patients' ages, personalities, genders, backgrounds, and educational levels. | 5.00 | 4.67 | 23.33 |
| 7. Findings highlight the importance of good nursing documentation practice to help healthcare providers take decisions for their patients and recognise who needs to go to a health care facility and who can be managed remotely. | 5.22 | 4.33 | 22.63 |

| | | | |
|---|---|---|---|
| 8. Nursing education must now include pre-planning on how to cope with diabetes and illnesses during pandemics. | 5.00 | 4.44 | 22.22 |
| 9.Findings flag the need to improve the case management system in which nurses help patients focus on controlling combined risk factors to provide good diabetes care. | 3.89 | 3.33 | 12.96 |

**Q6. When asked about the recommendations to develop nursing education,** all experts highly prioritized updating nursing education curricula, with a mean score of 25.48. This was followed by pre-planning and regular education of nursing staff, and revised curricula for schools and universities (mean scores = 24.42 and 23.70, respectively). Furthermore, preparing a T2DM pandemic resources information and action plan, healthcare accreditation of education and training for diabetes nurses, and providing education and training, career development, and networking opportunities received summary scores of 21.19, 20.00, and 19.11, respectively. However, development of robust metrics received less priority among all recommendations, with a mean score of 16.42 **(Table 5.5.f).**

**Table 5.5.f.** Expert panellists' scored and ranked recommendations could be made to develop nursing education to better prepare nurses to support people with T2DM during any future pandemic obtained in Delphi round three.

| | **Importance (mean score)** | **Feasibility (mean score)** | **Summary score (importance x feasibility)** |
|---|---|---|---|
| 1. The nursing education curricula should be updated with the new information and experience acquired from the COVID-19 pandemic in order to train nurses in effective clinical practice for diabetes during pandemics. | 5.33 | 4.78 | 25.48 |
| 2. Pre-planning and regular education of nursing staff about diabetes and guidelines will help to prepare for future pandemics. | 5.11 | 4.78 | 24.42 |
| 3. Revised curricula are essential for schools and universities to facilitate the inclusion of emergency preparedness and response content across all baccalaureate and graduate academic programs. | 5.33 | 4.44 | 23.70 |
| 4. Set up a T2DM pandemic resources information and action plan to be activated during future pandemics. | 4.89 | 4.33 | 21.19 |
| 5. Healthcare accreditors should include education and training for diabetes nurses on pandemic preparedness as a specific requirement beyond the current all-hazards approach, to better evaluate a healthcare organization's emergency preparedness. | 5.00 | 4.00 | 20.00 |
| 6. Healthcare accreditors should provide education and training, career development, and network opportunities to early career nurse scientists and nursing students. | 4.78 | 4.00 | 19.11 |
| 7. Schools of nursing should develop robust metrics for evaluating nurse preparedness, which should be implemented across academic and life-long learning programming. | 4.22 | 3.89 | 16.42 |

## 5.6. Summary

Nine of the twelve invited experts took part in this Delphi consultation. In the first Delphi round, 54 proposed recommendations were received; two were excluded as duplicates and 52 were entered into round two. In the second Delphi round, 43 proposed recommendations received >80% response agreement and were entered into round three. Nine proposed recommendations were not supported and were eliminated. In the third Delphi round, 43 recommendations were sent to each expert, who then ranked each according to their perception of its importance and feasibility scores. Item rankings were then combined to rank items for importance x feasibility.

Development of novel patient-centred technology for diabetes management and monitoring was identified as the most important and feasible implication of nursing practice. Some examples of these types of technologies include remote glucose monitoring, following by improving diabetes health education through digital programs, mobile apps and telehealth services. A well-trained mobile diabetes team was also found to be valuable. However, home-based physical activity programs to help with diabetes management received a lower priority. On the other hand, encouraging physical activity and home-based exercise programs as a means of preventing and managing diabetes, followed by counselling services, and mental health sessions, and updated glucose monitoring technology and telehealth were highly recommended by the expert panel to develop nursing practice to better manage care and support for people with T2DM during any future pandemic. The telehealth system and the role of psychiatrists in reducing pandemic-related stress and anxiety among people with diabetes were highly emphasized regarding implications for nursing and health service policy development or change. They also supported a to aid in diabetes management are a lower need for more funding for diabetes management and education. The panel highlighted the importance of developing new policies for monitoring and managing diabetes in community settings and disaster

planning. In order to develop nursing and health service policies to better manage care and support people with T2DM during any future pandemic, experts highly recommend health policymakers convene a national workshop of interdisciplinary subject matter experts to explore lessons learned from the national diabetes nurse response to COVID-19. A Jordanian Diabetes Registry should be created to track and improve care quality. Hospital managers should maintain crisis leadership skills. Pandemic education should be included for healthcare professionals.

Regarding implications for nursing education, panellists emphasized adaptable nursing education systems that train nurses in remote disease management and telehealth use and new ways to teach diabetes management to patients. Other priorities included focusing on people with diabetes difficulties, educating patients in diabetes self-management, addressing COVID-19 challenges, good nursing processes and documentation practices, and pandemic planning. Furthermore, experts recommend updating nursing education curricula with new information from the COVID-19 pandemic to prepare nurses for supporting people with diabetes during future pandemics. Regular education of nursing staff about diabetes and guidelines was also highly recommended. However, the development of metrics for evaluating nurse preparedness received less priority among all recommendations. The next chapter synthesizes the findings from each chapter, reflecting on the implications for practice whilst acknowledging some of the limitations of the research and presenting recommendations for future research.

# 6. CHAPTER 6 DISCUSSION

## 6.1. Introduction

This chapter provides a discussion of the findings in relation to the study research questions for all three phases of the study. Discussion of the findings in response to research question one ("What is known about glycaemic control and associated factors in people with type 2 diabetes in the Middle East and North Africa?") is set out in chapter three at section 3.4.

This chapter first reiterates the rationale for this study, then presents quantitative and qualitative findings of phase I and II, which address the second and third research questions of the study: "What was the glycaemic control of people with T2DM in Jordan before and after the Covid-19 lockdown?" and "What factors predicted the level of glycaemic control during the pandemic (before and after lockdown)?"

## 6.2. Rationale for the study

T2DM is one of the most common metabolic disorders worldwide, requiring maintenance of glucose levels (Felix et al., 2021). Lockdowns implemented as a containment measure to prevent the spread of the COVID-19 infection have undoubtedly affected the behaviours and lifestyles of people, particularly those with T2DM. In Portugal, during the total lockdown from 19 March to 2 May 2020, the amount of weekly exercise was drastically reduced, which corresponded to more than half of the amount of physical activity performed pre-COVID. In the period following the easing of lockdown measures, post-lockdown 3 May to 17 December, there was a slight increase in weekly minutes spent on physical exercise, but this was still well below the pre-pandemic level. In addition, at the time of the interviews, the participants reported themselves to be engaged in 90.1 min of physical activity weekly, which represented reductions of 61.6%, 7.2%, and 32.1% in physical exercise compared to

pre-COVID, lockdown and post-lockdown periods, respectively. From the thematic analysis of the interviews, we identified five major themes describing the participants' experiences lived throughout the pandemic period: (1) an altered social and relational life; (2) changes in routine and attitude regarding physical activity be- haviour; (3) home-related activities gained relevance; (4) health and well-being impact and management; and (5) thoughts about the post-pandemic period (Leite et al., 2022). During the pandemic, people with Type 2 Diabetes significantly changed their social and relational lives by reducing their exposure and refraining from participating in social activities. They found it challenging to adapt to the restrictions, such as limiting or avoiding contact with others, including close family members. Many spent more time at home to protect themselves during this difficult time. In terms of physical activity, people faced various barriers and facilitators during the pandemic. Some adapted by engaging in activities like walking in open and less crowded spaces to maintain an active lifestyle, while others feared exercising outside due to the increasing number of COVID cases. The closure of fitness centres also led to a lack of motivation for some individuals. Daily routines were largely replaced by home-related activities during the pandemic, with indoor activities becoming more relevant. However, essential activities like shopping for food, medicine, and other necessities continued (Leite et al., 2022). Managing diabetes during the pandemic became more challenging due to limited access to healthcare facilities. Many participants turned to telemedicine to seek advice on treatment and share concerns related to their disease with their physicians.

People with T2DM experience psychological issues, including fear, frustration, anxiety, and stress, primarily due to isolation as well as Individuals with pre-existing mental health conditions reported heightened vulnerability during the pandemic, feeling more anxious and less patient.

The most important underlying factors were found to be the inability to attend health centres or pharmacies – either due to lack of direct access or due to fear of infection – which led to an interruption in the follow-up of these patients and a delay in the performance of recommended management tests, beside increasing anxiety and stress in people with diabetes already predisposed to depression (Leite et al., 2022).

Lockdown has been shown to affect peoples' emotional states, which in turn was shown in Spain to influence their glycaemic management (Coma, Mora, et al., 2020). Circumstances derived from isolation, such as less physical activity and possibly nutritional modifications along with loss of family members' and caregivers' supervision, have also been shown to influence glycaemic management of people with T2DM in Italy (Biamonte et al., 2021).In a robust predictive model based on multinational data, with an $R^2$ of 0.99, that predicted outcomes for lockdowns of up to 90 days, HBA1c was projected to increase by 2.26% and 3.68% after 30 and 45 days of lockdown, respectively. This indicated that the duration of lockdown can be directly proportional to the worsening of glycaemic management and hence, to longer-term, diabetes-related complications (Ghosal et al., 2020).

With increasing duration of the lockdown, the increment in HBA1c from baseline continues to increase and carries along with it the increasing annual complication rates. The annual predicted percentage increment in complication rates from baseline at the end of 30-day lockdown due to COVID19 pandemic was 2.8% for non-proliferative diabetic retinopathy, 2.9% for proliferative diabetic retinopathy, 1.5% for retinal photocoagulation, 9.3% for microalbuminuria, 14.2% for overt proteinuria, 2.9% for peripheral neuropathy, 10.5% for amputation, 0.9% for myocardial infarction, 0.5% for stroke and 0.5% for infections. The annual predicted percentage increment in complication rates from baseline at the end of 45-day lockdown due to COVID19 pandemic was 4.5% for non-

proliferative diabetic retinopathy, 4.8% for proliferative diabetic retinopathy, 2.4% for retinal photocoagulation, 15.1% for microalbuminuria, 4.7% for overt proteinuria, 17.1% for peripheral neuropathy, 4.8% for amputation, 1.4% for myocardial infarction, 0.8% for stroke and 0.9% for infections (Ghosal et al., 2020).

One of the most worrisome factors is a restriction on routine physician consultations. As a result, patients suffering from chronic diseases, although stable, are not offered the usual standards of care. Not only physicians but also the para-medical staff numbers are reduced and channelized toward dedicated COVID-19-related care. As a result, non-COVID-related complication rates are expected to rise, which independently predisposes these patients to acquire COVID-19 infection (Ghosal et al., 2020).

With no prior studies from Jordan, it was crucial to study the glycaemic management of Jordanian people with T2DM during pre- and post-COVID-19 lockdown to support those living with T2DM and optimize their glycaemic management during any pandemic. Such an increase in diabetes-related complications was likely to have placed an additional load on the overburdened healthcare system and also increase COVID-19 infections in people with un- controlled glycemia (Ghosal et al., 2020).

Multiple studies in a systematic review conclusively shown uncontrolled blood glucose levels are a risk factor for poor clinical outcomes in people with T2DM ( Ojo et al., 2022). Thus, identifying factors associated with inadequate glycaemic management before lockdowns can support development of targeted interventions to improve control, prevent complications arising from diabetes, as well as optimize quality of life during challenging times, such as the lockdown. Furthermore, the experiences and knowledge gained during the 2020 lockdown can be utilized to improve future preparedness for further major outbreaks of infectious disease.

### 6.3. Summary of key findings

This study enrolled 323 patients who were diagnosed with T2DM and found that the COVID-19 lockdown had a predominantly negative impact on HbA1c values after the lockdown compared to before the lockdown. An increased proportion of participants exhibited inadequate glycaemic management three months following lockdown compared to six months before. Regarding factors that predicted the level of glycaemic management, insulin use and HTN were significant predictors pre-lockdown. In contrast, insulin and Glimepiride use, higher BMI, and non-smoking were significant predictive factors post-lockdown.

In terms of psychological and social factors, most participants reported symptom scores for depression, anxiety and stress within ranges designated as normal. However, those whose glycaemic values did not meet recommended target ranges post-lockdown showed significantly higher scores for these conditions. Additionally, the majority of participants had low physical activity levels, with no significant differences between those with adequate and inadequate glycaemic management.

The qualitative analysis confirmed the quantitative findings in terms of T2DM self-management during the lockdown; most participants reported a deterioration in blood glucose levels during the lockdown. Stress and experiencing mood effects such as fears and concerns about being infected with COVID-19 or anxiety about death led people with diabetes to experience more anxiety, so it was more challenging to control their blood glucose during than before the lockdown period. In addition, reduced levels of physical activity and increased unhealthy food intake were general findings among our T2DM participants during the lockdown, often reported as being caused by confinement in their homes for an extended period, with no chance to exercise, and not able to buy healthy food.

### 6.4. Characteristics of the phases I and II sample.

In considering the representativeness of the study sample for the population living with T2DM in Jordan, it is worth noting that study participants were broadly older adults with a long duration of diabetes (> 10 years), indicating earlier onset T2DM and a currently greater risk of comorbidities and diabetes complications. More than half the study population was female, probably as a result of the generally higher life expectancy of females, with a higher incidence of morbidity and disability and greater tendency to utilize healthcare services in their later years than their male counterparts (Redondo-Sendino et al., 2006). The majority of participants were married and lived with their spouses. This sample of married patients were perhaps more likely to have family members to support them to adhere to regular medical check-ups and compliance with the treatment regime (Paulsamy et al., 2021).

### 6.5. Glycaemic management of people with T2DM in Jordan pre and post the COVID-19 lockdown

The current study revealed a significant degradation in glycaemic management among patients diagnosed with T2DM; the median HbA1c levels increased by 0.3% from six months prior to the lockdown to three months post-lockdown. Uncontrolled blood glucose may cause a significant increase in the incidence of complications including micro- and macrovascular comorbidities, cardiac events as well as mortality (Banerjee et al., 2020). Also, another study reported elevated HbA1c is associated with End organ damage (ß (95% CI): 0.12 (0.01-0.23), atherosclerotic cardiovascular disease (ASCVD; 0.23(0.10-0.36)) and cardiovascular events (0.25 (0.10-0.40)) as well as oral medication (0.09 (0.03-0.15)), intermediate- or long-acting insulins (0.24 (0.16-0.32),

and fast-acting or mixed insulins (0.30(0.23-0.36)). Thus, it is important to prevent deterioration of glycaemic control in diabetic patients, even in crisis (Schäfer et al., 2023).

### 6.5.1 Baseline hyperglycaemia

According to ADA (2022), a fasting blood glucose level of more than 126 mg/dL (7.0 mmol/L) is considered one of the criteria for diagnosing diabetes. This study demonstrated an elevated mean fasting blood glucose level among people with T2DM at baseline with a median value of 210.0 mg/dl, with 97.8% displaying inadequate management (i.e. above the threshold value of 126 mg/dL /7.0 mmol/L). However, there was no significant gender difference in the median fasting blood glucose level and the proportion of people with glycaemic values at and above target. This is consistent with a previous a cross-sectional study of Azar cohort population study; there were no significant differences between poor and good glycaemic control regarding age, anthropometric measurements, gender, education level, physical activity level, smoking status, family history of diabetes and hypertension ( second-degree relatives) ((Dinavari et al., 2023).

### 6.5.2 Changes with COVID/ lockdown

A systematic review found that lockdown determined a short-term worsening in glycaemic parameters in people with T2DM between 3 weeks and 6 months, with a mean HbA1c difference of + 0.14 (Eberle & Stichling, 2021). This could be attributed to the fact that after the initial period of lockdown, patients could return to controlling their T2DM and manage it as usual. A Spanish study showed that the subgroup of people with T2DM who had poor glycaemic management (HbA1c ≥ 8.5%) suffered greater worsening during the lockdown, where numbers of patients with uncontrolled blood glucose values increased from 6 (10.5%) to 16 (28.6%) ($p < 0.05$) with relative risk 1.65. However, HbA1c values demonstrated a non-significant increase of 0.06 points from 7.37±1.7%

before confinement to 7.43±1.6% after it (p = 0.63) (Enguix et al., 2022). In the same way, a study from Italy included 140 T2DM people with adequate metabolic control, which was reported to be only approximately one-fourth the number of people with T2DM who were previously well-controlled (n= 29, 26%). These individuals displayed worsening short-term glucose control post 8 weeks of lockdown (an increase of 0.7% for HbA1c) (Biancalana et al., 2021). The consistent pattern of deterioration but variation in degree highlights the importance of obtaining local data to demonstrate local needs, rather than relying on international studies.

### 6.5.3 Potential causes for change (compared to other studies)

A possible reason for the change in values seen in Jordan may be attributed to alterations in lifestyle, including changes in the amount and type of diet and reduced physical activity consequent on the lockdown. In addition, limited access to healthcare facilities or pharmacies, interruption of treatment due to fear of infection, failure to receive critical interventions under physician oversight, and increasing anxiety and stress were all reported in Jordan, and have been identified as important factors elsewhere (Banerjee et al., 2020). A systematic search and narrative review revealed that diabetes management has been put under pressure due to lockdown of standard outpatient clinics, decreased inpatient capacity, staff shortage, medicine shortage, unaffordable medicine, delayed care seeking, limited self-care practice, transport difficulties, and undiagnosed cases/events (Mohseni et al., 2021). Another study found nearly three-quarters of the diabetic patients reported that they avoided going to the physician for regular non-emergent visits during the outbreak, and 69.5% stated that their access to insulin, other diabetic medications, and supplies was not affected by the pandemic situation. The majority of patients reported that COVID-19 did not affect their adherence to their medications. Almost 42% reported that COVID-19 has negatively affected their physical activity level and their healthy lifestyle habits, while 60% stated that it did not affect their diet. Additionally,

56.6% reported that they have noticed less control in their blood glucose readings. The findings may reflect that the patients high adherence rate to their medications and that they avoided going to the doctor's clinic to avoid contracting the virus (Al-Taani et al., 2024).

Because hospitals and clinics were closed, community pharmacists were the first-line healthcare providers and reliable information sources. According to Jordan's study, pharmacists revealed that individuals with chronic diseases, especially diabetic patients (55.5%), showed increased interest in self-care interventions during the lockdown (Dmour et al., 2023). Self-care measures included gloves, masks, alcohol-based disinfectants, and dietary supplements, with limited queries regarding antivirals and antimalarial drugs (Dmour et al., 2023).

Furthermore, implementing strict and frequent lockdowns, especially in a country with limited resources like Jordan, increased unemployment, leading to adverse mental health outcomes in people with diabetes, also seen elsewhere in people with diabetes, who are already susceptible to depression (Khatatbeh, 2020). The finding of this study was consistent with a systematic review and meta-analysis, including eleven studies and 16,895 participants, which demonstrated that the COVID-19 lockdown was associated with worsening of glycaemic management in people with T2DM by a rise in HbA1c levels, with a mean difference of 0.34 % (95% CI: 0.30, 0.38) compared to the pre-COVID group ($p < 0.01$) (Ojo et al., 2022).

Dietary habits changed during the lockdown due to more free-time availability and variations in food expenditure. Time spent cooking increased as well as the nourishment with high glycaemic index foods, like homemade pizza, pasta, bread, and desserts (Biamonte et al., 2021). Also, study in Jordanian society during the lockdown. found that the highest percentage changes were in the "very high" weekly consumption of fruits, processed juices, and fried foods (37.6 %, 36.7%, and 29.4%,

respectively) (Angor & Nawasreh, 2022). The highest change percentages in the "very little" weekly consumption were in drinking water, milk, and soft drinks (12.5%, 8.5%, and 7.4%, respectively). Dietary habits and the quality of the foods consumed while staying at home must be considered to avoid obesity and the accompanying diseases. Respondents (84.7%) reported taking medicine without any doctor's prescription. Dietary habits and the quality of the foods consumed during lockdown affected participants' weight (increase or decrease) by 69.5% (Angor & Nawasreh, 2022). Overall, high consumption of sugar-sweetened beverages, processed red meat, and refined grains, as well as diets low in fruits, vegetables, fiber, and whole-grain foods, are linked to higher T2DM risk. Notably, such associations (e.g., the association between higher intake of sugar-sweetened beverages and increased T2DM risk) appear to remain significant even after controlling for BMI (Kyrou et al., 2020). A cross sectional web-based survey in Qatar revealed over 40% of the participants with T2DM reported unhealthy dietary changes and a significant increase in the sitting/reclining, and screen times (Abed Alah et al., 2021). One third of the participants reported weight gain, while one fifth reported poorer glycaemic control since the start of home confinement measures. Participants who reported five unhealthy dietary behaviours were more than seven times more likely to perceive poorer glycaemic control during home confinement measures compared to those who did not report any unhealthy changes (OR: 7.27, 95%CI 1.60–33.5). Thus, adults with T2DM experienced adverse lifestyle changes during COVID-19 related home confinement measures (Abed Alah et al., 2021).

Furthermore, home confinement reduced the opportunities for physical exercise (Biamonte et al., 2021). Evidence corroborates that levels of physical activity were reduced due to the lockdown, leading to increased body weight and worse glycaemic control (Souza et al., 2023).

Conversely, a previous study in Jordan reported a slight improvement in HbA1c levels after the lockdown, with a non-significant increase in fasting blood glucose (FBG) levels (Alyahya et al.,

2022). The mean HbA1c decreased significantly for both males and females after the lockdown compared to pre-lockdown levels. However, despite this decrease, HbA1c levels remained high for all groups before and after the lockdown. The modest reduction in HbA1c was not associated with a decrease in FBG levels, suggesting limited clinical benefit from changes in glycaemic management (Alyahya et al., 2022). Additionally, another cross-sectional study in Jordan found a significant reduction in HbA1c during the lockdown, with 33.6% of patients experiencing one or more hypoglycaemic episodes, indicating improved blood glucose control (Nofal et al., 2023). Medication adherence was the main driver of this improvement, with 74.8% of the population being strongly adherent to their medications. Despite poor adherence to healthy diet and exercise—both critical for diabetes self-management—Jordanian patients achieved better glycaemic control during the COVID-19 lockdown, largely due to medication availability and adherence (Nofal et al., 2023).

Likewise, a multi-centre study conducted in Dubai using retrospective data collected from 341 people with T2DM showed a statistically significant improvement in HbA1c in all patients after lockdown with a mean difference of -0.20 (95 % C.I (-0.3, 0.06) ( $p = 0.003$) (Makki et al., 2021). According to a cross-sectional quantitative analysis from Morocco of 150 participants (T1DM: 46.7%, T2DM: 53.3%), there was a significant improvement post-lockdown, with mean ± SD HbA1c= 7.97 ± 1.57 compared to 8.35 ± 1.97 before lockdown ($p = 0.005$), suggesting that COVID-19 lockdown had no deleterious effect on HbA1c levels in these people with T1DM and T2DM (Kaddar et al., 2022).

Overall, discrepancies in the duration, length, and research design of different studies, as well as ethnicity, baseline glycaemic management, different interpretations of ‘lockdown’, including varied access to diabetic consultation may all contribute to varied outcomes compared to data from Jordan.

The specific infection control strategies applied to restrict the spread of COVID-19 in Jordan contribute to the unique findings observed in this study.

### 6.6. Predictive factors

According to the systematic review and meta-analysis reported in chapter three, which examined predictive factors related to glycaemic management among people with T2DM in the MENA region, inadequate glycaemic management was strongly associated with obesity, higher WHR, smoking and longer duration of diabetes (>10 years), followed by physical activity and self-management (Al-ma'aitah et al., 2022). However, glycaemic management was not influenced by age, gender, diabetes knowledge, depression, anxiety, occupation, or marital status (Al-ma'aitah et al., 2022).

The present study revealed that age, gender, BMI, education level, housing, occupation, income, and smoking were not associated with inadequate glycaemic management among people with T2DM pre-lockdown. This was consistent with previous studies conducted in Jordan and Saudi Arabia, which reported gender, age, marital status, education level, income status, employment status, and smoking status were not associated with poor glycaemic management (Khattab et al., 2010; Alzaheb & Altemani, 2018).

Post-lockdown, several factors emerged as significant predictors of inadequate glycaemic control among people with T2DM. Specifically, variables such as age, body mass index, duration of diabetes, education level, occupation, income, smoking status, and treatment type (oral agents or insulin) demonstrated a notable association with glycaemic inadequacy.

Contrary to our expectations and findings from previous research, our study did not identify a significant association between physical activity, as assessed by the A-IPAQ, and the adequacy of glycaemic management post-lockdown. This finding is in stark contrast to existing literature, such

as the study by Juni et al. (2021), which indicated a positive correlation between higher levels of physical activity and improved glycaemic control. This suggests that increased exercise may play a critical role in diabetes management, particularly during challenging circumstances (c, 2021)

Moreover, our results align with those of Nofal et al. (2023), who also reported that exercise did not significantly impact glycaemic control among people with T2DM during the COVID-19 lockdown in Jordan. Their research noted that a substantial proportion of participants (69.3%) engaged in sedentary lifestyles, potentially limiting the benefits of physical activity on glycaemic regulation (Nofal et al., 2023)

These observations imply that while lifestyle factors, such as diet and exercise, are fundamental components of diabetes management, their effects may be modulated by broader contextual factors, particularly in the context of health crises. Notably, the accessibility of medications and adherence to prescribed treatment regimens emerged as critical determinants in maintaining glycaemic management during this period. This underscores the importance of effective medication management, which can help mitigate the challenges associated with lifestyle modifications and adherence issues. It highlights the necessity for ongoing support and resources for people with T2DM, especially during unprecedented times.

### 6.6.1 Demographic characteristics (including age, sex, income/ low socio-economic status, education)

**Age and sex**

Examining demographic and clinical factors for association with the adequacy of glycaemic management post-lockdown, this study showed that an increase in age was significantly associated with inadequate glycaemic management during the lockdown. Our finding was in line with previous

studies carried out in Italy over the lockdown, which reported that older people with T2DM had the worst glycaemic management (Falcetta et al., 2021; Tao et al., 2020). There are several possible explanations for these results. First, it may be because the islet β-cells lose function gradually with increasing age, thus weakening the ability to control blood glucose levels (Zhu et al., 2021). Secondly, due to insufficient direct contact with the clinic for field visits for fear of infection and despite some services being offered online during the lockdown, elderly people with diabetes had a greater burden of complications, such as poor glycaemic management due to their lower digital skills and poorer familiarity with modern technologies compared to younger patients. Younger people were better able to control glucose or prevent complications by having most visits via email, telephone, and other media (Bonora et al., 2021). In contrast, prior cross-sectional research of 288 people with diabetes in Saudi Arabia indicated younger and less educated participants recorded higher HbA1c levels than older and more informed counterparts (Badedi et al., 2016). Once again, this highlighted the importance of local data for local service development.

**Income**

This study revealed that most participants had an income equating to less than US$3,000 per year, with those with incomes less than $3,000/year having a higher likelihood of inadequate glycaemic management post-lockdown compared to those with an income exceeding $3,000/year. An Ethiopian study showed that being male, not attending formal education, having a monthly income of <136 USD, overweight and obesity were factors associated with poor glycaemic management (Yosef et al., 2021). These conflicting findings evaluated by studies concerning factors associated with glycaemic management might be attributed to geographical, cultural and lifestyle differences in the study location, race and ethnicity, and the applied definition of glycaemic management.

**Low socio-economic status**

The findings indicated that poor sociodemographic status including low education level, those who were retired, and low income, were associated with inadequate glycaemic management post-lockdown. This suggested that financial and work instability in low socioeconomic populations restricts patients' ability to provide a good diet. Escalation of perceived stress due to fears and anxieties regarding the adequacy of food, exacerbated the worsening of glycaemic management. The economic crisis during the pandemic increased unemployment rates, and financial insecurity compromised people in lower socioeconomic positions. Home confinement, work-from-home regulations, and closure of public places such as parks and sports centres gave rise to a drastic decline in physical activity. This also limited patient access to medical treatment, was attended by a decline in the number of clinical visits and increase in the circumstance of substandard care, hence further impacting glycaemic management (Wafa et al., 2022).

**Education**

This study showed that almost half of the participants had completed secondary education, followed by primary education, and a smaller number had a bachelor's degree. In addition, those with education only at the primary school level were more likely to have inadequate glycaemic management post-lockdown than those with higher levels of education. Previous studies in Jourdan and Morocco found that most people with diabetes had just a secondary education or less, were unemployed, and had a low annual family income < 150 US$ (Adarmouch et al., 2020; Almomani & Al-Tawalbeh, 2022).

Similarly, a previous study by Kaddar et al. indicated the negative impact of a low educational level on an HbA1c status (Kaddar et al., 2022). More education (>12 years) was a protective factor

affecting glycaemic management for people with diabetes; compared to the group with poorly controlled diabetes, those with well-controlled blood glucose had a higher proportion of people with > 12 years of education (Tao et al., 2020) . As educational status is helpful in developing concordance with medically-recommended treatment regimes, moderate and high levels of education have been linked to improved glycaemic management (Gvozdanović et al., 2021; Paulsamy et al., 2021).

Further evidence shows that the majority of unemployed people are not able to attain the recommended targets for diabetes self-management. Indeed, the high unemployment (48%) and poverty in populations studied have played an essential role in the findings (Alkhormi et al., 2022). Furthermore, Dissanayake et al. (2022) revealed that decreases in family income predicted worsening glycemia, suggesting that low income decreases the likelihood of adherence with lifestyle modifications and treatment regimens. Low adherence to management plans is a known risk factor for poor glycaemic management.

### 6.6.2 Clinical characteristics

#### Diabetes duration / disease progression

A longer duration of diabetes is known to be a factor associated with poorer glycaemic management, possibly because of the progressive impairment of insulin secretion over time as a result of β-cell failure, which makes a response to diet alone or oral agents unlikely (ADA, 2019). This study's results revealed a slightly higher median of diabetes duration between people with inadequate glycaemic management compared to those with adequate glycaemic management; however, the difference did not reach statistical significance. This was similar to a previous study in Jordan that reported longer duration of diabetes was associated with poorer glycaemic management (Khattab et

al., 2010). Alramadan et al. (2018) also reported that early-onset T2DM was associated with poor glycaemic management and a higher risk of comorbidities and complications. In addition, a hospital-based cross-sectional study showed people with T2DM for > 10 years were found to be 3.15 times more likely to have inadequate glycaemic management than those with a shorter duration of the disease (Abera et al., 2022). People with T2DM commonly experience fatigue, which may be incapacitating and adversely affect self-care regimens, and perplexing problem for healthcare providers (Fritschi & Fink, 2012). Also, previously published evidence highlights that many people with T2DM do not achieve good control of blood glucose, leaving them at increased and avoidable risk of serious complications (Blonde et al., 2017). A systemic review found Diabetes complications can be related to the long duration of the disease or chronic hyperglycemia (Poonoosamy et al., 2023) This illustrates how difficult it is for physicians and patients to sustain effective management of T2DM and achieve glycaemic management objectives when the disease progresses, and multiple medications are subsequently needed.

Similarly, this study revealed that an increase in diabetes duration in Jordan was significantly associated with inadequate glycaemic management during the lockdown. Similar findings were reported in a Turkish study, which found that inadequate glycaemic management is related to a longer duration of diabetes (OR: 1.2) (Karatas et al., 2020). An Indian study also found a long duration of diabetes was positively associated with deterioration of glycaemic management during the lockdown (Kumar & Nachankar, 2022). It hypothesized that patients' failure to achieve the optimal values of HbA1C over time caused frustration and disappointment, lowering their self-efficacy (Paulsamy et al., 2021).

Tanharo found that patients' treatment non-adherence was due to an increase in the duration of diabetes (Tanharo et al., 2018). Prescribers often identify poor patient motivation and self-

management as leading barriers to achieving glycaemic targets. The second Diabetes, Attitudes, Wishes and Needs (DAWN2) study, included an online survey of 4785 healthcare professionals (HCPs) (~40% primary care clinicians, 30% diabetes specialists, 20% nurses and 10% dieticians) from 17 countries across four continents. The majority of the respondents (60%) indicated a need for improvements in self-management by people with diabetes, particularly in the area of diet and exercise. Resistance to lifestyle measures was also identified as a leading barrier by 252 primary care physicians, nurse practitioners and physician assistants in the United States,43 with 52% of HCPs indicating that it was often or almost always a factor contributing to chronic lack of glycaemic control. Other leading patient-related barriers identified by the HCPs included psychosocial issues (34%), reluctance to use insulin (31%) and non-compliance (30%) (Holt et al., 2013). A study in the United Kingdom examining the reasons for very poor glycaemic control [HbA1c ⩾ 10% (⩾86 mmol/mol)] in 128 people with T2DM with long diabetic duration found poor adherence to life-style measures to be most frequently involved. Other factors included infrequent clinic attendance (16%), side effects (16%), poor compliance with pharmacotherapy (14%), lack of knowledge of diabetes (14%), lack of titration of insulin (13%) and insulin refusal (12%) (H. Khan et al., 2011)

**Comorbidities/HTN**

Hypertension (HTN) is highly related to risk factors that impair glucose homeostasis and poor glycaemic management and is frequently presented as a component of metabolic syndrome (Przezak et al., 2022). In the current study, HTN was found to be the most prevalent comorbidity, with no significant difference between males and females. This study reported that HTN was the comorbidity most associated with inadequate glycaemic management before the lockdown.

Similarly, studies from Italy and Lebanon reported that hypertension as the most prevalent comorbidity among people with T2DM (Biamonte et al., 2021; Naous et al., 2022). A previous systematic review and meta-analysis including 12 eligible articles in 2021 -2020 found that patients with hypertension had a greater risk of suboptimal glycaemic management (Bin Rakhis et al., 2022). Likewise, Sazlina et al. (2015) demonstrated that high blood pressure was related to inadequate glycaemic management (OR:1.10, 95% CI:1.01–1.20). In contrast, other studies have not linked hypertension to poor glycaemic management in people with diabetes (Atcı et al., 2022; Badedi et al., 2016).

In a prospective study, it was found that the majority of people with T2DM had comorbidity (28.11% hypertension). The study also revealed a significant association between comorbidities, poor appointments, treatment, and diet compliance. Patients with any comorbidity were three times more likely to have poor appointment compliance while two times likely to have poor treatment compliance and diet compliance. A number of comorbidities were significantly associated with poor appointment compliance (Piparva et al., 2022). A population-based longitudinal study found compared with adequate glycaemic control, the hazard ratio of inadequate glycaemic control on hypertension was 1.54 (95% CI, 1.07–2.21) in the multivariate model suggesting insufficient glycaemic control was associated with a higher risk of hypertension among individuals with T2DM. Notably, the effect of glycaemic control on hypertension was more pronounced among those with lower educational attainment and those exhibiting depressive symptoms. These findings underscore the significance of vigilant glycaemic monitoring, educational background considerations, and mental health assessments in managing diabetic individuals (Chen et al., 2023).

**Overweight/ obesity**

T2DM is very significantly linked to being overweight (Alkhalidy et al., 2021). In this current study, more than half of the participants exhibited obesity, with no significant difference in median height and BMI or its distribution between males and females. However, males had statistically substantially higher body weights than females at the baseline. The reason why females had less weight than males can be attributed to the fact that body composition differs between men and women, with women having proportionally more fat mass while men have greater muscle mass. Therefore, it is common for females to weigh less than males due to this biological variation (Schorr et al., 2018).

In accordance with prior studies in Morocco and Turkey showing no association between BMI and glycaemic management (Atcı et al., 2022; Chetoui et al., 2022), this study also reported that BMI was not associated with poor glycaemic management pre-lockdown. Despite that, the relationship between BMI and poor glycaemic management cannot be ignored; several studies have showed that being overweight or obese (> 30 kg/m2) can be related to a significantly increased risk of having HbA1c ≥ 7% (Bae et al., 2016; Haghighatpanah et al., 2018: Demoz et al., 2019), results that have been attributed to irregular food patterns, and poor medication taking leading to worse glycaemic management and reduced insulin sensitivity.

Moreover, the present study reported that an increase in BMI was another negative contributing factor to inadequate glycaemic management among people with T2DM during the lockdown. It is well-established that weight gain exacerbates insulin resistance and worsens glucose metabolism in people with T2DM (Wondmkun, 2020). Consistent with the findings of Biamonte et al. (2021), a worsening in glycated haemoglobin was directly associated with the increase in all three

anthropometric indexes (body weight, body mass index, and waist circumference). Also, Tanji et al. (2020) revealed that people with BMI >25 kg/m2 may have experienced inadequate glycaemic management but not those with a BMI of < 25kg/m2. This suggested that the COVID-19 lockdown measures may have exacerbated all the risk factors for weight gain, including unfavourable eating habits and changes in lifestyle in people with T2DM.

**Mental health**

Although the current study exhibited a worse effect on glycaemic management, most participants had symptom scores in the normal ranges for emotional states of depression, anxiety, and stress during the COVID-19 lockdown; only one person suffered from severe anxiety, and none scored in highly severe ranges. However, studies have shown that COVID lockdowns and restrictions placed during different waves of contagion have undoubtedly affected the lifestyles of people with Type 2 Diabetes Mellitus and their emotional state, leading to symptoms of anxiety, stress, and depression, which can in turn influence their glycaemic management (Coma et al., 2020; Dyer et al., 2021; Hossain et al., 2021; Troughton et al., 2021)

Alshaikh et al. (2020) reported that more than half of people living with diabetes in Jeddah, Saudi Arabia, felt more anxious or distressed during the lockdown. A previous systematic review and meta-analysis comprising thirty-seven articles with a total of 13,932 patients with diabetes found a prevalence of anxiety and diabetes distress of 20% and 36%, respectively, among people with T2DM (García-Lara et al., 2022) compared to 18% (Chaturvedi et al., 2019)and 29.4% (Huynh et al., 2021) in people with T2DM before the pandemic. The interplay of diabetes and lockdown creates an unsettling environment for the development of psychological issues creating a complex situation that may affect the patient's lifestyle and eating habits, affecting their glycaemic management.

Regarding emotional states, research has shown a high prevalence of evidence of psychological distress among people with diabetes during the COVID-19 pandemic and related limitations, and subsequent refusal to initiate insulin therapy among this population under certain conditions (Alessi et al., 2020). Presence of anxiety symptoms have been associated with deterioration in glycaemic management post-lockdown (Cheng et al., 2023). Further, an increment of HbA1c pre- and post-lockdown was observed in people with anxiety symptoms ($9.39 \pm 0.49$ vs $10.16 \pm 0.54\%$, $p = 0.028$). Therefore, stress and negative emotions can have an impact on glycaemic levels as a response towards a new change in life. As a result of the new emerging change, this study showed that people with T2DM who had symptoms of depression, anxiety, or stress were also more likely to have inadequate glycaemic management compared to their counterparts with adequate management post-lockdown.

The current study demonstrated that most participants had inadequate blood glucose control during the lockdown because they were unable to manage their glycaemic index. An explorative descriptive qualitative study found that most participants verbalized their worries as a consequence of the COVID-19 pandemic lockdown on their blood sugar, as shown in the comment below:

> "I was a bit worried about it [lockdown] . . . you know for some of us (people with diabetes) it's going to be horrible if we couldn't control our blood sugar . . . diabetes brings other problems"(Al-Moteri et al., 2022).

**Drug & insulin use.**

Metformin, either alone or in combination, has been the most often prescribed antidiabetic treatment for people with diabetes during the last seven years, followed by insulin or insulin analogs, gliptins, SGLT- 2i, sulfonylurea, glitazones, GLP-1a, and glucosidase inhibitors (Engler et al., 2020). As

diabetes is a progressive condition with deteriorating beta-cell activity, second-line ADAs were added to metformin monotherapy to achieve glycaemic management (Chan et al., 2018). In this study, more than half of the participants managed their diabetes by using oral medications and diet only, whereas the remaining individuals used oral agents and insulin and diet as well. Additionally, Metformin was the most frequently used antidiabetic medication, followed by insulin. According to a study conducted in Lebanon, most people with T2DM (77.7%) used oral anti-diabetes drugs exclusively, while 15.7% use injectable therapy alone, and just 6.4% use both oral and injectable treatment (Naous et al., 2022).

In the current study, those treated with oral agents and insulin as well as diet had inadequate glycaemic management pre-lockdown compared to those who received oral agents and diet only. Our finding was consistent with a survey by Chetoui et al. (2022), which showed that patients using diet and oral agents alone were better controlled than those treated with insulin alone or combined oral agents and insulin. This finding reflects the fact of deterioration of diabetes over time, with the requirement for higher doses or additional medications increasing over time. Therefore, patients treated with combination therapy of oral antidiabetic agents and insulin had a more progressive disease, which required more aggressive treatment to provide glycaemic management, but this phenomenon could also be attributed to delay in applying insulin in the treatment of people with poor glycaemic management (Atcı et al., 2022). Furthermore, people with HbA1c > 7% had a higher likelihood of receiving a prescription for a combination of oral agents and insulin, suggesting that physicians are attempting multitherapy to provide better disease control.

This study revealed that those who used insulin as their regular diabetes treatment were more likely to have inadequate glycaemic management before the lockdown. In line with an earlier study, poor glycaemic management was significantly associated with insulin use, suggesting the use of insulin

was not effective in maintaining adequate glycaemic levels, as T2DM management goes beyond drug therapy (Atcı et al., 2022). Also, Abera et al. (2022) reported that individuals who received insulin therapy had a 3-fold greater risk of inadequate glycaemic management than those who received other treatment regimens. Still, it is noteworthy that people with diabetes face barriers imposed by insulin therapy itself, such as repetitive injections and the respective discomfort, lack of supplies (materials) or access to home care, as well as difficulty in maintaining regularity and adherence to therapy recommendations (food, medication, and physical activity), and understanding the disease and its consequences.

People living with diabetes who used insulin alone or in combination with oral medications were more likely to have inadequate glycaemic management after the lockdown (Tao et al., 2020). With limitations in the transportation of goods and the movement of patients, there was expected to be a shortage of drugs, insulin, glucose testing strips, and glucose meters. All these factors could potentially increase stress levels and their associated impact on the pre-existing disease (Ghosal et al., 2020).

Multivariate logistic regression analysis indicated that people with insulin usage and hypertension were more likely to be associated with poor glycaemic management pre-lockdown, as suggested in a previous survey (Espinosa et al., 2021). Survey findings inferred that poor glycaemic management was significantly associated ($p < 0.05$) with the following factors: insulin use (Prevalence Ratio (PR) = 2.03), and presence of hypertension (PR = 0.79) (Espinosa et al., 2021).

Further, the final multivariate model demonstrated that use of insulin and Glimepiride were factors that strongly predicted inadequate glycaemic management during the lockdown, followed by BMI and smoking. In a similar multivariate model, insulin therapy was the only independent significant

predictor of HbA1c increase (OR: 2.40) (Biamonte et al., 2021). Also, Falcetta et al. (2021) observed insulin therapy conveyed 2-fold higher risk of worsening glycaemic management (OR: 1.96). This may reflect the challenge of managing this therapeutic approach, particularly in those with T2DM, with the limitations of transportation of goods and movement of patients during the restriction leading to a shortage of drugs, insulin, glucose testing strips, and glucose meters. A previous survey also noted that older people with T2DM with a heavier complication burden and complex pharmacotherapies could not contact their clinics for a non-site visit or remote consultation (Bonora et al., 2021)**.** Thus, the lockdown had a toll on the most fragile patients, who needed more attention during the limited functioning of many healthcare services. Additionally, low adherence to injectable medication regimens because of social stigma, interference with daily activity, and fear of hypoglycaemia have been suggested to increase the risk of poor control among people using injectable medications (Mitiku et al., 2022).

### 6.6.3 Lifestyle practices and behaviours

#### Smoking

In the present study, we found that nearly half the participants were smokers, with a significantly higher proportion of men smoking compared to women. Smokers were more likely to have inadequate glycaemic management after the lockdown. According to a previous study, smoking prevalence among Lebanese people with T2DM was 41%, and smoking was associated with significantly lower scores in the Audit of Diabetes-Dependent Quality of life (ADDQoL) during the lockdown (Naous et al., 2022).

Consistent with Alkhormi et al.(2022), who found that smoking and Khat chewing were inappropriate diabetic self-care management activities, the current Jordanian study found that

smoking was related to poor glycaemic management. This may directly affect glucose homeostasis through several mechanisms, such as raising IR, reducing insulin secretion, or disrupting pancreatic beta cell function leading to the reduced effectiveness of insulin (Fina Lubaki et al., 2022). Further, people who smoke have a more negative experience with diabetes regarding the quality of life, treatment satisfaction, and mental health, which may have implications for glycaemic management (Kim & Kim, 2022).

**Physical activity (PA)**

Physical activity has been shown to be an effective non-pharmacological therapeutic strategy for T2DM management, helping to improve glycaemic management by increasing insulin sensitivity and glucose tolerance and preventing its related complications (Harrington & Henson, 2021). Despite the importance of physical activity, evidence indicates that the COVID-19 lockdown led to a reduction in physical activity levels and prolonged sitting time due to house confinement, which might have had a worse metabolic effect on people living with diabetes (Ammar et al., 2020; Martinez-Ferran et al., 2020). The current study revealed that, according to A-IPAQ scores, the majority of people with T2DM engaged in low levels of physical activity during the lockdown. In addition, vigorous activity was at a median of 0 days/week with very low average minutes. Moderate activity and weekly walking also decreased, confirming the negative impact of COVID-19 restrictions on physical activity among people with T2DM. This finding was consistent with an Iranian study using IPAQ that demonstrated 71% of the people with T2DM participated in low levels of physical activity during the COVID-19 outbreak (Peimani et al., 2022). Others, like a study from Saudi Arabia, reported a significant decrease in physical activity and exercise rates during lockdown in the T2DM group (Al-Daghri et al., 2022).

There are several factors that may have led to physical activity decline during COVID-19, including home confinement as the primary containment measure to restrain the COVID-19 spread, the closure of different sports centres such as gyms and clubs, limited access to coaches and equipment, and park closures. The lockdown was reported to have resulted in the closure of parks and recreational centres, limiting opportunities for physical activities like walking and cycling (Amini et al., 2020).

However, the current study results showed that lower physical activity was not associated with inadequate glycaemic management in people with T2DM during the lockdown. These findings were in line with the results of a systematic review, which found that lockdowns for curbing COVID-19 had no negative impact on glucose control despite declining physical activity among people with diabetes (Aldukhayel, 2022). Oli et al. (2022) reported that of 183 people with poor glycaemic management, 79 (43.2%) had below the recommended physical activity level. Also, Brakenridge et al. (2022) revealed that restrictions imposed by COVID-19 were related to lower levels of physical activity and higher levels of inactive time in a convenience sample of persons with T2DM but these changes in behaviour were not predicted to have adverse effects on glycaemic management and the treatment of diabetes.

Qualitative findings from the current study revealed that nearly half the participants reported physical inactivity during the lockdown period. This was a change from their normal lifestyle and consequently affected their diabetes control. Similarly, Leite et al. (2022) attributed a significant reduction in overall physical exercise habits during the lockdown to well below the recommended level for physical activity. International guidelines for physical activity recommend people to undertake at least 150 min/week of moderate-to-vigorous aerobic exercise spread out over a minimum of 5 days, and moderate-to-vigorous resistance training at least 2–3 days/week on non-consecutive days, complemented with flexibility and balance exercises to delay or prevent the long-

term health complications related to diabetes (Colberg et al., 2016). The lockdown also led to increased inactivity among younger people, and created challenges for people living with diabetes, restricting physical activity and limiting access to healthy food devices (Rahman et al., 2020; Al-Moteri et al., 2022). Innovative indoor exercise strategies, like aerobic exercises and yoga, are needed to improve mobility and calorie burn.

**Diabetes self-care**

In terms of Diabetes Self-care Activities, the current study reported a lower degree of adherence among participants regarding diet, exercise, and foot care, and blood sugar testing was the only domain with higher adherence. The study also revealed that participants with inadequate glycaemic management had lower adherence with diet, exercise, blood sugar testing, and foot care compared to those with adequate management post-lockdown. With an increase in carbohydrate and unhealthy snack consumption and a decrease in exercise reported due to the COVID-19 lockdown, all factors may contribute to the worsening of hyperglycaemia. In Indonesia, a cross-sectional study including 89 people with T2DM demonstrated that the highest aspect of self-care management done by the respondents was medication treatment, followed by diet, physical activity, and foot care aspects (Malini et al., 2022). Meanwhile, the lowest self-care management aspect was blood glucose monitoring, with an overall mean score of 3.07 days per week, which indicated people with T2DM had only moderate self-care management (70.8%) during the lockdown (Malini et al., 2022). Similarly, Nouhjah et al. (2022) found the highest aspect of self-care management among Iranian people with T2DM was healthy diets, followed by adherence to medication, foot care, and physical activity recommendations. However, monitoring blood glucose had the lowest self-care management score (Nouhjah et al., 2022).

On the other hand, a descriptive cross-sectional study was conducted on people with T2DM in the chosen diabetic clinics of a Corporate Hospital in Chennai, India. (Paulsamy et al., 2021). The study findings revealed that the highest adherence score was for the general diet, followed by glucose monitoring and foot care scores, while exercise was the lowest. It suggested that although the participants knew the value of regular exercise, they lacked motivation and familial support. Also, most study participants were female and likely didn't have time to exercise due to household responsibilities (Paulsamy et al., 2021). Conversely, another study revealed no effect or positive effects of the pandemic lockdown on the self-management of T2DM (Nachimuthu et al., 2020). Based on their findings, most people with diabetes followed regular exercise and healthy diet control during the lockdown, while only 28% of the participants checked their blood glucose levels regularly (Nachimuthu et al., 2020). These disparities may be attributed to differences in geographical locations, the nature of the restrictions imposed, government messaging, and measurement methods. Hence, it is crucial to provide appropriate and continuous motivation to people with diabetes, including their families, and to ensure that the expected self-care behaviours for promoting health and preventing DM-related complications remain congruent with local resource and support availability.

The present study found that inadequate glycaemic management in people with T2DM was associated with a decrease in compliance with diet, exercise, blood sugar testing, and foot care during the lockdown. This finding is in line with those of Paulsamy et al. (2021), who found a significant relationship between diabetes self-care activities and glycaemic management in people with diabetes, where mean scores were 4.31 ±2.06 and 3.50±1.73, respectively, for people with HbA1c < 6.5% and HbA1c ≥ 6.5%. Also, Oli et al. (2022) found that most people with poor glycaemic management were challenged with dietary intake during the COVID-19 lockdown. The level of

practice was linearly correlated with the HbA1c level, and SDSCA ≥3.5 was associated with optimal glycaemic management (HbA1c ≤7%) with 82.0% sensitivity and 77.0% specificity. Ghosh et al. ( 2020) found the effect of the COVID-19 lockdown on the lifestyle of people with diabetes entailed: increased carbohydrate consumption, snacking, physical inactivity, decreased duration of physical activity, reduced SMBG, and increase in mental stress, all are challenging issues and may exacerbate glycemia. Hence, it is crucial to implement context and culture-specific programs that encourage people with T2DM to engage in self-care behaviours, like exercise and social support, to boost self-efficacy for better diabetes management and to reduce diabetes complications.

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## 6.7. Lessons and recommendations for Nursing Practice, education and training: Analysing Findings from the Delphi Study

### Enhancing diabetes-specific nursing practice

According to the present phase III Delphi study, the implications of these findings for nursing practice require urgent attention to address the challenges of diabetes management and monitoring during crises such as the COVID-19 pandemic. Through a rigorous assessment of importance and feasibility, these experts identified the need for developing patient-centered technologies, it was revealed that the need to develop a novel patient centred diabetes management technology such as remote glucose monitoring is a promising avenue for improving diabetes management. Additionally, digital programs, mobile apps, and telehealth services should be leveraged for diabetes health education. The value of a well-trained mobile diabetes team is undeniable. Nevertheless, home-based physical activity programs to aid in diabetes management are a lower priority. The COVID-19 pandemic has necessitated a rapid transition towards remote consultations via telehealth, telephone, video, and electronic consultation, with the aim of limiting the transmission of the virus while maintaining healthcare services (Khunti et al., 2022). However, healthcare professionals continue to face several challenges as services are being restored. They are tasked with addressing backlogs accrued across all domains and recovering all aspects of clinical care amidst workforce pressures due to clinician fatigue, illness, and self-isolation during the pandemic (Caballero et al., 2020). Additionally, the emergence of mutant strains of COVID-19 has resulted in people with diabetes fearing to attend healthcare facilities. As a result, a hybrid model with both virtual and face-to-face consultations will likely remain even as the number of face-to-face appointments increases.

A meta-analysis showed that participants receiving a telehealth intervention achieved a greater reduction in the HbA1C compared to those receiving usual care, with a weighted-mean difference

of -0.59 (95 % CI -0.84 to -0.35, $p < .001$, $I^2 = 74.1$ %, high certainty of evidence). Participants receiving telehealth interventions experienced better secondary outcomes, including reduced fasting blood sugar, decreased body mass index, and decreased low-density lipoprotein. Thus, it established telehealth's positive impact on glycaemic control in people with T2DM patients. Healthcare professionals can use telehealth in diabetes care (Chiaranai et al., 2024).

Currently, healthcare providers and patients who are self-isolating, telehealth is certainly appropriate in minimizing the risk of COVID-19 transmission. This solution has the potential to prevent any sort of direct physical contact, provide continuous care to the community, and finally reduce morbidity and mortality in COVID-19 outbreak (Monaghesh & Hajizadeh, 2020).

A longitudinal study conducted over 15 weeks of an inpatient virtual diabetes management service showed the feasibility of such a transition while providing similar outcomes to traditional face-to-face care (Jones et al., 2020). However, there are some disadvantages associated with telehealth interventions such as difficulty in establishing rapport due to poor expression of emotional well-being, a tendency of the patient to safeguard concerns, or insufficient non-verbal cues to enhance communication in a virtual environment. When clinical tests or physical examinations are required and cannot be conducted remotely, direct contact will still be essential (Khunti et al., 2022).

### Enhancing diabetes-specific nursing and health service policies

During this Delphi panel discussion, the participants discussed different implications for nursing and health service policy development or change. All the panellists agreed that telehealth systems could provide support and ensure the safety of healthcare providers and patients, which was highly prioritized (mean score = 26.01). During the COVID-19 pandemic, different technologies, including telehealth, are maximised to mitigate the risks and consequences of the disease. Telehealth has been widely utilised because of its usability and safety in providing healthcare services during the COVID-19 pandemic. However, a systematic literature review which provides extensive evidence on the impact of COVID-19 through telehealth, and which covers multiple directions in a large-scale research remains lacking. This study aims to review telehealth literature comprehensively since the pandemic started. the beginning of the pandemic, telehealth has been presented in diverse cases. However, it still warrants further attention. Regardless of category, the articles focused on the challenges which hinder the maximisation of telehealth in such times and how to address them. With the rapid increase in the utilization of telehealth in different specialized hospitals and clinics, the importance of establishing frameworks or guidelines to support the future application and opportunities of telehealth has been highlighted (Garfan et al., 2021).

Furthermore, the results of Delphi study have highlighted the pressing need for establishing new policies related to monitoring and managing diabetes in community settings. Furthermore, the need for a national disaster planning system to assist diabetes patients and healthcare providers in maintaining diabetes control during a pandemic has been identified as a key priority. The study also emphasized the importance of diabetes education as a critical component in addressing fear among people living with T2DM during a pandemic, albeit with a mean score of 17.28, indicating a relatively lower level of priority assigned to this vital aspect. Four critically important, inter-related

domains needing improvement individually, interpersonally, within communities, and for critical public policy reform were identified: Social determinants of health, mental health, communication, and the nursing workforce. The four domains identified in this analysis demonstrate the challenges generated or intensified by the COVID-19 pandemic, their dynamic interconnectedness, and the critical importance of health equity to resilient health systems, an effective pandemic response, and better health for all (Reynolds et al., 2023).

The education of people with diabetes brought an increase in the health and quality of life while the coronavirus disease pandemic had negative consequences on the same parameters (Gvozdanović et al., 2021). Experts recommend developing nursing and health service policies to better manage care and support people with T2DM during any future pandemic. Health policymakers should convene a national workshop of interdisciplinary subject matter experts to explore the lessons learned from the national diabetes nurse response to COVID-19 and ways to take forward any subsequent recommendations in preparation for any future pandemic. This recommendation was highly prioritized among the panelists, with a mean score of 28.43.

In addition, experts also recommend creating a Jordanian Diabetes Registry to track and improve the quality of care and outcomes of people with T2DM. Hospital managers should establish and maintain crisis leadership skills in nurse administrators, managers, and executives who can help foster and champion nurse preparedness and response at the highest levels. These recommendations received mean scores of 28.43 and 25.93, respectively.

The panelists discussed the implications for nursing education and emphasized the importance of adaptable nursing education systems that must be flexible and adaptive (mean score 30.86). They also highlighted the need for training nurses in remote disease management and telehealth use.

Moreover, new ways to teach diabetes management to patients and improving nursing education by focusing on people with diabetes difficulties were given high priority (mean scores of 29.63 and 24.37, respectively). Educating patients in diabetes self-management and addressing COVID-19 challenges were also identified as important (mean scores = 24.30 and 24.20).

In terms of recommendations to develop nursing education to better prepare nurses to support people with T2DM during any future pandemic, the experts highly prioritized encouraging updated nursing education curricula with the new information and experience acquired from the COVID-19 pandemic to train nurses in effective clinical practice for diabetes (mean score 25.48). Pre-planning and regular education of nursing staff about diabetes and guidelines, as well as revised curricula to help prepare for future pandemics, also had high priority.

**Enhancing Diabetes-Specific Nursing Education**

The integration of specialized diabetes education into the nursing curriculum is crucial, particularly in the context of Jordan, where diabetes prevalence is notably high. This need is emphasized by existing literature, which reveals significant gaps in nurses' knowledge of diabetes management across various countries, including Jordan. For instance, studies by Alotaibi et al. (2016, 2017) have uncovered substantial discrepancies between perceived and actual diabetes knowledge among nurses, especially in tertiary hospitals (Alotaibi et al., 2016, 2017). These gaps can severely impact the quality of care provided to diabetic patients, underlining the importance of targeted education and training.

In Jordan, the distinction between generalist and specialist nursing roles is particularly relevant. Yacoub et al. specifically assessed the diabetes-related knowledge of registered nurses in Jordanian hospitals, finding significant deficiencies in critical areas such as insulin management and

hypoglycemia treatment. This underscores the urgent need for enhanced diabetes education within Jordanian nursing programs (M. I. Yacoub et al., 2014).

The COVID-19 pandemic further highlights the necessity of strengthening the nursing curriculum with a focus on diabetes management. While chronic and medical conditions generally warrant specialized training, diabetes presents unique challenges, particularly in crisis scenarios. However, the integration of diabetes-specific education should not overwhelm the existing curriculum. Instead, the development of targeted modules or continuing education programs can ensure that nurses, particularly those in specialist roles, are equipped with the essential skills to manage diabetes effectively, thereby improving patient outcomes.

## 6.8. Limitations of the study

### 6.8.1. Limitations of phase I

Phase 1 of the study relies on clinical data for research purposes. One limitation of this phase is that the data may be incomplete due to missing information. This can lead to the use of incomplete cohorts for analysis, which could limit the generalizability of findings and affect the robustness of conclusions drawn. Additionally, the quality of clinical data used in this phase may be influenced by the experience and expertise of the clinician recording it. Variations in skill level and documentation practices among clinicians may introduce inconsistencies or inaccuracies in the data, potentially affecting the reliability and validity of study outcomes.

The Cronbach's Alpha value of the A-IPAQ was 0.544, indicating low internal consistency. This could be due to various reasons such as insufficient number of items, item homogeneity, item redundancy, sample characteristics, scale reliability, and response bias. To improve the scale's internal consistency, increasing the number of items, refining scale items, or analysing subgroup differences could be helpful.

In Phase I, it was crucial to identify potential factors that may have influenced the changes in blood glucose or HbA1c values. One such factor is steroid use, although there is no reason to expect that numbers of patients with T2DM would have stopped, started or changed the dosage of steroids during the pandemic. Steroids can affect glucose metabolism, causing hyperglycaemia or hypoglycaemia. Failure to account for steroid use during the study cmay have led to misleading interpretations of changes in glycaemic parameters.

### 6.8.2. Limitations of phase II

In Phase II, the study collected self-report survey data, which have limitations as a data collection method. Self-report data are susceptible to various biases such as response bias, recall bias, and social desirability bias. Participants may provide responses that are influenced by their subjective interpretations, memory limitations, or desire to present themselves in a favourable light. Therefore, the accuracy and reliability of the survey data may be compromised, leading to potential inaccuracies in the analysis and interpretation of results.

In Phase II, the interview recruitment response rate was only 15 of 323 participants who agreed to participate in the interviews, which was less than expected. This could be due to the ongoing presence of COVID-19 cases in the country, which may have led to hesitancy among participants due to concerns about their health and safety. Despite the data collection being conducted post-lockdown, the fear of infection might have still been prevalent, influencing their decision to avoid further participation. Additionally, this highlights the continued impact of the pandemic on individuals' willingness to engage in research activities, even within a post-lockdown context.

This limitation is significant as it underscores not only the direct influence of the pandemic on health-related fears but also the broader psychological and behavioural responses that continue to persist among the population. The reluctance to participate may reflect a deeper, more pervasive sense of uncertainty and vulnerability, particularly among individuals managing chronic conditions such as type 2 diabetes. The enduring effects of pandemic-related anxiety appear to have manifested in cautious behaviour, even in research participation, where the perceived risk, however minimal, could outweigh the perceived benefit. This scenario serves as a reminder of the complex interplay between

public health crises and research engagement, particularly in a landscape still shadowed by the repercussions of COVID-19.

### 6.8.3. Limitations of phase III

Phase III of the study involved gathering input and perspectives from experts primarily from acute care settings. However, a limitation arose from the lack of representation of community perspectives. Since the experts were predominantly from acute care settings, the perspectives may not have fully reflected the realities and challenges faced by communities, particularly those related to people with type 2 diabetes mellitus in non-acute settings. This limitation could have impacted the comprehensiveness and applicability of the study's conclusions and recommendations, as community-based insights may be crucial for informing nursing education and practice in diverse healthcare settings.

While the Delphi technique is a well-established and supported method for achieving consensus among subject experts, it is not without its limitations. One potential bias is that participants may change their opinions from one round to the next, which can raise concerns about the reliability of the consensus achieved. This change in opinion could be influenced by the additional information provided between rounds or the evolving dynamics of group thinking, which may not always reflect the participants' initial perspectives. However, it is important to acknowledge that this change is also an integral part of the Delphi process, as it facilitates the convergence of expert opinions towards a consensus.

Despite these limitations, the Delphi method remains a robust tool for generating consensus in complex areas of study, particularly where diverse expert opinions are involved. The iterative nature of the Delphi process, wherein participants are given the opportunity to reconsider their views in

light of new insights, ultimately strengthens the validity of the consensus reached. The positive aspects of the Delphi technique, including its structured approach to capturing expert judgment and its ability to synthesize diverse viewpoints, outweigh the potential drawbacks. This study has demonstrated that the Delphi process successfully identified a consensus among the subject experts, reinforcing the method's overall reliability and appropriateness for the research objectives.

# 7. CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

## 7.1. Conclusion

The COVID-19 lockdown had a negative impact on people with T2DM in Jordan, with a significant increase in HbA1c three months after the lockdown compared to HbA1c six months before the lockdown. This study demonstrated a significant increase in the overall proportion of patients who had inadequate glycaemic management three months post-lockdown as compared to six months pre-lockdown, indicating that it was not only those with inadequate glycaemic management pre-lockdown that were vulnerable to restrictive measures during the mandated periods of lockdown. However, pre-lockdown hyperglycaemia clearly indicated vulnerability and indicated one group that urgently needed to be prioritized for follow-up efforts during mandated lockdown periods.

The majority of people with T2DM demonstrated low physical activity. Contrary to expectations, there was no significant association between A-IPAQ categorization and adequacy of glycaemic management post-lockdown. Notably, people with inadequate control exhibited markedly higher scores for depression, anxiety, and stress in contrast to those with adequate control post-lockdown regarding DASS-21 findings. People with inadequate glycaemic management consistently reported low levels of self-care behaviour, particularly for exercise, diet, foot care, and blood sugar testing. This study unequivocally emphasizes the prevalence of psychological and self-care behaviour disruptions among individuals with diabetes, particularly those with inadequate glycaemic management during the COVID-19 pandemic.

Nonetheless, some clinical features, in particular longer diabetes duration, higher BMI, Glimepiride, and insulin therapy, seem to identify subgroups of people with a greater risk of glycaemic management deterioration. These characteristics may help address patients requiring more attention - if not special protection - by developing special programs during challenging societal situations.

Also, the qualitative study definitively revealed the experiences and emotional reactions of people with T2DM during home confinement and changes in their diabetes management in Jordan. Most participants had inadequate blood glucose control during the lockdown due to their inability to manage their glycaemic index. Due to their health status, patients reported feeling highly stressed and anxious about infection. Besides this, people with T2DM struggled to establish self-care routines for physical activity and nutrition. These results can help guide the design and implementation of self-care-focused strategies and explore new ways of empowering people without access to healthcare personnel.

As more is learnt more about SARS-CoV-2 and its impact, it is becoming clear that people with T2DM are particularly vulnerable, especially in terms of healthy lifestyle behaviours and emotional well-being. This could lead to an increase in diabetes-related complications in the future. Effective diabetes self-management is crucial to help counteract these effects. However, delays in delivering self-management education programs are a major concern, as such programs have been shown to have positive effects on both physical and mental health, may play an important role in minimizing the negative health impacts of the pandemic.

Based on the findings of the Delphi study phase III, nursing practice needs to focus on developing patient-centered diabetes management and monitoring technologies. This includes remote monitoring for blood glucose levels. Home-based physical activity programs are considered less

important and feasible compared to other implications for nursing practice identified in the study. This suggests that while these programs may have some value, they may not be prioritized as highly within nursing practice based on the findings from phases 1 and 2 of the study. In order to effectively manage care and support for people with T2DM during pandemics, it is recommended that nurses promote physical activity and home-based exercise programs. These programs are critical components in preventing and managing diabetes, while also improving mental well-being during quarantine and future pandemics.

According to the implications for nursing and health service policy development or change, experts emphasized that Telehealth systems can support healthcare providers and ensure patient safety. Even though diabetes education is important for addressing the fears among people living with T2DM during a pandemic, it is given low priority in terms of implications in nursing and health service policy development or change. A national workshop is recommended to explore the lessons learned from the national diabetes nurse response to COVID-19. This will help prepare for future pandemics and ensure quality patient care. Additionally, establishing a Jordanian Diabetes Registry can improve the quality of care and outcomes for people with diabetes by collecting data on key performance measures.

In regards to the impact of these discoveries on implications for nursing education, the expert panel prioritized the need for flexible and adaptive nursing education systems, followed closely by the training of nurses in telehealth. They stressed the critical importance of training nurses in telehealth and educating patients on self-management of diabetes, specifically addressing the challenges faced by those with T2DM. There is a need to improve the case management system in which nurses help patients focus on controlling combined risk factors to provide good diabetes care; however, this received the lowest mean score among the implications considered.

Experts recommend updating nursing education curricula to better equip nurses in providing assistance to people with diabetes during pandemics. The updated curriculum should include latest COVID-19 experiences for effective clinical practice. Regular education and pre-planning can also help prepare nursing staff for future pandemics.

### 7.2 Recommendations

This research provides valuable insights that can inform practical and policy-related improvements in diabetes management. Based on the findings, key recommendations are proposed to enhance diabetes management, service delivery, and future research, ensuring better outcomes during health crises and beyond.

**1. Recommendations for Practice**

- **Actions addressing the findings of this study will benefit individuals**. Results indicate that increasing the frequency of blood glucose measurements during home quarantine and providing education to patients about the importance of medication compliance are important aspects to consider. The findings indicate the duration of DM, age/life expectancy, comorbidities, degree of microvascular or macrovascular complications, and unawareness of hypoglycaemia are important to consider in the development of educational tools. This education should strongly encourage following a healthy lifestyle and nutritional intake, and regularly engaging in physical activity.

**2. Recommendations for Policy Development**

- **Prioritizing Telehealth and Remote Monitoring**: Given the significant role that telehealth and remote monitoring played in facilitating diabetes management during the COVID-19 lockdown, policymakers should prioritize investments in telehealth infrastructure. This includes ensuring reimbursement mechanisms for telehealth services and promoting the adoption of remote monitoring technologies by healthcare providers.

- **Integration of Diabetes Care into Public Health Emergency Plans**: Policy frameworks should be developed or updated to explicitly integrate diabetes management strategies into broader public health emergency plans. This involves collaboration between public health authorities, healthcare providers, and diabetes advocacy organizations to ensure that the unique needs of diabetic patients are addressed during crises.

- **Ensuring Access to Essential Medications and Supplies**: Policymakers should implement measures to guarantee uninterrupted access to essential medications, glucose monitoring supplies, and other diabetes management resources during lockdown situations. This may involve stockpiling essential supplies, facilitating home delivery services, and coordinating with pharmaceutical companies to mitigate supply chain disruptions.

- **Enhancing Public Health Messaging**: Clear and targeted public health messaging is essential for empowering people with T2DM to manage their condition effectively during crises. Policymakers should support the development and dissemination of evidence-based communication materials that provide actionable guidance on diabetes self-care, medication taking, and lifestyle modifications during lockdowns.

**3. Recommendations for Policy and Service Development**

- **Supporting Healthcare Workforce Training**: Policymakers should invest in training programs for healthcare professionals to enhance their skills in delivering remote care and telehealth services. This includes training on the use of telemedicine platforms, remote monitoring devices, and effective communication strategies for virtual consultations.

- **Promoting Community Engagement and Support Networks**: Policymakers should encourage the establishment of community-based support networks for people with T2DM. This includes initiatives to foster peer support, facilitate virtual diabetes education sessions, and connect people with local resources for assistance with medication access, food security, and mental health support during lockdowns. Additionally, the engagement of volunteer and peer support organizations should be promoted to enhance the effectiveness of these efforts. These organizations play a crucial role in providing emotional support, practical advice, and shared experiences, which can be particularly valuable for individuals managing chronic conditions like T2DM. By leveraging the lived experiences of peers, these groups offer a unique form of social support that complements professional healthcare services, fostering a sense of community and reducing feelings of isolation. Furthermore, volunteer-driven initiatives can help to bridge gaps in healthcare access, particularly during periods of crisis such as lockdowns, by facilitating outreach, disseminating essential information, and ensuring that vulnerable populations receive the resources and assistance they need to manage their condition effectively.

- **Updating Nursing Education Curricula**: Updating nursing education curricula is essential to provide nurses with resources so they are better prepared to provide support to people with T2DM during pandemics and times where patients are unable to access their usual support services. This updated curriculum should use the latest information and experience acquired from the COVID-19 pandemic as a foundation upon which to train nurses in effective clinical practice for diabetes during pandemics. Pre-planning and regular education of nursing staff about diabetes and guidelines can help to prepare for future pandemics.

## 4. Implications for Policy

- **This study could be used by the government to formulate policy to ensure older people with T2DM who need particular attention are provided with strategies to deal with newly emerging psychological concerns**. This could ensure older people are encouraged and provided with education to lead a healthy lifestyle, to monitor and maintain their health.

- **Enhancing the Utilization of Nursing Skills in Diabetes Care**: One of the key implications for policy involves the more effective use of nursing skills in diabetes management. In many healthcare systems, including Jordan, there is significant potential to enhance diabetes care through better utilization of nursing professionals. Currently, the focus on patient monitoring and education may not fully leverage the diverse skills that nurses possess. Policies should be developed to expand the scope of nursing roles in diabetes care, enabling nurses to play a more central role in patient management. This includes providing comprehensive education on diabetes self-management, facilitating regular monitoring of patients, and offering continuous support to improve adherence to treatment plans.

- **Integration of Specialized Diabetes Nursing Roles**: A critical policy implication is the integration of specialized diabetes nursing roles, such as Diabetes Nurse Practitioners and Credentialled Diabetes Nurse Educators. These roles are well-established in western countries and have been shown to significantly enhance patient outcomes through specialized care and education. Diabetes Nurse Practitioners are trained to manage complex diabetes cases, prescribe medications, and develop individualized care plans, while Credentialled Diabetes Nurse Educators focus on patient education and empowerment. Introducing these roles into the Jordanian healthcare system could provide patients with more tailored and effective

diabetes management, improve overall care quality, and optimize the use of available healthcare resources.

- **Addressing Under-Utilization of Nursing Workforce**: The current under-utilization of the nursing workforce in diabetes care highlights a gap that policy changes could address. By recognizing the value of specialized diabetes nursing roles and incorporating them into the healthcare system, Jordan can enhance the effectiveness of diabetes management. Policies should encourage the training and certification of nurses in diabetes care, support the development of these specialized roles, and integrate them into the existing healthcare framework. This approach would not only improve patient outcomes but also ensure that the nursing workforce contributes more effectively to managing chronic conditions like diabetes.

**5. Recommendations for Future Research**

- **This program of work has uncovered implications of the COVID-19 lockdown and provides evidence to support several recommendations for treatment and care for patients diagnosed with T2DM to improve health outcomes**. T2DM is a progressive disease, and as such, several awareness initiatives on diabetes care and self-management should be encouraged.

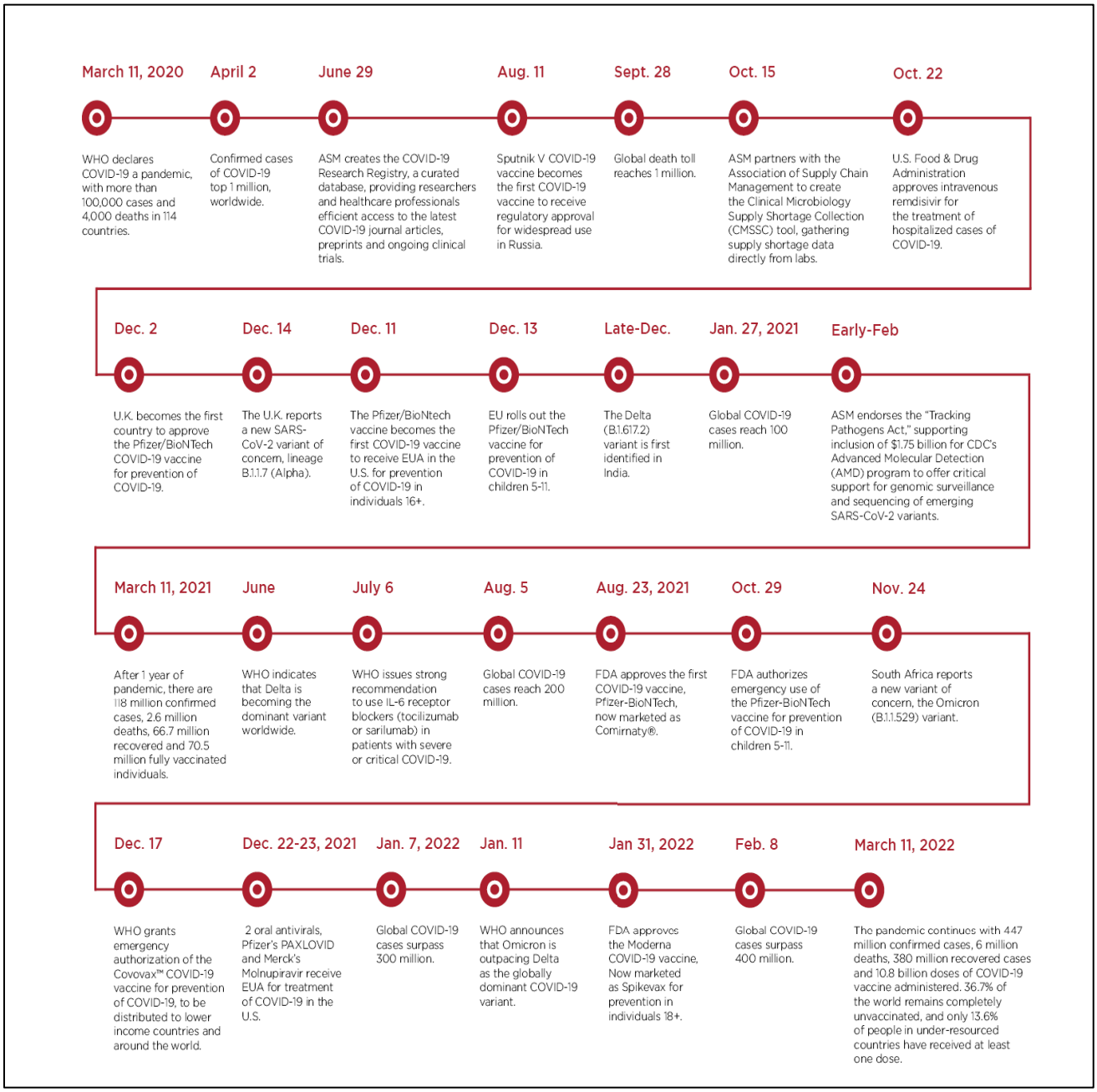
- **Future research is required to consider the effects on diabetes self-care across the whole of the COVID-19 lockdown periods**. These were at times sporadic and unknown; therefore, research looking at a longer time period could provide further information to inform education and treatment plans. Lockdowns or times where patients are restricted to their homes have unintended consequences (for example, psychological health problems, domestic and family

violence), and it will be important to undertake future systematic and comprehensive studies of the broader and longer-term effects for people with diabetes.

- **This program of work has provided valuable findings that could be used in future pandemic situations as well as in situations of emergency or critical incidents**. For example, storms or floods, or any time where people living with diabetes are unable to access their usual diabetes support.

# 8. APPENDICES

## Appendix 1.1. Timeline of the critical events of the COVID-19 outbreak (American Society for Microbiology, 2022



**Appendix 2.1. Assessment tools.**

**Demographic data.**

| | |
|---|---|
| 1. Age: What is your age? (Years) Or Date of Birth | 1-العمر: ما هو عمرك؟(سنوات) أو تاريخ الميلاد |
| 2. Diabetes duration: (Years) | 2- مدة مرض السكري: (سنوات) |
| 3. Body mass Index: (Kg/$m^2$) | 3-مؤشر كتلة الجسم (كجم/م2)؟ |
| 4. Gender: What is your gender?<br>a. Male<br>b. Female | 4-الجنس: ما هو جنسك؟<br>أنثى<br>ذكر |
| 5. Marital Status: What is your marital status?<br>a. Single<br>b. Married<br>c. Separated<br>d. Divorced<br>e. Widowed | 5-الحالة الاجتماعية: ما هي حالتك الاجتماعية؟<br>أ- أعزب<br>ب- متزوج<br>ت- منفصل<br>ث- مطلق<br>ج- أرمل |
| 6. Education level: What is the highest grade or year of school/college you have completed?<br>a. Primary<br>b. Secondary<br>c. High School<br>d. Vocational training<br>e. Bachelor degree<br>f. Master/Doctoral degree | 6-المستوى التعليمي: ما هي أعلى مرحلة او درجة دراسية / كلية أكملتها؟<br>أ- ابتدائي او أمي<br>ب- ثانوي<br>ت- دبلوم متوسط<br>ث- درجة البكالوريوس<br>ث- درجة الماجستير / الدكتوراه |

| | |
|---|---|
| 7. Domicile: Which of the following are applicable to your living situation?<br>a. Living alone<br>b. Living with parents/guardians/relatives/ friends<br>c. Living with spouse | **7- السكن: أي مما يلي ينطبق على وضعك المعيشي الحالي؟**<br>أ- العيش وحيدا<br>ب- العيش مع الوالدين أو الأوصياء / الأقارب/الأصدقاء<br>ت- العيش مع الزوج أو الزوجة |
| 8. Occupation: What is your current occupation?<br>a. Unemployed<br>b. Employed<br>c. Studying full time<br>d. Retired | **8- الوظيفة: ما هي مهنتك الحالية؟**<br>أ- عاطل عن العمل<br>ب- موظف<br>ت- الدراسة بدوام كامل<br>ث- متقاعد |
| 9. Income: What is your total annual income?<br>a. Less than $3,000<br>b. $3,000-$7,000<br>c. $7,000-$10,000<br>d. $10,000+ | **9- الدخل: ما هو إجمالي دخلك السنوي؟**<br>أ- أقل من 3000 دولار<br>ب- ما بين 3000-7000 دولار<br>ج- ما بين 7000 دولار إلى 10000 دولار<br>د- أكثر من 10000 دولار |
| 10. Do you currently smoke cigarettes/ use tobacco?<br>a. Yes, on a regular basis<br>b. Yes, but only once in a while<br>c. Not anymore, I quit<br>d. No, I have never used tobacco | **10- هل تستخدم التبغ بأي من أشكاله الحالية (دخان أو أرجيلة)؟**<br>أ- نعم بشكل منتظم<br>ب- نعم ، ولكن مرة واحدة كل فترة<br>ج- ليس بعد الآن، لقد توقفت.<br>د- لا، لم أستخدم التبغ أبدًا |
| 11. Type of regular diabetes treatment:<br>a. Diet only<br>b. Oral agents and diet only<br>c. Oral agents and insulin as well as diet | **11- نوع العلاج المنتظم لمرض السكري**<br>أ- النظام الغذائي فقط<br>ب- الدوية الفموية والنظام الغذائي فقط<br>ج- الدوية الفموية والأنسولين بالإضافة إلى النظام الغذائي |

**International physical activity questionnaire short last 7 days self-administered format.**

## INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (August 2002)

## SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

### FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

***Background on IPAQ***
The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

***Using IPAQ***
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

***Translation from English and Cultural Adaptation***
Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

***Further Developments of IPAQ***
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

***More Information***
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

# INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

**This is the end of the questionnaire, thank you for participating.**

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

# Arabic version of International Physical Activity Questionnaire

## استبانة النشاط البدني الدولية (يوليو ٢٠١٤)

**لقياس مستوى النشاط البدني في الأيام السبعة الماضية (للشباب والكبار ١٥-٦٩ سنة)**

## الصيغة المختصرة للاستبانة، للاستخدام عن طريق التعبئة الشخصية

تتضمن استبانة النشاط البدني الدولية (IPAQ) أربع مجموعات من الاستبانات؛ صيغة مطولة (تتكون من ٥ حقول مستقلة من الأنشطة البدنية)، وصيغة مختصرة (مكونة من ٤ بنود عامة). لكل صيغة من الصيغتين استبانتان، إحداها للاستخدام بواسطة الهاتف، والأخرى للاستخدام الذاتي (يتم تعبئتها من قبل الشخص نفسه). إن هدف هذه الاستبانات هو توفير أداة مشتركة يمكن من خلال استخدامها الحصول على بيانات عن مستوى النشاط البدني المرتبط بالصحة، قابلة للمقارنة دولياً.

### خلفية عن استبانة النشاط البدني الدولية

بدأت عملية بناء مقياس دولي للنشاط البدني في مدينة جنيف في عام ١٩٩٨م، وتبع ذلك في عام ٢٠٠٠م إجراء اختبارات مكثفة لصدق المقياس وثباته، شملت ١٢ دولة (١٤ موقعاً). ولقد أظهرت النتائج النهائية أن المقاييس المستخدمة تمتاز بخواص قياس مقبولة، لاستخدامها في أماكن متعددة وبلغات مختلفة، مع صلاحيتها للاستعمال في الدراسات الوطنية لمعرفة شيوع ممارسة النشاط البدني لدى السكان.

### استخدام استبانة النشاط البدني الدولية

يُحث على استخدام استبانة النشاط البدني الدولية لمراقبة مستوى النشاط البدني، ولغرض البحث العلمي. ويوصي بعدم إحداث أي تغيير في ترتيب الأسئلة أو في الكلمات المستخدمة، لأن ذلك يؤثر في الخصائص السيكومترية للأداة.

### الترجمة من اللغة الإنجليزية والملاءمة الثقافية

إن ترجمة استبانة النشاط البدني الدولية من اللغة الإنجليزية إلى لغات أخرى أمر يستحق التأييد، مما يسهل استعمالها على نطاق واسع. ويمكن الحصول على المعلومات المتعلقة بتوفر الاستبانة الدولية للنشاط البدني بلغات مختلفة من الموقع التالي: www.ipaq.ki.se ، وفي حالة الشروع في ترجمة الاستبانة، فإننا نوصي بشدة أن يتم استخدام طريقة الترجمة العكسية (Back translation) الموضحة على موقع الاستبانة الإلكتروني. فضلاً، إذا كان ممكناً، ضع في الاعتبار إتاحة النسخة المترجمة من الاستبانة الدولية للآخرين، وذلك بوضعها في الموقع الإلكتروني، ويمكن الحصول على معلومات إضافية حول الترجمة والملاءمة الثقافية من خلال موقع استبانة النشاط البدني الدولية.

### إدخال البيانات وترميزها

ملحق مع إجابات كل سؤال من أسئلة استبانة النشاط البدني الدولية رموز مقترحة للمتغيرات والمدى المتوقع للإجابات، لتسهيل عملية إدخال البيانات والتعامل معها، وللمساعدة في عملية تدريب القائمين على إجراء المقابلات، ويوصي بأن يتم بالضبط تسجيل الإجابة الفعلية للمجيب، فعلى سبيل المثال: " ١٢٠ دقيقة " تكتب ١٢٠ في خانة الدقائق، وفي حالة الإجابة بساعتين، فتكتب ٢ في خانة الساعات، أما في حالة كون الإجابة " ساعة ونصف " فتكتب على أساس ١ في عامود الساعات، و ٣٠ في عامود الدقائق.

### تطورات استبانة النشاط البدني الدولية

إن التعاون الدولي حول استبانة النشاط البدني الدولية مستمر، وحالياً يتم إنجاز دراسة دولية حول شيوع ممارسة النشاط البدني. ولمزيد من المعلومات، يمكن الرجوع إلى الموقع الإلكتروني لاستبانة النشاط البدني الدولية.

### معلومات إضافية

يتوافر في الموقع الإلكتروني التالي: www.ipaq.ki.se معلومات إضافية حول إجراءات استبانة النشاط البدني الدولية وطرق البحث المستخدمة في بنائها، ويمكن الرجوع للمرجع التالي: Booth, M. L. (2000). Assessment of Physical Activity: An International Perspective. Research Quarterly for Exercise and Sport, 71 (2): s 114-20. كما يتوفر، على الموقع الإلكتروني، عرض موجز لبحوث أخرى نشرت أو ألقيت في مؤتمرات علمية، حول استخدام استبانة النشاط البدني الدولية.

## الصيغة المختصرة لاستبانة النشاط البدني الدولية، للاستخدام بواسطة التعبئة الشخصية

نحن مهتمون بمعرفة أنواع الأنشطة البدنية التي يقوم بها الأفراد كجزء من حياتهم اليومية. الأسئلة التالية ترتكز حول الوقت الذي قضيته في ممارسة أنشطة بدنية خلال الأيام السبعة الماضية. فضلاً أجب عن كل سؤال من الأسئلة التالية حتى وإن كنت تعتبر نفسك غير نشيط بدنياً. فكر في الأنشطة البدنية التي تمارسها خلال عملك، وكجزء من أعمالك المنزلية، وأثناء تنقلك من مكان لآخر، وتلك التي تقوم بها في وقت فراغك بغرض الترويح أو التمرين أو الرياضة.

الآن فكر في جميع الأنشطة البدنية التي تتطلب جهداً بدنياً مرتفع الشدة والتي قمت بممارستها خلال الأيام السبعة الماضية. الأنشطة البدنية مرتفعة الشدة هي تلك الأنشطة التي تجعل تنفسك أعلى بكثير من المعتاد، مثل رفع أشياء ثقيلة، أو حرث الأرض، أو ركوب الدراجة بسرعة عالية، أو الجري، أو ممارسة كرة القدم، أو كرة السلة، أو السباحة، أو نط الحبل. فكر فقط في الأنشطة البدنية مرتفعة الشدة التي قمت بممارستها لمدة ١٠ دقائق على الأقل في كل مرة.

١ – خلال الأيام السبعة الماضية، كم يوماً مارست فيه نشاطاً بدنياً مرتفع الشدة؟

_____ يوم في الأسبوع

☐ لا أقوم بأي نشاط بدني مرتفع الشدة. ← انتقل مباشرة إلى السؤال رقم ٣

٢ – في المعتاد، كم من الوقت قضيته في ممارسة نشاط بدني مرتفع الشدة في أحد تلك الأيام؟

_____ ساعة في اليوم

_____ دقيقة في اليوم

☐ لا أدري/ أو غير متأكد.

الآن فكر في جميع الأنشطة البدنية التي تتطلب جهداً بدنياً **معتدل الشدة** والتي قمت بممارستها خلال الأيام السبعة الماضية. الأنشطة البدنية معتدلة الشدة هي تلك الأنشطة التي تجعل تنفسك أعلى من المعتاد إلى حداً ما، ويمكن أن تتضمن رفع أشياء خفيفة، أو ركوب الدراجة بسرعة عادية، أو ممارسة كرة الطائرة، أو ممارسة تنس الطاولة، أو كنس المنزل، أو غسل الملابس يدوياً، أو غسل السيارة. لا تحسب المشي ضمن هذه الأنشطة. مرة أخرى، فكر فقط في الأنشطة البدنية معتدلة الشدة التي قمت بممارستها لمدة ١٠ دقائق على الأقل في كل مرة.

٣- خلال الأيام السبعة الماضية، كم يوماً مارست فيه نشاطاً بدنياً معتدل الشدة؟

_____ يوم في الأسبوع

☐ لا أقوم بأي نشاط بدني معتدل الشدة. ← **انتقل مباشرة إلى السؤال رقم ٥**

٤- في المعتاد، كم من الوقت قضيته في ممارسة نشاط بدني معتدل الشدة في أحد تلك الأيام؟

_____ ساعة في اليوم

_____ دقيقة في اليوم

☐ لا أدري/ أو غير متأكد.

الآن فكر في الوقت الذي قضيته في المشي خلال الأيام السبع الماضية، ويتضمن ذلك المشي إلى العمل، والمشي أثناء العمل، وفي البيت، وخلال انتقالك من مكان لآخر، أو أي نوع من أنواع المشي بغرض الترويح أو الرياضة.

٥- خلال الأيام السبعة الماضية، كم يوماً مارست فيه **المشي** لمدة ١٠ دقائق على الأقل في كل مرة؟

_____ يوم في الأسبوع

☐ لا أقوم بممارسة المشي إطلاقا. ← **انتقل مباشرة إلى السؤال رقم ٧**

٦- في المعتاد، كم من الوقت قضيته في ممارسة المشي في أحد تلك الأيام؟

_____ ساعة في اليوم

_____ دقيقة في اليوم

☐ لا أدري/ أو غير متأكد.

الآن فكر في الوقت الذي قضيته جالساً خلال الأيام السبعة الماضية. أحسب وقت الجلوس في العمل، وفي المنزل، وفي الدراسة، وفي الترفيه. من الممكن أن يتضمن ذلك وقت الجلوس على المكتب، وأثناء العمل على الكمبيوتر، وأثناء زيارتك لصديق، وأثناء القراءة، والجلوس أو الاستلقاء لمشاهدة التلفزيون.

٧- خلال الأيام السبعة الماضية، كم من الوقت قضيته جالساً في أحد هذه الأيام من غير أيام الإجازة الأسبوعية؟

_____ ساعة في اليوم

_____ دقيقة في اليوم

☐ لا أدري/ أو غير متأكد.

**(نهاية الاستبانة، شكراً لمشاركتكم)**

**Summary of Diabetes Self-care Activities scale - Arabic (SDSCA-Arabic)**

**ملخص لمقياس أنشطة الرعاية الذاتية لمرضى السكري**

Arabic Summary of Diabetes Self-care Activities scale (SDSCA-Arabic)

| No. | Items | الأجابة | السؤال | التسلسل |
|---|---|---|---|---|
| | **Diet** | | **التغذية** | |
| 1 | During the last seven days, for how many days did you follow a healthy diet? | 0-1-2-3-4-5-6-7 | خلال السبعة أيام الماضية, كم عدد الأيام التي اتبعت فيها نظام غذاء صحي؟ | 1 |
| 2 | How well did you follow your diet during the last month (rate of days in the week) | 0-1-2-3-4-5-6-7 | ما مدى إتباعك لنظامك الغذائي خلال الشهر الماضي ( كم معدل عدد الأيام خلال الأسبوع) ؟ | 2 |
| | **Exercise** | | **الرياضة** | |
| 3 | During the last seven days, for how many days did you practice physical activities in general for at least 30 minutes?(Total minutes of activities including walking) | 0-1-2-3-4-5-6-7 | خلال السبعة أيام الماضية, كم عدد الأيام التي مارست فيها في أنشطة بدنيةبصفة عامة لمدة 30 دقيقة على الأقل ( مجموع الدقائق الكلية للأنشطة بما فيها المشي) | 3 |
| 4 | During the last seven days, for how many days did you practice a strict training exercise session (such as swimming, walking ...etc) exclude activities that are performed around your house or at your work? | 0-1-2-3-4-5-6-7 | خلال السبعة أيام الماضية, كم عدد الأيام التي مارست فيها في جلسة تمرين رياضي محدد (السباحة, المشي ...الخ) عدا تلك التي تقوم بها في محيط منزلك أو اللتي تكون جزءا من عملك؟ | 4 |
| | **Blood Sugar Testing** | | **فحص سكر الدم** | |
| 5 | During the last seven days, for how many days did you test your blood sugar level? | 0-1-2-3-4-5-6-7 | خلال السبعة أيام الماضية, كم عدد الأيام التي فحصت فيها سكر الدم؟ | 5 |
| 6 | During the last seven days, for how many days did you test your blood sugar level according to your physician's instructions? | 0-1-2-3-4-5-6-7 | خلال السبعة أيام الماضية, كم عدد الأيام التي فحصت فيها سكر الدم حسب العدد المذكور في تعليمات طبيبك؟ | 6 |
| | **Foot Care** | | **العناية بالقدم** | |
| 7 | During the last seven days, for how many days did you check your feet? | 0-1-2-3-4-5-6-7 | خلال السبعة أيام الماضية, كم عدد الأيام التي فحصت فيها قدميك؟ | 7 |
| 8 | During the last seven days, for how many days did you check the interior of your shoes (to insure that there are no materials that could cause any injury to your feet)? | 0-1-2-3-4-5-6-7 | خلال السبعة أيام الماضية, كم عدد الأيام التي فحصت فيها حذائك من الداخل (للتأكد من عدم وجود اشياء تسبب الجروح مثل قطع في الحذاء أو نتوءات)؟ | 8 |

**Depression Anxiety Stress Scale (DASS21)**

# DASS21

Name: Date:

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you **over the past week**. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree or a good part of time
3 Applied to me very much or most of the time

| | | | | | |
|---|---|---|---|---|---|
| 1 (s) | I found it hard to wind down | 0 | 1 | 2 | 3 |
| 2 (a) | I was aware of dryness of my mouth | 0 | 1 | 2 | 3 |
| 3 (d) | I couldn't seem to experience any positive feeling at all | 0 | 1 | 2 | 3 |
| 4 (a) | I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion) | 0 | 1 | 2 | 3 |
| 5 (d) | I found it difficult to work up the initiative to do things | 0 | 1 | 2 | 3 |
| 6 (s) | I tended to over-react to situations | 0 | 1 | 2 | 3 |
| 7 (a) | I experienced trembling (e.g. in the hands) | 0 | 1 | 2 | 3 |
| 8 (s) | I felt that I was using a lot of nervous energy | 0 | 1 | 2 | 3 |
| 9 (a) | I was worried about situations in which I might panic and make a fool of myself | 0 | 1 | 2 | 3 |
| 10 (d) | I felt that I had nothing to look forward to | 0 | 1 | 2 | 3 |
| 11 (s) | I found myself getting agitated | 0 | 1 | 2 | 3 |
| 12 (s) | I found it difficult to relax | 0 | 1 | 2 | 3 |
| 13 (d) | I felt down-hearted and blue | 0 | 1 | 2 | 3 |
| 14 (s) | I was intolerant of anything that kept me from getting on with what I was doing | 0 | 1 | 2 | 3 |
| 15 (a) | I felt I was close to panic | 0 | 1 | 2 | 3 |
| 16 (d) | I was unable to become enthusiastic about anything | 0 | 1 | 2 | 3 |
| 17 (d) | I felt I wasn't worth much as a person | 0 | 1 | 2 | 3 |
| 18 (s) | I felt that I was rather touchy | 0 | 1 | 2 | 3 |
| 19 (a) | I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat) | 0 | 1 | 2 | 3 |
| 20 (a) | I felt scared without any good reason | 0 | 1 | 2 | 3 |
| 21 (d) | I felt that life was meaningless | 0 | 1 | 2 | 3 |

## DASS-21 Scoring Instructions

The DASS-21 should not be used to replace a face to face clinical interview. If you are experiencing significant emotional difficulties you should contact your GP for a referral to a qualified professional.

**Depression, Anxiety and Stress Scale - 21 Items (DASS-21)**

The Depression, Anxiety and Stress Scale - 21 Items (DASS-21) is a set of three self-report scales designed to measure the emotional states of depression, anxiety and stress.

Each of the three DASS-21 scales contains 7 items, divided into subscales with similar content. The depression scale assesses dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest / involvement, anhedonia and inertia. The anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. The stress scale is sensitive to levels of chronic non-specific arousal. It assesses difficulty relaxing, nervous arousal, and being easily upset / agitated, irritable / over-reactive and impatient. Scores for depression, anxiety and stress are calculated by summing the scores for the relevant items.

The DASS-21 is based on a dimensional rather than a categorical conception of psychological disorder. The assumption on which the DASS-21 development was based (and which was confirmed by the research data) is that the differences between the depression, anxiety and the stress experienced by normal subjects and clinical populations are essentially differences of degree. The DASS-21 therefore has no direct implications for the allocation of patients to discrete diagnostic categories postulated in classificatory systems such as the DSM and ICD.

Recommended cut-off scores for conventional severity labels (normal, moderate, severe) are as follows:

NB Scores on the DASS-21 will need to be multiplied by 2 to calculate the final score.

| | Depression | Anxiety | Stress |
|---|---|---|---|
| Normal | 0-9 | 0-7 | 0-14 |
| Mild | 10-13 | 8-9 | 15-18 |
| Moderate | 14-20 | 10-14 | 19-25 |
| Severe | 21-27 | 15-19 | 26-33 |
| Extremely Severe | 28+ | 20+ | 34+ |

Lovibond, S.H. & Lovibond, P.F. (1995). Manual for the Depression Anxiety & Stress Scales. (2nd Ed.)Sydney: Psychology Foundation.

- **Arabic Version of The Depression Anxiety Stress Scale-21.**

## Arabic DASS21

اسم:_____ التاريخ:_____

اقرأ كل من النصوص التالية ثم ضع دائرة حول الرقم ٠،١،٢ أو ٣ الذي يبين درجة انطباق هذا الشعور عليك في الأسبوع الماضي. لا يوجد إجابات صحيحة أو خاطئة. لا تقضي وقتاً طويلاً في أي منها.

استعمل التقديرات التالية:

٠ لا ينطبق عليّ بتاتاً
١ ينطبق عليّ بعض الشيء أو قليلاً من الأوقات
٢ ينطبق عليّ بدرجة ملحوظة أو بعض الأوقات
٣ ينطبق عليّ كثيراً جداً، أو معظم الأوقات

| | | | | | |
|---|---|---|---|---|---|
| ١ | وجدت صعوبة في الاسترخاء والراحة | ٠ | ١ | ٢ | ٣ |
| ٢ | شعرت بجفاف في حلقي | ٠ | ١ | ٢ | ٣ |
| ٣ | لم يبدو لي أن بإمكاني الإحساس بمشاعر إيجابية على الإطلاق | ٠ | ١ | ٢ | ٣ |
| ٤ | شعرت بصعوبة في التنفس (شدة التنفس السريع، اللهثان بدون القيام بمجهود جسدي مثلاً) | ٠ | ١ | ٢ | ٣ |
| ٥ | وجدت صعوبة في أخذ المبادرة بعمل الأشياء | ٠ | ١ | ٢ | ٣ |
| ٦ | كنت أميل إلى ردة فعل مفرطة للظروف والأحداث | ٠ | ١ | ٢ | ٣ |
| ٧ | شعرت برجفة (باليدين مثلاً) | ٠ | ١ | ٢ | ٣ |
| ٨ | شعرت بأنني أستهلك الكثير في الطاقة العصبية (شعرت بأنني أستهلك الكثير من قدرتي على تحمل التوتر العصبي) | ٠ | ١ | ٢ | ٣ |
| ٩ | كنت خائفاً من مواقف قد أفقد فيها السيطرة على أعصابي واسبب إحراجاً لنفسي | ٠ | ١ | ٢ | ٣ |
| ١٠ | شعرت بأن ليس لدي أي شيء أتطلع إليه | ٠ | ١ | ٢ | ٣ |
| ١١ | شعرت بأنني مضطرب ومنزعج | ٠ | ١ | ٢ | ٣ |
| ١٢ | أجد صعوبة في الاسترخاء | ٠ | ١ | ٢ | ٣ |
| ١٣ | شعرت بالحزن والغم | ٠ | ١ | ٢ | ٣ |
| ١٤ | كنت لا أستطع تحمل أي شيء يحول بيني وبين ما أرغب في القيام به | ٠ | ١ | ٢ | ٣ |
| ١٥ | شعرت بأنني على وشك الوقوع في حالة من الرعب المفاجئ بدون سبب | ٠ | ١ | ٢ | ٣ |
| ١٦ | فقدت الشعور بالحماس لأي شيء | ٠ | ١ | ٢ | ٣ |
| ١٧ | شعرت بأن قيمتي قليلة كشخص | ٠ | ١ | ٢ | ٣ |
| ١٨ | شعرت بأنني أميل إلى الغيظ بسرعة | ٠ | ١ | ٢ | ٣ |
| ١٩ | شعرت بضربات قلبي بدون مجهود جسدي (زيادة في معدل الدقات، أو غياب دقة قلب، مثلاً) | ٠ | ١ | ٢ | ٣ |
| ٢٠ | شعرت بالخوف بدون أي سبب وجيه | ٠ | ١ | ٢ | ٣ |
| ٢١ | شعرت بأن الحياة ليس لها معنى | ٠ | ١ | ٢ | ٣ |

**Appendix 2.2 Human Research Ethics Committees documents**

**Research Data Management Plan (RDMP).**




# The effects of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of patients with type 2 diabetes mellitus: Implications for Nursing Education.

**Description**

The aims of this study are:

- To examine the impact of the first lockdown implemented to manage the spread of SARS-CoV2 and COVID-19 in Jordan on the glycaemic control of patients with T2DM.
- To determine what factors affected patients' ability to self-manage their disease and maintain their blood glucose within normal limits, in a time of pandemic.
- To create a consensus of expert opinions regarding the impact of the findings of this study for nursing education and practice.

This information will shed light on the impact of pandemic management policies on glycemic control and associated factors and support the development of recommendations for future pandemic management to optimise glycemic control for patients with T2DM

Expand/Collapse all

- Project

# Project overview

**Project name**

The effects of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of patients with type 2 diabetes mellitus: Implications for Nursing Education.

**Research Master Project Code / Student ID**

**HDR student project**

**Project description**

The aims of this study are:

- To examine the impact of the first lockdown implemented to manage the spread of SARS-CoV2 and COVID-19 in Jordan on the glycaemic control of patients with T2DM.
- To determine what factors affected patients' ability to self-manage their disease and maintain their blood glucose within normal limits, in a time of pandemic.
- To create a consensus of expert opinions regarding the impact of the findings of this study for nursing education and practice.

This information will shed light on the impact of pandemic management policies on glycemic control and associated factors and support the development of recommendations for future pandemic management to optimise glycemic control for patients with T2DM

**Keywords**

**Start date**

14/02/2020

**End date**

14/02/2024

**Funders**

Funding for this project has been received in the form of a doctoral scholarship from Mutah University, Jordan.

**Grant ID**

- People

# People

### First-named chief investigator / UTS supervisor

| Name | Email | Project Role | ORCID |
|---|---|---|---|
| Linda Perry | Lin.Perry@uts.edu.au | Chief Investigator | |

### Data manager

| Name | Email | ORCID |
|---|---|---|
| Odai Al-Ma'Aitah | Odai.Al-MaAitah@student.uts.edu.au | |

### Contributors

| Name | Email | ORCID |
|---|---|---|
| Samantha Jakimowicz | Samantha.Jakimowicz@uts.edu.au | |

### Additional supervisors

| Name | Email | ORCID |
|---|---|---|
| Daniel Demant | daniel.demant@uts.edu.au | |

- Ethics and security

## Ethics and Security

**Initially your research data is classifed as UTS Internal. To improve the accuracy of this classification, please answer the following**

**Information Security Classification**
UTS: Confidential

**Does the research involve:**
Human participant data

**Will the data you collect from individuals include personal information?**
Yes

**Will the data you collect from individuals include sensitive personal information other than health information?**
Yes

**Will the data you collect from individuals include health information?**
Yes

**Will any data or information be individually identifiable or potentially re-identifiable (i.e. include codes) at any stage of the research?**
Yes

**Outline any potential risk to participants from accidental disclosure of the data and any strategies for minimising those risks**
Data for this project will be managed in accordance with UTS data management policy. A data management plan will be created in Stash, and data will be stored in OneDrive, with long term data to be stored on eResearch Store. Data kept on external hard drives will be encrypted, and all laptops and external hard drives will be password protected and kept in a locked cabinet in my office. Supervisors will also have copies of keys and passwords to access data in the event of my misadventure.

**If you are collecting data from residents of countries other than Australia, which countries?**
Jordan

**Is Ethics approval required for your project?**
Yes

# Data collection and storage

**Please provide a brief description of your data collection methodology**
This study will be performed as a mixed methods study, which is defined by Johnson and his colleagues as "a type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e. g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration."
The study will be conducted in three phases:

Phase I: This will entail a retrospective investigation of the impact of the first COVID¬19 full lockdown in Jordan from 21/03/2020 to 06/06/2020, on the glycaemic control of patients with T2DM. This period was chosen as the out¬patient clinics were not running as normal during the lockdown, solely running to see patients with major problems or emergencies. This phase will involve reviewing the electronic medical records in the hospital databases of individuals who visited the diabetes clinic of the public health facilities before, during and after this period (bearing in mind that HbA1c measurements reflect the glycaemic control of the previous approximately 12 weeks). The hospital sites of this study are Al Karak Public Hospital, New Zarqa Governmental Hospital, and Ma'an Government Hospital.

Phase II: Cross-sectional interviews including structured questionnaires and open questions with eligible patients (as Phase 1) to investigate the link between glycaemic control and potential explanatory factors related to the COVID¬19 pandemic and its management, including lockdown, such as physical activity, self-management, anxiety, and depression. This stage will be held in the Diabetes clinic within the patients' hospital. An internet based survey consisting of five sections will be sent to the participant for self¬-report or completion during a face-to-face interview. For the face-to-face interview, the researcher will audio recording this and take field notes. Individual interviews have been selected to ensure privacy and confidentiality and ensure each participant's view is heard. Consenting patients will
be offered their choice of up to three ways to complete the survey:
1) Complete the survey as a self-report questionnaire accessed via a link embedded in the invitation letter.
2) Complete the survey in a face-to-face interview with participants when they next attend their out¬patient clinic appointments.

Interviews will be conducted in such a way as to be COVID ¬secure and compliant with the COVID regulations in place at the time. Details of the interview methods may require adjustment to remain compliant with requirements at the time of interview. Furthermore, two open-ended questions will be added to the questionnaire to be answered during the face-to-face interview. However, both questions will be optional. The two qualitative questions are:
- What was it like for you managing your diabetes during the lockdown?
- How did you feel during the lockdown period? How was your glycaemic control compared to your normal or usual control before the lockdown?

Phase III: This phase will entail an electronic Delphi consultation to develop a consensus statement based on the experts' opinions on the implications and recommendations from study findings in relation to nursing education and practice to optimise self-management and glycaemic control of patients with diabetes. We anticipate that the consultation process will be conducted in three rounds via email. The findings of phases I and II of the study will be presented by the researcher to the panel through email, and the panel will be

asked for their recommendations on how to improve nurse education and practice to optimise self-management and glycaemic control of patients with diabetes. Consensus recommendations will be sought through an iterative process, reviewing and revising participants' contributions.

**Predominant file type(s), e.g. textual, tabular, image or recording. Give file format if known**

Phase I: This phase will involve reviewing the electronic medical records in the hospital databases.
Phase II: This phase including structured questionnaires and open questions with eligible patients (as in Phase 1).
Phase III: This phase will entail an electronic Delphi consultation.

**Data storage location**

UTS provided collaboration space (e.g. CloudStor, OneDrive etc)

**If other, provide further details: (Including access arrangements for the minimum retention period)**

**Describe the form(s) of the identifiable or re-identifiable data**

Participants Demographic Data

**What platforms or tools will you use to collect or import identifiable or re-identifiable data?**

OneDrive
Qualtrics

**Where will the identifiable or re-identifiable data be stored?**

OneDrive

**Will you be seeking prior informed consent to publish identifiable participant data?**

No

**Will identifiable or re-identifiable data be transferred in or out of secure UTS storage (e.g. in from linkage agency, out for transcription)?**

No

**Will you de-identify the data?**

Yes

**Outline how and when (e.g. after transcription, before analysis) you will de-identify the data:**

**Where will any link files (files that match pseudonyms/codes to identifiable information) be stored?**

Data for this project will be managed in accordance with UTS data management policy. A data management plan will be created in Stash, and data will be stored in OneDrive, with long term data to be stored on eResearch Store. Data kept on external hard drives will be encrypted, and all laptops and external hard drives will be password protected and kept in a locked cabinet in my office. Supervisors will also have copies of keys and passwords to access data in the event of my misadventure.

– Data retention and disposal

## Data retention and disposal

**Minimum retention period**
5 years (general research)

**The data steward is:**
Linda Perry

**Have you made commitments to destroy part of the data prior to end of retention period (e.g original recordings, linking/code files)?**
No

**When should it be destroyed?**

– Access and rights

## Access and rights

**Copyright and intellectual property owners of data created in project**

**Please list any other owners:**

**Access after the project will be**
Not available due to sensitivities

**Briefly state why the data cannot be available:**
As Personal Health Information

**Are you using any secondary or third-party data?**
Yes

**Is the data:**
Privately held data source

**Have the data custodian/s, if any, agreed to provide access to the data for use in the proposed research?**
Yes

**What ownership agreement governs your use of the data?**
Research project agreement/ contract

**If your access and use is governed by a licence or other agreement, outline any special requirements that we need to be aware of regarding: 1. Security:**

**2. Disposal:**

**3. Attribution:**

**4. Access arrangements:**

**5. Other**
**Licences or Agreements:**

- Research Workspace

# Research Workspace

## Associated workspaces

| Name | Description | Location | Type |
|---|---|---|---|

**UTS Consent Matters Subject.**



**Jordanian Ethics approval document**

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**Ref.:** Moh/REC/2021/148
**Date:**
**Corresponding to:**

**Decision of the Scientific Research Ethics Committee**

The Scientific Research Ethics Committee met on 16/08/2021 to discuss and study the scientific research submitted by doctoral student Odai Hamed Al-Ma'aitah.

Titled:

"The effect of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of Jordanian patients with type 2 diabetes mellitus".

Accordingly, the committee decided to approve conducting the research related to the above-mentioned, while adhering to the ethics of scientific research and the rights and consent of patients, and it was duly signed by the members of the committee.

| | | | |
|---|---|---|---|
| **Committee Rapporteur**<br>Human Resource Development Unit<br>Mr. Akram Alanani<br>Signed | **Member**<br>Nursing Manager<br>Dr. Hani Alqudah<br>Signed | **Member**<br>Pharmacist<br>Hanan Sartawi<br>Signed | **Member**<br>General Surgery Specialist<br>Dr. Farouq Hamdan<br>Signed |
| **Member**<br>Head of the Internal Department<br>Dr. Yousef Alqdeimat<br>Signed | **Member**<br>Laboratory Director<br>Dr. Muath Badawi<br>Signed | **Member**<br>Pediatrician<br>Dr. Issam Alkhawaja<br>Signed | **Member**<br>Director of Administrative and Financial Affairs<br>Ghaleb Alqawasmeh<br>Signed |

**Chairman of the Committee**
Director of Al-Bashir Hospitals Administration
Doctor Abdelmanea Ahmad Alsulaimat
Signed

Certifed True Translation
Translated By: Alaa AlShishani
Signature: 12-09-2022

Address : Al-Sweifieh ,Paris Street , Hijazi Albayer Complex No. 67 , 3rd Floor
Mob. No. [redacted] . Email: [redacted]
العنوان: شارع باريس، مجمع حجازي البابر رقم ٦٧، الطابق الثالث، الصويفية، عمان، الاردن

## The Hashemite Kingdom of Jordan

### Ministry of Health

Tel.: +96265200230 – Fax: +962656882730 P.O.Box 86 Amman 11118 Jordan Website: www.moh.gov.jo

**Ref.:** 23/08/2021
**Date:** MBA/Ethics Committee/ 11944
**Corresponding to:**

**Director of Education and Human Resource Development**

By referring to your letter No. Development / Studies/ 7821 dated on 09/08/2021 regarding the scientific research submitted by a doctoral student **Odai Hamed Al-Ma'aitah**.

Attached is the decision of the Scientific Research Ethics Committee, which includes approval to conduct the research related to the above-mentioned, provided that we are provided with the results of the study related to the aforementioned research.

For your review and procedures,

**Best Regards,**

**Director of Al-Bashir Hospitals Administration**
**Doctor Abdelmanea Ahmad Alsulaimat**
Signed

Information 1608166

Certifed True Translation
Translated By: Aaa Al Shishani
Signature: 12.09.2022

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الشيشاني للترجمة المعتمدة وخدمات التأشيرة

## The Hashemite Kingdom of Jordan

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Tel.: +96265200230 – Fax: +962656882730 P.O.Box 86 Amman 11118 Jordan Website: www.moh.gov.jo

**Ref.:** Development / Studies/ 9021
**Date:**
**Corresponding to:** 25/08/2021

**Hospital Director……..**

**Greetings,**

Attached herewith a copy of the Director of the Administration of Al-Bashir Hospitals letter / Chairman of the Ethics Committee of Scientific Research No. MBA / Ethics Committee / 11944 dated 23/08/2021 regarding the approval of a doctoral student from (University of Technology Sydney) UTS, **Odai Hamed Al-Ma'aitah** to conduct a research titled:

"The effect of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of Jordanian patients with type 2 diabetes mellitus".

This was done by distributing the attached questionnaire, a copy of it, to patients with type 2 diabetes mellitus who attended diabetes clinics in government hospitals affiliated with the Ministry of Health.

Kindly instruct those necessary to facilitate the task of conducting the above study, provided that the Scientific Research Ethics Committee is provided with the results of the study related to the above research.

**Best Regards,**

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**Director of Education and Human Resource Development**
Doctor Reham Alhmoud
Signed

Certifed True Translation
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وزارة الصحة

الرقم .....
التاريخ ..... Moh/REC/2021/148
الموافق .....

قرار لجنة أخلاقيات البحث العلمي

اجتمعت لجنة أخلاقيات البحث العلمي بتاريخ ٢٠٢١/٨/١٦ لمناقشة ودراسة البحث العلمي المقدم من قبل طالب الدكتوراه عدي حامد المعايطة .

بعنوان:-

**" تأثير الحجر المتبع للحماية من مرض فيروس كورونا المستجد في السيطرة على سكر الدم للمرضى الأردنيين المصابين بداء السكري من النوع ٢"**

وبناءً عليه قررت اللجنة الموافقة على اجراء البحث العائد للمذكور اعلاه ،مع الالتزام بأخلاقيات البحث العلمي و حقوق المرضى وموافقتهم ، وتم التوقيع من قبل أعضاء اللجنة حسب الأصول.

مقرر اللجنة
وحدة تنمية الموارد البشرية
السيد/ اكرم العنائي

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عضو
مدير التمريض
د. هاني القضاة

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عضو
الصيدلاني
حنان سرطاوي

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عضو
أخصائي جراحه عامه
د. فاروق حمدان

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عضو
رئيس قسم الباطني
د. يوسف القديمات

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عضو
مدير مديرية المختبرات
د. معاذ بدوي

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عضو
أخصائي الأطفال
د.عصام الخواجا

عضو
مدير الشؤون الإدارية والمالية
غالب القواسمي

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رئيس اللجنة
مدير ادارة مستشفيات البشير

الدكتور عبد الباسط احمد السليمات

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بسم الله الرحمن الرحيم

وزارة الصحة

الرقم ٢٠٢١/٨/٢٣

التاريخ م ب أ/ لجنة أخلاقيات / ١١٩٤٤

الموافق

مدير مديرية التعليم وتطوير الموارد البشرية

تحية طيبة وبعد،

اشارة لكتابكم رقم تطوير/معلومات/٧٨٢١ تاريخ ٢٠٢١/٨/٩ بخصوص البحث العلمي المقدم من قبل طالب الدكتوراه عدي حامد المعايطه .

أرفق بطيه قرار لجنة اخلاقيات البحث العلمي والمتضمن الموافقة على اجراء البحث العائد المذكور اعلاه على ان يتم موافاتنا بنتائج الدراسة العائدة للبحث الانف الذكر.

للاطلاع واجراءاتكم لطفا.

واقبلو فائق الاحترام ،،،،،

مدير ادارة مستشفيات البشير

الدكتور عبدالمانع احمد السليمات

١٦٠٨١٦٦

معلومات

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ا ع

المملكة الأردنية الهاشمية
هاتف: ٩٦٢٦٥٢٠٠٢٣٠+ فاكس: ٩٦٢٦٥٦٨٨٢٧٣٠+ ص.ب ٨٦ عمان ١١١١٨ الأردن . الموقع الإلكتروني: www.moh.gov.jo

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وزارة الصحة

الرقم تطوير/معلومات/٩٠٢١

التاريخ

الموافق ٢٠٢١/٨/٢٥

مدير مستشفى .....

تحية طيبة وبعد ،،،

أرفق طياً صورة عن كتاب مدير إدارة مستشفيات البشير / رئيس لجنة أخلاقيات البحث العلمي رقم م ب أ/ لجنة أخلاقيات /١١٩٤٤ تاريخ ٢٠٢١/٨/٢٣ بخصوص الموافقة لطالب الدكتوراه من جامعة UTS ( UNIVERSITY OF TECHNOLOGY SYDNEY ) **عدي حامد المعايطه** اجراء بحث بعنوان :-

***(The Effects of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of Jordanian patients with type 2 diabetes mellitus )***

**(تأثير الحجر الصحي المتبع للحماية من مرض فيروس كورونا المستجد في السيطرة على سكر الدم للمرضى الأردنيين المصابين بداء السكري من النوع ٢)**

وذلك عن طريق توزيع الاستبيان المرفق صورة عنه على المرضى المصابين بداء السكري / النوع ٢ من المراجعين لعيادات السكري في المستشفيات الحكومية التابعة لوزارة الصحة .

أرجو التكرم بالإيعاز لمن يلزم تسهيل مهمة إجراء الدراسة أعلاه ، على ان يتم موافاة لجنة اخلاقيات البحث العلمي بنتائج الدراسة العائدة للبحث اعلاه .

وتفضلوا بقبول فائق الاحترام ،،،

مدير مديرية التعليم وتطوير الموارد البشرية

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الدكتورة رهام الحمود

المملكة الأردنية الهاشمية
هاتف: ٠٦٥٢٠٠٢٣٠ +٩٦٢ فاكس: ٠٦٥٦٨٨٣٧٣ +٩٦٢ ص.ب: ٨٦ عمان ١١١١٨ الأردن. الموقع الإلكتروني: www.moh.gov.jo

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**UTS Ethics Approval for Phase I and Phase (ETH21-6333).**

- **UTS Ethics Approval for Phase I and Phase II (ETH22-6925).**

- **UTS Ethics Approval for Phase I III (ETH22-7224).**

**Appendix 3.1. Published paper "Glycaemic control and its associated factors in people with type 2 diabetes in the Middle East and North Africa: An updated systematic review and meta-analysis".**

Received: 6 May 2021 | Revised: 5 February 2022 | Accepted: 23 March 2022
DOI: 10.1111/jan.15255

REVIEW

JAN Leading Global Nursing Research WILEY

# Glycaemic control and its associated factors in patients with type 2 diabetes in the Middle East and North Africa: An updated systematic review and meta-analysis

Odai Hamed Al-ma'aitah[1] | Daniel Demant[2,3] | Samantha Jakimowicz[1] | Lin Perry[1,4]

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**Correspondence**
Odai Hamed Al-ma'aitah, School of Nursing and Midwifery, Faculty of Health, University of Technology Sydney, Ultimo, NSW, Australia.
Email: odai.al-maaitah@student.uts.edu.au

**Funding information**
Odai Hamed Al-ma'aitah declared that he received a Doctorate scholarship from Mutah University, Jordan; however, this study was conducted independently with the authors' own fund.

**Abstract**

**Aims:** To examine the patient-related factors that have been linked to glycaemic control in people living with type 2 diabetes mellitus in Middle Eastern countries.

**Design:** A systematic review and meta-analysis.

**Data Sources:** A computerized search was conducted using the databases MEDLINE (via PubMed and Ovid), EMBASE, Scopus and CINAHL to identify peer-reviewed articles published in English between 1 January 2010 and 21 May 2020. On 28 June 2021, the search was updated with the same keywords and databases; however, no further relevant studies were identified.

**Review Methods:** Extracted data were analysed using Review Manager 5.4.

**Results:** The final sample consisted of 54 articles with a total of 41,079 participants. Pooled data showed an increased risk of inadequate glycaemic control in smokers [OR = 1.26, 95% confidence interval (CI): 1.05, 1.52; $p = .010$], obese patients (OR = 1.30, 95% CI: 1.10, 1.54; $p = .002$), patients with elevated waist to hip ratio (OR = 1.62, 95% CI: 1.16, 2.26; $p = .004$) and longer disease duration (OR = 2.01, 95% CI: 1.64, 2.48; $p < .001$). A lower risk of inadequate control was associated with physical activity (OR = 0.40, 95% CI: 0.24, 0.67; $p < .001$) and self-management (OR = 0.49, 95% CI: 0.29, 0.82; $p = .006$).

**Conclusion:** These findings highlight the opportunity to address factors to improve glycaemic control. Further longitudinal studies are required to better understand these variations, to assess all predictors of glycaemic control in participants with type 2 diabetes, and to provide a strong basis for future measures to optimize glycaemic control.

KEYWORDS
glycaemic control, Middle East, systematic review, meta-analysis, type 2 diabetes mellitus

## 1 | INTRODUCTION

Diabetes is a major public health issue with an increasing burden globally (Johar et al., 2019). The latest data show that in 2019, 463 million adults were living with diabetes. It has been estimated that, without action to reduce the rising prevalence, by 2030, 578 million people will live with diabetes (Williams et al., 2019). One of the most affected areas is the Middle Eastern and North African (MENA) region, where approximately 54.8 million adults aged 20–79 were living with diabetes in 2019 (Williams et al., 2019). It was estimated that the number

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of patients with diabetes in the MENA region will reach 76 million by 2030 (Williams et al., 2019). Effective management of diabetes is, therefore, a priority for the countries of this region.

If not properly controlled, diabetes and its complications can result in frequent hospital admissions and premature death. Glycaemic control is a fundamental determinant of the prognosis of diabetes (Mamo et al., 2019). As a result, it is targeted by physicians to prevent diabetes-related complications and mortality (Khattab et al., 2010). A wide variety of factors are associated with glycaemic control among participants with type 2 diabetes mellitus (T2DM); these include demographic factors such as age, gender, marital status and education (Abdullah et al., 2020; Aghili et al., 2016). Lifestyle parameters have also been linked with T2DM, such as smoking, obesity and physical inactivity (Al Slamah et al., 2020). In addition, correlations have also been noted between psychological status (e.g. depression and anxiety) and glycaemic status (Ahmadian et al., 2018; Al Hayek et al., 2014). Many of these factors have the potential to be influenced by the local context and cultural considerations. However, little information is available to inform priorities for the MENA region and clinical guidelines to direct healthcare professionals on how this information may be used to improve health and prevent or delay the onset of the complications of diabetes.

**Impact**

**What problem did the study address?**

Rising rates of diabetes, particularly in Middle Eastern regions, make it imperative to identify factors linked to glycaemic control among patients with Type 2 Diabetes in these areas.

**What were the main findings?**

Smoking, obesity, disease duration, physical activity and self-management were the main factors linked to glycaemic control

**Where and on whom will the research have impact?**

Results will be relevant for policymakers, physicians, medical staff and patients with diabetes in the MENA region, informing them of key factors that should be considered concerning the management of diabetes.

## 2 | THE REVIEW

### 2.1 | Aims

Given the high and rising prevalence of T2DM in the MENA region, and to minimize cultural and geographic heterogeneity, this systematic review and meta-analysis was conducted to examine the patient-related factors that have been linked to glycaemic control in people living with T2DM in the MENA region, to make recommendations for locally appropriate diabetes care.

### 2.2 | Design

This systematic review and meta-analysis followed the Preferred Reporting Items of Systematic Reviews and Meta-analysis (Moher et al., 2016). Review methods and analyses were conducted in accordance with international recommendations (Agency for Healthcare Research and Quality, 2014; Higgins et al., 2019). The protocol of this study has been registered in PROSPERO (https://www.crd.york.ac.uk/prospero/; ID:CRD42021227250).

### 2.3 | Search methods

A search strategy was developed based on the format of PEO: P (population), E (exposure, in this review interpreted as characteristics) and O (outcome). The search strategy was structured as follows:

P: Participants with T2DM living in Middle Eastern countries [Jordan, the United Arab of Emirates, Bahrain, Iraq, Saudi Arabia, Kuwait, Yemen, Iran, Syria, Israel, Oman, Palestine, Qatar, Lebanon, Egypt and Turkey (TeachMideast, 2020)].

E: Exposure (or characteristics) included demographic details (age, gender, race or ethnicity, education, marital and employment status); clinical characteristics (insulin use, duration of diabetes, body mass index and waist-hip ratio); behavioural variables (smoking, diet, and physical activity); and mental and physical wellbeing characteristics such as anxiety and depression. Characteristics were chosen where they were examined in included studies, where there was a recognized rationale for a potential link to glycaemic control.

O: Outcomes sought were glycaemic control.

A computerized search was conducted using databases MEDLINE (via PubMed and Ovid), EMBASE, Scopus and CINAHL identify peer-reviewed articles published in English between 1 January 2010 and 21 May 2020. On 28 June 2021, the search was updated with the same search strategy and databases; however, no further relevant studies were identified. Addtionally, all reference lists of included and any review articles were checked for potentially relevant studies. MESH terms were applied, and synonyms identified and used as keywords, linked with Boolian operands, as follows:

LINE 1: ("Non-insulin-dependent diabetes", "Diabetes Mellitus, Type 2", "Type II diabetes", "Type 2 diabetes", "NIDDM").

AND

LINE 2: ("Middle East" OR "Jordan" OR "UAE" OR "Bahrain" OR "Iraq" OR "Saudi Arabia" OR "Kuwait" OR "Yemen" OR "Iran" OR "Syria" OR "Israel" OR "Oman" OR "Palestine" OR "Qatar" OR "Lebanon" OR "Egypt" OR "Turkey").

AND

LINE 3: ("Glycaemic control", "Glycemic Control", "Blood Glucose", "Haemoglobin A1c", "HBA1c").

NOT

LINE 4: (child* or kid* or adolescen*).

### 2.4 | Eligibility criteria

To be included in the review, studies had to meet the criteria set out in the PEO framework. Studies were also required to be observational in design (case–control, cohort or cross-sectional studies). Studies that were not available in English; animal studies; case-reports or not full reports of primary research (e.g. conference abstracts and review articles) were excluded.

### 2.5 | Search outcomes

Citations were downloaded into EndNote x9, and duplicate studies were removed using the "remove duplication" function. Two independent reviewers (O. H. A. and S. J.) screened the retrieved articles in two steps. First, only the titles and abstracts were independently screened to remove papers not meeting eligibility criteria. Then, the full-texts of the remaining papers were retrieved for full-text screening of their eligibility for inclusion. Full-text screening focused predominantly on the methods and results sections to confirm the eligibility of the study and provision of relevant data. Any discrepancies between reviewers' decisions were addressed in discussion of the eligibility criteria with the third reviewer (L. P.).

### 2.6 | Data abstraction

A standardized extraction form was prepared using MS excel (Microsoft), including the domains shown in Table 1. Data extraction was done independently by two investigators (O. H. A. and S. J.), with any discrepancies resolved in discussion with a third reviewer (L. P.). Missing odds ratios were calculated with review manager 5.3 using the required data (event and total of experiment and control groups). Missing standard deviations (SD) were calculated from the standard error (SE) with the following formula:

$$SD = SE \times \sqrt{N},$$

and from the confidence interval (CI) using this formula:

$$SD = \sqrt{N} \times (\text{upper limit} - \text{lower limit}) / 3.92.$$

The Newcastle-Ottawa Scale (NOS) for observational studies (Case–control, Cohort, and Cross-sectional studies) was used (Wells et al., 2014) to critically appraise all included studies (see Supplementary File 1).

### 2.7 | Synthesis

Data were analysed in three forms based on our objectives:

1. We performed a generic inverse variance analysis using the logarithmic odds ratio (LogOR) and SE to identify the association between glycaemic control and characteristics reported as associated with glycaemic control in bivariate analyses, such as age, gender, marital status, education, mental status, physical activity, smoking, obesity and self-monitoring.
2. We used the Inverse Variance (I-V) model to calculate the mean difference (MD) between adequate (HbA1c <7) and inadequate (HbA1c equal to or more than 7) levels of glycaemic control according to participants' characteristics such as age, Body mass index (BMI) and duration of diagnosis (ADA, 2021).
3. Moreover, we used the I-V model to calculate the MD of HBA1c according to the studied groups [male vs. female, current smokers vs. non-smokers, older (≥50 years) vs. younger aged (<50 years), obese (BMI ≥30 kg/m$^2$) vs. non-obese (BMI <30 kg/m$^2$)] (World Health Organization, 2020).

Data analysis was performed using Review Manager Version 5.3 for windows.

### 2.8 | Sensitivity analysis and publication bias

According to Egger and Smith (1998), publication bias assessment is relicable where ≥10 studies are pooled. Therefore, we assessed the publication bias using funnel plots and the Egger test. We performed a sensitivity analysis to ensure that none of the included studies affected the results and whether the overall effect size was statistically robust. We excluded one study in each scenario to determine the effect of each study on the overall effect size (Agency for Healthcare Research and Quality, 2014).

## 3 | RESULTS

### 3.1 | Study selection

The literature search of databases yielded 3345 records. Following the title/abstract and full-text screening, 54 articles with a total of 41,079 participants were retained for inclusion in the systematic review. Of these, 32 articles reported adequate and relevant data for inclusion in the meta-analysis. The flow of the study selection process is shown in Figure 1.

### 3.2 | Study characteristics

Of the included studies, 17 articles were conducted in Saudi Arabia, seven each in Turkey and Iran, six in Jordan, three each in

TABLE 1 Summary of included studies and patients

| Cross-sectional studies | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Selection | | | | Comparability | Outcome | | |
| Study ID | Ascertainment of the exposure (risk factor) | Non-respondents | Sample size | Representativeness of the sample | The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled | Assessment of the outcome | Statistical test | Quality score |
| Abdullah et al. (2020) | ** | * | * | * | ** | ** | * | 10 |
| Abuhegazy (2017) | ** | | | * | ** | ** | * | 8 |
| Adham et al. (2010) | ** | * | * | * | ** | ** | * | 10 |
| Aghili et al. (2016) | ** | * | | * | ** | ** | * | 9 |
| Ahmadian et al. (2018) | ** | | | | ** | ** | * | 6 |
| Al-Hayek et al. (2012) | ** | | | * | ** | ** | * | 8 |
| Al Saweer (2015) | ** | | | * | ** | ** | * | 8 |
| Al Slamah et al. (2020) | ** | * | * | * | ** | * | * | 10 |
| ALaboudi et al. (2016) | ** | * | | * | * | ** | * | 8 |
| Al Balushi et al. (2014) | ** | * | | * | ** | ** | * | 9 |
| Albasheer et al. (2018) | ** | * | * | * | * | ** | * | 9 |
| Al Dossari et al. (2019) | ** | * | * | * | * | ** | * | 9 |
| AL-Eitan et al. (2016) | ** | | | * | * | ** | * | 8 |
| Al Hayek et al. (2014) | ** | | | * | ** | ** | * | 8 |
| Ali & Shahwan (2013) | ** | | | | ** | ** | * | 7 |
| Al-Lawati et al. (2012) | ** | | * | * | * | ** | * | 8 |
| Almetwazi et al. (2019) | ** | | | * | * | ** | * | 7 |
| Al-Mukhtar et al. (2012) | ** | | | * | * | ** | * | 7 |
| Awwad Al qahtani et al. (2015) | ** | | | * | * | ** | * | 7 |
| Alqudah et al. (2019) | ** | | * | * | * | ** | * | 8 |
| Alramadan et al. (2018) | ** | | * | * | * | ** | * | 8 |
| Al-Rasheedi (2014) | ** | | * | * | ** | ** | * | 9 |
| Alromaihi et al. (2019) | ** | | | * | * | ** | * | 7 |
| Al-Shahrani et al. (2012) | ** | | | * | * | * | * | 6 |
| Azadi et al. (2020) | ** | * | * | * | * | ** | * | 9 |
| Baltaci et al. (2012) | ** | | | * | ** | ** | * | 8 |
| Baltaci et al. (2015) | ** | | | * | ** | ** | * | 8 |

TABLE 1 (Continued)

| Cross-sectional studies | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Selection | | | | Comparability | Outcome | | |
| Study ID | Ascertainment of the exposure (risk factor) | Non-respondents | Sample size | Representativeness of the sample | The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled | Assessment of the outcome | Statistical test | Quality score |
| Channanath (2018) | ** | | | * | * | ** | * | 7 |
| Cosansu & Erdogan (2014) | ** | | | * | ** | ** | * | 8 |
| Greenberger et al. (2014) | ** | | | | * | ** | * | 6 |
| Gucuk (2016) | ** | | | * | ** | ** | * | 8 |
| Habib (2013a,b) | ** | | | * | * | ** | * | 7 |
| Jahanlou & Karami (2011) | ** | | | * | * | ** | * | 7 |
| Khattab et al. (2010) | ** | | | * | * | ** | * | 7 |
| Maddah & Attarpour (2016) | ** | | | * | * | ** | * | 7 |
| Ibrahim et al. (2020) | ** | | | * | * | ** | * | 7 |
| Mirahmadizadeh et al. (2020) | ** | * | * | * | ** | ** | * | 10 |
| Mosleh et al. (2017) | ** | | * | * | ** | ** | * | 9 |
| Nemeh et al. (2011) | ** | | * | * | ** | ** | * | 9 |
| Noureddine et al. (2014) | ** | | | * | ** | ** | * | 8 |
| Al Nozha (2014) | ** | | * | * | ** | ** | * | 9 |
| Qteishat & Ghananim (2016) | ** | | | * | ** | ** | * | 8 |
| Radwan et al. (2018) | ** | | * | * | ** | ** | * | 9 |
| Saad et al. (2017) | ** | | | * | ** | ** | * | 8 |
| Saghir et al. (2019) | ** | | * | * | ** | ** | * | 9 |
| Samancioglu et al. (2017) | ** | | * | * | ** | ** | * | 9 |
| Samara et al. (2017) | ** | | * | * | ** | ** | * | 9 |
| Arda Sürücü et al. (2018) | ** | | * | * | * | ** | * | 8 |
| Tol et al. (2012) | ** | | | * | * | ** | * | 7 |
| Yacoub et al. (2011) | ** | | | * | * | ** | * | 7 |

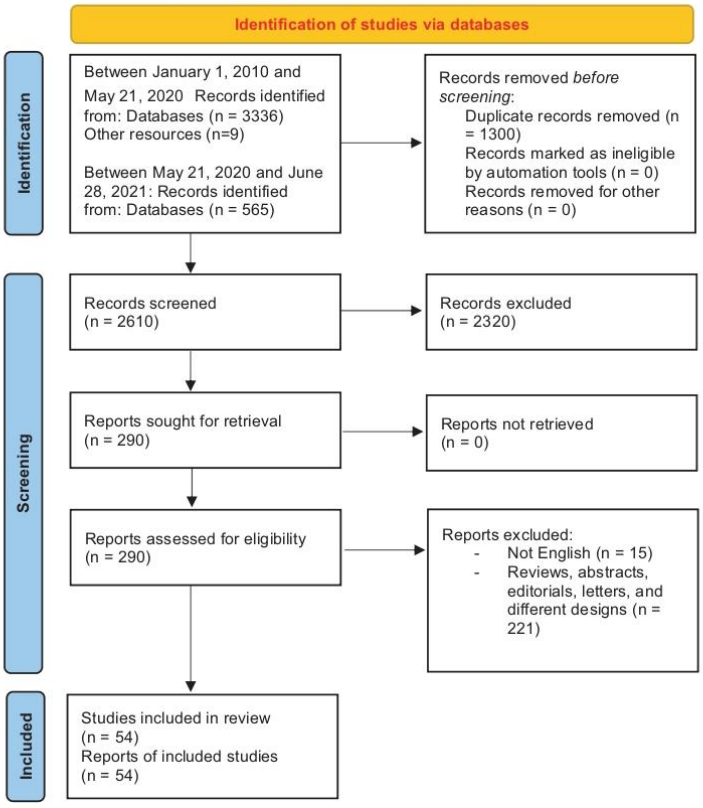


**FIGURE 1** PRISMA flow diagram of included studies

Iraq and Palestine, two each in Egypt, Bahrain, Kuwait and Oman, and one each in Lebanon, United Arab Emirates and Yemen. Forty-nine studies were cross-sectional, and five were cohort studies. Both genders were represented equally in the majority of the included studies. A total of 34 studies reported participants' level of education, with an average of 79.6% being university-level educated. Insulin therapy was reported in 33 studies, on average used by 38.8% of participants. Obesity was reported in 47.6% of the participant population, and 25.5% were smokers. Uncontrolled diabetes (HbA1c >7%) was reported in 63% of the participants. Table 1 shows the baseline characteristics of the included studies and participants.

## 3.3 | Quality of included studies

The quality of included studies, assessed using the NOS tool, ranged from good to very good for cross-sectional studies, and was deemed very good for all included cohort studies participants (Table 2).

## 3.4 | Characteristics of the participants linked to glycaemic control

### 3.4.1 | Older age (>50 years)

Overall effect estimates of 17 studies showed no significant association between risk of inadequate glycaemic control and older age (>50 years) (OR = 0.97, 95% CI: 0.90, 1.05; $p = .49$). Overall pooled data were heterogenous ($I^2 = 73\%$, $p < .0001$). A subgroup analysis showed no significant association between risk of inadequate glycaemic control and older age in Saudi Arabia (OR = 0.84, 95% CI: 0.69, 1.01; $p = .06$) and Jordan (OR = 1.43, 95% CI: 0.89, 2.29; $p = .14$). In studies conducted in Palestine, older participants were associated with a lower risk of inadequate glycaemic control (OR = 0.97, 95% CI: 0.94, 1.00; $p = .02$). Pooled data in the subgroup analysis were homogenous ($I^2 = 0\%$, $p = .62$), Figure 2. Moreover, participants with adequate glycaemic control were older than those with inadequate glycaemic control (MD = 0.70 years, 95% CI: 0.11, 1.29; $p = .02$), and the pooled data were homogenous ($I^2 = 28\%$, $p = .18$), see Supplementary File 1, Figure A.

### 3.4.2 | Female gender

Overall random-effect estimates of 22 studies showed no significant association between risk of inadequate glycaemic control for female compared with male participants (OR = 1.12, 95% CI: 0.97, 1.30; $p$ = .13). Overall pooled data were heterogenous ($I^2$ = 78%, $p$ < .0001). Subgroup analysis showed no significant association between risk of inadequate glycaemic control in female compared with male participants in Saudi Arabia (OR = 1.06, 95% CI: 0.90, 1.25; $p$ = .48), Jordan (OR = 0.74, 95% CI: 0.40, 1.37; $p$ = .33), Kuwait (OR = 1.20, 95% CI: 0.57, 2.55; $p$ = .63), and Iran (OR = 1.21, 95% CI: 0.94, 1.56; $p$ = .14). For Palestine and other countries, female gender was associated with higher risk of inadequate glycaemic control (OR = 1.57, 95% CI: 1.07, 2.30; $p$ = .02 and OR = 1.36, 95% CI: 1.07, 1.74; $p$ = .01), respectively. Pooled data from Palestine were homogenous ($I^2$ = 0%, $p$ = .92). The heterogeneity in the other subgroup was resolved by excluding the data from Noureddine et al. (2014) ($I^2$ = 0%, $p$ = .65), with an effect estimate of (OR = 1.48, 95% CI: 1.34, 1.62; $p$ < .0001), see Figure 3.

### 3.4.3 | Elevated WHR

Pooled data of two studies demonstrated a significant elevation of the risk of inadequate glycaemic control in patients with elevated waist to hip ratio (WHR) (OR = 1.62, 95% CI: 1.16, 2.26; $p$ = .004). Pooled data were homogenous ($I^2$ = 0%, $p$ = .69), see Figure 4.

### 3.4.4 | Obesity

Overall random effect estimates of 16 studies showed a significantly increased risk of inadequate glycaemic control in obese patients (BMI >30 kg/m$^2$) (OR = 1.30, 95% CI: 1.10, 1.54; $p$ = .002). Overall pooled data were heterogenous ($I^2$ = 81%, $p$ < .0001). Subgroup analyses showed a significant elevation in the risk of inadequate glycaemic control in obese participants in Saudi Arabia (OR = 1.58, 95% CI: 1.04, 2.39; $p$ = .03), Jordan (OR = 1.48, 95% CI: 1.03, 2.13; $p$ = .03) and Kuwait (OR = 1.50, 95% CI: 1.34, 1.67; $p$ < .00001), see Figure 5. Moreover, participants with adequate glycaemic control had lower BMI compared with those with inadequate glycaemic control (MD = −1.16 kg/m$^2$, 95% CI: −1.85, −0.47; $p$ = .001), and the pooled data were heterogenous ($I^2$ = 73%, $p$ < .0001). The heterogeneity was managed by excluding the data from Channanath et al. (2018) ($I^2$ = 47%, $p$ = .06), see Supplementary File 1, Figure B. Furthermore, there was an association between glycaemic control and BMI, with lower HbA1c levels more likely in participants with lower BMI (<30 kg/m$^2$) than participants with BMI >30 (MD = −0.32, 95% CI: −0.52, −0.12; $p$ = .002). Pooled data were homogenous ($I^2$ = 5%, $p$ = .35), see Supplementary File 1, Figure C.

### 3.4.5 | Smoking

Overall random-effect estimates of 10 studies showed that the risk of inadequate glycaemic control was significantly elevated in smokers (OR = 1.26, 95% CI: 1.05, 1.52; $p$ = .01). Overall pooled data were homogenous ($I^2$ = 0%, $p$ = 1.00), see Figure 6.

### 3.4.6 | Duration of diabetes (>10 years)

Overall, random-effect estimates of 13 studies showed an increased risk of inadequate glycaemic control in patients with longer duration of diabetes (OR = 2.01, 95% CI: 1.64, 2.48; $p$ < .001). Overall pooled data were heterogeneous ($I^2$ = 98%, $p$ < .001), see Figure 7. The heterogeneity could not be resolved by sensitivity analysis. Subgroup analysis demonstrated that in the Saudi population, the risk of inadequate glycaemic control was tripled in participants who had diabetes for more than 10 years compared with those who experienced the disease for a shorter duration (<10 years; OR = 3.02, 95% CI: 2.34, 3.91; $p$ < .0001). Subgroup pooled data were homogenous ($I^2$ = 0%, $p$ = .51). Moreover, participants with adequate glycaemic control tended to report shorter duration of diabetes (MD = −1.86, 95% CI: −3.55, −0.16; $p$ = .03), see Supplementary File 1, Figure D.

### 3.4.7 | Self-management

Pooled analysis of seven studies showed a significant association between lower risk of inadequate glycaemic control and self-management (OR = 0.49, 95% CI: 0.29, 0.82; $p$ = .006). Overall pooled data were heterogenous ($I^2$ = 94%, $p$ < .001), see Figure 8. Heterogeneity was best resolved by excluding the data from (Aghili et al., 2016; Al-Hayek et al., 2012; Khattab et al., 2010) ($I^2$ = 31%, $p$ = .23), with the overall effect estimate still significant (OR = 0.65, 95% CI: 0.47, 0.89; $p$ = .007).

### 3.4.8 | Physical activity

Overall random-effect estimates of eight studies showed a significant association between the lower risk of inadequate glycaemic control and physical activity (OR = 0.40, 95% CI: 0.24, 0.67; $p$ = .0005). Overall pooled data were heterogenous ($I^2$ = 80%, $p$ < .0001), see Figure 9. Heterogeneity was best resolved by excluding the data from (AL-Eitan et al., 2016; Alramadan et al., 2018; Mosleh et al., 2017) ($I^2$ = 49%, $p$ = .10), with the overall effect estimate still significant (OR = 0.25, 95% CI: 0.15, 0.40; $p$ < .0001).

### 3.4.9 | Diabetes knowledge

The pooled analysis of four studies showed no significant association between diabetes knowledge and glycaemic control (OR = 0.67,

TABLE 2 The Newcastle-Ottawa Scale (NOS) of Cross-sectional studies and Cohort studies

| Cohort studies | | | | |
|---|---|---|---|---|
| | Selection | | | |
| Study ID | Representativeness of the exposed cohort | Selection of the non-exposed cohort | Ascertainment of exposure | Demonstration that outcome of interest was not present at start of study |
| Akin et al. (2019) | * | | | * |
| Almutairi & Alkharfy (2013) | * | | * | * |
| Alzaheb & Altemani (2018) | * | * | * | * |
| Alzahrani et al. (2018) | * | * | * | * |
| Mansour et al. (2020) | * | | * | * |

Each (*) mean 1 on the score of NOS, and the final column count the total of these stars to give a final decision.

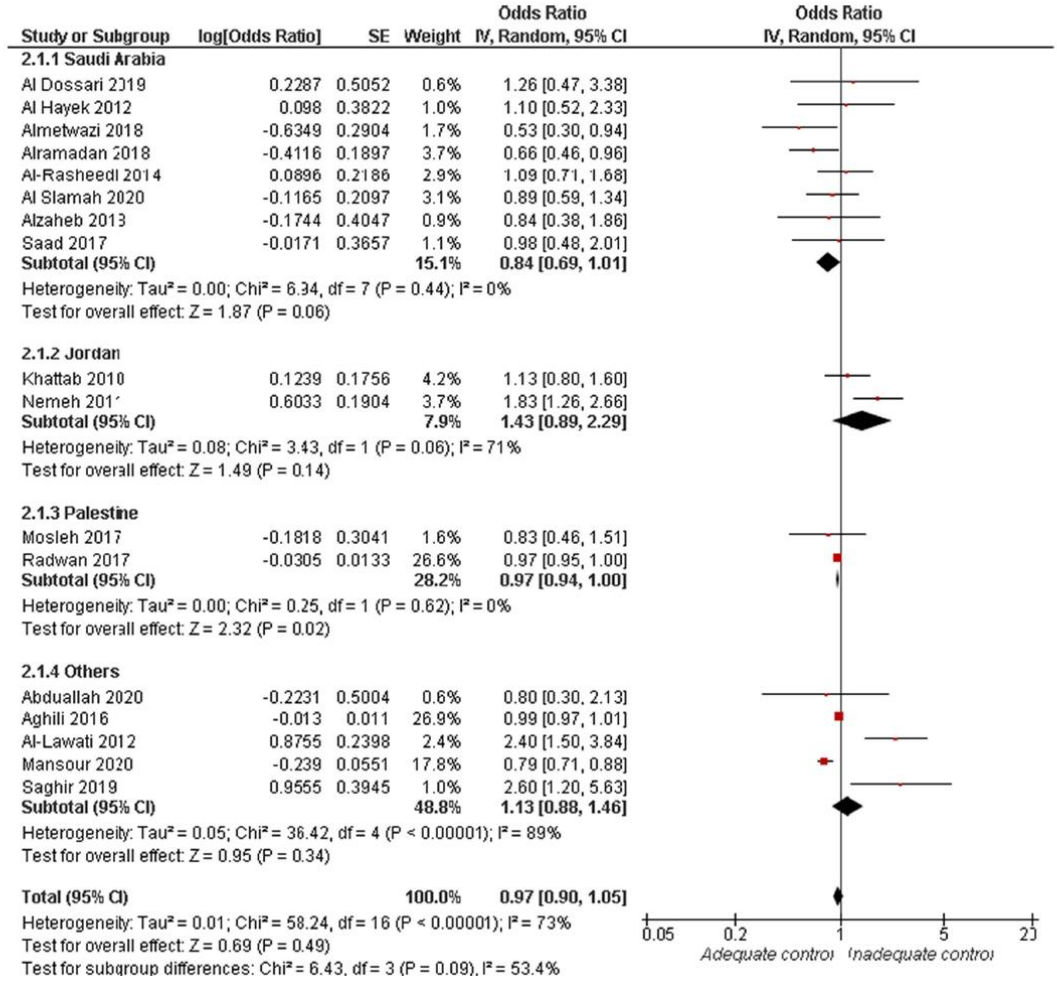


FIGURE 2 Forest plot of the odds ratio of age (>50years) in relation to adequate glycaemic control

| Comparability | Outcome | | | |
|---|---|---|---|---|
| Comparability of cohorts on the basis of the design or analysis controlled for confounders | Assessment of the outcome | Was follow-up long enough for outcomes to occur | Adequacy of follow-up of cohorts | Quality score |
| ** | * | * | * | 7 |
| ** | * | * | * | 8 |
| ** | * | * | * | 9 |
| ** | * | * | * | 9 |
| ** | * | * | * | 8 |

95% CI: 0.39, 1.16; $p = .15$). Overall pooled analysis was heterogenous ($I^2 = 81\%$, $p = .001$). Subgroup analysis showed no significant association in Saudi Arabia (OR = 0.55, 95% CI: 0.28, 1.07; $p = .08$) and other countries (OR = 0.89, 95% CI: 0.55, 1.42; $p = .62$), see Supplementary File 1, Figure E.

### 3.4.10 | Depression

Pooled analysis of three studies demonstrated no significant difference between depressed and non-depressed participants in terms of glycaemic control (OR = 0.98, 95% CI: 0.93, 1.03; $p = .42$). Overall pooled data were homogenous ($I^2 = 0\%$, $p = .89$). Subgroup analysis showed no significant association in Saudi Arabia (OR = 1.07, 95% CI: 0.74, 1.55; $p = .73$) and Iran (OR = 0.98, 95% CI: 0.93, 1.03; $p = .39$), see Supplementary File 1, Figure F.

### 3.4.11 | Anxiety

Data from three studies indicated no significant association between anxiety and glycaemic control (OR = 1.01, 95% CI: 0.99, 1.03; $p = .53$). Overall pooled data were homogenous ($I^2 = 5\%$, $p = .35$). Subgroup analysis showed no significant association in Saudi Arabia (OR = 1.25, 95% CI: 0.89, 1.76; $p = .20$) and Iran (OR = 1.01, 95% CI: 0.98, 1.03; $p = .59$), see Supplementary File 1, Figure G.

### 3.4.12 | Employment

The overall fixed-effect showed no significant association between employment and glycaemic status (OR = 1.03, 95% CI: 0.85, 1.24; $p = .75$). Overall pooled data were homogenous ($I^2 = 19\%$, $p = .28$). Subgroup analysis showed no significant association in Saudi Arabia (OR = 0.95, 95% CI: 0.75, 1.19; $p = .63$) and other countries (OR = 1.23, 95% CI: 0.89, 1.72; $p = .21$), see Supplementary File 1, Figure H.

### 3.4.13 | Marital status

The overall random-effect estimate demonstrated no significant association between marital status and glycaemic control (OR = 1.07, 95% CI: 0.85, 1.35; $p = .55$). Overall pooled data showed minor heterogeneity ($I^2 = 38\%$, $p = .09$). Subgroup analysis showed no significant association in Saudi Arabia (OR = 1.06, 95% CI: 0.68, 1.67; $p = .79$), Iran (OR = 0.96, 95% CI: 0.72, 1.27; $p = .76$), Jordan (OR = 1.30, 95% CI: 0.92, 1.84; $p = .14$), and Palestine (OR = 0.84, 95% CI: 0.24, 2.96; $p = .79$), see Supplementary File 1, Figure I.

## 4 | DISCUSSION

Previous meta-analyses focused on the relationship between individual factors and the development of diabetes (Lustman et al., 2000; Rodríguez-Gutiérrez & Montori, 2016); however, this review is the first to examine a broad spectrum of elements regarding their possible influence on glycaemic control in participants with established T2DM in the MENA region. This systematic review and meta-analysis found no significant association between glycaemic control and age, gender, diabetes knowledge, depression, anxiety, employment or marital status. However, in Palestine, older participants and females had a lower risk of inadequate glycaemic control. Overall, a greater risk of inadequate glycaemic control was seen in participants with obesity, higher WHR, smokers and those who had lived with diabetes for a longer duration (>10 years). Studies from Saudi Arabia demonstrated those with obesity and longer duration with diabetes at greater risk of inadequate control, as were participants from Jordan and Kuwait with obesity. Moreover, those with better self-management and greater physical activity had a lower risk of inadequate glycaemic control.

Regarding the effect of demographic factors on the development of inadequate glycaemic control, our findings demonstrated a significant difference in age between participants with adequate and inadequate glycaemic control (MD = 0.70 years, $p = .020$). A cross-sectional analysis of 1438 participants by Berkowitz et al. (2013), reported that young age patients were significantly associated with

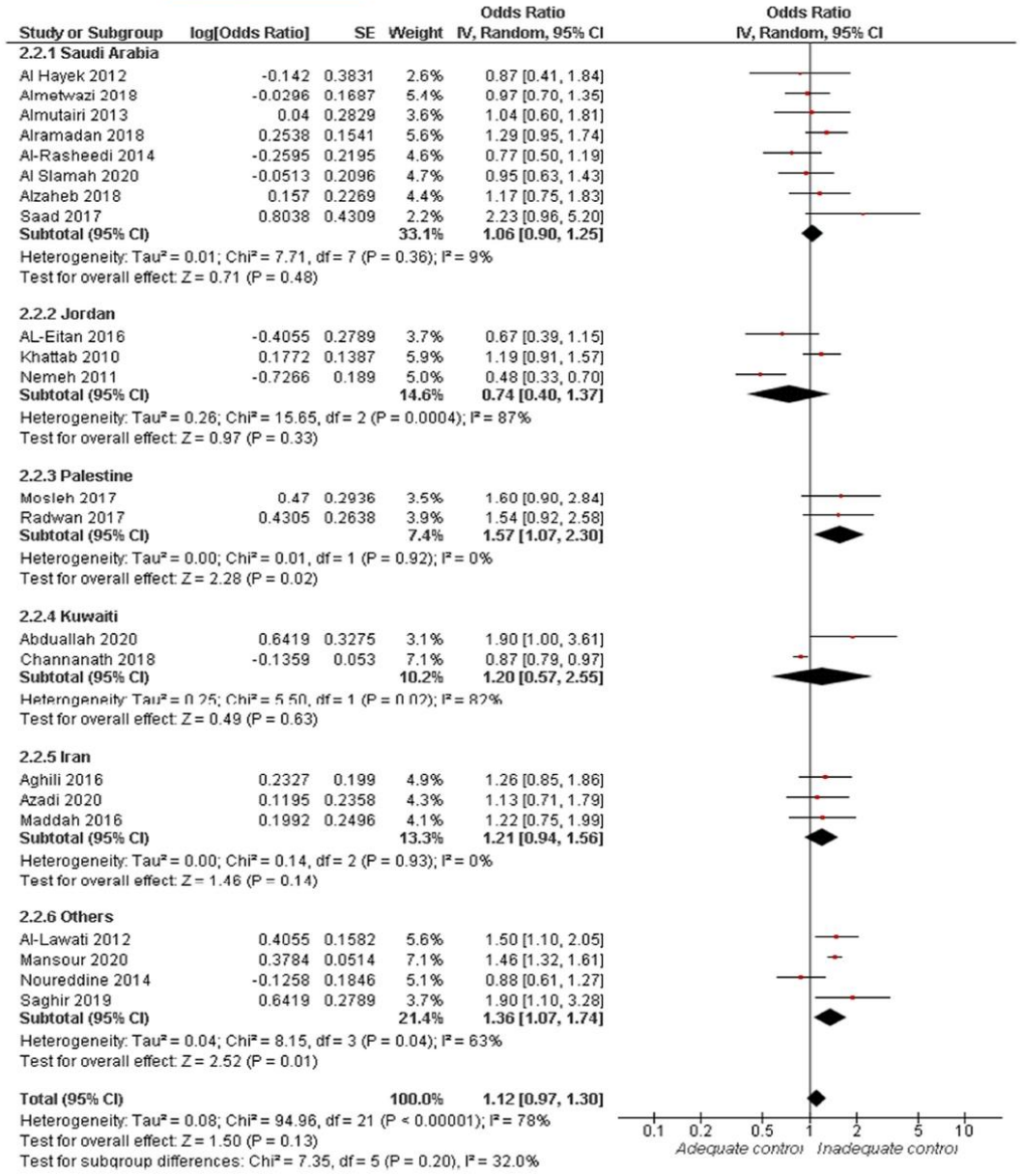


**FIGURE 3** Forest plot of the odds ratio of inadequate glycaemic control by gender

inadequate glycaemic control ($p < .001$). Similarly, a nationwide cross-sectional study of 697 American patients with T2DM showed that adequate glycaemic control was prevalent among older patients. Moreover, these authors suggested that young patients undergo HbA1c assessments at least annually (Comellas et al., 2019). One suggested explanation for these observations is that older age is associated with a reduction in the lifespan of the red blood corpuscles, reducing their exposure to circulating glucose, thereby lowering blood levels of HbA1c (Dubowitz et al., 2014; Shperling & Danon, 1990). However, the overall odds ratio in our study

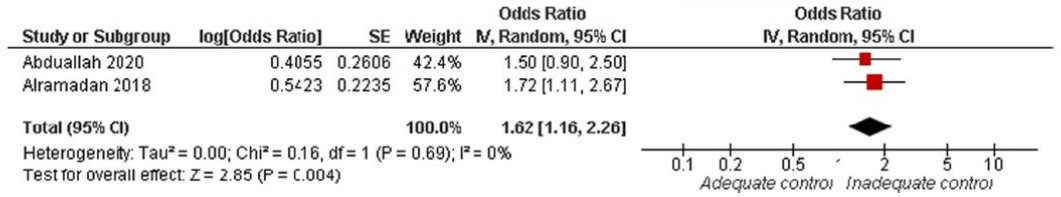


FIGURE 4 Forest plot of the odds ratio for inadequate glycaemic control in relation to elevated WHR

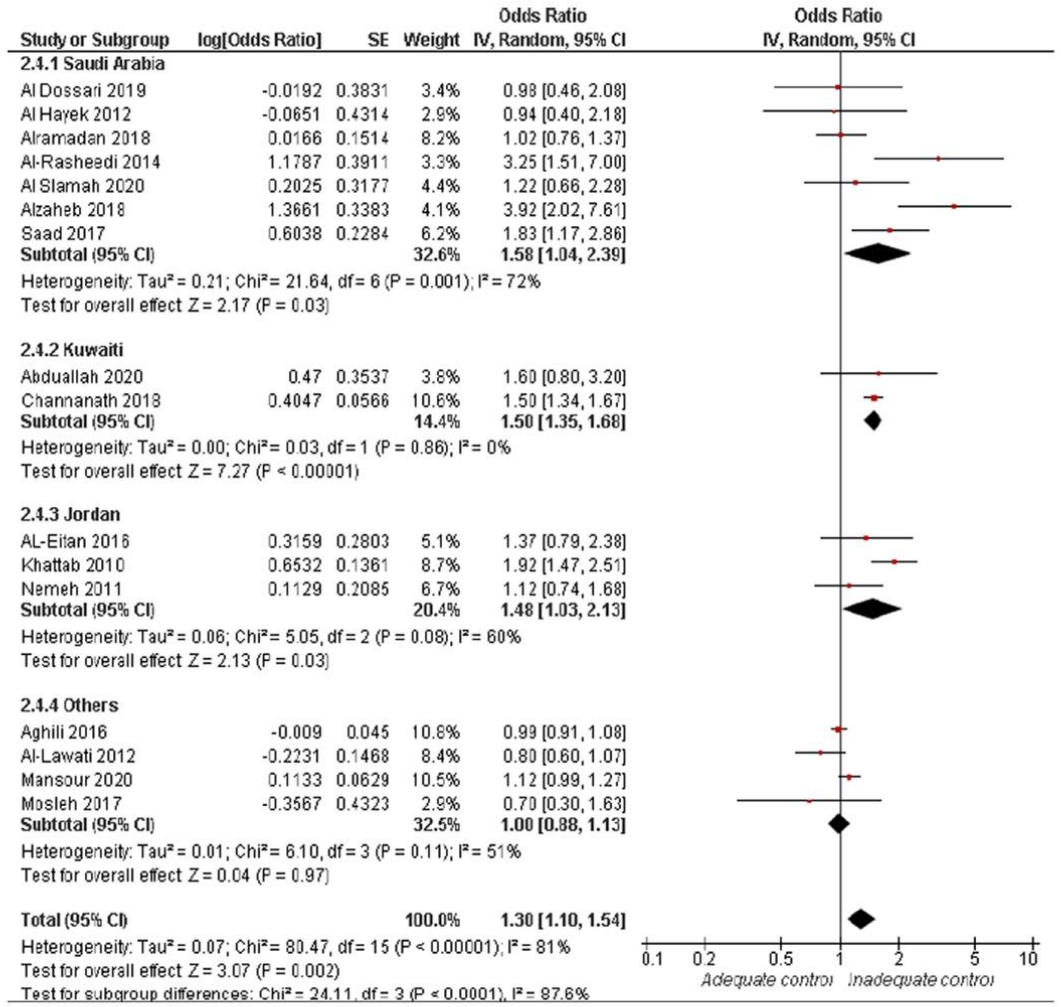


FIGURE 5 Forest plot of the odds ratio of inadequate glycaemic control in relation to obesity (BMI >30 kg/m$^2$)

showed no association between these variables. Similarly, Wiener & Roberts (1999) found no significant correlation in 399 participants between age and HbA1c levels. The lack of significance was ascribed to the exclusion of participants who had impaired glucose tolerance yet were eligible for inclusion in the normoglycaemic group based on a fasting plasma glucose value <6.4 mmol/L, a criterion that does

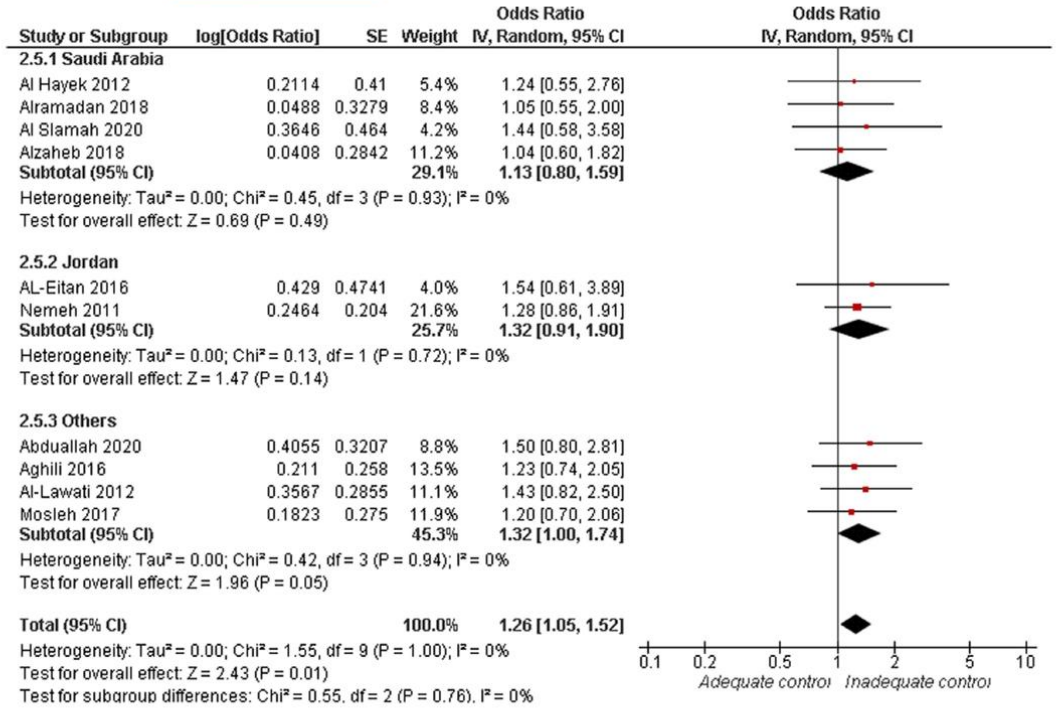


**FIGURE 6** Forest plot of the odds ratio of inadequate glycaemic control by smoking status

not completely rule out diabetes in all participants, particularly non-insulin-independent diabetes.

Subgroup analysis surprisingly showed a significant inverse relationship between age and HbA1c among Palestinian participants. This relationship can perhaps be attributed to differences in attitudes among young participants compared with their elders. Younger individuals are often regarded or observed to be more negligent of the hazards of diabetes and the necessary self-management activities to control their glucose levels; conversely, older participants tend to be more careful and adherent to their treatment regimen (Toh, 2011). Radwan et al. (2018) found a significant association between old age and adequate glycaemic control (OR = 0.97; 95% CI: 0.945, 0.995). Their results contradict previous findings because of differences in the demographics of the studied populations, especially in terms of the age distribution (Radwan et al., 2018). Higher percentages of participants were of older age in the Palestinian samples than in other study groups, with 34% of participants >61 years (Radwan et al., 2018) and more than 50% ≥58 years (Mosleh et al., 2017). However, studies from Aldossari et al. (2019), Nemeh et al. (2011), and Saghir et al. (2019) providing data from Saudi Arabia, Jordan, and other locations, respectively, did not show a significant inverse correlation between age and HbA1c. This could be attributed to the lower proportion of people >60 years in these studies [10.5% in Aldossari et al. (2019), 26% in Nemeh et al. (2011), and 25% in Saghir et al. (2019)].

The second demographic aspect examined was gender. No significant correlation was seen between gender and the risk of inadequate glycaemic control. This finding is inconsistent with a previous patient-level pooled analysis of six RCTs, totalling 2600 participants with diabetes, which found women more prone to hypoglycaemia and high HbA1c levels (Kautzky-Willer et al., 2015). Another systematic review and meta-analysis from 2015 found that the risk of inadequate glycaemic control was higher in women; however, three of their included studies were deemed unreliable due to the high risk of bias (Sobers-Grannum et al., 2015). Various explanations have been put forward for these observations. It has been proposed that women show lower levels of adherence to medications, to which they more frequently report side effects (Thunander Sundbom & Bingefors, 2012). Differences in lifestyles (e.g. exercise) as well as in psychosocial perceptions might also play a role in gender-based differences in glycaemic control (Walker et al., 2006). Socio-economic differences might also play a part; however, these were not considered in any study. Differences in physiology have also been suggested to underlie any sex-based differences in HbA1c levels; however, further investigation is required of any sex-based differences in efficacy/

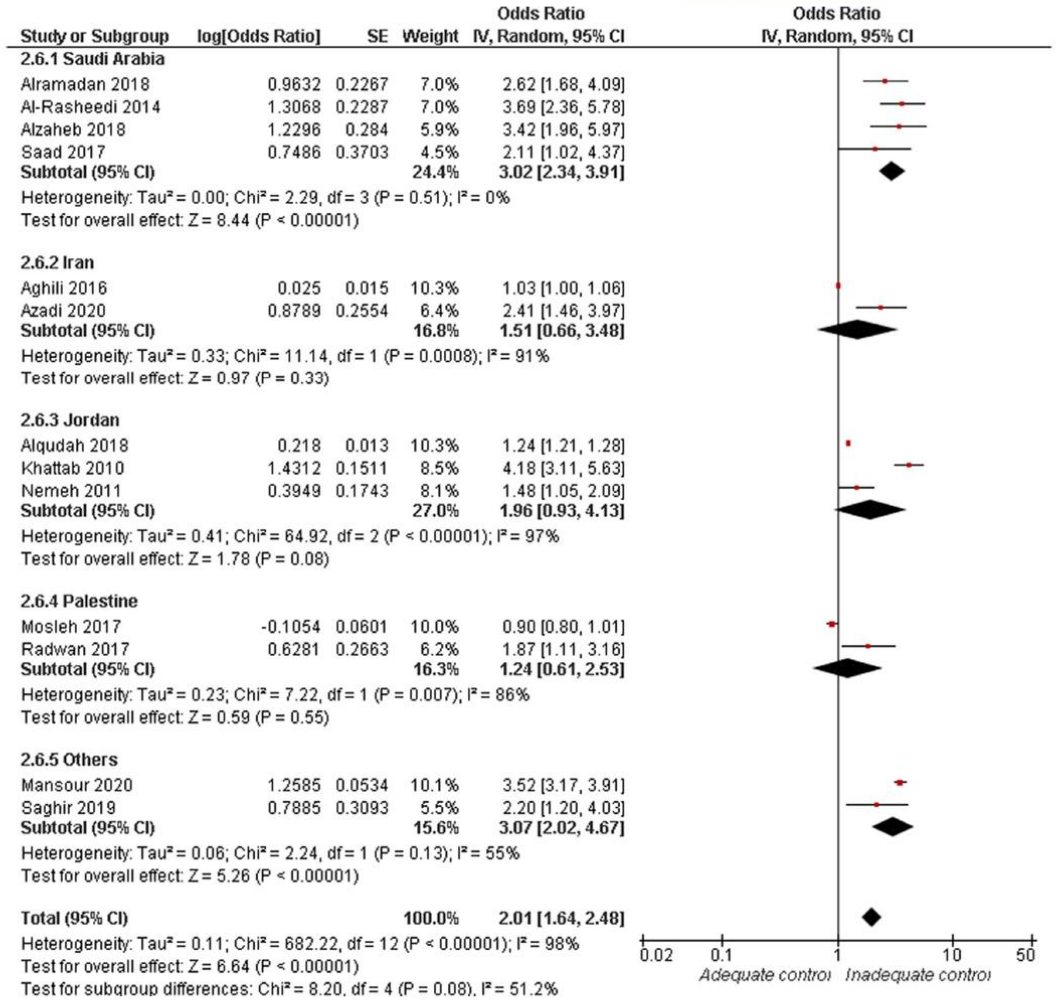


FIGURE 7 Forest plot of the odds ratio of inadequate glycaemic control in relation to extended duration of diabetes (>10 years)

treatment response, as current evidence for factors such as dissimilarities in body composition is unlikely to provide sufficient explanation for such observations (Radwan et al., 2018). In Lebanon, Noureddine et al. (2014) found no association between gender and the risk of T2DM within the Lebanese population (Noureddine et al., 2014). Similarly, in Saudi Arabia, Al-Rasheedi (2014) failed to demonstrate a significant connection between the two factors (Al-Rasheedi, 2014). However, though insignificant, both studies showed that the percentage of males within the inadequate glycaemic control group was higher than in the adequate glycaemic control group.

With regard to the anthropometric measures, this review found a significant association between increased WHR and high HbA1c levels ($p < .05$). Such results are congruent with the findings from (Vazquez et al., 2007), where 32 different populations from 29 studies were analysed. In that study, WHR was found to correlate well with the incidence of diabetes. WHR is considered by some a reliable measure of visceral fat (Gadekar et al., 2020). An elevated WHR indicates greater accumulation of visceral fat stores, a feature that negatively influences the metabolism of hormones such as insulin through free fatty acid secretion, which hinders insulin uptake by the liver leading to hyperinsulinemia and subsequent insulin resistance (Despres et al., 1995; Kahn & Flier, 2000). Nevertheless, reports have questioned the reliability of WHR for accurately reflecting changes in visceral fat (Van Der Kooy et al., 1993). This suggests that more sensitive measures should

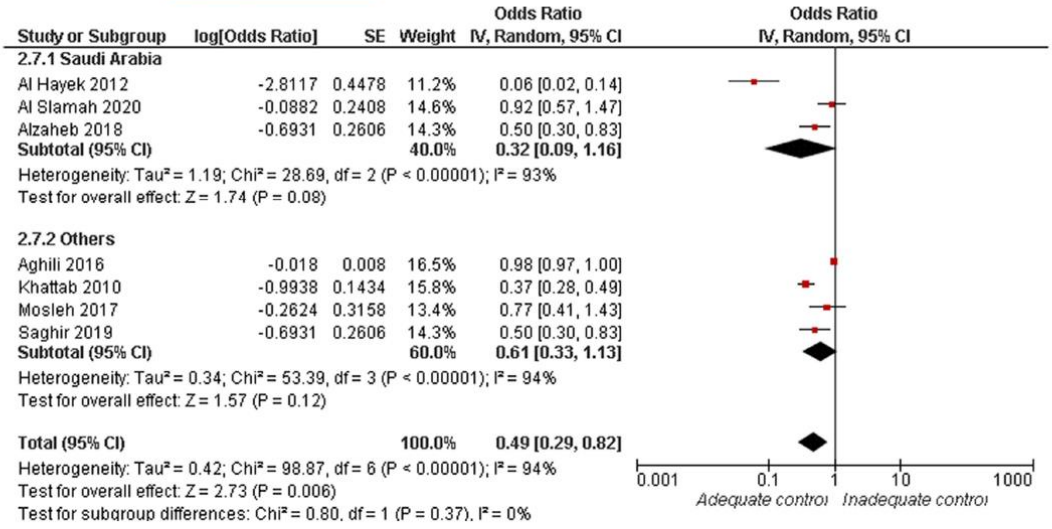


**FIGURE 8** Forest plot of the odds ratio of inadequate glycaemic management in relation to self-management

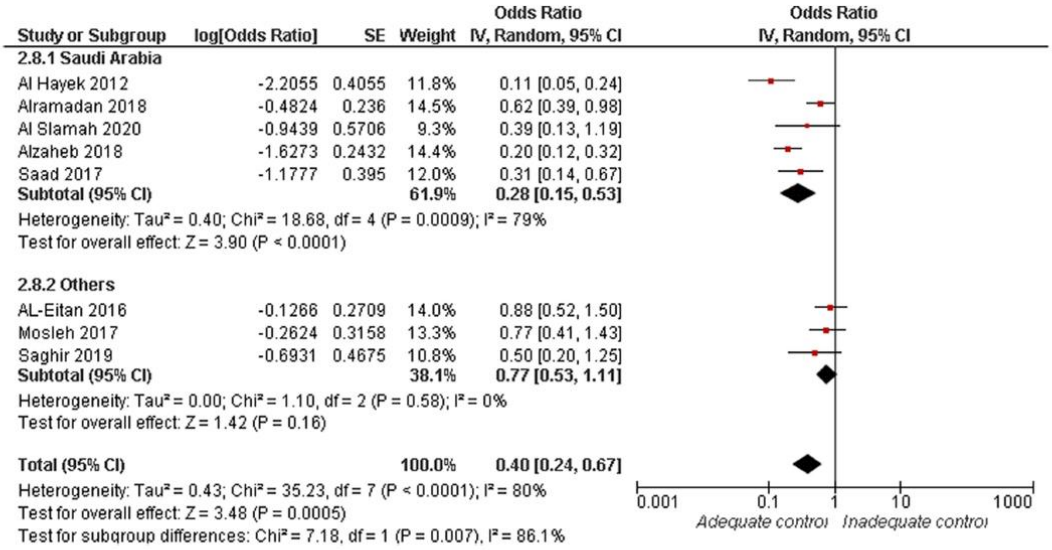


**FIGURE 9** Forest plot of the odds ratio of inadequate glycaemic control in relation to physical activity

be used to properly explore the relationship between fat mass and glycaemic control.

Obesity, signified by BMI >30 kg/m$^2$, was significantly associated with an increased risk of inadequate glycaemic control. This observation supports the findings of Abdullah et al. (2020). Moreover, a significant association was detected between BMI and HbA1c levels. As mentioned above, obesity (represented by both high WHR and BMI) is usually accompanied by insulin resistance and insensitivity due to the effect of visceral fat on insulin secretion and clearance. Accordingly, this sheds some light on a possible association between insulin resistance itself and HbA1c. Saha and Schwarz (2017) found HbA1c a reliable tool for predicting insulin resistance and inadequate

glycaemic control among 3578 normoglycaemic and hyperglycaemic individuals (Saha & Schwarz, 2017).

The third category of factors related to glycaemic control is that of lifestyle. This includes physical activity, smoking, and psychological and social patterns. This review indicated a significant association between smoking and inadequate glycaemic control. Other meta-analyses have found significant associations between smoking (whether active or passive) and the risk of developing T2DM (Pan et al., 2015; Soulimane et al., 2014; Wang et al., 2013). With the exception of Alzaheb and Altemani (2018), all the included studies that analysed smoking used HbA1c as an index for glycaemic control, and reported significant positive correlations between smoking and HbA1c. Numerous explanations have been put forward to explain the relationship between smoking and glycaemic control. One theory proposed that smoking raises HbA1c levels by altering the erythrocytic membrane permeability to glucose, consequently increasing haemoglobin glycation (Higgins et al., 2009). Moreover, smoking lowers oxygen saturation in the blood, which leads to higher levels of deoxyhemoglobin, which is more readily glycated than oxyhemoglobin, accelerating HbA1c formation. Other possible explanations pertain to the amplifying effect exerted by smoking on the levels of 2,3-diphosphoglycerate, an intermediate of glycolysis that correlates with high levels of HbA1c. Furthermore, one of the components of tobacco smoke, carbon monoxide, increases the lifespan of circulating erythrocytes, increasing their blood glucose exposure (Beutler, 1975; Smith et al., 1982). The strong association between smoking and T2DM may offer a new approach for avoiding a rise in HbA1c levels, and therefore reducing the incidence of the disease. For example, awareness campaigns could educate people living with diabetes regarding the particular seriousness of smoking and its harmful influence on their glycaemic status.

Regarding physical activity, this review found that increased physical effort led to a significant reduction in the risk of inadequate glycaemic control ($p < .001$). Similarly, Aune et al. (2015) presented a meta-analysis of 87 studies (including three RCTs and 84 cohorts) demonstrating an inverse relationship between total physical activity (i.e. leisure-time, occupational and transport) and the risk of inadequate glycaemic control (Aune et al., 2015). The consequential reduction in body adiposity, a major contributing factor to the development of diabetes, can explain this response to sustained, regular physical activity (Mozaffarian et al., 2011; Rana et al., 2007). Alternatively, Aune et al. (2015) pointed out that physical exercise involves concentric contractions of the body's skeletal muscles, which take up glucose from the circulation (Aune et al., 2015). This process is mediated through the GLUT4 glucose transporter located on the membranes of striated muscle cells. Studies have reported that physical activity enhances GLUT4 translocation on the myocytic membrane, thereby increasing the rate of glucose uptake by muscles and improving glucose homeostasis (Colberg et al., 2010; Perseghin et al., 1996; Röckl et al., 2008). On sensitivity analysis, three records were excluded to resolve the observed heterogeneity (AL-Eitan et al., 2016; Alramadan et al., 2018; Mosleh et al., 2017). The first two of these observed no significant association between physical exercise and glycaemic control, which AL-Eitan et al. (2016) ascribed to possible selective information sharing by the participants during their interviews, commonly known as reporting bias, resulting in the inconsistent findings of studies in this review (AL-Eitan et al., 2016).

Another factor frequently included in lifestyle-modification interventions is self-management (Ali et al., 2012; Muchiri et al., 2016; Zheng et al., 2019). In the analysis by Garcia-Molina et al., 16 studies introduced self-management as part of their intervention. These observations emphasise the importance of implementing lifestyle changes to achieve better glycaemic control. García-Molina et al. (2020) found, analysing the findings of 28 studies, that lifestyle interventions were more efficient than standard care in reducing the risk of inadequate glycaemic control (García-Molina et al., 2020). Heterogeneity in this analysis was best resolved by excluding (Aghili et al., 2016; Al-Hayek et al., 2012; Khattab et al., 2010). Aghili et al. (2016) noted a negative relation between self-care practices and HbA1c levels, ascribed to the strong association between self-management and diabetes-related distress. The latter has been associated with negative responses (e.g. increasing depressive symptoms linked to reducing adherence to medication), directly and indirectly leading to uncontrolled glucose levels (Aikens, 2012; Gonzalez et al., 2008). Khattab et al. (2010) and Al-Hayek et al. (2012) used self-report to collect data concerning participants' medication adherence, glucose self-monitoring and dietary-intake (i.e. self-management practices), which risked recall bias, a type of error that might have led to exaggerated findings (Al-Hayek et al., 2012; Khattab et al., 2010).

Lastly, a highly significant link was demonstrated between longer disease duration and inadequate glycaemic control. By contrast, a UK-based cross-sectional study found an inverse relation between the two variables. This finding may be attributed to the different healthcare systems of developing and developed countries. Abubakari et al. (2016) hypothesized that longer disease duration allows participants to better understand their condition's nature, consequences and responsibilities, which assists in the management of negative emotions that might affect their response, allowing them to better control their disease (Abubakari et al., 2016).

### 4.1 | Strengths and limitations

There are several limitations to this meta-analysis. First, most included studies used self-report to collect outcome data, potentially leading to recall bias, which might either exaggerate or underestimate the true effect size. Second, in terms of the anthropometric markers, only two measures were observed, WHR and BMI. These measurements have been reported as less informative measures of obesity than other measurements such as waist circumference and the waist-to-height ratio (Rajput et al., 2014; Vazquez et al., 2007). Third, the high heterogeneity observed between studies was not always resolvable, potentially indicating diversity in the methodology or baseline criteria of the included studies. Greater consistency in

design among studies is recommended for the future. Fourth, we only included English language studies, and peer-reviewed published articles to ensure the quality of the included studies' methodologies.

The strengths of this review include the relatively large number of included studies, adding to the strength of association between the predictors of glycaemic control.

In conclusion, the current evidence suggests an increased risk of inadequate glycaemic control in patients with elevated WHR, longer disease duration, obesity and smokers, with lower risk of inadequate control associated with physical activity and self-management. Further longitudinal studies are required to better understand these variations and to assess all predictors of glycaemic control in participants with T2DM, and to further provide a strong basis for future recommendations to optimize glycaemic control.

## 5 | RECOMMENDATIONS

Review findings illustrated some variability in variables which exert significant impact across the countries of the Middle East and North Africa. Irrespective of whether they are middle-income or high-income, countries should use national and regional data to inform the development of strategies sensitive to local and global influences. Broadly, however, policymakers and clinicians should pay attention to spreading awareness campaigns to educate people living with diabetes regarding the seriousness and implications of obesity and smoking for glycaemic status. Regular exercise is essential, especially in people with living with diabetes for long periods, who should be encouraged to follow a balanced physical program to improve their glycaemic status. Diabetes education and self-care management should be integral to the management of all people living with diabetes regardless of their medication and management pathways.

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### CONFLICT OF INTEREST

None.

### PEER REVIEW

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### REFERENCES

Abdullah, A., Alkandari, A., Longenecker, J. C., Devarajan, S., Alkhatib, A., Al-Wotayan, R., Al-Duwairi, Q., & Tuomilehto, J. (2020). Glycemic control in Kuwaiti diabetes patients treated with glucose-lowering medication. *Primary Care Diabetes*, *14*(4), 311–316. https://doi.org/10.1016/j.pcd.2019.12.001

Abubakari, A. R., Cousins, R., Thomas, C., Sharma, D., & Naderali, E. K. (2016). Sociodemographic and clinical predictors of self-management among people with poorly controlled type 1 and type 2 diabetes: The role of illness perceptions and self-efficacy. *Journal of Diabetes Research*, *2016*, 1–12. https://doi.org/10.1155/2016/6708164

Abuhegazy, H. (2017). Depression and glycemic control in a sample of patients with type 2 diabetes. *MOJ Addiction Medicine & Therapy*, *3*(5), 2–3. https://doi.org/10.15406/mojamt.2017.03.00054

ADA. (2021). Professional practice committee: Standards of medical care in diabetes—2021. *Diabetes Care*, *44*(Supplement 1), S3–S3. https://doi.org/10.2337/dc21-Sppc

Adham, M., Froelicher, E. S., Batieha, A., & Ajlouni, K. (2010). Glycaemic control and its associated factors in type 2 diabetic patients in Amman, Jordan. *Eastern Mediterranean Health Journal*, *16*(7), 732–739.

Akin, S., Bölük, C., Ozgur, Y., Aladağ, N., Geçmez, G., Keskin, O., Boru, U. T., & Tasdemir, M. (2019). Overtreatment and hypoglycemia prevalence in geriatric patients with type-2 diabetes in the Turkish population. *Acta Endocrinologica*, *15*(3), 311–316. https://doi.org/10.4183/aeb.2019.311

Albasheer, O. B., Mahfouz, M. S., Solan, Y., Khan, D. A., Muqri, M. A., Almutairi, H. A., Alelyani, A. M., & Alahmed, H. A. (2018). Depression and related risk factors among patients with type 2 diabetes mellitus, Jazan area, KSA: A cross-sectional study. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, *12*(2), 117–121. https://doi.org/10.1016/j.dsx.2017.09.014

Al Dossari, K. K., Ahmad, G., Aljowair, A., Alqahtani, N., Shibrayn, M. B., Alshathri, M., Alshehri, D., Akhlaq, S., Hejab, F. B., Alqahtani, A., & Razzak, H. A. (2019). Association of vitamin D with glycemic control in Saudi patients with type 2 diabetes: A retrospective chart review study in an emerging university hospital. *Journal of Clinical Laboratory Analysis*, *34*(2), 1–7. https://doi.org/10.1002/jcla.23048

Alzahrani, S. H., Baig, M., Aashi, M. M., Al-shaibi, F. K., Alqarni, D. A., & Bakhamees, W. H. (2019). Association between glycated hemoglobin (HbA1c) and the lipid profile in patients with type 2 diabetes mellitus at a tertiary care hospital: A retrospective study. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *12*, 1639–1644. https://doi.org/10.2147/DMSO.S222271

Agency for Healthcare Research and Quality. (2014). *Methods guide for effectiveness and comparative effectiveness review*. Agency for Healthcare Research and Quality. https://www.ncbi.nlm.nih.gov/books/NBK47095/

Aghili, R., Polonsky, W. H., Valojerdi, A. E., Malek, M., Keshtkar, A. A., Esteghamati, A., Heyman, M., & Khamseh, M. E. (2016). Type 2 diabetes: Model of factors associated with glycemic control. *Canadian Journal of Diabetes*, *40*(5), 424–430. https://doi.org/10.1016/j.jcjd.2016.02.014

Ahmadian, A., Mazaheri, A., & Shakrizes, R. (2018). The relation between anxiety, depression and sexual dysfunction and the level of blood glucose control in patients with type 2 diabetes attending endocrine clinic of taleghani hospital. *Annals of Tropical Medicine and Public Health*, *6*(1.2 Special Issue), SP19. https://doi.org/10.24896/jrmds.20186233

Aikens, J. E. (2012). Prospective associations between emotional distress and poor outcomes in type 2 diabetes. *Diabetes Care*, *35*(12), 2472–2478. https://doi.org/10.2337/dc12-0181

Alaboudi, I., Hassali, M., Shafie, A., & Saleem, F. (2016). Self-efficacy, self-care behaviours and glycaemic control in type 2 diabetic patients in Riyadh, Saudi Arabia. *Journal of Public Health*, *24*(4), 281–290. https://doi.org/10.1007/s10389-016-0723-x

Al Balushi, K. A., Al-Haddabi, M., Al-Zakwani, I., & Al Za'Abi, M. (2014). Glycemic control among patients with type 2 diabetes at a primary

health care center in Oman. *Primary Care Diabetes*, *8*(3), 239–243. https://doi.org/10.1016/j.pcd.2014.01.003

Alromaihi, D., Bastawrous, M., & Bastawrous, D. (2019). Factors affecting glycemic control among patients with type 2 diabetes in Bahrain. *Bahrain Medical Bulletin*, *41*(3), 146–149. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85073271041&partnerID=40&md5=141f4d750f7645d8ac8b662cf4bbdf1d

Al Hayek, A. A., Robert, A. A., Al Saeed, A., Alzaid, A. A., & Al Sabaan, F. S. (2014). Factors associated with health-related quality of life among saudi patients with type 2 diabetes mellitus: A cross-sectional survey. *Diabetes and Metabolism Journal*, *38*(3), 220–229. https://doi.org/10.4093/dmj.2014.38.3.220

Al Saweer, A. (2015). The profile of vitamin D among type 2 diabetes mellitus patients. *Bahrain Medical Bulletin*, *37*(3), 184–188. https://doi.org/10.12816/0014443

Al-Shahrani, A. M., Hassan, A., Al-Rubeaan, K. A., Al Sharqawi, A. H., & Ahmad, N. A. (2012). Effects of diabetes education program on metabolic control among Saudi type 2 diabetic patients. *Pakistan Journal of Medical Sciences*, *28*(5), 925–930. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84869185251&partnerID=40&md5=de69f320de2b4e0f714a8c165b45f395

Al Slamah, T., Nicholl, B. I., Alslail, F. Y., Harris, L., Kinnear, D., & Melville, C. A. (2020). Correlates of type 2 diabetes and glycaemic control in adults in Saudi Arabia a secondary data analysis of the Saudi health interview survey. *BMC Public Health*, *20*(1), 1–13. https://doi.org/10.1186/s12889-020-08597-6

AL-Eitan, L. N., Nassar, A. M., Saadeh, N. A., & Almomani, B. A. (2016). Evaluation of glycemic control, lifestyle and clinical characteristics in patients with type 2 diabetes treated at king Abdullah University Hospital in Jordan. *Canadian Journal of Diabetes*, *40*(6), 496–502. https://doi.org/10.1016/j.jcjd.2016.04.009

Al-Hayek, A. A., Robert, A. A., Alzaid, A. A., Nusair, H. M., Zbaidi, N. S., Al-Eithan, M. H., & Sam, A. E. (2012). Association between diabetes self-care, medication adherence, anxiety, depression, and glycemic control in type 2 diabetes. *Saudi Medical Journal*, *33*(6), 681–683.

Al-Mukhtar, S. B., Fadhil, N. N., & Hanna, B. E. (2012). General and gender characteristics of type 2 diabetes mellitus among the younger and older age groups. *Oman Medical Journal*, *27*(5), 375–382. https://doi.org/10.5001/omj.2012.94

Ali, M., Schifano, F., Robinson, P., Phillips, G., Doherty, L., Melnick, P., Laming, L., Sinclair, A., & Dhillon, S. (2012). Impact of community pharmacy diabetes monitoring and education programme on diabetes management: A randomized controlled study. *Diabetic Medicine*, *29*(9), e326–e333. https://doi.org/10.1111/j.1464-5491.2012.03725.x

Ali, D. A., & Shahwan, M. (2013). Evaluation of factors associated with inadequate glycemic control and some other health care indicators among patients with type 2 diabetes in Ramallah, Palestine. *Research Journal of Pharmaceutical Biological and Chemical Sciencesl*, *4*(3), 455.

Almutairi, N., & Alkharfy, K. M. (2013). Direct medical cost and glycemic control in type 2 diabetic Saudi patients. *Applied Health Economics and Health Policy*, *11*(6), 671–675. https://doi.org/10.1007/s40258-013-0065-6

Almetwazi, M., Alwhaibi, M., Balkhi, B., Almohaini, H., Alturki, H., Alhawassi, T., Ata, S., AlQahtani, N., Mahmoud, M., & Alshammari, T. (2019). Factors associated with glycemic control in type 2 diabetic patients in Saudi Arabia. *Saudi Pharmaceutical Journal*, *27*(3), 384–388. https://doi.org/10.1016/j.jsps.2018.12.007

Alqudah, S., Jarab, A. S., Alefishat, E. A., Mayyas, F., Khdour, M., & Pinto, S. (2019). Factors associated with poor hemoglobin A1c control in patients with type 2 diabetes. *Current Diabetes Reviews*, *15*(2), 164–170. https://doi.org/10.2174/1573399814666180510144858

Al Nozha, O. M. (2014). Diabetes care and control: The effect of frequent visits to diabetes care center. *Annals of Saudi Medicine*, *34*(3), 229–234. https://doi.org/10.5144/0256-4947.2014.229

Alramadan, M. J., Magliano, D. J., Almigbal, T. H., Batais, M. A., Afroz, A., Alramadhan, H. J., Mahfoud, W. F., Alragas, A. M., & Billah, B. (2018). Glycaemic control for people with type 2 diabetes in Saudi Arabia - an urgent need for a review of management plan. *BMC Endocrine Disorders*, *18*(1), 62. https://doi.org/10.1186/s12902-018-0292-9

Al-Rasheedi, A. A. S. (2014). The role of educational level in glycemic control among patients with type II diabetes mellitus. *International Journal of Health Sciences*, *8*(2), 177–187. https://doi.org/10.12816/0006084

Al-Lawati, J. A., Barakat, M. N., Al-Maskari, M., Elsayed, M. K., Al-Lawati, A. M., & Mohammed, A. J. (2012). HbA1c levels among primary healthcare patients with type 2 diabetes mellitus in Oman. *Oman Medical Journal*, *27*(6), 465–470. https://doi.org/10.5001/omj.2012.111

Alzaheb, R. A., & Altemani, A. H. (2018). The prevalence and determinants of poor glycemic control among adults with type 2 diabetes mellitus in Saudi Arabia. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *11*, 15–21. https://doi.org/10.2147/DMSO.S156214

Arda Sürücü, H., Büyükkaya Besen, D., & Erbil, E. Y. (2018). Empowerment and social support as predictors of self-care behaviors and glycemic control in individuals with type 2 diabetes. *Clinical Nursing Research*, *27*(4), 395–413. https://doi.org/10.1177/1054773816688940

Aune, D., Norat, T., Leitzmann, M., Tonstad, S., & Vatten, L. J. (2015). Physical activity and the risk of type 2 diabetes: A systematic review and dose-response meta-analysis. *European Journal of Epidemiology*, *30*(7), 529–542. https://doi.org/10.1007/s10654-015-0056-z

Awwad Al qahtani, M. A., Khan, N. A., Alakhali, K. M., & Alavudeen, S. S. (2015). Impact of family history in glycemic control among type-2 diabetes mellitus patients in Aseer Diabetic Center. *International Research Journal of Pharmacy*, *6*(3), 191–194. https://doi.org/10.7897/2230-8407.06341

Azadi, S., Jabbarzadeh, F., Aghamohammadzadeh, N., Sarbakhsh, P., & Roshangar, F. (2020). The relationship of self-efficacy and demographic characteristics with blood glucose control in Iranian older adults with diabetes type II: A cross-sectional study. *Crescent Journal of Medical and Biological Sciences*, *7*(1), 96–103. http://www.cjmb.org/

Baltaci, D., Kutlucan, A., Ozturk, S., Saritas, A., Celer, A., Celbek, G., Deler, H., Aydin, Y., & Ankarali, H. (2012). Effectiveness for self-monitoring of blood sugar on blood glucose control in Turkish patients with type 2 diabetes mellitus. *Medicinski Glasnik*, *9*(2), 211–217. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84868219225&partnerID=40&md5=93698e70c245807775f00b09f4ccac0c

Baltaci, D., Kutlucan, A., Turker, Y., Harun Deler, M., Sariguzel, F., Ozcan, E., Ankarali, H., Yılmaz, A., Hamdi Kara, İ., Davut Baltaci, A., Kendi Kendine Kan Şekeri İzleminin Klinik Etkinliğinin Değerlendirilmesi, H., Basamak Tabanlı Bir Çalışma, B., Kelimeler, A., Mellitus, D., Basamak, B., Kendine Kan Şekeri İzlemi, K., & Kontrol, G. (2015). Evaluation of clinical effectiveness of self-monitoring blood glucose level in patients with type 2 diabetes mellitus treated with non-insulin regimens in Düzce: Primary care-based study Düzce İlinde İnsülin Kullanmayan Tip 2 Diyabet. *Konuralp Tip Dergisi*, *7*(1), 15–22. www.konuralptipdergi.duzce.edu.tr

Berkowitz, S. A., Meigs, J. B., & Wexler, D. J. (2013). Age at type 2 diabetes onset and glycaemic control: Results from the National Health and Nutrition Examination Survey (NHANES) 2005-2010. *Diabetologia*, *56*(12), 2593–2600. https://doi.org/10.1007/s00125-013-3036-4

Beutler, E. (1975). The effect of carbon monoxide on red cell life span in sickle cell disease. *Blood*, *46*(2), 253–259. https://doi.org/10.1182/blood.v46.2.253.253

Channanath, A. M., AlWotayan, R., Alkandari, H., Davidsson, L., Tuomilehto, J., & Thanaraj, T. A. (2018). Glycaemic control in native Kuwaiti Arab patients with type 2 diabetes. *Primary Care Diabetes*, *12*(6), 526–532. https://doi.org/10.1016/j.pcd.2018.07.009

Colberg, S. R., Albright, A. L., Blissmer, B. J., Braun, B., Chasan-Taber, L., Fernhall, B., Regensteiner, J. G., Rubin, R. R., Sigal, R. J.; American College of Sports Medicine, & American Diabetes Association. (2010). Exercise and type 2 diabetes: American College of Sports Medicine and the American Diabetes Association: Joint position statement. *Medicine and Science in Sports and Exercise*, *42*(12), 2282–2303. https://doi.org/10.1249/MSS.0b013e3181eeb61c

Comellas, M., Marrero, Y., George, F., & Matthews, L. (2019). Age and glycemic control among adults with type 2 diabetes in the United States: An assessment from the National Health and Nutrition Examination Survey (NHANES) 2013-2014. *Diabetes & Metabolic Syndrome*, *13*(6), 3069–3073. https://doi.org/10.1016/j.dsx.2019.11.004

Cosansu, G., & Erdogan, S. (2014). Influence of psychosocial factors on self-care behaviors and glycemic control in Turkish patients with type 2 diabetes mellitus. *Journal of Transcultural Nursing*, *25*(1), 51–59. https://doi.org/10.1177/1043659613504112

Despres, J. P., Lemieux, S., Lamarche, B., Prud'Homme, D., Moorjani, S., Brun, L. D., Gagne, C., & Lupien, P. J. (1995). The insulin resistance dyslipidemic syndrome: Contribution of visceral obesity and therapeutic implications. *International Journal of Obesity*, *19*(SUPPL. 1), S76–S86.

Dubowitz, N., Xue, W., Long, Q., Ownby, J. G., Olson, D. E., Barb, D., Rhee, M. K., Mohan, A. V., Watson-Williams, P. I., Jackson, S. L., Tomolo, A. M., Johnson, T. M., & Phillips, L. S. (2014). Aging is associated with increased HbA1c levels, independently of glucose levels and insulin resistance, and also with decreased HbA1c diagnostic specificity. *Diabetic Medicine*, *31*(8), 927–935. https://doi.org/10.1111/dme.12459

Egger, M., & Smith, G. D. (1998). Meta-analysis bias in location and selection of studies. *British Medical Journal*, *316*(7124), 61–66.

Gadekar, T., Dudeja, P., Basu, I., Vashisht, S., & Mukherji, S. (2020). Correlation of visceral body fat with waist–hip ratio, waist circumference and body mass index in healthy adults: A cross sectional study. *Medical Journal Armed Forces India*, *76*(1), 41–46. https://doi.org/10.1016/j.mjafi.2017.12.001

García-Molina, L., Lewis-Mikhael, A. M., Riquelme-Gallego, B., Cano-Ibáñez, N., Oliveras-López, M. J., & Bueno-Cavanillas, A. (2020). Improving type 2 diabetes mellitus glycaemic control through lifestyle modification implementing diet intervention: A systematic review and meta-analysis. *European Journal of Nutrition*, *59*(4), 1313–1328. https://doi.org/10.1007/s00394-019-02147-6

Gonzalez, J. S., Peyrot, M., McCarl, L. A., Collins, E. M., Serpa, L., Mimiaga, M. J., & Safren, S. A. (2008). Depression and diabetes treatment nonadherence: A meta-analysis. *Diabetes Care*, *31*(12), 2398–2403. https://doi.org/10.2337/dc08-1341

Gucuk, S. (2016). Effects of the behavior of elderly type2 diabetic patients and their relatives as caregivers on diabetes follow-up parameters in Bolu, Turkey. *Geriatrics and Gerontology International*, *16*(2), 182–190. https://doi.org/10.1111/ggi.12449

Greenberger, C., Freier Dror, Y., Lev, I., & Hazan Hazoref, R. (2014). The inter-relationships between self-efficacy, self-management, depression and glycaemic control in Israeli people with type 2 diabetes. *Journal of Diabetes Nursing*, *18*(8), 333–339. http://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=103905460&site=ehost-live

Habib, S. S. (2013a). Gender differences in lipid and glycemic control in Saudi patients with type 2 diabetes mellitus. *Rawal Medical Journal*, *38*(1), 22–25. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84874448755&partnerID=40&md5=b807a9346af867912f6a499c2023469d

Habib, S. S. (2013b). Serum lipoprotein(a) and high sensitivity C reactive protein levels in Saudi patients with type 2 diabetes mellitus and their relationship with glycemic control. *Turkish Journal of Medical Sciences*, *43*(2), 333–338. https://doi.org/10.3906/sag-1205-75.

Higgins, T., Cembrowski, G., Tran, D., Lim, E., & Chan, J. (2009). Influence of variables on hemoglobin A1c values and nonheterogeneity of hemoglobin A1c reference ranges. *Journal of Diabetes Science and Technology*, *3*(4), 644–648. https://doi.org/10.1177/193229680900300404

Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J. & Welch, V. A. (Eds.). (2019). *Cochrane handbook for systematic reviews of interventions version 6.3* (2nd ed.). John Wiley & Sons. www.training.cochrane.org/handbook

Ibrahim, F., Megahed, A. -L., & Farg, H. K. (2020). Most effiecnt factors affecting glycemic control of type II diabetic patients attending Suez Canal University Hospitals in Egypt applying stepwise regression. https://doi.org/10.32474/LOJMS.2020.04.000200

Jahanlou, A. S., & Karami, N. A. (2011). The effect of literacy level on health related-quality of life, self-efficacy and self-management behaviors in diabetic patients. *Acta Medica Iranica*, *49*(3), 153–158.

Johar, D., Ahmed, S. M., El Hayek, S., Al-Dewik, N., Bahbah, E. I., Omar, N. H., Mustafa, M., Salman, D. O., Fahmey, A., Mottawea, M., Azouz, R. A. M., & Bernstein, L. (2019). Diabetes-induced proteome changes throughout development. *Endocrine, Metabolic & Immune Disorders Drug Targets*, *19*(6), 732–743. https://doi.org/10.2174/1871530319666190305153810

Kahn, B. B., & Flier, J. S. (2000). Obesity and insulin resistance. *Journal of Clinical Investigation*, *106*(4), 473–481. https://doi.org/10.1172/JCI10842

Kautzky-Willer, A., Kosi, L., Lin, J., & Mihaljevic, R. (2015). Gender-based differences in glycaemic control and hypoglycaemia prevalence in patients with type 2 diabetes: Results from patient-level pooled data of six randomized controlled trials. *Diabetes, Obesity and Metabolism*, *17*(6), 533–540. https://doi.org/10.1111/dom.12449

Khattab, M., Khader, Y. S., Al-Khawaldeh, A., & Ajlouni, K. (2010). Factors associated with poor glycemic control among patients with type 2 diabetes. *Journal of Diabetes and its Complications*, *24*(2), 84–89. https://doi.org/10.1016/j.jdiacomp.2008.12.008

Lustman, P. J., Anderson, R. J., Freedland, K. E., de Groot, M., Carney, R. M., & Clouse, R. E. (2000). Depression and poor glycemic control: A meta-analytic review of the literature. *Diabetes Care*, *23*(7), 934–942. https://doi.org/10.2337/diacare.23.7.934

Maddah, M., & Attarpour, L. (2016). Glycemic control and its predictors among iranian diabetic patients. *Mediterranean Journal of Nutrition and Metabolism*, *9*(1), 1–6. https://doi.org/10.3233/MNM-160053

Mansour, A. A., Alibrahim, N. T. Y., Alidrisi, H. A., Alhamza, A. H., Almomin, A. M., Zaboon, I. A., Kadhim, M. B., Hussein, R. N., Nwayyir, H. A., Mohammed, A. G., Al-Waeli, D. K. J., Hussein, I. H., & Group, F. S. (2020). Prevalence and correlation of glycemic control achievement in patients with type 2 diabetes in Iraq: A retrospective analysis of a tertiary care database over a 9-year period. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, *14*(3), 265–272. https://doi.org/10.1016/j.dsx.2020.03.008

Mamo, Y., Bekele, F., Nigussie, T., & Zewudie, A. (2019). Determinants of poor glycemic control among adult patients with type 2 diabetes mellitus in Jimma University Medical Center, Jimma zone, south west Ethiopia: A case control study. *BMC Endocrine Disorders*, *19*(1), 91. https://doi.org/10.1186/s12902-019-0421-0

Mirahmadizadeh, A., Khorshidsavar, H., Seif, M., & Sharifi, M. H. (2020). Adherence to medication, diet and physical activity and the associated factors amongst patients with type 2 diabetes. *Diabetes Therapy*, *11*(2), 479–494. https://doi.org/10.1007/s13300-019-00750-8

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., Estarli, M., Barrera, E. S. A., Martínez-Rodríguez, R., Baladia, E., Agüero, S. D., Camacho, S., Buhring, K., Herrero-López, A., Gil-González, D. M., Altman, D. G., Booth, A., … Whitlock, E. (2016). Preferred reporting items for systematic

review and meta-analysis protocols (PRISMA-P) 2015 statement. *Revista Espanola de Nutricion Humana y Dietetica*, *4*. https://doi.org/10.1186/2046-4053-4-1

Mosleh, R. S., Abd Aziz, N., Ali, S. M., Manan, M. M., Zyoud, S., Shah, I. M., & Jarrar, Y. B. (2017). Predictors of good glycemic control among type II diabetes patients in Palestine. *Asian Journal of Pharmaceutical and Clinical Research*, *10*(9), 341–347. https://doi.org/10.22159/ajpcr.2017.v10i9.19453

Mozaffarian, D., Hao, T., Rimm, E. B., Willett, W. C., & Hu, F. B. (2011). Changes in diet and lifestyle and long-term weight gain in women and men. *New England Journal of Medicine*, *364*(25), 2392–2404. https://doi.org/10.1056/NEJMoa1014296

Muchiri, J. W., Gericke, G. J., & Rheeder, P. (2016). Effect of a nutrition education programme on clinical status and dietary behaviours of adults with type 2 diabetes in a resource-limited setting in South Africa: A randomised controlled trial. *Public Health Nutrition*, *19*(1), 142–155. https://doi.org/10.1017/S1368980015000956

Nemeh, A.-A.-A., Yousef, S. K., & Aysha, M. A. (2011). Glycemic control and its determinants among patients with type 2 diabetes mellitus attending a teaching hospital. *Journal of Diabetes and Metabolism*, *2*(4), 1–5. https://doi.org/10.4172/2155-6156.1000129

Noureddine, H., Nakhoul, N., Galal, A., Soubra, L., & Saleh, M. (2014). Level of A1C control and its predictors among Lebanese type 2 diabetic patients. *Therapeutic Advances in Endocrinology and Metabolism*, *5*(3), 43–52. https://doi.org/10.1177/2042018814544890

Pan, A., Wang, Y., Talaei, M., Hu, F. B., & Wu, T. (2015). Relation of active, passive, and quitting smoking with incident type 2 diabetes: A systematic review and meta-analysis. *The Lancet Diabetes and Endocrinology*, *3*(12), 958–967. https://doi.org/10.1016/S2213-8587(15)00316-2

Perseghin, G., Price, T. B., Petersen, K. F., Roden, M., Cline, G. W., Gerow, K., Rothman, D. L., & Shulman, G. I. (1996). Increased glucose transport–phosphorylation and muscle glycogen synthesis after exercise training in insulin-resistant subjects. *New England Journal of Medicine*, *335*(18), 1357–1362. https://doi.org/10.1056/nejm199610313351804

Qteishat, R. R., & Ghananim, A. R. (2016). Comprehensive assessment of variables affecting metabolic control in patients with type 2 diabetes mellitus in Jordan. *Diabetes & Metabolic Syndrome*, *10*(1 Supplement 1), S56–S59. https://doi.org/10.1016/j.dsx.2015.09.014

Radwan, M., Elsous, A., Al-Sharif, H., & Abu Mustafa, A. (2018). Glycemic control among primary care patients with type 2 diabetes mellitus in the Gaza strip, Palestine. *Therapeutic Advances in Endocrinology and Metabolism*, *9*(1), 3–14. https://doi.org/10.1177/2042018817742070

Rajput, R., Rajput, M., Bairwa, M., Singh, J., Saini, O., & Shankar, V. (2014). Waist height ratio: A universal screening tool for prediction of metabolic syndrome in urban and rural population of Haryana. *Indian Journal of Endocrinology and Metabolism*, *18*(3), 394–399. https://doi.org/10.4103/2230-8210.131201

Rana, J. S., Li, T. Y., Manson, J. A. E., & Hu, F. B. (2007). Adiposity compared with physical inactivity and risk of type 2 diabetes in women. *Diabetes Care*, *30*(1), 53–58. https://doi.org/10.2337/dc06-1456

Röckl, K. S. C., Witczak, C. A., & Goodyear, L. J. (2008). Signaling mechanisms in skeletal muscle: Acute responses and chronic adaptations to exercise. *IUBMB Life*, *60*(3), 145–153. https://doi.org/10.1002/iub.21

Rodríguez-Gutiérrez, R., & Montori, V. M. (2016). Glycemic control for patients with type 2 diabetes mellitus: Our evolving faith in the face of evidence. *Circulation: Cardiovascular Quality and Outcomes*, *9*(5), 504–512. https://doi.org/10.1161/CIRCOUTCOMES.116.002901

Saad, A. M. J., Younes, Z. M. H., Ahmed, H., Brown, J. A., Al Owesie, R. M., & Hassoun, A. A. K. (2018). Self-efficacy, self-care and glycemic control in Saudi Arabian patients with type 2 diabetes mellitus: A cross-sectional survey. *Diabetes Research and Clinical Practice*, *137*, 28–36. https://doi.org/10.1016/j.diabres.2017.12.014

Saghir, S. A. M., Alhariri, A. E. A., Alkubati, S. A., Almiamn, A. A., Aladaileh, S. H., & Alyousefi, N. A. (2019). Factors associated with poor glycemic control among type-2 diabetes mellitus patients in Yemen. *Tropical Journal of Pharmaceutical Research*, *18*(7), 1539–1546. https://doi.org/10.4314/tjpr.v18i7.26

Saha, S., & Schwarz, P. E. H. (2017). Impact of glycated hemoglobin (HbA1c) on identifying insulin resistance among apparently healthy individuals. *Journal of Public Health (Germany)*, *25*(5), 505–512. https://doi.org/10.1007/s10389-017-0805-4

Samancioglu, S., Surucu, H. A., Donmez, R. O., & Cevik, A. B. (2017). Factors affecting glycemic control in type 2 diabetics and diabetics' attitude towards the disease. *International Journal of Caring Sciences*, *10*(2), 889–896.

Samara, M., Horoub, A., Ibaidi, N., & Sweileh, W. (2017). Prevalence of glycemic control and factors associated with increasing levels of HbA1c among a sample of Palestinian patients with type 2 diabetes mellitus. *Palestinian Medical and Pharmaceutical Journal*, *2*(2), 82–92.

Shperling, T., & Danon, D. (1990). Age population distribution of erythrocytes in young and old healthy donors. *Experimental Gerontology*, *25*(5), 413–422. https://doi.org/10.1016/0531-5565(90)90030-6

Smith, R. J., Koenig, R. J., & Binnerts, A. (1982). Regulation of hemoglobin A(I)(c) formation in human erythrocytes in vitro. Effects of physiologic factors other than glucose. *Journal of Clinical Investigation*, *69*(5), 1164–1168. https://doi.org/10.1172/JCI110552

Sobers-Grannum, N., Murphy, M. M., Nielsen, A., Guell, C., Samuels, T. A., Bishop, L., & Unwin, N. (2015). Female gender is a social determinant of diabetes in the Caribbean: A systematic review and meta-analysis. *PLoS One*, *10*(5), e0126799. https://doi.org/10.1371/journal.pone.0126799

Soulimane, S., Simon, D., Herman, W. H., Lange, C., Lee, C. M. Y., Colagiuri, S., Shaw, J. E., Zimmet, P. Z., Magliano, D., Ferreira, S. R. G., Dong, Y., Zhang, L., Jorgensen, T., Tuomilehto, J., Mohan, V., Christensen, D. L., Kaduka, L., Dekker, J. M., Nijpels, G., … Balkau, B. (2014). HbA1c, fasting and 2 h plasma glucose in current, ex- and never-smokers: A meta-analysis. *Diabetologia*, *57*(1), 30–39. https://doi.org/10.1007/s00125-013-3058-y

TeachMideast. (2020). *Middle East Countries*. https://teachmideast.org/country-profiles/

Thunander Sundbom, L., & Bingefors, K. (2012). Women and men report different behaviours in, and reasons for medication non-adherence: A nationwide Swedish survey. *Pharmacy Practice (Internet)*, *10*(4), 207–221. https://doi.org/10.4321/S1886-36552012000400005

Toh M. (2011). Association of younger age with poor glycemic and cholesterol control in Asians with type 2 diabetes mellitus in Singapore. *Journal of Endocrinology and Metabolism*. https://doi.org/10.4021/jem13e

Tol, A., Sharifirad, G., Shojaeezadeh, D., Alhani, F., & Tehrani, M. M. (2012). Determination of empowerment score in type 2 diabetes patients and its related factors. *Journal of the Pakistan Medical Association*, *62*(1). http://jpma.org.pk/PdfDownload/3219.pdf

Van Der Kooy, K., Leenen, R., Seidell, J. C., Deurenberg, P., Droop, A., & Bakker, C. J. G. (1993). Waist-hip ratio is a poor predictor of changes in visceral fat. *American Journal of Clinical Nutrition*, *57*(3), 327–333. https://doi.org/10.1093/ajcn/57.3.327

Vazquez, G., Duval, S., Jacobs, D. R., & Silventoinen, K. (2007). Comparison of body mass index, waist circumference, and waist/hip ratio in predicting incident diabetes: A meta-analysis. *Epidemiologic Reviews*, *29*(1), 115–128. https://doi.org/10.1093/epirev/mxm008

Walker, E. A., Molitch, M., Kramer, M. K., Kahn, S., Ma, Y., Edelstein, S., Smith, K., Johnson, M. K., Kitabchi, A., & Crandall, J. (2006). Adherence to preventive medications: Predictors and outcomes in the diabetes prevention program. *Diabetes Care*, *29*(9), 1997–2002. https://doi.org/10.2337/dc06-0454

Wang, Y., Ji, J., Liu, Y. J., Deng, X., & He, Q. Q. (2013). Passive smoking and risk of type 2 diabetes: A meta-analysis of prospective cohort studies. *PLoS One*, *8*(7), e69915. https://doi.org/10.1371/journal.pone.0069915

Wells, G., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., & Tugwell, P. (2014). Newcastle-Ottawa quality assessment scale cohort studies. *Visual Communication Quarterly*.

Wiener, K., & Roberts, N. B. (1999). Age does not influence levels of HbA(1c) in normal subject. *QJM*, *92*(3), 169–173. https://doi.org/10.1093/qjmed/92.3.169

Williams, R., Colagiuri, S., Chan, J., Gregg, E., Ke, C., Lim, L. -L., & Yang, X. (2019). *IDF atlas* (9th ed.).International Diabetes Federation.

World Health Organization (WHO). (2020). *Obesity and overweight*.

Yacoub, S. E., Mansur, M. H., & Raheem, Y. A. (2011). Effect of frequent self-monitoring of blood glucose on HbAlc level among type 2 diabetic patients. *Research Journal of Medical Sciences*, *5*(3), 145–149. https://doi.org/10.3923/rjmsci.2011.145.149

Zheng, F., Liu, S., Liu, Y., & Deng, L. (2019). Effects of an outpatient diabetes self-management education on patients with type 2 diabetes in China: A randomized controlled trial. *Journal of Diabetes Research*, *2019*, 1–7. https://doi.org/10.1155/2019/1073131

## SUPPORTING INFORMATION

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**Appendix 3.2 The Newcastle-Ottawa Scale (NOS) for quality appraisal of observational studies:**

The Newcastle-Ottawa Scale (NOS) for observational studies (Case-control, Cohort, and Cross-sectional studies) was used (Wells et al., 2014). The NOS uses a star system (with a maximum of 9 stars) to evaluate a study in 3 domains: selection of participants (4 items; Representativeness of the sample, Selection of the Non-Exposed, Ascertainment of Exposure, Non-respondents); comparability of study groups (2 items; Control for Confounders); and the ascertainment of outcomes of interest (3 items; Assessment of outcome, Was Follow-Up Long Enough for Outcomes to Occur, Adequacy of Follow-Up of Cohorts) (Table 3.2). We interpreted the score as follows: very good studies (9 points), good studies (7-8 points), satisfactory studies (5-6 points), unsatisfactory studies (0-4 points) (Modesti et al., 2016).

**Assessment of Heterogeneity:** Forest plots were inspected visually for any heterogeneity. We assessed the heterogeneity using the I-square ($I^2$) and Chi-square ($Chi^2$) tests. For the $Chi^2$ test of the Q-statistics, an alpha level below 0.1 was considered significant heterogeneity (J. P. T. Higgins et al., 2019). To quantify the magnitude of heterogeneity among effect estimates of the included studies, we interpreted the $I^2$ test results as the follows: values from 0% to 30% indicated likely minimal heterogeneity; values from 30% to 60%, likely moderate, and values from 60% to 100%, likely substantial heterogeneity (Higgins et al., 2019).

**Appendix 3.3. Summary table of baseline characteristics of the included studies and patients.**

| Study ID | Study title | Country | Sample size | Age | Gender | Educated | Use of insulin (%) | Disease duration | % of uncontrolled Glycaemic | BMI | HbA1c (%) | Fasting plasma glucose (mmol/L) | Obesity | Smoking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abdullah et al.(2020) | Glycaemic control in Kuwaiti diabetes patients treated with glucose-lowering medication | Kuwait | 278 | 51.1 (11.7) | M: 40% F: 60% | NA | 45.7% | NA | 65.5% | 33.1 (6.7) | 8.17 (2.24) | 9.42 (4.26) | 68.2% | 11.2% |
| Abuhegazy (2017) | Depression and glycaemic control in a sample of people with type 2 diabetes | Egypt | 180 | 51.2 (6.1) | M:180 | 64.4% | NA | 10.8 (3.6) | NA | 31.7 (5.9) | 8.7 (2.04) | 179.6 (7.6) | NA | 44.4% |
| Adham et al.(2010) | Glycaemic control and its associated factors in type 2 diabetic patients in Amman, Jordan | Jordan | 1000 | 58.1 (9.3) | M:49.5% F: 50.5% | 90% | 45.6% | 9.4 (7.2) | 75.9% | NA | 8.1 (1.8) | NA | 57.6% | 15% |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aghili et al.(2016) | Type 2 Diabetes: Model of Factors Associated with Glycaemic Control | Iran | 380 | 54.73 (8.00) | M:46.6% F:53.4% | 100% | 43.4% | 8.94 (6.57) | NA | 28.3 (4.30) | 7.78 (1.7) | NA | NA | 13.7% |
| Ahmadian et al. (2018) | The Relation between Anxiety, Depression and Sexual Dysfunction and the Level of Blood Glucose Control in People with Type 2 Diabetes Attending Endocrine Clinic of Taleghani Hospital | Iran | 141 | NA | NA | NA | NA | NA | 48.2% | NA | NA | NA | NA | NA |
| Akin (2019) | Overtreatment and Hypoglycemia Prevalence In Geriatric People with Type-2 Diabetes In The Turkish Population | Turkey | 755 | 70.9 (5.9) | M: 38.3% F: 60.67 | NA | 65.8% | M: 18.3 (8.5)<br>F: 18.7 (9.1) | 65.9% | 32.7 (5.4) | M: 7.8 (1.6) F: 7.6 (1.4) | NA | NA | NA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Al-Hayek et al. (2012) | Association between diabetes self-care, medication adherence, anxiety, depression, and glycaemic control in type 2 diabetes | Saudi Arabia | 147 | 57.3 (14.4) | M: 67.3% F: 32.7% | NA | NA | 12.7 (7.3) | 83.4% | NA | <7%: 29.3%<br>>7%: 70.7 | NA | 22.4% | 28.6% |
| Al Saweer (2015) | The Profile of Vitamin D among Type 2 Diabetes Mellitus Patients | Bahrain | 268 | 57.6 (10.6) | M: 43% F: 57% | 94.55 | NA | 8.5 (12.08) | NA | NA | NA | NA | NA | NA |
| Al Slamah et al. (2020) | Correlates of type 2 diabetes and glycaemic control in adults in Saudi Arabia a secondary data analysis of the Saudi health interview survey | Saudi Arabia | 808 | 38.38 (16.1) | M: 59% F: 41% | 40.8% | NA | NA | 41% | NA | NA | NA | 86.2% | 14.1% |
| ALAboudi et al. (2016) | Self-efficacy, self-care behaviours and glycaemic control in | Saudi Arabia | 75 | 54 (9.2) | M:77.3% | 100% | 37.4% | 12.6 (8.4) | 96% | NA | 9.26 (1.68) | NA | NA | NA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | type 2 diabetic patients in Riyadh, Saudi Arabia | | | | F:22.7 % | | | | | | | | | |
| Al Balushi et al. (2014) | Glycaemic control among people with type 2 diabetes at a primary health care center in Oman | Oman | 177 | 53 (12) | M: 40% F: 60% | NA | 11% | 5.0 (2.3-7.0) | 65% | 30 (12) | NA | NA | NA | NA |
| Albasheer et al. (2018) | Depression and related risk factors among people with type 2 diabetes mellitus, Jazan area, KSA: A cross-sectional study | Saudi Arabia | 385 | 47.9 (11.4) | M: 47.8% F: 52.2% | 78.7% | NA | 3.07 (0.89) | 28.05% | NA | 3.08 (1.0) | NA | NA | NA |
| Al Dossari et al. (2019) | Association of vitamin d with glycaemic control in Saudi people with type 2 diabetes: A retrospective chart review study in an | Saudi Arabia | 200 | 42.4 (14.8) | M:41 % F:59 % | NA | NA | NA | 36.5% | 29.0 (6.5) | 7.1 (1.98) | 7.9 (3.7) | 42.5% | NA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | emerging university hospital | | | | | | | | | | | | | |
| AL-Eitan et al. (2016) | Evaluation of Glycaemic Control, Lifestyle and Clinical Characteristics in People with Type 2 Diabetes Treated at King Abdullah University Hospital in Jordan | Jordan | 237 | 56.85 (9.31) | M: 38% F: 62% | 100% | 40% | 9.20 (8.10) | 60.8% | 32.4 (6.04) | 7.99 (2.20) | 152.82 (73.4) | 66.7% | 9.7% |
| Al Hayek et al. (2014) | Factors Associated with Health-Related Quality of Life among Saudi People with Type 2 Diabetes Mellitus: A Cross-Sectional Survey | Saudi Arabia | 283 | 56.4 (13.2) | M:62.9% F:37.1% | 100% | 26.9% | (<5 - >15) years | NA | NA | NA | NA | NA | NA |
| Ali et al. (2013) | Evaluation of factors associated with inadequate glycaemic control and some other | UAE | 450 | NA | M: 225 F:225 | NA | NA | NA | 70.9% | NA | 7.6 (1.3) | NA | 90.7% | NA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | health care indicators among people with type 2 diabetes in Ramallah, Palestine | | | | | | | | | | | | | |
| Al-Lawati et al. (2012) | HbA1c Levels among Primary Healthcare People with Type 2 Diabetes Mellitus in Oman | Oman | 1266 | 53.3 (11.5) | M:45% F:55% | NA | 12.7% | <5: 54%<br>>5: 46% | 68% | 30.1 (5.7) | 8.2 (2.0) | NA | NA | 6% |
| Almetwazi et al. (2019) | Factors associated with glycaemic control in type 2 diabetic patients in Saudi Arabia | Saudi Arabia | 728 | 45-60 | M:35.16% F: 64.84% | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Al-Mukhtar et al. (2012) | General and Gender Characteristics of Type 2 Diabetes Mellitus Among the Younger and Older Age Groups | Iraq | 462 | 52.5 (6.4) | M: 52.8 F: 47.2 | NA | NA | <5:>10 | 78.3% | NA | NA | NA | 34.8% | 51.9% |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Almutairi & Alkharfy, (2013) | Direct Medical Cost and Glycaemic Control in Type 2 Diabetic Saudi Patients | Saudi Arabia | 300 | 58.3 (13.5) | M: 56% F: 44% | 72% | NA | NA | 66.67% | NA | NA | NA | NA | NA |
| Al qahtani et al. (2015) | Impact of family history in glycaemic control among type-2 diabetes mellitus patients in Aseer diabetic center | Saudi Arabia | 343 | 59.8 (10.39) | M: 62% F: 38% | NA | NA | 15.95 (7.55) | NA | 30.37(5.61) | 9.78 (2.12) | NA | NA | NA |
| Alqudah et al. (2019) | Factors Associated with Poor Hemoglobin A1c Control in People with Type 2 Diabetes | Jordan | 171 | 64 (9.8) | M:56.7% F: 43.3% | 25.7% | 77.2% | 9.9 (7.5) | NA | NA | NA | NA | NA | 49.7% |
| Alramadan et al. (2018b) | Glycaemic control for people with type 2 diabetes in Saudi Arabia – an urgent need for a review of management plan | Saudi Arabia | 1111 | 57.6 (11.1) | M: 65.2% F: 34.8% | 97.9% | NA | 13.9 (8.4) | 54.2% | 69.4 (15.5) | NA | NA | 61.1% | 5.67% |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Al-Rasheedi (2014) | The Role of Educational Level in Glycaemic Control among People with Type II Diabetes Mellitus | Saudi Arabia | 384 | 56 (10.91) | M:47.9% F: 52.1% | 82.3 | 28.7% | <7: >15 | 67.7% | 44 | NA | NA | 50.5 | NA |
| Alromaihi (2019) | Factors Affecting Glycaemic Control among People with Type 2 Diabetes in Bahrain | Bahrain | 205 | 54.8 (11.7) | M:47.9% F:52.1% | 33.5% | 63.4% | <5:>10 | 71.1% | NA | NA | NA | 67.6% | 13.9% |
| Al-Shahrani et al. (2012) | Effects of diabetes education program on metabolic control among Saudi type 2 diabetic patients | Saudi Arabia | 438 | 55.84 (10) | M: 63.9% F: 36.1% | NA | NA | NA | NA | NA | 8.78 (1.78) | 9.99 (2.62) | NA | NA |
| Alzaheb & Altemani (2018) | The prevalence and determinants of poor glycaemic control among adults with type 2 diabetes | Saudi Arabia | 423 | 30–49 | M:52.7% F: 47.3% | 93.4% | 43.97% | <5:>10 | 74.9% | NA | NA | NA | 21.5% | 19.38% |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mellitus in Saudi Arabia | | | | | | | | | | | | | |
| Alzahrani et al. (2019) | Association between glycated hemoglobin (HbA1c) and the lipid profile in people with type 2 diabetes mellitus at a tertiary care hospital: a retrospective study | Saudi Arabia | 206 | 60.46 (13.54) | M: 31.5% F: 68.4% | NA | NA | NA | 56.3% | 30.8 (6.1) | 7.65 (1.78) | 147.7 (58.7) | NA | NA |
| Azadi et al. (2020) | The Relationship of Self-efficacy and Demographic Characteristics With Blood Glucose Control in Iranian Older Adults With Diabetes Type II: A Cross-Sectional Study | Iran | 290 | 71.80 (5.39) | M: 46.2 F: 53.8% | 100% | 14.5% | NA | 51.37% | NA | 7.82 (9.7) | NA | NA | 35% |
| Baltaci et al. (2012) | Effectiveness for self-monitoring of blood sugar on blood | Turkey | 349 | 54.2 (9.7) | M:41.3% | 87.1% | 0% | 6.5 (4.9) | 39.2% | 31.5 (5.6) | 7.6 (1.7) | 158.8 (59.5) | NA | 16.9% |

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| | glucose control in Turkish people with type 2 diabetes mellitus | | | | F: 58.7% | | | | | | | | | |
| Baltaci et al. (2015a) | Evaluation of Clinical Effectiveness of Self-Monitoring Blood Glucose Level in People with Type 2 Diabetes Mellitus Treated with Non Insulin Regimens in Düzce: Primary Care-Based Study | Turkey | 680 | 55.4 (10.8) | M:40.8% F: 59.2% | 90.2% | NA | 6.9 (4.3) | NA | 32.7 (5.9) | 7.6 (1.6) | NA | NA | 18.8% |
| Channanath et al. (2018) | Glycaemic control in native Kuwaiti Arab people with type 2 diabetes | Kuwait | 765 7 | 50.3 (12.1) | M: 43.9% F: 56.01 % | NA | 26% | 8 (7.35) | 74.4% | 31.8 (6.2) | NA | NA | 36.04 % | NA |
| Cosansu & Erdogan (2013) | Influence of Psychosocial Factors on Self-Care | Turkey | 350 | 53.42 (8.02) | M:40.3% | 100% | 41.6% | 8.61 (6.03) | NA | 30.8 (5.35) | 7.34 (1.62 ) | NA | NA | NA |

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| | Behaviors and Glycaemic Control in Turkish People with Type 2 Diabetes Mellitus | | | | F: 59.7% | | | | | | | | | |
| Greenberger et al. (2014) | The inter-relationships between self-efficacy, self-management, depression and glycaemic control in Israeli people with type 2 diabetes | Israel | 600 | 70 years | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Gucuk (2015) | Effects of the behavior of elderly type 2 diabetic patients and their relatives as caregivers on diabetes follow-up parameters in Bolu, Turkey | Turkey | 115 | 71 (5.01) | M:44.3% F: 55.7% | 86.1% | NA | 12.14 (6.74) | 44.34% | 30.2 (4.2) | 7.09 (0.64) | NA | 50.4% | NA |
| Habib (2013) | Gender differences in lipid and glycaemic control in Saudi | Saudi Arabia | 10 | 54.5 (11.23) | M:50.1 F:49.9 | NA | NA | NA | 77.58% | 30.1 (5.39) | 9.36 (3.06) | 10.13 (5.28) | NA | NA |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | people with Type 2 diabetes mellitus | | 00 | | | | | | | | | | | |
| Jahanlou & Alishan (2011) | The Effect of Literacy Level on Health Related-Quality of Life, Self Efficacy and Self-Management Behaviors in Diabetic Patients | Iran | 256 | 49.15 (9.5) | M:32.5% F: 67.5% | NA | 0% | 6.33 (5.12) | 70% | NA | NA | NA | 16.5% | NA |
| Khattab et al. (2010) | Factors associated with poor glycaemic control among people with Type 2 diabetes | Jordan | 917 | 57.4 (9.6) | M: 455 F: 462 | 88.98% | 37.7% | 9.03 (7.04) | 65.1% | 31.8 (5.7) | NA | NA | 58% | NA |
| Maddah & Attarpour (2016) | Glycaemic control and its predictors among Iranian diabetic patients | Iran | 367 | 53.2 (11.3) | M: 35.9% F: 64.1% | 100% | 15.45% | NA | 72.9% | NA | 7.7 (1.05) | 183.9 (62.5) | NA | NA |
| Mansour et al. (2020) | Prevalence and correlation of glycaemic control achievement in people with type 2 diabetes | Iraq | 12869 | 51.4 (11.34) | M:45.6% F: 54.4% | NA | 54.2% | 9.7 (11.34) | 75.7% | 29.9 (11.3) | 10.1 (22.68) | NA | NA | NA |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in Iraq: A retrospective analysis of a tertiary care database over a 9-year period | | | | | | | | | | | | | |
| Megahed & Farg (2020) | Most Effiecnt Factors Affecting Glycaemic Control of Type II Diabetic Patients Attending Suez Canal University Hospitals in Egypt Applying Stepwise Regression | Egypt | 92 | 49.76 (9.19) | M: 31.5% F: 68.5% | 57.6% | NA | 2.63 (1.6) | 65.2% | 32.5 (5.65) | NA | NA | 60.9% | 3.3% |
| Mirahmadizadeh et al. (2020) | Adherence to Medication, Diet and Physical Activity and the Associated Factors Amongst People with Type 2 Diabetes | Iran | 500 | 56.92 (0.52) | M: 41.2% F:58.8% | 79.6% | 28.4% | NA | 60.2% | NA | 7.48 (0.06) | NA | 22.1% | 12.8% |
| Mosleh et al. (2017) | Predictors of Good Glycaemic Control Among Type II | Palestinian | 330 | 60 (9.7) | M:51.2% | 89.7% | 76.4% | 14.0 (9-20) | 79.7% | NA | 8.4 (1.7) | NA | 47.2% | 36.2% |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diabetes Patients in Palestine | | | | F: 48.8% | | | | | | | | | |
| Nemeh A et al. (2011) | Glycaemic Control and Its Determinants among People with type 2 Diabetes Mellitus Attending a Teaching Hospital | Jordan | 533 | 50.1 (14.1) | M: 38% F: 62% | NA | NA | NA | 40.3% | 27.6 (3.5) | NA | NA | 22.3% | 75.9% |
| Noureddine et al . (2014) | Level of A1C control and its predictors among Lebanese type 2 diabetic patients | Lebanon | 551 | 58.5 (12.4) | M: 57.5% F: 42.4% | NA | 32.3% | 8.2 (7.5) | 68.2% | 30.5 (5.5) | NA | NA | 46% | 56.1% |
| Al Nozha (2014) | Diabetes care and control: the effect of frequent visits to diabetes care center | Saudi Arabia | 100 | 52.0 (15.2) | M: 42% F: 58% | 90% | 17% | 12 (2.1) | NA | 28.8 (6.4) | 8.3 (1.6) | NA | NA | 32% |
| Qteishat & Ghananim (2016) | Comprehensive assessment of variables affecting metabolic control in people with type 2 | Jordan | 200 | 53.53 (10.38) | M:40 % F: 60% | 83% | 27.5% | NA | 67% | NA | 8.4 (1.95) | NA | 55% | NA |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | diabetes mellitus in Jordan | | | | | | | | | | | | | |
| Radwan et al.(2017) | Glycaemic control among primary care people with type 2 diabetes mellitus in the Gaza Strip, Palestine | Palestine | 369 | 56.38 (10.36) | M: 44.1% F: 55.8% | NA | 23% | 10.48 (8.1) | 80.4% | NA | 8.97 (2.02) | NA | NA | NA |
| Saad et al. (2018) | Self-efficacy, Self-care and Glycaemic control in Saudi Arabian people with type 2 Diabetes Mellitus: A Cross-sectional Survey | Saudi Arabia | 123 | 61.97 (11.53) | M: 72.4% F: 27.6% | 73.2% | 47.1% | NA | NA | NA | 7.6 (1.7) | NA | 43.1% | 13% |
| Saghir et al. (2019) | Factors associated with poor glycaemic control among type-2 diabetes mellitus patients in Yemen | Yemen | 246 | 49.5 (11.8) | M: 52.4% F: 47.6% | 70.7% | 25.2% | 7.1 (5.1) | 73.2% | 25.8 (4.9) | 8.8 (2.2) | NA | 16.7% | 29.3% |

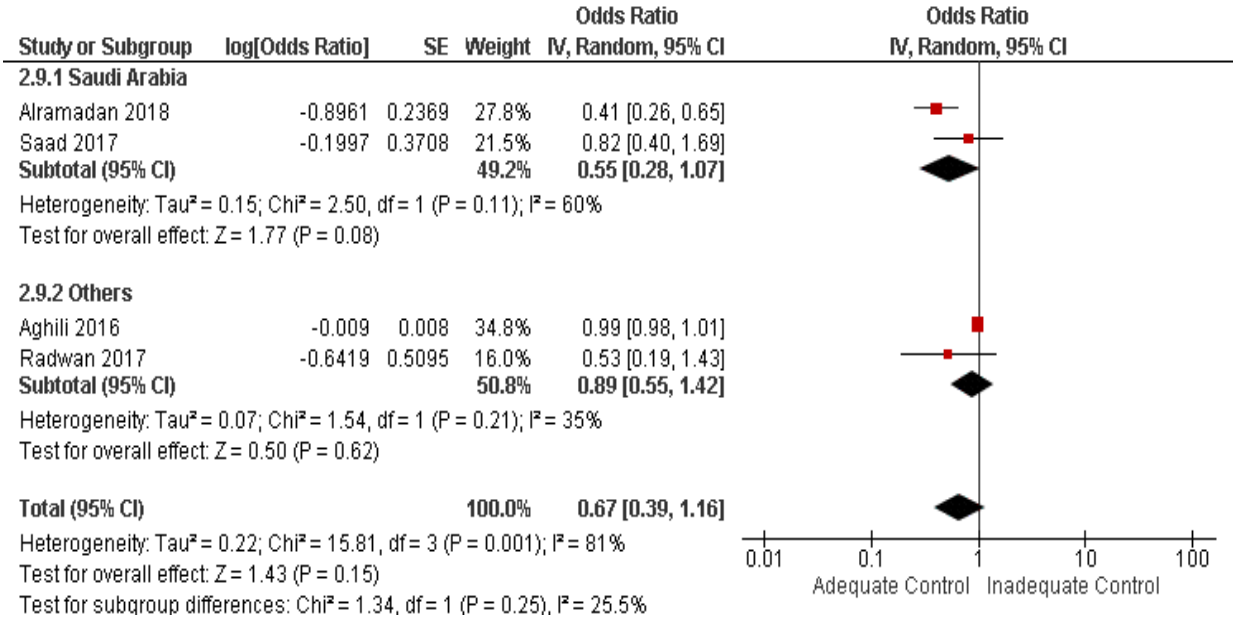
| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Samancioglu et al.(2017) | Factors Affecting Glycaemic Control in Type 2 Diabetics and Diabetics' Attitude towards the Disease | Turkey | 341 | NA | M: 36.1% F: 63.9% | 100% | 62.8% | NA | 22.9% | NA | 9.80 (3.43) | NA | NA | NA |
| Samara et al.(2017) | Prevalence of Glycaemic Control and Factors Associated With Increasing Levels of Hba1c Among A Sample of Palestinian People with Type 2 Diabetes Mellitus | Palestine | 380 | 11.2 (8.2) | M: 42.1% F: 57.9% | 86.8% | 58.4% | 11.2 (8.2) | 73.2% | 32.7 (6) | 8.3 (1.8) | NA | 68.9% | 26.3% |
| Sürücü et al.(2017) | Empowerment and Social Support as Predictors of Self-Care Behaviors and Glycaemic Control in Individuals With Type 2 Diabetes | Turkey | 220 | 53.63 (11.48) | M: 46.4% F: 53.6% | 73.1% | 74.5% | 10.17 (7.95) | NA | NA | 9.95 (2.22) | NA | NA | NA |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tol et al. (2012) | The Relationship between perceived social support from family and diabetes control among people with diabetes type 1 and type 2 | Iran | 317 | 35-60 | M: 45.4% F: 54.6% | 68.1% | NA | NA | 45.4% | NA | NA | NA | 23.7% | NA |
| Yacoub et al. (2011) | Effect of Frequent Self-Monitoring of Blood Glucose on HbAlc Level Among Type 2 Diabetic Patients | Iraq | 126 | 41.58 (13.8) | M:50.7% F: 49.3% | 100% | 77.78% | NA | NA | 27.05(4.9) | 7.01 (1.23) | NA | NA | NA |

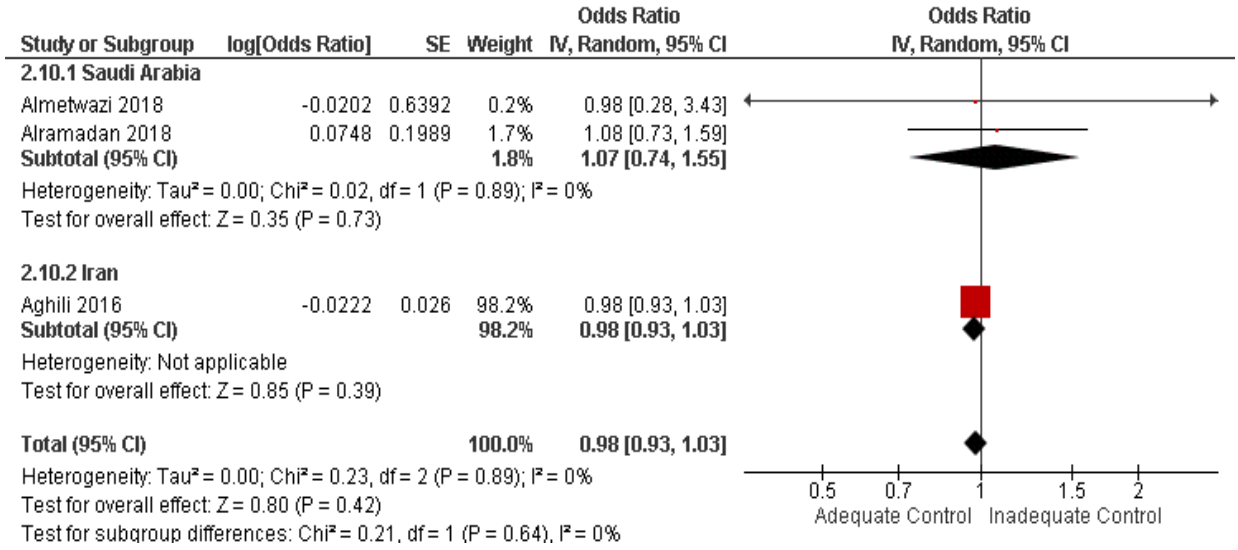
NA: Not available; M: Male; F: Female.

**Appendix 3.4. Forest plot of the mean difference between adequate and inadequate glycaemic control in terms of participants' characteristics**

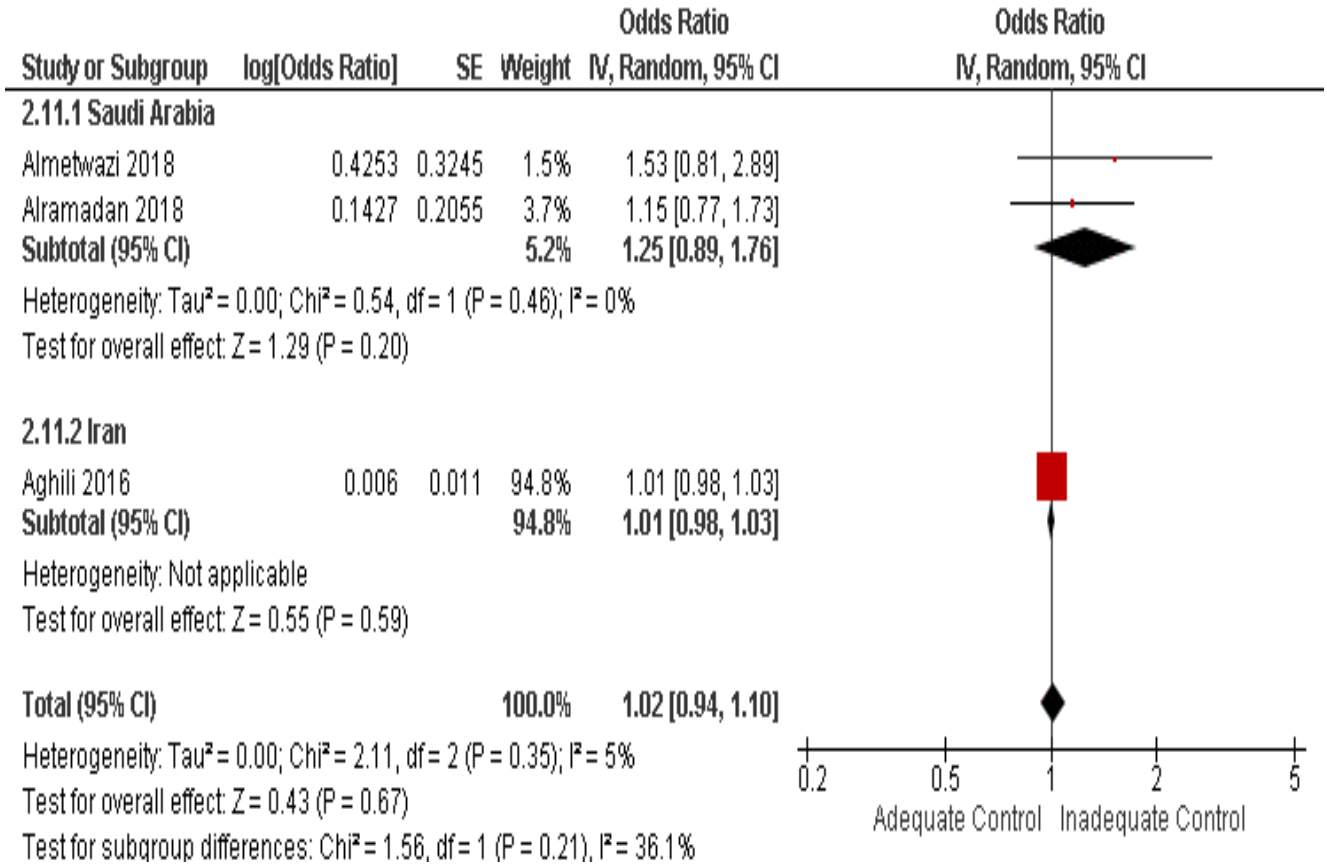
**A) Forest plot of the Odds Ratio of inadequate glycaemic control in relation to diabetes knowledge**



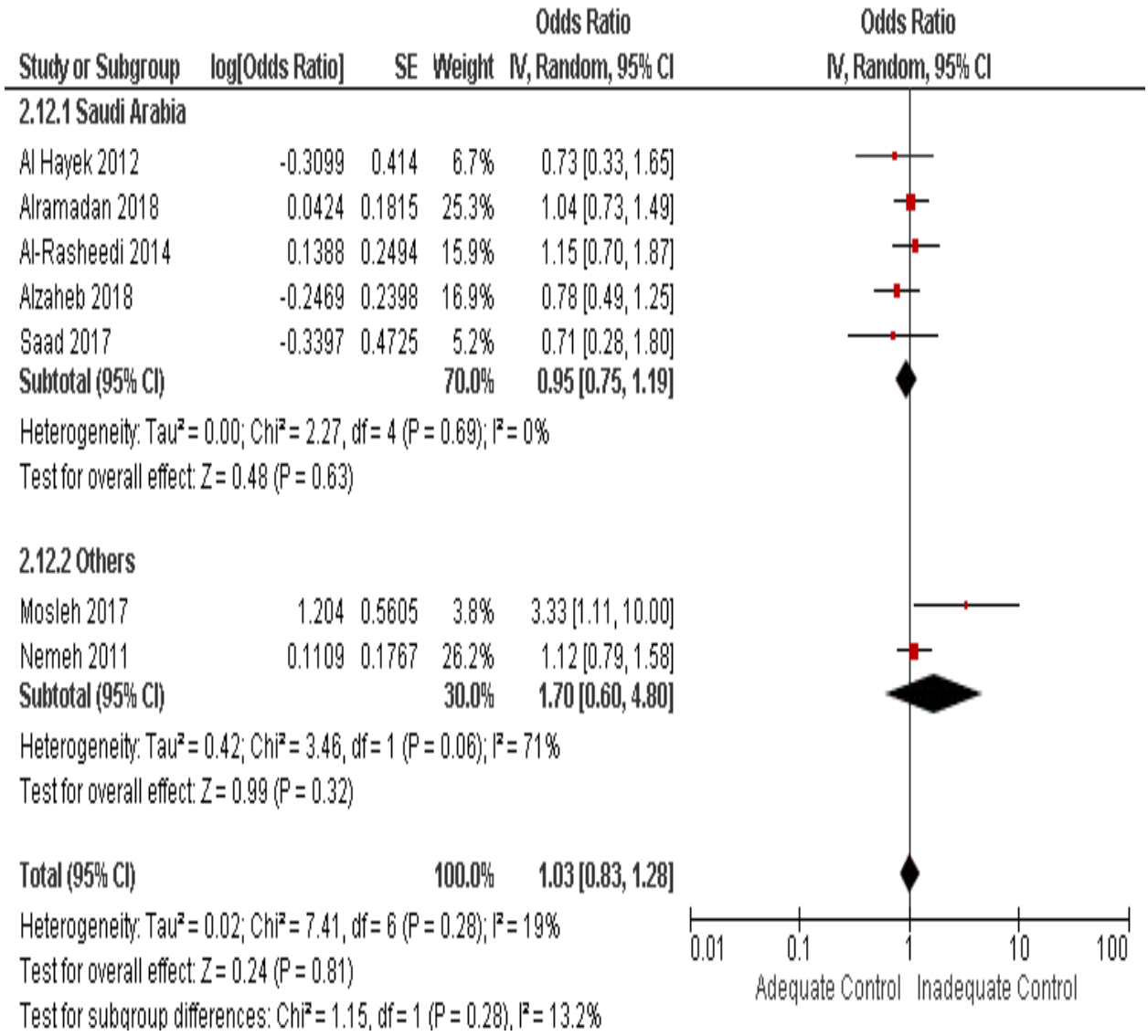
**B) Forest plot of the Odds Ratio of inadequate glycaemic control in relation to depression**



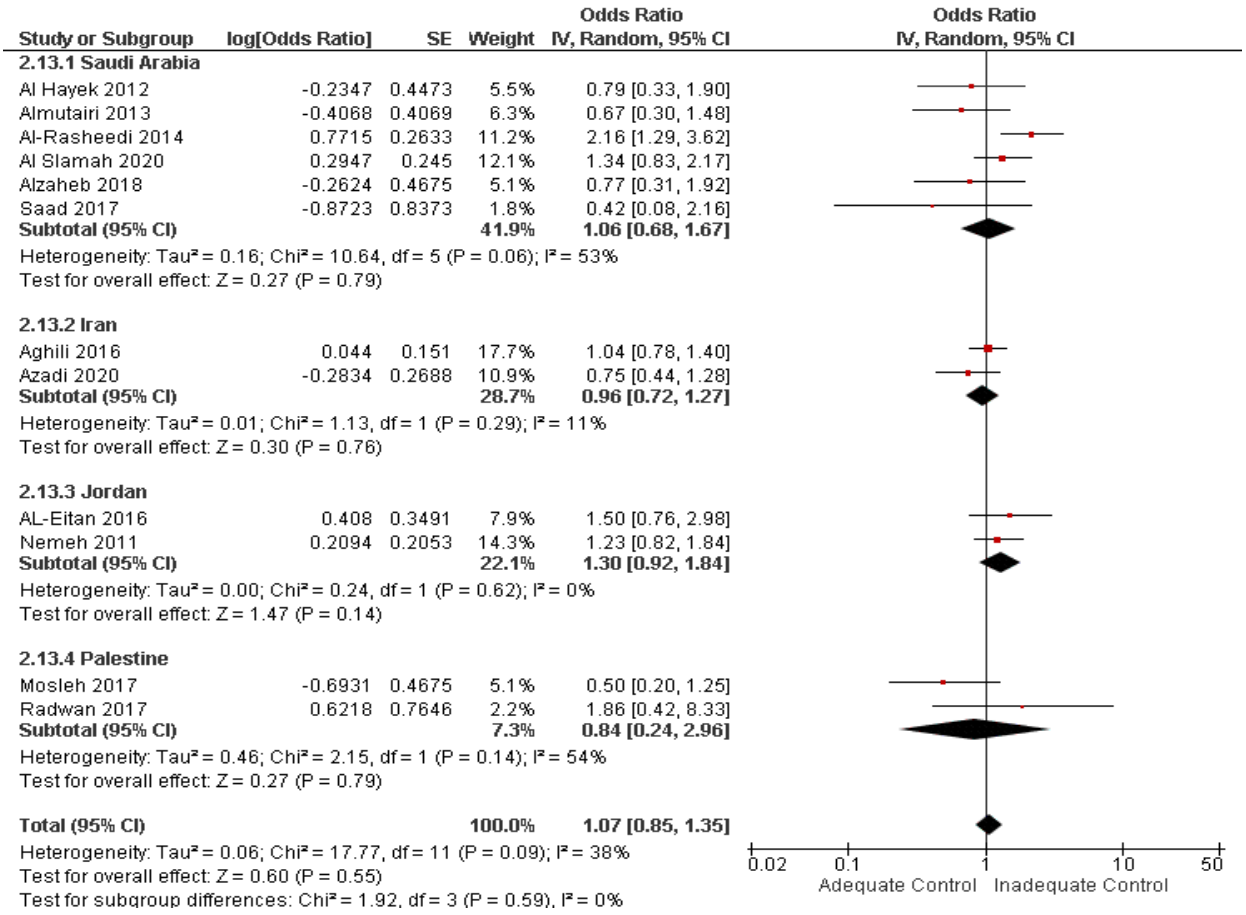
**C) Forest plot of the Odds Ratio of inadequate glycaemic control in relation to Anxiety**



**D) Forest plot of the Odds Ratio of inadequate glycaemic control in relation to Employment**



- **E) Forest plot of the Odds Ratio of inadequate glycaemic control in relation to Marital status**



**Appendix 4.1 Depression Anxiety and Stress Scales (DASS-21) item responses.**

| DASS items | | | N (%) |
|---|---|---|---|
| **Depression sub-scale** | I couldn't seem to experience any positive feeling at all | Did not apply to me at all | 229(71.1%) |
| | | Applied to me to some degree, or some of the time | 91(28.3%) |
| | | Applied to me to a considerable degree or a good part of time | 2(0.6%) |
| | I found it difficult to work up the initiative to do things | Did not apply to me at all | 265(82.0%) |
| | | Applied to me to some degree, or some of the time | 56(17.3%) |
| | | Applied to me to a considerable degree or a good part of time | 2(0.6%) |
| | I felt that I had nothing to look forward to | Did not apply to me at all | 280(86.7%) |
| | | Applied to me to some degree, or some of the time | 41(12.7%) |
| | | Applied to me to a considerable degree or a good part of time | 2(0.6%) |
| | I felt down-hearted and blue | Did not apply to me at all | 144(44.6%) |
| | | Applied to me to some degree, or some of the time | 163(50.5%) |
| | | Applied to me to a considerable degree or a good part of time | 12(3.7%) |
| | | Applied to me very much or most of the time | 4(1.2%) |
| | I was unable to become enthusiastic about anything | Did not apply to me at all | 294(91.0%) |
| | | Applied to me to some degree, or some of the time | 28(8.7%) |
| | | Applied to me to a considerable degree or a good part of time | 1(0.3%) |
| | | Did not apply to me at all | 291(90.1%) |

| | | | |
|---|---|---|---|
| | I felt I wasn't worth much as a person | Applied to me to some degree, or some of the time | 32(9.9%) |
| | I felt that life was meaningless | Did not apply to me at all | 314(97.2%) |
| | | Applied to me to some degree, or some of the time | 7(2.2%) |
| | | Applied to me to a considerable degree or a good part of time | 2(0.6%) |
| **Stress sub-scale** | I found it hard to wind down | Did not apply to me at all | 136(42.1%) |
| | | Applied to me to some degree, or some of the time | 181(56.0%) |
| | | Applied to me to a considerable degree or a good part of time | 6(1.9%) |
| | I tended to over-react to situations | Did not apply to me at all | 292(90.7%) |
| | | Applied to me to some degree, or some of the time | 29(9.0%) |
| | | Applied to me to a considerable degree or a good part of time | 1(0.3%) |
| | I felt that I was using a lot of nervous energy | Did not apply to me at all | 143(44.4%) |
| | | Applied to me to some degree, or some of the time | 168(52.2%) |
| | | Applied to me to a considerable degree or a good part of time | 11(3.4%) |
| | I found myself getting agitated | Did not apply to me at all | 123(38.1%) |
| | | Applied to me to some degree, or some of the time | 187(57.9%) |
| | | Applied to me to a considerable degree or a good part of time | 11(3.4%) |
| | | Applied to me very much or most of the time | 2(0.6%) |
| | | Did not apply to me at all | 143(44.4%) |

| | | | |
|---|---|---|---|
| | I found it difficult to relax | Applied to me to some degree, or some of the time | 175(54.3%) |
| | | Applied to me to a considerable degree or a good part of time | 4(1.2%) |
| | I was intolerant of anything that kept me from getting on with what I was doing | Did not apply to me at all | 302(93.8%) |
| | | Applied to me to some degree, or some of the time | 19(5.9%) |
| | | Applied to me to a considerable degree or a good part of time | 1(0.3%) |
| | I felt that I was rather touchy | Did not apply to me at all | 240(74.5%) |
| | | Applied to me to some degree, or some of the time | 80(24.8%) |
| | | Applied to me to a considerable degree or a good part of time | 2(0.6%) |
| **Anxiety Stress sub-scale** | I was aware of dryness of my mouth | Did not apply to me at all | 314(97.2%) |
| | | Applied to me to some degree, or some of the time | 9(2.8%) |
| | I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion) | Did not apply to me at all | 154(47.7%) |
| | | Applied to me to some degree, or some of the time | 163(50.5%) |
| | | Applied to me to a considerable degree or a good part of time | 6(1.9%) |
| | I experienced trembling (e.g., in the hands) | Did not apply to me at all | 220(68.1%) |
| | | Applied to me to some degree, or some of the time | 99(30.7%) |
| | | Applied to me to a considerable degree or a good part of time | 4(1.2%) |
| | | Did not apply to me at all | 293(91.0%) |

| | | |
|---|---|---|
| I was worried about situations in which I might panic and make a fool of myself | Applied to me to some degree, or some of the time | 25(7.8%) |
| | Applied to me to a considerable degree or a good part of time | 3(0.9%) |
| | Applied to me very much or most of the time | 1(0.3%) |
| I felt I was close to panic | Did not apply to me at all | 314(97.8%) |
| | Applied to me to some degree, or some of the time | 7(2.2%) |
| I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat) | Did not apply to me at all | 239(74.2%) |
| | Applied to me to some degree, or some of the time | 81(25.2%) |
| | Applied to me to a considerable degree or a good part of time | 2(0.6%) |
| I felt scared without any good reason | Did not apply to me at all | 294(91.3%) |
| | Applied to me to some degree, or some of the time | 28(8.7%) |

**Appendix 4.2 Summary of Diabetes Self-Care Activities (SDACA-A) scale item responses**

| Item | Number of Days | N (%) |
|---|---|---|
| **1) Diet** | | |
| During the last seven days, for how many days did you follow a healthy diet? | 0 | 11(3.4%) |
| | 1 | 157(48.6%) |
| | 2 | 120(37.2%) |
| | 3 | 30(9.3%) |
| | 4 | 3(0.9%) |
| | 5 | 2(0.6%) |
| How well did you follow your diet during the last month (How many days in the week)? | 0 | 11(3.4%) |
| | 1 | 156(48.3%) |
| | 2 | 121(37.5%) |
| | 3 | 29(9.0%) |
| | 4 | 4(1.2%) |
| | 5 | 2(0.6%) |
| **2) Exercise** | | |
| During the last seven days, for how many days did you practice physical activities in general for at least 30 minutes? (Total minutes of activities including walking) | 0 | 166(51.4%) |
| | 1 | 112(34.7%) |
| | 2 | 33(10.2%) |
| | 3 | 8(2.5%) |
| | 4 | 4(1.2%) |
| During the last seven days, for how many days did you practice a strict training exercise session (such as swimming, walking…etc.) exclude activities that are performed around your house or at your work? | 0 | 28(8.7%) |
| | 1 | 220(68.1%) |
| | 2 | 55(17.0%) |
| | 3 | 16(5.0%) |
| | 4 | 4(1.2%) |
| **3) Blood Sugar Testing** | | |
| During the last seven days, for how many days did you test your blood sugar level? | 1 | 13(4.0%) |
| | 2 | 100(31.0%) |
| | 3 | 159(49.2%) |

| | | |
|---|---|---|
| | 4 | 45(13.9%) |
| | 5 | 6(1.9%) |
| During the last seven days, for how many days did you test your blood sugar level according to your physician's instructions? | 0 | 1(0.3%) |
| | 1 | 9(2.8%) |
| | 2 | 96(29.7%) |
| | 3 | 162(50.2%) |
| | 4 | 49(15.2%) |
| | 5 | 6(1.9%) |
| **4) Foot Care** | | |
| During the last seven days, for how many days did you check your feet? | 0 | 22(6.8%) |
| | 1 | 261(80.8%) |
| | 2 | 28(8.7%) |
| | 3 | 7(2.2%) |
| | 4 | 3(0.9%) |
| | 5 | 2(0.6%) |
| During the last seven days, for how many days did you check the interior of your shoes (to ensure that there are no materials that could cause any injury to your feet)? | 0 | 18(5.6%) |
| | 1 | 262(81.1%) |
| | 2 | 33(10.2%) |
| | 3 | 4(1.2%) |
| | 4 | 2(0.6%) |
| | 5 | 2(0.6%) |
| | 7 | 2(0.6%) |

**Appendix 5.1. A PowerPoint slide pack of key findings of phases 1 and 2 of this study.**

## The effects of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of patients with type 2 diabetes mellitus: A Delphi Study to Determine the Implications for Nursing Education.




**Odai Al-Ma'Aitah**

Faculty of Health

**Supervisors:**

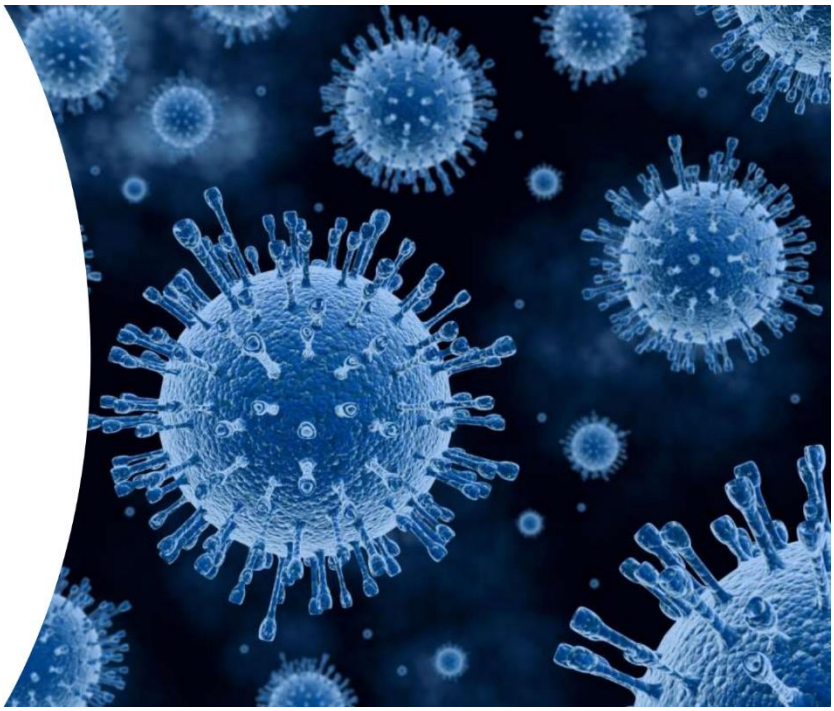
Prof. Lin Perry

Dr. Daniel Demant

Dr. Samantha Jakimowicz

# Corona Virus

**COVID-19**



# COVID-19 lockdowns



# Study Phases (1 & 2)

PHASE 1

PHASE 2

**Phase 1**

**323** patients were selected retrospectively by reviewing the electronic medical records.

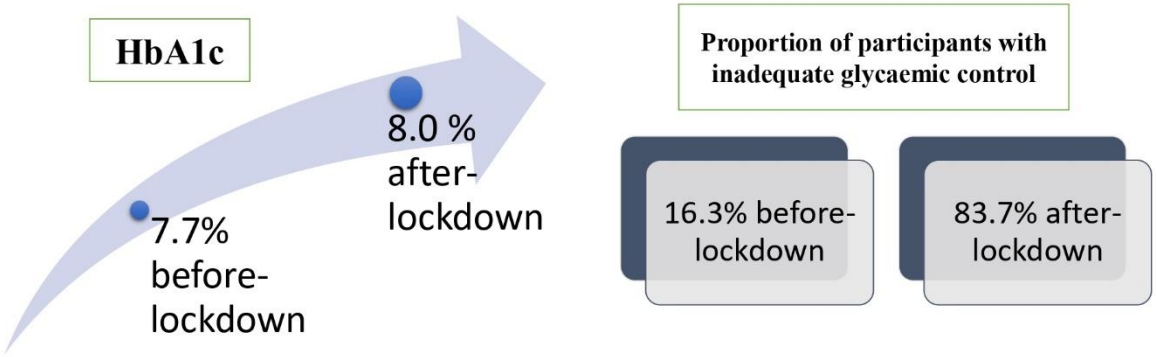


# Phase 1

- **What was the glycaemic control of patients with T2DM before and after the Covid-19 lockdown?**

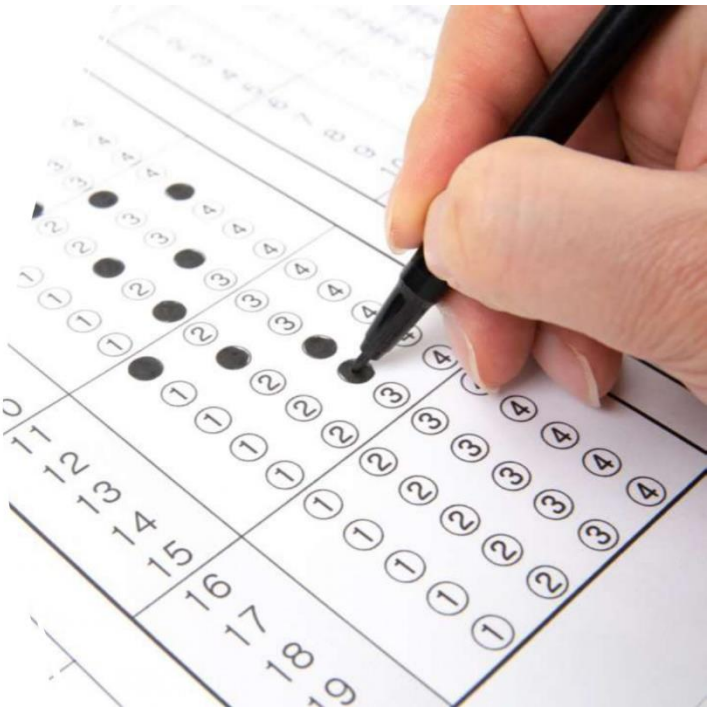


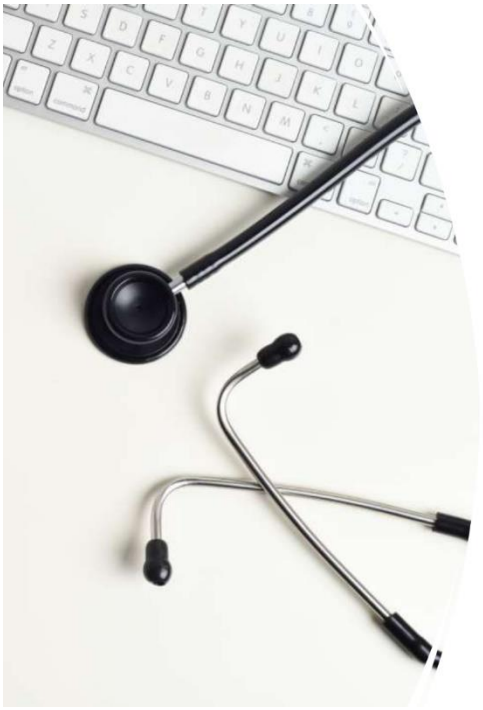
## Findings of Phase 1 (Question 2)



# Phase 2

- **Structured questionnaires (323)**
- **Open questions (15)**



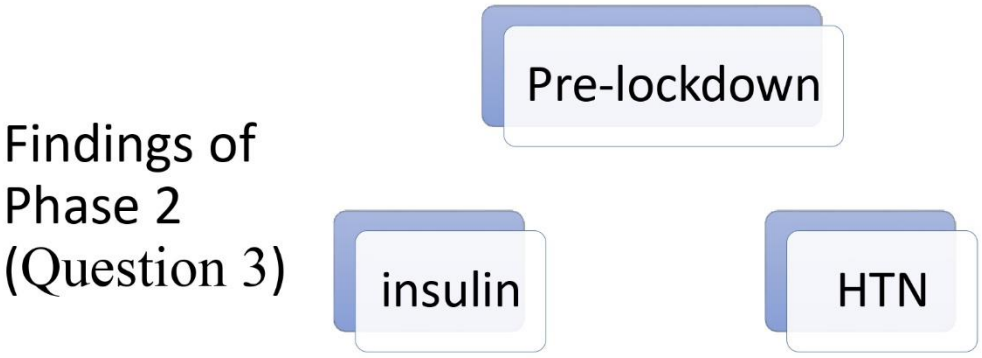


# Phase 2

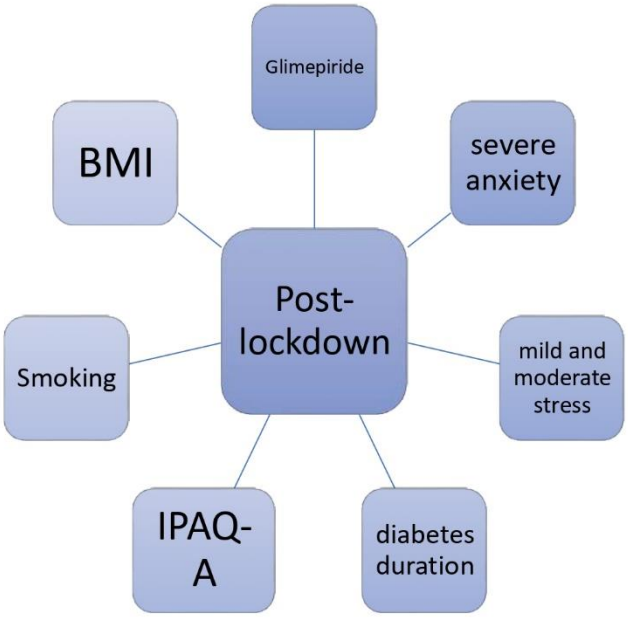
- **What factors did predict the level of glycaemic control during the pandemic (before and after lockdown)?**

## Findings of Phase 2 (Question 3)



# Findings of Phase 2 (Question 3)




**interview**

Most of participants 11 (73.3%) reported a deterioration in control of their diabetes.

The mean blood glucose level had risen from 7.6 ±1.1% before the lockdown to 8.9 ± 2.1% after the lockdown.



## Reasons for inadequate glycaemic control

- Fear of COVID-19.
- Lack of resources.
- Mental health problems.
- Physical **Inactivity.**

# Round 1

1- What are the implications of these findings for nursing practice?

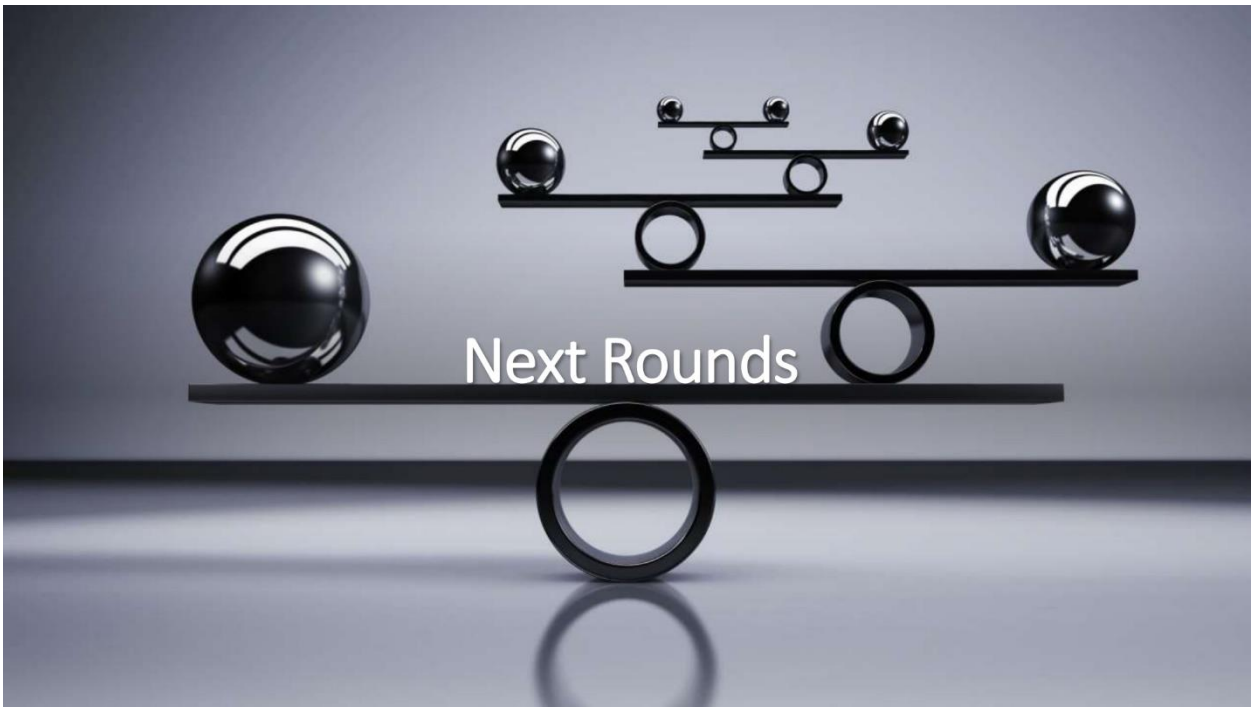
2- What are the implications of these findings for nursing and health service policy development or change?

3- What are the implications of these findings for nursing education?

4- What recommendations could be made to develop nursing practice to better manage care and support for patients with T2DM during any future pandemic?

5- What recommendations could be made to develop nursing and health service policies to better manage care and support patients with T2DM during any future pandemic?

6- What recommendations could be made to develop nursing education to better prepare nurses to support patients with T2DM during any future pandemic?


Next Rounds


Thank
You

- **A brief written report.**

**The effects of the 2019 lockdown for coronavirus disease (COVID-19) on glycaemic control of people with type 2 diabetes mellitus: A Delphi Study to Determine the Implications for Nursing Education.**

**Summary of Phases 1 and 2**

Coronavirus disease 2019, or COVID-19, is A highly contagious respiratory disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It was first identified in Wuhan, China in late 2019 and rapidly spread across the world, such that it was declared a pandemic by the World Health Organization.

By the end of March 2020, most countries around the world had implemented either a full or partial lockdown, affecting billions of people. Particularly vulnerable people with chronic diseases such as Type 2 diabetes.

This study has been conducted in 2 phases:

**Phase 1: 323** patients were selected retrospectively using purposive sampling. To extract data from electronic medical records at the Al Karak Public Hospital, Al Bashir Hospital, and Ma'an. Hospital of people with T2DM who visited the diabetes clinic pre and post the lockdown period which is from 21/03/2020 to 06/06/2020.

**Question 1: What was the glycaemic control of people with T2DM before and after the Covid-19 lockdown?**

After comparing the HbA1c before and after the lockdown

The lockdown imposed by the COVID-19 pandemic impacted glycaemic control where there was a statistically significant increase in HbA1c from 7.7% before lockdown to 8.0 % after lockdown. In addition to that, there was an increase in the proportion of participants with inadequate glycaemic control from (16.3% before lockdown) to (83.7% after lockdown)"

**Phase 2:** This phase entailed using a structured questionnaire including open questions. To investigate the link between glycaemic control and potential explanatory factors related to the COVID-19 pandemic and its management, such as physical activity, self-management, anxiety, and depression.

A survey consisting of four sections was sent to the **323** patients whose data had been collected in Phase I, and all patients were invited to a face-to-face interview. However, only **15** patients have accepted this invitation. The data of the respondents were used for qualitative analysis.

**Question 2: What factors did predict the level of glycaemic control during the pandemic (before and after lockdown)?**

In order to address this question, these variables were considered: demographic factors (age, body mass index, gender, marital status, education level, occupation and income), clinical characteristics (diabetes duration, smoking, the type of regular diabetes treatment, and comorbidities), physical activity, mental health and diabetes self-management

Pre-lockdown, there was a significant association between participants who used insulin and having HTN and inadequate glycaemic control.

In contrast, participants who used insulin and Glimepiride, with extremely severe anxiety, mild and moderate stress sub-scales, BMI, diabetes duration, Smoking, and IPAQ-A scores were all significantly associated factors with inadequate glycaemic control after lockdown.

**The interview results:**

A total of 15 survey participants with T2DM completed the semi-structured interview questions. Due to the exceptional nature of the situation and the stress, worry, and changes in their daily lives during the covid 19 lockdown, most participants (n=11, 73.3%) reported a deterioration in control of their diabetes during the lockdown period.

In addition to that, the mean blood glucose level had risen from 7.6 ±1.1% before the lockdown to 8.9 ± 2.1% after the lockdown.

So, the majority of participants (n=11, 73.3%) reported the control of their diabetes as poor.

The reasons they gave for this included fear of COVID-19, lack of resources, and associated mental health problems and physical **Inactivity.**

## 9. REFERENCES


Abdullah, A., Alkandari, A., Longenecker, J. C., Devarajan, S., Alkhatib, A., Al-Wotayan, R., Al-Duwairi, Q., & Tuomilehto, J. (2020). Glycemic control in Kuwaiti diabetes patients treated with glucose-lowering medication. *Primary Care Diabetes*, *14*(4), 311–316. https://doi.org/10.1016/j.pcd.2019.12.001

Abed Alah, M., Abdeen, S., Kehyayan, V., & Bougmiza, I. (2021). Impact of COVID-19 related home confinement measures on the lifestyle, body weight, and perceived glycemic control of diabetics. *Metabolism Open*, *12*(October), 100144. https://doi.org/10.1016/j.metop.2021.100144

Abera, R. G., Demesse, E. S., & Boko, W. D. (2022). Evaluation of glycemic control and related factors among outpatients with type 2 diabetes at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia: a cross-sectional study. *BMC Endocrine Disorders*, *22*(1), 1–11. https://doi.org/10.1186/s12902-022-00974-z

Abu Mansour, S. I., & Abu Shosha, G. M. (2022). Experiences of first-line nurse managers during COVID-19: A Jordanian qualitative study. *Journal of Nursing Management*, *30*(2), 384–392. https://doi.org/10.1111/jonm.13530

Abubakari, A. R., Cousins, R., Thomas, C., Sharma, D., & Naderali, E. K. (2016). Sociodemographic and Clinical Predictors of Self-Management among People with Poorly Controlled Type 1 and Type 2 Diabetes: The Role of Illness Perceptions and Self-Efficacy. *Journal of Diabetes Research*, *2016*, 1–12. https://doi.org/10.1155/2016/6708164

Abudahab, S., Hakooz, N., Al-Etian, L., Shishani, K., Bashqawi, A., Connolly, J., Glessner, J. T.,

Qu, H. Q., Qu, J., Hakonarson, H., & Dajani, R. (2023). The Circassians and the Chechens in Jordan: results of a decade of epidemiological and genetic studies. *Journal of Community Genetics*, *14*(6), 505–517. https://doi.org/10.1007/s12687-023-00668-6

Abuhegazy, H. (2017). Depression and Glycemic Control in a Sample of Patients with Type 2 Diabetes. *MOJ Addiction Medicine & Therapy*, *3*(5). https://doi.org/10.15406/mojamt.2017.03.00054

Abuhendi, N., Qush, A., Naji, F., Abunada, H., Al Buainain, R., Shi, Z., & Zayed, H. (2019). Genetic polymorphisms associated with type 2 diabetes in the Arab world: A systematic review and meta-analysis. *Diabetes Research and Clinical Practice*, *151*, 198–208. https://doi.org/10.1016/j.diabres.2019.03.037

Abumayyaleh, M., Núñez Gil, I. J., Viana-LLamas, M. C., Raposeiras Roubin, S., Romero, R., Alfonso-Rodríguez, E., Uribarri, A., Feltes, G., Becerra-Muñoz, V. M., Santoro, F., Pepe, M., Castro Mejía, A. F., Signes-Costa, J., Gonzalez, A., Marín, F., López-País, J., Manzone, E., Vazquez Cancela, O., Paeres, C. E., … Akin, I. (2023). Post-COVID-19 syndrome and diabetes mellitus: a propensity-matched analysis of the International HOPE-II COVID-19 Registry. *Frontiers in Endocrinology*, *14*(May), 1–12. https://doi.org/10.3389/fendo.2023.1167087

ACOG. (2015). Ethical Considerations for Including Women as Research Participants. *Obstetrics and Gynecology*, *126*(5), 1127–1128. https://doi.org/10.1097/AOG.0000000000001145

ADA. (2018). American Diabetes Association. 6 . Glycemic Targets : Standards of Medical Care in Diabetes d 2018. *Diabetes Care*, *41(Suppl.1*(January), 55–64.

ADA. (2019). Introduction: Standards of Medical Care in Diabetes—2019. *Diabetes Care*, *42*(Supplement_1), S1–S2. https://doi.org/10.2337/dc19-Sint01

ADA. (2021). Professional Practice Committee: Standards of Medical Care in Diabetes—2021. *Diabetes Care*, *44*(Supplement 1), S3–S3. https://doi.org/10.2337/dc21-Sppc

ADA. (2022a). 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2022. *Diabetes Care*, *45*(Supplement_1), S17–S38. https://doi.org/10.2337/dc22-S002

ADA. (2022b). Standards of Medical Care in Diabetes—2022 Abridged for Primary Care Providers. *Clinical Diabetes*, *40*(1), 10–38. https://doi.org/10.2337/cd22-as01

Adarmouch, L., Sebbani, M., Dahmash, L., & Amine, M. (2020). Self-Care Activities among Patients with Type 2 Diabetes in Morocco: Prevalence and Determinants. *Open Journal of Epidemiology*, *10*(01), 55–65. https://doi.org/10.4236/ojepi.2020.101005

Adham, M., Froelicher, E. S., Batieha, A., & Ajlouni, K. (2010). Glycaemic control and its associated factors in type 2 diabetic patients in Amman, Jordan. *Eastern Mediterranean Health Journal*, *16*(7), 732–739. https://doi.org/10.26719/2010.16.7.732

Afrin, L. B., Weinstock, L. B., & Molderings, G. J. (2020). Covid-19 hyperinflammation and post-Covid-19 illness may be rooted in mast cell activation syndrome. *International Journal of Infectious Diseases*, *100*, 327–332. https://doi.org/10.1016/j.ijid.2020.09.016

Agency for Healthcare Research and Quality. (2014). Methods guide for effectiveness and comparative effectiveness review. *Ahrq*, *January*, 384.

Aghili, R., Polonsky, W. H., Valojerdi, A. E., Malek, M., Keshtkar, A. A., Esteghamati, A., Heyman, M., & Khamseh, M. E. (2016). Type 2 Diabetes: Model of Factors Associated with Glycemic Control. *Canadian Journal of Diabetes*, *40*(5), 424–430. https://doi.org/10.1016/j.jcjd.2016.02.014

Agrawal, U., Katikireddi, S. V., McCowan, C., Mulholland, R. H., Azcoaga-Lorenzo, A., Amele, S., Fagbamigbe, A. F., Vasileiou, E., Grange, Z., Shi, T., Kerr, S., Moore, E., Murray, J. L. K., Shah, S. A., Ritchie, L., O'Reilly, D., Stock, S. J., Beggs, J., Chuter, A., … Sheikh, A. (2021). COVID-19 hospital admissions and deaths after BNT162b2 and ChAdOx1 nCoV-19 vaccinations in 2·57 million people in Scotland (EAVE II): a prospective cohort study. *The Lancet Respiratory Medicine*, *9*(12), 1439–1449. https://doi.org/10.1016/S2213-2600(21)00380-5

Agu, C. F., Stewart, J., McFarlane-Stewart, N., & Rae, T. (2021). COVID-19 pandemic effects on nursing education: looking through the lens of a developing country. *International Nursing Review*, *68*(2), 153–158. https://doi.org/10.1111/inr.12663

Ahmad, N. A. A., Sallehuddin, M. A. A., Teo, Y. C., & Abdul Rahman, H. (2020). Self-Care Management of Patients with diabetes: nurses' perspectives. *Journal of Diabetes and Metabolic Disorders*, *19*(2), 1537–1542. https://doi.org/10.1007/s40200-020-00688-w

Ahmadian, A., Mazaheri, A., & Shakrizes, R. (2018). The relation between anxiety, depression and sexual dysfunction and the level of blood glucose control in patients with type 2 diabetes attending endocrine clinic of taleghani hospital. *Annals of Tropical Medicine and Public Health*, *6*(1.2 Special Issue), SP19. https://doi.org/10.24896/jrmds.20186233

Ahn, D. T. (2020). The COVID-19 Pandemic: A "Tech"-tonic Shift Toward Virtual Diabetes

Care. *Journal of Diabetes Science and Technology*, *14*(4), 708–709. https://doi.org/10.1177/1932296820929719

AI, J., LIU, Y., & SUN, J.-H. (2013). Advanced glycation end-products stimulate basic fibroblast growth factor expression in cultured Müller cells. *Molecular Medicine Reports*, *7*(1), 16–20. https://doi.org/10.3892/mmr.2012.1152

Aikens, J. E. (2012). Prospective Associations Between Emotional Distress and Poor Outcomes in Type 2 Diabetes. *Diabetes Care*, *35*(12), 2472–2478. https://doi.org/10.2337/dc12-0181

Ajilore, O., & Thames, A. D. (2020). The fire this time: The stress of racism, inflammation and COVID-19. *Brain, Behavior, and Immunity*, *88*, 66–67. https://doi.org/10.1016/j.bbi.2020.06.003

Ajlouni, K., Batieha, A., Jaddou, H., Khader, Y., Abdo, N., El-Khateeb, M., Hyassat, D., & Al-Louzi, D. (2019a). Time trends in diabetes mellitus in Jordan between 1994 and 2017. *Diabetic Medicine*, *36*(9), 1176–1182. https://doi.org/10.1111/dme.13894

Ajlouni, K., Batieha, A., Jaddou, H., Khader, Y., Abdo, N., El-Khateeb, M., Hyassat, D., & Al-Louzi, D. (2019b). Time trends in diabetes mellitus in Jordan between 1994 and 2017. *Diabetic Medicine*, *36*(9), 1176–1182. https://doi.org/10.1111/dme.13894

Akhlaghipour, I., Bina, A. R., Mogharrabi, M. R., Fanoodi, A., Ebrahimian, A. R., Khojasteh Kaffash, S., Babazadeh Baghan, A., Khorashadizadeh, M. E., Taghehchian, N., & Moghbeli, M. (2022). Single-nucleotide polymorphisms as important risk factors of diabetes among Middle East population. *Human Genomics*, *16*(1), 1–28. https://doi.org/10.1186/s40246-022-00383-2

Akin, S. (2019). Overtreatment and Hypoglycemia Prevalence in Geriatric Patients with Type-2 Diabetes in the Turkish Population. *Acta Endocrinologica (Bucharest)*, *15*(3), 311–316. https://doi.org/10.4183/aeb.2019.311

Akinci, Y. (2022). Clinical manifestation and diagnosis. In *Coronavirus Disease* (pp. 71–119). Elsevier. https://doi.org/10.1016/B978-0-12-824409-8.00006-0

Akinosoglou, K., Schinas, G., Bletsa, E., Bristianou, M., Lanaras, L., Michailides, C., Katsikas, T., Barkas, F., Liberopoulos, E., Kotsis, V., Tentolouris, K., Grigoropoulou, P., Frangou, A., Basoulis, D., Alexiou, Z., Daganou, M., Bostantzoglou, C., Dimakopoulou, V., Koutsoukou, A., … Tentolouris, N. (2023). COVID-19 Outcomes and Diabetes Mellitus: A Comprehensive Multicenter Prospective Cohort Study. *Microorganisms*, *11*(6), 1–17. https://doi.org/10.3390/microorganisms11061416

Al-Azzam, N., Elsalem, L., Abu Mousa, B. M., & Saadeh, N. (2024). Population Study Insights Linked to Genetic Variants (rs16890979 and rs206833) and Type 2 Diabetes Control in Northern Jordan. *BIO Integration*, *5*(1), 1–8. https://doi.org/10.15212/bioi-2024-0005

Al-Azzam, S. I., Khabour, O. F., Alzoubi, K. H., Ghanma, M. W., & Alhasan, A. Y. (2014). The role of TNF-α G-308A promoter polymorphism in glycemic control in Type 2 diabetes patients. *Journal of Endocrinological Investigation*, *37*(2), 113–118. https://doi.org/10.1007/s40618-013-0002-4

Al-Bataineh, R., Al-Hammouri, M., & Al-Jaraideh, W. (2023). The accessibility and quality of health services for diabetes mellitus and chronic respiratory disease patients during Covid-19 in Northern Jordan: A mixed method study. *Plos One*, *18*(11), e0294655. https://doi.org/10.1371/journal.pone.0294655

Al-Daghri, N. M., Almiman, A. A., Wani, K., Khattak, M. N. K., Aljohani, N. J., Alfawaz, H., Al-Hameidi, A., Aldisi, D., Alkhaldi, G., & Sabico, S. (2022). COVID-19 Lockdown and Lifestyle Changes in Saudi Adults With Types 1 and 2 Diabetes. *Frontiers in Public Health*, *10*(July), 1–10. https://doi.org/10.3389/fpubh.2022.912816

Al-Dwairi, R. A., Rwashdeh, H., & Otoom, M. (2021). The Influence of COVID-19 Lockdown in Jordan on Patients with Diabetic Retinopathy: A Case–Control Study. *Therapeutics and Clinical Risk Management*, *Volume 17*(September), 1011–1022. https://doi.org/10.2147/TCRM.S316265

Al-Eitan, L. N., Aman, H., Alkhatib, R., & Alghamdi, M. A. (2020). Genetic association of SH2B1 gene polymorphisms in Jordanian Arab patients with type 2 diabetes mellitus. *Diabetes, Metabolic Syndrome and Obesity*, *13*, 1825–1834. https://doi.org/10.2147/DMSO.S245843

Al-Eitan, L. N., Nassar, A. M., Dajani, R. B., Almomani, B. A., & Saadeh, N. A. (2017). Diabetes mellitus in two genetically distinct populations in Jordan: A comparison between Arabs and Circassians/Chechens living with diabetes. *Saudi Medical Journal*, *38*(2), 163–169. https://doi.org/10.15537/smj.2017.2.17910

AL-Eitan, L. N., Nassar, A. M., Saadeh, N. A., & Almomani, B. A. (2016). Evaluation of Glycemic Control, Lifestyle and Clinical Characteristics in Patients with Type 2 Diabetes Treated at King Abdullah University Hospital in Jordan. *Canadian Journal of Diabetes*, *40*(6), 496–502. https://doi.org/10.1016/j.jcjd.2016.04.009

AL-Eitan, L., Saadeh, H., Alnaamneh, A., Darabseh, S., AL-Sarhan, N., Alzihlif, M., Hakooz, N., Ivanova, E., Kelsey, G., & Dajani, R. (2020). The genetic landscape of Arab Population,

Chechens and Circassians subpopulations from Jordan through HV1 and HV2 regions of mtDNA. *Gene*, *729*, 144314. https://doi.org/10.1016/j.gene.2019.144314

Al-Hayek, A. A., Robert, A. A., Alzaid, A. A., Nusair, H. M., Zbaidi, N. S., Al-Eithan, M. H., & Sam, A. E. (2012a). Association between diabetes self-care, medication adherence, anxiety, depression, and glycemic control in type 2 diabetes. *Saudi Medical Journal*, *33*(6), 681–683. https://doi.org/22729127

Al-Hayek, A. A., Robert, A. A., Alzaid, A. A., Nusair, H. M., Zbaidi, N. S., Al-Eithan, M. H., & Sam, A. E. (2012b). Association between diabetes self-care, medication adherence, anxiety, depression, and glycemic control in type 2 diabetes. *Saudi Medical Journal*, *33*(6), 681–683.

Al-Hazzaa, H. M. (2007). Health-enhancing physical activity among Saudi adults using the International Physical Activity Questionnaire (IPAQ). *Public Health Nutrition*, *10*(1), 59–64. https://doi.org/10.1017/S1368980007184299

Al-Jabir, A., Kerwan, A., Nicola, M., Alsafi, Z., Khan, M., Sohrabi, C., O'Neill, N., Iosifidis, C., Griffin, M., Mathew, G., & Agha, R. (2020). Impact of the Coronavirus (COVID-19) pandemic on surgical practice - Part 1. *International Journal of Surgery*, *79*(January), 168–179. https://doi.org/10.1016/j.ijsu.2020.05.022

Al-Khalayfa, S., Mashal, S., Khanfar, M., Srour, L., Mustafa, L., Battah, A., Zayed, A. A., Khader, Y. S., & Azab, B. (2023). Association of E23K (rs5219) polymorphism in the KCNJ11 gene with type 2 diabetes mellitus risk in Jordanian population. *Human Gene*, *37*(March), 26–31. https://doi.org/10.1016/j.humgen.2023.201201

Al-Lawati, J. A., Barakat, M. N., Al-Maskari, M., Elsayed, M. K., Al-Lawati, A. M., & Mohammed, A. J. (2012). HbA1c Levels among Primary Healthcare Patients with Type 2 Diabetes Mellitus in Oman. *Oman Medical Journal*, *27*(6), 465–470. https://doi.org/10.5001/omj.2012.111

Al-Moteri, M., Plummer, V., Youssef, H. A. M., Yaseen, R. W. H., Al Malki, M., Elryah, A. A. I., & Al Karani, A. (2022). The experiences of people with diabetes during covid-19 pandemic lockdown. *International Journal of Environmental Research and Public Health*, *19*(1). https://doi.org/10.3390/ijerph19010340

Al-Mukhtar, S. B., Fadhil, N. N., & Hanna, B. E. (2012). General and Gender Characteristics of Type 2 Diabetes Mellitus Among theYounger and Older Age Groups. *Oman Medical Journal*, *27*(5), 375–382. https://doi.org/10.5001/omj.2012.94

Al-Rasheedi, A. A. S. (2014). The Role of Educational Level in Glycemic Control among Patients with Type II Diabetes Mellitus. *International Journal of Health Sciences*, *8*(2), 177–187. https://doi.org/10.12816/0006084

Al-sahouri, A., Merrell, J., & Snelgrove, S. (2019). *Attitudes , Knowledge , and Perceptions of Patients Regarding Type-2 Diabetes in Jordan*. 1–13. https://doi.org/10.4236/jdm.2019.91001

Al-Shahrani, A. M., Hassan, A., Al-Rubeaan, K. A., Al Sharqawi, A. H., & Ahmad, N. A. (2012). Effects of diabetes education program on metabolic control among Saudi type 2 diabetic patients. *Pakistan Journal of Medical Sciences*, *28*(5), 925–930.

Al-Taani, G. M., Muflih, S. M., Alsharedeh, R., Karasneh, R., & Al-Azzam, S. I. (2024). The

impact of COVID-19 pandemic on treatment adherence, access to care, and disease control in diabetic patients in Jordan, an online survey. *Journal of Applied Pharmaceutical Science*, *14*(09), 247–254. https://doi.org/10.7324/japs.2024.179700

Al-Tammemi, A. B., Tarhini, Z., & Akour, A. (2021). A swaying between successive pandemic waves and pandemic fatigue: Where does Jordan stand? In *Annals of Medicine and Surgery* (Vol. 65). https://doi.org/10.1016/j.amsu.2021.102298

Al-zoubi, N. A., Obeidat, B. R., Al-Ghazo, M. A., Hayajneh, W. A., Alomari, A. H., Mazahreh, T. S., Al-Faouri, I. G., Obeidat, K., Issa, A. B., & Aleshawi, A. (2020). Prevalence of positive COVID-19 among asymptomatic health care workers who care patients infected with the novel coronavirus: A retrospective study. *Annals of Medicine and Surgery*, *57*(June), 14–16. https://doi.org/10.1016/j.amsu.2020.06.038

Al-ma'aitah, O. H., Demant, D., Jakimowicz, S., & Perry, L. (2022). Glycaemic control and its associated factors in patients with type 2 diabetes in the Middle East and North Africa: An updated systematic review and meta-analysis. *Journal of Advanced Nursing*, *78*(8), 2257–2276. https://doi.org/10.1111/jan.15255

Al Balushi, K. A., Al-Haddabi, M., Al-Zakwani, I., & Al Za'abi, M. (2014). Glycemic control among patients with type 2 diabetes at a primary health care center in Oman. *Primary Care Diabetes*, *8*(3), 239–243. https://doi.org/10.1016/j.pcd.2014.01.003

Al Dossari, K. K., Ahmad, G., Aljowair, A., Alqahtani, N., Shibrayn, M. Bin, Alshathri, M., Alshehri, D., Akhlaq, S., Hejab, F. Bin, Alqahtani, A., & Razzak, H. A. (2019). Association of vitamin d with glycemic control in Saudi patients with type 2 diabetes: A retrospective chart review study in an emerging university hospital. *Journal of Clinical Laboratory*

*Analysis*, *34*(2). https://doi.org/10.1002/jcla.23048

Al Dossari, K. K., Ahmad, G., Aljowair, A., Alqahtani, N., Shibrayn, M. Bin, Alshathri, M., Alshehri, D., Akhlaq, S., Hejab, F. Bin, Alqahtani, A., & Razzak, H. A. (2020). Association of vitamin d with glycemic control in Saudi patients with type 2 diabetes: A retrospective chart review study in an emerging university hospital. *Journal of Clinical Laboratory Analysis*, *34*(2), 1–7. https://doi.org/10.1002/jcla.23048

Al Hayek, A. A., Robert, A. A., Al Saeed, A., Alzaid, A. A., & Al Sabaan, F. S. (2014). Factors Associated with Health-Related Quality of Life among Saudi Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Survey. *Diabetes & Metabolism Journal*, *38*(3), 220. https://doi.org/10.4093/dmj.2014.38.3.220

Al Mahrouqi, A. S., Mallinson, R. K., Oh, K. M., & Weinstein, A. A. (2022). Patients' and Nurses' Perceptions of Diabetes Self-Management in Oman: A Qualitative Study. *International Journal of Environmental Research and Public Health*, *19*(11), 6929. https://doi.org/10.3390/ijerph19116929

Al Nozha, O. M. (2014). Diabetes care and control: the effect of frequent visits to diabetes care center. *Annals of Saudi Medicine*, *34*(3), 229–234. https://doi.org/10.5144/0256-4947.2014.229

Al qahtani, M. A. A., Khan, N. A., Alakhali, K. M., & Alavudeen, S. S. (2015). Impact of family history in glycemic control among type-2 diabetes mellitus patients in aseer diabetic center. *International Research Journal of Pharmacy*, *6*(3), 191–194. https://doi.org/10.7897/2230-8407.06341

Al Saweer, A. (2015). The Profile of Vitamin D among Type 2 Diabetes Mellitus Patients. *Bahrain Medical Bulletin*, *37*(3), 184–188. https://doi.org/10.12816/0014443

Al Slamah, T., Nicholl, B. I., Alslail, F. Y., Harris, L., Kinnear, D., & Melville, C. A. (2020). Correlates of type 2 diabetes and glycaemic control in adults in Saudi Arabia a secondary data analysis of the Saudi health interview survey. *BMC Public Health*, *20*(1), 1–13. https://doi.org/10.1186/s12889-020-08597-6

Al Subhi, L. K., Bose, S., & Al Ani, M. F. (2015). Prevalence of physically active and sedentary adolescents in 10 Eastern Mediterranean countries and its relation with age, sex, and body mass index. *Journal of Physical Activity & Health*, *12*(2), 257–265. https://doi.org/10.1123/jpah.2013-0134

ALAboudi, I. S., Hassali, M. A., Shafie, A. A., & Saleem, F. (2016). Self-efficacy, self-care behaviours and glycaemic control in type 2 diabetic patients in Riyadh, Saudi Arabia. *Journal of Public Health*, *24*(4), 281–290. https://doi.org/10.1007/s10389-016-0723-x

Albasheer, O. B., Mahfouz, M. S., Solan, Y., Khan, D. A., Muqri, M. A., Almutairi, H. A., Alelyani, A. M., & Alahmed, H. A. (2018). Depression and related risk factors among patients with type 2 diabetes mellitus, Jazan area, KSA: A cross-sectional study. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, *12*(2), 117–121. https://doi.org/10.1016/j.dsx.2017.09.014

Aldukhayel, A. (2022). The COVID-19 lockdown does not necessarily worsen diabetes control, in spite of lower physical activity - a systematic review. *Endokrynologia Polska*, *73*(1), 131–148. https://doi.org/10.5603/EP.a2022.0006

Alessi, J., De Oliveira, G. B., Franco, D. W., Brino Do Amaral, B., Becker, A. S., Knijnik, C. P., Kobe, G. L., De Carvalho, T. R., Telo, G. H., Schaan, B. D., & Telo, G. H. (2020). Mental health in the era of COVID-19: Prevalence of psychiatric disorders in a cohort of patients with type 1 and type 2 diabetes during the social distancing. *Diabetology and Metabolic Syndrome*, *12*(1), 1–10. https://doi.org/10.1186/s13098-020-00584-6

Alhazzani, W., Moller, M. H., Arabi, Y. M., Loeb, M., Gong, M. N., & Fan, E. (2020). Surviving sepsis cam- paign: guidelines on the management of criti- cally ill adults with coronavirus disease 2019 (COVID 19. *Intensive Care Med*, *48*(6), 440–69.

Ali, A. M., Ahmed, A., Sharaf, A., Kawakami, N., Abdeldayem, S. M., & Green, J. (2017). The Arabic Version of The Depression Anxiety Stress Scale-21: Cumulative scaling and discriminant-validation testing. *Asian Journal of Psychiatry*, *30*(17), 56–58. https://doi.org/10.1016/j.ajp.2017.07.018

Ali, D., Abduelkarem, A., Shahwan, M., & Shahwan, M. (2013). Evaluation of factors associated with inadequate glycemic control and some other health care indicators among patients with type 2 diabetes in Ramallah, Palestine. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, *4*(3), 445–451.

Ali, M., Schifano, F., Robinson, P., Phillips, G., Doherty, L., Melnick, P., Laming, L., Sinclair, A., & Dhillon, S. (2012). Impact of community pharmacy diabetes monitoring and education programme on diabetes management: A randomized controlled study. *Diabetic Medicine*, *29*(9), e326–e333. https://doi.org/10.1111/j.1464-5491.2012.03725.x

Aljohani, K., & Kendall, G. (2014). Psychometric Evaluation of the Summary of Diabetes Self-Care Activities-Arabic (SDSCA-Arabic): Translation and Analysis Process. *Journal of*

*Transcultural Nursing*, *27*. https://doi.org/10.1177/1043659614526255

Alkhalidy, H., Orabi, A., Alnaser, K., Al-Shami, I., Alzboun, T., Obeidat, M. D., & Liu, D. (2021). Obesity measures as predictors of type 2 diabetes and cardiovascular diseases among the jordanian population: A cross-sectional study. *International Journal of Environmental Research and Public Health*, *18*(22). https://doi.org/10.3390/ijerph182212187

Alkhormi, A. H., Mahfouz, M. S., Alshahrani, N. Z., Hummadi, A., Hakami, W. A., Alattas, D. H., Alhafaf, H. Q., Kardly, L. E., & Mashhoor, M. A. (2022). Psychological Health and Diabetes Self-Management among Patients with Type 2 Diabetes during COVID-19 in the Southwest of Saudi Arabia. *Medicina (Lithuania)*, *58*(5), 1–14. https://doi.org/10.3390/medicina58050675

Almetwazi, M., Alwhaibi, M., Balkhi, B., Almohaini, H., Alturki, H., Alhawassi, T., Ata, S., AlQahtani, N., Mahmoud, M., & Alshammari, T. (2019). Factors associated with glycemic control in type 2 diabetic patients in Saudi Arabia. *Saudi Pharmaceutical Journal*, *27*(3), 384–388. https://doi.org/10.1016/j.jsps.2018.12.007

Almogati, J. G., & Ahmed, E. O. (2019). Glycated hemoglobin as a predictor of the length of hospital stay in patients following coronary bypass graft surgery in the saudi population. *Brazilian Journal of Cardiovascular Surgery*, *34*(1), 28–32. https://doi.org/10.21470/1678-9741-2018-0202

Almomani, M. H., & Al-Tawalbeh, S. (2022). Glycemic Control and Its Relationship with Diabetes Self-Care Behaviors Among Patients with Type 2 Diabetes in Northern Jordan: A Cross-Sectional Study. *Patient Preference and Adherence*, *16*(January), 449–465.

https://doi.org/10.2147/PPA.S343214

Almutairi, N., & Alkharfy, K. M. (2013). Direct Medical Cost and Glycemic Control in Type 2 Diabetic Saudi Patients. *Applied Health Economics and Health Policy*, *11*(6), 671–675. https://doi.org/10.1007/s40258-013-0065-6

Alnatour, D., Nassar, R. I., Salhi, Y., Thiab, S., & Alsayed, A. R. (2023). Perception and Attitudes toward COVID- 19 Vaccines in Jordan: Lessons for future Pandemics. *Pharmacy Practice*, *21*(1), 01–09. https://doi.org/10.18549/PharmPract.2023.1.2781

Alnjadat, R. M., Al-Rawashdeh, A. B., Almutairi, F. A., & Shahin, M. A. H. (2024). The Effects of the COVID-19 Pandemic on the Clinical Practicum of Undergraduate Nursing and Midwifery Students in Jordan: A Descriptive Survey. *SAGE Open Nursing*, *10*. https://doi.org/10.1177/23779608241246877

Alnuqaydan, A. M., Almutary, A. G., Sukamaran, A., Yang, B. T. W., Lee, X. T., Lim, W. X., Ng, Y. M., Ibrahim, R., Darmarajan, T., Nanjappan, S., Chellian, J., Candasamy, M., Madheswaran, T., Sharma, A., Dureja, H., Prasher, P., Verma, N., Kumar, D., Palaniveloo, K., … Chellappan, D. K. (2021). Middle East Respiratory Syndrome (MERS) Virus—Pathophysiological Axis and the Current Treatment Strategies. *AAPS PharmSciTech*, *22*(5), 173. https://doi.org/10.1208/s12249-021-02062-2

Alorjani, M., Matalka, I., Baker, S. A., Al-Khatib, S., Al Bashir, S., & Al-Qudah, M. (2021). Cellular pathology practice in the era of COVID-19 pandemic-related lockdowns - Experience from a tertiary hospital: A retrospective observational study. *Annals of Medicine and Surgery*, *63*(February), 102155. https://doi.org/10.1016/j.amsu.2021.02.001

Alotaibi, A., Al-Ganmi, A., Gholizadeh, L., & Perry, L. (2016). Diabetes knowledge of nurses in different countries: An integrative review. *Nurse Education Today*, *39*, 32–49. https://doi.org/10.1016/j.nedt.2016.01.017

Alotaibi, A., Gholizadeh, L., Al-Ganmi, A., & Perry, L. (2017). Examining perceived and actual diabetes knowledge among nurses working in a tertiary hospital. *Applied Nursing Research*, *35*, 24–29. https://doi.org/10.1016/j.apnr.2017.02.014

Alqudah, S., Jarab, A. S., Alefishat, E. A., Mayyas, F., Khdour, M., & Pinto, S. (2019). Factors Associated with Poor Hemoglobin A1c Control in Patients with Type 2 Diabetes. *Current Diabetes Reviews*, *15*(2), 164–170. https://doi.org/10.2174/1573399814666180510144858

Alqutob, R., Al Nsour, M., Tarawneh, M. R., Ajlouni, M., Khader, Y., Aqel, I., Kharabsheh, S., & Obeidat, N. (2020). COVID-19 Crisis in Jordan: Response, Scenarios, Strategies, and Recommendations. *JMIR Public Health Surveill*, *6*(3), e19332. https://doi.org/10.2196/19332

Alramadan, M. J., Magliano, D. J., Almigbal, T. H., Batais, M. A., Afroz, A., Alramadhan, H. J., Mahfoud, W. F., Alragas, A. M., & Billah, B. (2018a). Glycaemic control for people with type 2 diabetes in Saudi Arabia - an urgent need for a review of management plan. *BMC Endocrine Disorders*, *18*(1), 62. https://doi.org/10.1186/s12902-018-0292-9

Alramadan, M. J., Magliano, D. J., Almigbal, T. H., Batais, M. A., Afroz, A., Alramadhan, H. J., Mahfoud, W. F., Alragas, A. M., & Billah, B. (2018b). Glycaemic control for people with type 2 diabetes in Saudi Arabia – an urgent need for a review of management plan. *BMC Endocrine Disorders*, *18*(1), 62. https://doi.org/10.1186/s12902-018-0292-9

Alromaihi, D. (2019). *Factors affecting glycaemic control among patients with type 2 diabetes in Bahrain*. https://doi.org/10.26226/morressier.5d9b6231ea541d6ca8493b26

Alsabi, H., Saadon, M. S. I., & Mohammad, A. M. (2023). Nexus of COVID-19 Crises and Health Care Performance in Jordan: The Moderation Role of Telemedicine, Innovation, and Infrastructure. *International Journal of Sustainable Development and Planning*, *18*(12), 3895–3908. https://doi.org/10.18280/ijsdp.181221

Alshaikh, A., Mallawi, M., Aljuhani, S., Alkhotani, R., Aljohani, N., Aljehani, D., Alsayyad, L., Alghamdi, R., Baz, A., Alsayed, M., & Alluhaybi, R. (2020). COVID-19 pandemic effects on diabetic patients in Jeddah, Saudi Arabia. *International Journal of Medicine in Developing Countries*, *4*(October), 1912–1917. https://doi.org/10.24911/ijmdc.51-1601567409

Alshareef, R., Al Zahrani, A., Alzahrani, A., & Ghandoura, L. (2020). Impact of the COVID-19 lockdown on diabetes patients in Jeddah, Saudi Arabia. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, *14*(5), 1583–1587. https://doi.org/10.1016/j.dsx.2020.07.051

Alshoubaki, W., & Harris, M. (2021). Jordan's Public Policy Response to COVID-19 Pandemic: Insight and Policy Analysis. *Public Organization Review*, *21*(4), 687–706. https://doi.org/10.1007/s11115-021-00564-y

Alshukry, A., Bu Abbas, M., Ali, Y., Alahmad, B., Al-Shammari, A. A., Alhamar, G., Abu-Farha, M., AbuBaker, J., Devarajan, S., Dashti, A. A., Al-Mulla, F., & Ali, H. (2021). Clinical characteristics and outcomes of COVID-19 patients with diabetes mellitus in Kuwait. *Heliyon*, *7*(4), e06706. https://doi.org/10.1016/j.heliyon.2021.e06706

Alshwiah, A. A. (2023). Emergency remote teaching during COVID-19: traits and constraints that arise when teaching computer skills to Saudi preparatory year students. *Journal of Computers in Education*, *10*(2), 403–431. https://doi.org/10.1007/s40692-022-00235-x

Alyahya, M. S., Okour, N. S., Khader, Y., & Al-sheyab, N. (2022). Retrospective study on the impact of COVID-19 lockdown on patients with type 2 diabetes in Northern Jordan. *BMJ Open*, *12*(11), e065148. https://doi.org/10.1136/bmjopen-2022-065148

Alzaheb, R. A., & Altemani, A. H. (2018). The prevalence and determinants of poor glycemic control among adults with type 2 diabetes mellitus in Saudi Arabia. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *11*, 15–21. https://doi.org/10.2147/DMSO.S156214

Alzaheb, R., & Altemani, A. (2018). The prevalence and determinants of poor glycemic control among adults with type 2 diabetes mellitus in Saudi Arabia. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *Volume 11*, 15–21. https://doi.org/10.2147/dmso.s156214

Alzahrani, S. H., Baig, M., Aashi, M. M., Al-shaibi, F. K., Alqarni, D. A., & Bakhamees, W. H. (2019). Association between glycated hemoglobin (HbA1c) and the lipid profile in patients with type 2 diabetes mellitus at a tertiary care hospital: a retrospective study. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *Volume 12*, 1639–1644. https://doi.org/10.2147/dmso.s222271

American Diabetes Association. (2018). Standards of Medical Care in Diabetes-2018 Abridged for Primary Care Providers. *Clinical Diabetes : A Publication of the American Diabetes Association*, *36*(1), 14–37. https://doi.org/10.2337/cd17-0119

American Diabetes Association. (2021). 6. Glycemic Targets: Standards of Medical Care in Diabetes—2021. *Diabetes Care*, *44*(Supplement_1), S73–S84. https://doi.org/10.2337/dc21-S006

Amini, H., Isanejad, A., Chamani, N., Movahedi-Fard, F., Salimi, F., Moezi, M., & Habibi, S. (2020). Physical activity during COVID-19 pandemic in the Iranian population: A brief report. *Heliyon*, *6*(11), e05411. https://doi.org/10.1016/j.heliyon.2020.e05411

Ammar, A., Brach, M., Trabelsi, K., Chtourou, H., Boukhris, O., Masmoudi, L., Bouaziz, B., Bentlage, E., How, D., Ahmed, M., Müller, P., Müller, N., Aloui, A., & Hammouda, O. (2020). Effects of COVID-19 Home Confinement on Eating Behaviour and Physical Activity : Results of the. *Nutrients*, *12*(1583), 13.

Angor, M. M., & Nawasreh, A. O. (2022). Effect of Lockdown in the COVID-19 Pandemic on Dietary Habits and Self-Medication Practice in People Living in Jordan. *International Journal of Nutrition, Pharmacology, Neurological Diseases*, *12*(4), 263–268. https://doi.org/10.4103/ijnpnd.ijnpnd_50_22

Ansari, P., Tabasumma, N., Snigdha, N. N., Siam, N. H., Panduru, R. V. N. R. S., Azam, S., Hannan, J. M. A., & Abdel-Wahab, Y. H. A. (2022). Diabetic Retinopathy: An Overview on Mechanisms, Pathophysiology and Pharmacotherapy. *Diabetology*, *3*(1), 159–175. https://doi.org/10.3390/diabetology3010011

Aquila, A., Grimley, K., Jacobs, B., Kosturko, M., Mansfield, J., Mather, C., Parniawski, P., Wood, L., & Niederhauser, V. (2020). Nursing leadership during COVID-19: Enhancing patient, family and workforce experience. *Patient Experience Journal*, *7*(2), 136–143. https://doi.org/10.35680/2372-0247.1482

Aryan, F., & Ahmad, M. (2022). Nursing knowledge and perceptions of COVID-19 pandemic in Jordanian intensive care units. *Applied Nursing Research*, *67*(January), 151628. https://doi.org/10.1016/j.apnr.2022.151628

Assaye, A. M., Wiechula, R., Schultz, T. J., & Feo, R. (2022). Missed nursing care, nurse staffing levels and patient safety outcomes in low-income country acute care settings: An observational study. *International Journal of Nursing Practice*, *28*(1). https://doi.org/10.1111/ijn.13031

Atcı, M. M., Cerciz, Ö. P., Kayar, Y., Borlu, F., & Altuntaş, Y. (2022). The relationship between poor glycaemic control and risk factors in patients with type 2 diabetes mellitus. *Eurasian Journal of Medical Advances*, *2*(2), 46–54. https://doi.org/10.14744/ejma.2022.87597

Atri, D., Siddiqi, H. K., Lang, J. P., Nauffal, V., Morrow, D. A., & Bohula, E. A. (2020). COVID-19 for the Cardiologist: Basic Virology, Epidemiology, Cardiac Manifestations, and Potential Therapeutic Strategies. *JACC: Basic to Translational Science*, *5*(5), 518–536. https://doi.org/10.1016/j.jacbts.2020.04.002

Augustin, M., Schommers, P., Stecher, M., Dewald, F., Gieselmann, L., Gruell, H., Horn, C., Vanshylla, K., Cristanziano, V. Di, Osebold, L., Roventa, M., Riaz, T., Tschernoster, N., Altmueller, J., Rose, L., Salomon, S., Priesner, V., Luers, J. C., Albus, C., … Lehmann, C. (2021). Post-COVID syndrome in non-hospitalised patients with COVID-19: a longitudinal prospective cohort study. *The Lancet Regional Health - Europe*, *6*, 100122. https://doi.org/10.1016/j.lanepe.2021.100122

Aune, D., Norat, T., Leitzmann, M., Tonstad, S., & Vatten, L. J. (2015). Physical activity and the risk of type 2 diabetes: A systematic review and dose-response meta-analysis. *European*

*Journal of Epidemiology*, *30*(7), 529–542. https://doi.org/10.1007/s10654-015-0056-z

Awad, S. F., Huangfu, P., Dargham, S. R., Ajlouni, K., Batieha, A., Khader, Y. S., Critchley, J. A., & Abu-Raddad, L. J. (2020). Characterizing the type 2 diabetes mellitus epidemic in Jordan up to 2050. *Scientific Reports*, *10*(1), 1–10. https://doi.org/10.1038/s41598-020-77970-7

Azadi, S., Jabbarzadeh, F., Aghamohammadzadeh, N., Sarbakhsh, P., & Roshangar, F. (2020). The relationship of self-efficacy and demographic characteristics with blood glucose control in Iranian older adults with diabetes type II: a cross-sectional study. *Crescent Journal of Medical and Biological Sciences*, *7*(1), 96-103. https://www.cochranelibrary.com/central/doi/10.1002/central/CN-02077413/full

Azhar, E. I., Hui, D. S. C., Memish, Z. A., Drosten, C., & Zumla, A. (2019). The Middle East Respiratory Syndrome (MERS). *Infectious Disease Clinics of North America*, *33*(4), 891–905. https://doi.org/10.1016/j.idc.2019.08.001

Badedi, M., Solan, Y., Darraj, H., Sabai, A., Mahfouz, M., Alamodi, S., & Alsabaani, A. (2016). *Factors Associated with Long-Term Control of Type 2 Diabetes Mellitus*. *2016*.

Bae, J. P., Lage, M. J., Mo, D., Nelson, D. R., & Hoogwerf, B. J. (2016). Obesity and glycemic control in patients with diabetes mellitus: Analysis of physician electronic health records in the US from 2009-2011. *Journal of Diabetes and Its Complications*, *30*(2), 212–220. https://doi.org/10.1016/j.jdiacomp.2015.11.016

Bajgain, K. T., Badal, S., Bajgain, B. B., & Santana, M. J. (2021). Prevalence of comorbidities among individuals with COVID-19: A rapid review of current literature. *American Journal*

*of Infection Control*, *49*(2), 238–246. https://doi.org/10.1016/j.ajic.2020.06.213

Baltaci, D., Kutlucan, A., Ozturk, S., Saritas, A., Celer, A., Celbek, G., Deler, H., Aydin, Y., & Ankarali, H. (2012). Effectiveness for self-monitoring of blood sugar on blood glucose control in Turkish patients with type 2 diabetes mellitus. *Medicinski Glasnik : Official Publication of the Medical Association of Zenica-Doboj Canton, Bosnia and Herzegovina*, *9*(2), 211–217. http://www.ncbi.nlm.nih.gov/pubmed/22926352

Baltaci, D., Kutlucan, A., Turker, Y., Harun Deler, M., Sariguzel, F., Ozcan, E., Ankarali, H., Yılmaz, A., Hamdi Kara, İ., Davut Baltaci, A., Kendi Kendine Kan Şekeri İzleminin Klinik Etkinliğinin Değerlendirilmesi, H., Basamak Tabanlı Bir Çalışma, B., Kelimeler, A., Mellitus, D., Basamak, B., Kendine Kan Şekeri İzlemi, K., & Kontrol, G. (2015a). Evaluation of Clinical Effectiveness of Self-Monitoring Blood Glucose Level in Patients with Type 2 Diabetes Mellitus Treated with Non-Insulin Regimens in Düzce: Primary Care-Based Study Düzce İlinde İnsülin Kullanmayan Tip 2 Diyabet. *Konuralp Tıp Dergisi*, *7*(1), 15–22.

Baltaci, D., Kutlucan, A., Turker, Y., Harun Deler, M., Sariguzel, F., Ozcan, E., Ankarali, H., Yılmaz, A., Hamdi Kara, İ., Davut Baltaci, A., Kendi Kendine Kan Şekeri İzleminin Klinik Etkinliğinin Değerlendirilmesi, H., Basamak Tabanlı Bir Çalışma, B., Kelimeler, A., Mellitus, D., Basamak, B., Kendine Kan Şekeri İzlemi, K., & Kontrol, G. (2015b). Evaluation of Clinical Effectiveness of Self-Monitoring Blood Glucose Level in Patients with Type 2 Diabetes Mellitus Treated with Non-Insulin Regimens in Düzce: Primary Care-Based Study Düzce İlinde İnsülin Kullanmayan Tip 2 Diyabet. *Konuralp Tıp Dergisi*, *7*(1), 15–22. www.konuralptipdergi.duzce.edu.tr

Banerjee, M., Chakraborty, S., & Pal, R. (2020). Diabetes self-management amid COVID-19 pandemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 351–354. https://doi.org/https://doi.org/10.1016/j.dsx.2020.04.013

Barron, E., Bakhai, C., Kar, P., Weaver, A., Bradley, D., Ismail, H., Knighton, P., Holman, N., Khunti, K., Sattar, N., Wareham, N. J., Young, B., & Valabhji, J. (2020). Associations of type 1 and type 2 diabetes with COVID-19-related mortality in England: a whole-population study. *The Lancet Diabetes & Endocrinology*, *8*(10), 813–822. https://doi.org/10.1016/S2213-8587(20)30272-2

Bashir, M., Inzamam, W., Robbani, I., Banday, T. R., Al-Misned, F. A., El-Serehy, H. A., & Vladulescu, C. (2023). Patients with Diabetes Experienced More Serious and Protracted Sickness from the COVID-19 Infection: A Prospective Study. *Medicina (Lithuania)*, *59*(3). https://doi.org/10.3390/medicina59030472

Beck, J., Greenwood, D. A., Blanton, L., Bollinger, S. T., Butcher, M. K., Condon, J. E., Cypress, M., Faulkner, P., Fischl, A. H., Francis, T., Kolb, L. E., Lavin-Tompkins, J. M., MacLeod, J., Maryniuk, M., Mensing, C., Orzeck, E. A., Pope, D. D., Pulizzi, J. L., Reed, A. A., … Wang, J. (2017). 2017 National Standards for Diabetes Self-Management Education and Support. *Diabetes Care*, *40*(10), 1409–1419. https://doi.org/10.2337/dci17-0025

Beck, J., Greenwood, D. A., Blanton, L., Bollinger, S. T., Butcher, M. K., Condon, J. E., Cypress, M., Faulkner, P., Fischl, A. H., Francis, T., Kolb, L. E., Lavin-Tompkins, J. M., MacLeod, J., Maryniuk, M., Mensing, C., Orzeck, E. A., Pope, D. D., Pulizzi, J. L., Reed, A. A., … Wang, J. (2018). 2017 National Standards for Diabetes Self-Management

Education and Support. *Diabetes Educator*, *44*(1), 35–50. https://doi.org/10.1177/0145721718754797

Becker, R. C. (2021). COVID-19 and its sequelae: a platform for optimal patient care, discovery and training. *Journal of Thrombosis and Thrombolysis*, *51*(3), 587–594. https://doi.org/10.1007/s11239-021-02375-w

Belkhadir, J. (2020). COVID-19 and diabetes from IDF MENA region. *Diabetes Research and Clinical Practice*, *166*, 108277. https://doi.org/10.1016/j.diabres.2020.108277

Bellou et al. (2018). Risk factors for type 2 diabetes mellitus: An exposure-wide umbrella review of meta-analyses. PLoS ONE [revista en Internet] 2018 [acceso 20 de agosto de 2020]; 13(3): 1-27. *PLoS ONE*, *13*(3), 1–27. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5860745/pdf/pone.0194127.pdf

Bergwerk, M., Gonen, T., Lustig, Y., Amit, S., Lipsitch, M., Cohen, C., Mandelboim, M., Levin, E. G., Rubin, C., Indenbaum, V., Tal, I., Zavitan, M., Zuckerman, N., Bar-Chaim, A., Kreiss, Y., & Regev-Yochay, G. (2021). Covid-19 Breakthrough Infections in Vaccinated Health Care Workers. *New England Journal of Medicine*, *385*(16), 1474–1484. https://doi.org/10.1056/NEJMoa2109072

Berkowitz, S. A., Meigs, J. B., & Wexler, D. J. (2013). Age at type 2 diabetes onset and glycaemic control: Results from the National Health and Nutrition Examination Survey (NHANES) 2005-2010. *Diabetologia*, *56*(12), 2593–2600. https://doi.org/10.1007/s00125-013-3036-4

Berlin, D. A., Gulick, R. M., & Martinez, F. J. (2020). Severe Covid-19. *The New England*

*Journal of Medicine*, *383*(25), 2451–2460. https://doi.org/10.1056/NEJMcp2009575

Beutler, E. (1975). The effect of carbon monoxide on red cell life span in sickle cell disease. *Blood*, *46*(2), 253–259. https://doi.org/10.1182/blood.v46.2.253.253

Bhandari, S., Rankawat, G., Singh, A., Gupta, V., & Kakkar, S. (2020). Impact of glycemic control in diabetes mellitus on management of COVID-19 infection. *International Journal of Diabetes in Developing Countries*, *40*(3), 340–345. https://doi.org/10.1007/s13410-020-00868-7

Bhatti, J. S., Sehrawat, A., Mishra, J., Sidhu, I. S., Navik, U., Khullar, N., Kumar, S., Bhatti, G. K., & Reddy, P. H. (2022). Oxidative stress in the pathophysiology of type 2 diabetes and related complications: Current therapeutics strategies and future perspectives. *Free Radical Biology and Medicine*, *184*, 114–134. https://doi.org/10.1016/j.freeradbiomed.2022.03.019

Bhurosy, T., & Jeewon, R. (2014). Overweight and Obesity Epidemic in Developing Countries: A Problem with Diet, Physical Activity, or Socioeconomic Status? *The Scientific World Journal*, *2014*, 1–7. https://doi.org/10.1155/2014/964236

Biamonte, E., Pegoraro, F., Carrone, F., Facchi, I., Favacchio, G., Lania, A. G., Mazziotti, G., & Mirani, M. (2021). Weight change and glycemic control in type 2 diabetes patients during COVID-19 pandemic : the lockdown effect. *Endocrine*, 604–610. https://doi.org/10.1007/s12020-021-02739-5

Biancalana, E., Parolini, F., Mengozzi, A., & Solini, A. (2021). Short-term impact of COVID-19 lockdown on metabolic control of patients with well-controlled type 2 diabetes: a single-centre observational study. *Acta Diabetologica*, *58*(4), 431–436.

https://doi.org/10.1007/s00592-020-01637-y

Blonde, L., Aschner, P., Bailey, C., Ji, L., Leiter, L. A., & Matthaei, S. (2017). Gaps and barriers in the control of blood glucose in people with type 2 diabetes. *Diabetes and Vascular Disease Research*, *14*(3), 172–183. https://doi.org/10.1177/1479164116679775

Bolge, S. C., Flores, N. M., & Phan, J. H. (2016). The Burden of Poor Mental Well-being Among Patients With Type 2 Diabetes Mellitus. *Journal of Occupational & Environmental Medicine*, *58*(11), 1121–1126. https://doi.org/10.1097/JOM.0000000000000874

Bonora, B. M., Morieri, M. L., Avogaro, A., & Fadini, G. P. (2021). The toll of lockdown against COVID-19 on diabetes outpatient care: Analysis from an outbreak area in northeast italy. *Diabetes Care*, *44*(1), e18–e21. https://doi.org/10.2337/dc20-1872

Boroumand, A. B., Forouhi, M., Karimi, F., Moghadam, A. S., Naeini, L. G., Kokabian, P., & Naderi, D. (2022). Immunogenicity of COVID-19 vaccines in patients with diabetes mellitus: A systematic review. *Frontiers in Immunology*, *13*(August). https://doi.org/10.3389/fimmu.2022.940357

Boudina, S., & Abel, E. D. (2010). Diabetic cardiomyopathy, causes and effects. *Reviews in Endocrine and Metabolic Disorders*, *11*(1), 31–39. https://doi.org/10.1007/s11154-010-9131-7

Boulé, N. G., Haddad, E., Kenny, G. P., Wells, G. A., & Sigal, R. J. (2001). Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. *JAMA*, *286*(10), 1218–1227. https://doi.org/10.1001/jama.286.10.1218

Boutin, S., Hildebrand, D., Boulant, S., Kreuter, M., Rüter, J., Pallerla, S. R., Velavan, T. P., & Nurjadi, D. (2021). Host factors facilitating SARS-CoV-2 virus infection and replication in the lungs. *Cellular and Molecular Life Sciences*, *78*(16), 5953–5976. https://doi.org/10.1007/s00018-021-03889-5

Boyle, C. N., Lutz, T. A., & Le Foll, C. (2018). Amylin – Its role in the homeostatic and hedonic control of eating and recent developments of amylin analogs to treat obesity. *Molecular Metabolism*, *8*, 203–210. https://doi.org/10.1016/j.molmet.2017.11.009

Brakenridge, C. J., Salim, A., Healy, G. N., Grigg, R., Carver, A., Rickards, K., Owen, N., & Dunstan, D. W. (2022). The Associations of COVID-19 Lockdown Restrictions with Longer-Term Activity Levels of Working Adults with Type 2 Diabetes: Cohort Study. *JMIR Diabetes*, *7*(2), 1–11. https://doi.org/10.2196/36181

Brufsky, A. (2020). Hyperglycemia, hydroxychloroquine, and the COVID-19 pandemic. *Journal of Medical Virology*, *92*(7), 770–775. https://doi.org/10.1002/jmv.25887

Brunetti, L., & Kalabalik, J. (2012). Management of type-2 diabetes mellitus in adults: focus on individualizing non-insulin therapies. *P & T : A Peer-Reviewed Journal for Formulary Management*, *37*(12), 687–696. https://doi.org/23319847

Buitrago-Garcia, D., Egli-Gany, D., Counotte, M. J., Hossmann, S., Imeri, H., Ipekci, A. M., Salanti, G., & Low, N. (2020). Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: A living systematic review and meta-analysis. *PLoS Medicine*, *17*(9), e1003346. https://doi.org/10.1371/journal.pmed.1003346

Burkle, F. M., Bradt, D. A., & Ryan, B. J. (2021). Global Public Health Database Support to

Population-Based Management of Pandemics and Global Public Health Crises, Part I: The Concept. *Prehospital and Disaster Medicine*, *36*(1), 95–104. https://doi.org/10.1017/S1049023X20001351

Busetto, L., Wick, W., & Gumbinger, C. (2020). How to use and assess qualitative research methods. *Neurological Research and Practice*, *2*(1). https://doi.org/10.1186/s42466-020-00059-z

Caballero, A. E., Ceriello, A., Misra, A., Aschner, P., Mcdonnell, M. E., Hassanein, M., & Ji, L. (2020). *COVID-19 in people living with diabetes: An international consensus*. *January*.

Car, J., Koh, G. C.-H., Foong, P. S., & Wang, C. J. (2020). Video consultations in primary and specialist care during the covid-19 pandemic and beyond. *BMJ*, m3945. https://doi.org/10.1136/bmj.m3945

Carboni, E., Carta, A. R., & Carboni, E. (2020). Can pioglitazone be potentially useful therapeutically in treating patients with covid-19? *Medical Hypotheses*, *140*(January). https://doi.org/10.1016/j.mehy.2020.109776

Carfì, A., Bernabei, R., & Landi, F. (2020). Persistent Symptoms in Patients After Acute COVID-19. *JAMA*, *324*(6), 603. https://doi.org/10.1001/jama.2020.12603

Carino, M., Quill, Z., Gabbs, M., Sellers, E., Hamilton, J., Pinto, T., Jetha, M., Ho, J., Alecio, O. G., Dart, A., & Wicklow, B. (2022). Impact of COVID-19 Pandemic on Adolescents and Young Adults Living With Type 2 Diabetes. *Canadian Journal of Diabetes*, *46*(4), 404–410. https://doi.org/10.1016/j.jcjd.2022.01.002

Cartagena, V. M., Tort-Nasarre, G., Romeu-Labayen, M., & Vidal-Alaball, J. (2022). The

experiences of patients with diabetes and strategies for their management during the first COVID-19 lockdown: a qualitative study. *BMC Nursing*, *21*(1), 1–11. https://doi.org/10.1186/s12912-022-00911-4

Carvajal, J. J., García-Castillo, V., Cuellar, S. V., Campillay-Véliz, C. P., Salazar-Ardiles, C., Avellaneda, A. M., Muñoz, C. A., Retamal-Díaz, A., Bueno, S. M., González, P. A., Kalergis, A. M., & Lay, M. K. (2024). New insights into the pathogenesis of SARS-CoV-2 during and after the COVID-19 pandemic. *Frontiers in Immunology*, *15*(June). https://doi.org/10.3389/fimmu.2024.1363572

Carvalho-schneider, C., Laurent, E., Lemaignen, A., Laribi, S., Flament, T., Beau, E., Ste, K., Gaudy-graf, C., Bernard, L., & Grammatico-guillon, L. (2020). *Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information* (Issue January).

Casas, G. C., Català, A., Carretero Hernández, G., Rodríguez-Jiménez, P., Fernández-Nieto, D., Rodríguez-Villa Lario, A., Navarro Fernández, I., Ruiz-Villaverde, R., Falkenhain-López, D., Llamas Velasco, M., García-Gavín, J., Baniandrés, O., González-Cruz, C., Morillas-Lahuerta, V., Cubiró, X., Figueras Nart, I., Selda-Enriquez, G., Romaní, J., Fustà-Novell, X., … García-Doval, I. (2020). Classification of the cutaneous manifestations of COVID-19: a rapid prospective nationwide consensus study in Spain with 375 cases. *British Journal of Dermatology*, *183*(1), 71–77. https://doi.org/10.1111/bjd.19163

Cascella, M., Rajnik, M., Aleem, A., Dulebohn, S. C., & Di Napoli, R. (2022). Features, Evaluation, and Treatment of Coronavirus (COVID-19). In *StatPearls*.

http://www.ncbi.nlm.nih.gov/pubmed/32150360

Chalmers, J., & Armour, M. (2018). The Delphi Technique. In *Handbook of Research Methods in Health Social Sciences* (pp. 1–21). Springer Singapore. https://doi.org/10.1007/978-981-10-2779-6_99-1

Chan, C. W., Yu, C. L., Lin, J. C., Hsieh, Y. C., Lin, C. C., Hung, C. Y., Li, C. H., Liao, Y. C., Lo, C. P., Huang, J. L., Lin, C. H., & Wu, T. J. (2018). Glitazones and alpha-glucosidase inhibitors as the second-line oral anti-diabetic agents added to metformin reduce cardiovascular risk in Type 2 diabetes patients: A nationwide cohort observational study. *Cardiovascular Diabetology*, *17*(1), 1–13. https://doi.org/10.1186/s12933-018-0663-6

Chan, F.-W. J., Yuan, S., Kok, K.-H., To, K. K.-W., Chu, H., Yang, J., Xing, F., Liu, J., Yip, C. C.-Y., Poon, R. W.-S., Tsoi, H.-W., Lo, S. K.-F., Chan, K.-H., Poon, V. K.-M., Chan, W.-M., Ip, J. D., Cai, J.-P., Cheng, V. C.-C., Chen, H., … Yuen, K.-Y. (2020). A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *The Lancet*, *395*(10223), 514–523. https://doi.org/10.1016/S0140-6736(20)30154-9

Chan, J. F. W., Lau, S. K. P., To, K. K. W., Cheng, V. C. C., Woo, P. C. Y., & Yuen, K.-Y. (2015). Middle East respiratory syndrome coronavirus: another zoonotic betacoronavirus causing SARS-like disease. *Clinical Microbiology Reviews*, *28*(2), 465–522. https://doi.org/10.1128/CMR.00102-14

Channanath, A. M., AlWotayan, R., Alkandari, H., Davidsson, L., Tuomilehto, J., & Thanaraj, T. A. (2018). Glycaemic control in native Kuwaiti Arab patients with type 2 diabetes. *Primary Care Diabetes*, *12*(6), 526–532. https://doi.org/10.1016/j.pcd.2018.07.009

Chaturvedi, S. K., Manche Gowda, S., Ahmed, H. U., Alosaimi, F. D., Andreone, N., Bobrov, A., Bulgari, V., Carrà, G., Castelnuovo, G., Girolamo, G. De, Gondek, T., Jovanovic, N., Kamala, T., Kiejna, A., Lalic, N., Lecic-Tosevski, D., Minhas, F., Mutiso, V., Ndetei, D., … Sartorius, N. (2019). More anxious than depressed: Prevalence and correlates in a 15-nation study of anxiety disorders in people with type 2 diabetes mellitus. *General Psychiatry*, *32*(4), 1–9. https://doi.org/10.1136/gpsych-2019-100076

Chatzis, D. G., Magounaki, K., Pantazopoulos, I., & Bhaskar, S. M. M. (2022). COVID-19 and the cardiovascular system-current knowledge and future perspectives. *World Journal of Clinical Cases*, *10*(27), 9602–9610. https://doi.org/10.12998/wjcc.v10.i27.9602

Chaudhury, A., Duvoor, C., Reddy Dendi, V. S., Kraleti, S., Chada, A., Ravilla, R., Marco, A., Shekhawat, N. S., Montales, M. T., Kuriakose, K., Sasapu, A., Beebe, A., Patil, N., Musham, C. K., Lohani, G. P., & Mirza, W. (2017). Clinical Review of Antidiabetic Drugs: Implications for Type 2 Diabetes Mellitus Management. *Frontiers in Endocrinology*, *8*, 1–12. https://doi.org/10.3389/fendo.2017.00006

Chen, H.-J., Huang, W.-H., Chan, H.-L., & Hwang, L.-C. (2021). Improvement in Cardiometabolic Risk Factors During Smoking Cessation Treatment in Patients with Type 2 Diabetes: A Retrospective Cohort Study. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *Volume 14*, 1695–1702. https://doi.org/10.2147/DMSO.S303446

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Qiu, Y., Wang, J., Liu, Y., Wei, Y., Xia, J., Yu, T., Zhang, X., & Zhang, L. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The Lancet*, *395*(10223), 507–513. https://doi.org/10.1016/S0140-6736(20)30211-7

Chen, S., Zhu, Y., Jin, S., Zhao, D., Guo, J., Chen, L., & Huang, Y. (2023). Association of glycemic control with hypertension in patients with diabetes: a population-based longitudinal study. *BMC Cardiovascular Disorders*, *23*(1), 1–8. https://doi.org/10.1186/s12872-023-03478-3

Cheng, H. P., Wong, J. S. L., Selveindran, N. M., Mohamed Nor, L., & Hong, J. Y. H. (2023). Mental Well-being in Adolescents with Diabetes during the COVID-19 Pandemic and Impact on Glycaemic Control. *Malaysian Journal of Paediatrics and Child Health*, *29*(2), 1–7. https://doi.org/10.51407/mjpch.v29i2.250

Chetoui, A., Kaoutar, K., Elmoussaoui, S., Boutahar, K., El Kardoudi, A., Chigr, F., & Najimi, M. (2022). Prevalence and determinants of poor glycaemic control: A cross-sectional study among Moroccan type 2 diabetes patients. *International Health*, *14*(4), 390–397. https://doi.org/10.1093/inthealth/ihz107

Chiaranai, C., Chularee, S., Saokaew, S., Bhatarasakoon, P., Umnuaypornlert, A., Chaomuang, N., Doommai, N., & Nimkuntod, P. (2024). Effectiveness of telehealth on the glycemic control of patients with type 2 diabetes mellitus during the COVID-19 pandemic: A systematic review and meta-analysis of randomised controlled trials. *International Journal of Nursing Studies Advances*, *6*, 100169. https://doi.org/10.1016/j.ijnsa.2023.100169

Chu, D., Singh, V., Vu Ngoc, S.-M., Nguyen, T., & Barceló, D. (2022). Transmission of SARS-CoV-2 infections and exposure in surfaces, points and wastewaters: A global one health perspective. *Case Studies in Chemical and Environmental Engineering*, *5*(January), 100184. https://doi.org/10.1016/j.cscee.2022.100184

Cognigni, M., D'Agostin, M., Schiulaz, I., Giangreco, M., Carletti, C., Faleschini, E., Barbi, E.,

& Tornese, G. (2021). HbA1c and BMI after lockdown for COVID-19 in children and adolescents with type 1 diabetes mellitus. *Acta Paediatrica, International Journal of Paediatrics*, *110*(7), 2206–2207. https://doi.org/10.1111/apa.15838

Coker, A. O., Coker, O. O., & Sanni, D. (2018). Psychometric properties of the 21-item Depression Anxiety Stress Scale (DASS-21). *African Research Review*, *12*(2), 135. https://doi.org/10.4314/afrrev.v12i2.13

Colberg, S. R., Albright, A. L., Blissmer, B. J., Braun, B., Chasan-Taber, L., Fernhall, B., Regensteiner, J. G., Rubin, R. R., Sigal, R. J., American College of Sports Medicine, & American Diabetes Association. (2010). Exercise and type 2 diabetes: American College of Sports Medicine and the American Diabetes Association: Joint Position Statement. *Medicine and Science in Sports and Exercise*, *42*(12), 2282–2303. https://doi.org/10.1249/MSS.0b013e3181eeb61c

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., Horton, E. S., Castorino, K., & Tate, D. F. (2016). Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. *Diabetes Care*, *39*(11), 2065–2079. https://doi.org/10.2337/dc16-1728

Cole, J. B., & Florez, J. C. (2020). Genetics of diabetes mellitus and diabetes complications. *Nature Reviews Nephrology*, *16*(7), 377–390. https://doi.org/10.1038/s41581-020-0278-5

Coma, E., Basora, J., & A, S. M., et al. (2020). Impact of the COVID-19 pandemic on diabetes management and the psychosocial well-being of patients with diabetes. *Diabetes & Metabolism*, *46*(5), 393-398. https://doi.org/https://doi.org/10.1016/j.diabet.2020.05.006

Coma, E., Mora, N., Méndez, L., Benítez, M., Hermosilla, E., Fàbregas, M., Fina, F., Mercadé, A., Flayeh, S., Guiriguet, C., Balló, E., Martinez Leon, N., Mas, A., Cordomí, S., Lejardi, Y., & Medina, M. (2020). Primary care in the time of COVID-19: Monitoring the effect of the pandemic and the lockdown measures on 34 quality of care indicators calculated for 288 primary care practices covering about 6 million people in Catalonia. *BMC Family Practice*, *21*(1), 1–9. https://doi.org/10.1186/s12875-020-01278-8

Comellas, M., Marrero, Y., George, F., & Matthews, L. (2019). Age and glycemic control among adults with type 2 diabetes in the United States: An assessment from the National Health and Nutrition Examination Survey (NHANES) 2013-2014. *Diabetes & Metabolic Syndrome*, *13*(6), 3069–3073. https://doi.org/10.1016/j.dsx.2019.11.004

Conti, P., Ronconi, G., Caraffa, A., Gallenga, C. E., Ross, R., Frydas, I., & Kritas, S. K. (2020). Induction of pro-inflammatory cytokines (IL-1 and IL-6) and lung inflammation by Coronavirus-19 (COVI-19 or SARS-CoV-2): anti-inflammatory strategies. In *Journal of biological regulators and homeostatic agents* (Vol. 34, Issue 2, pp. 327–331). NLM (Medline). https://doi.org/10.23812/CONTI-E

Corrao, S., Pinelli, K., Vacca, M., Raspanti, M., & Argano, C. (2021). Type 2 Diabetes Mellitus and COVID-19: A Narrative Review. *Frontiers in Endocrinology*, *12*(March), 1–10. https://doi.org/10.3389/fendo.2021.609470

Cosansu, G., & Erdogan, S. (2013). Influence of Psychosocial Factors on Self-Care Behaviors and Glycemic Control in Turkish Patients With Type 2 Diabetes Mellitus. *Journal of Transcultural Nursing*, *25*(1), 51–59. https://doi.org/10.1177/1043659613504112

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E.,

Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International physical activity questionnaire: 12-Country reliability and validity. *Medicine and Science in Sports and Exercise*, *35*(8), 1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB

Crouse, A. B., Grimes, T., Li, P., Might, M., & Ovalle, F. (2021). *Metformin Use Is Associated With Reduced Mortality in a Diverse Population With COVID-19 and Diabetes*. *11*(January), 1–8. https://doi.org/10.3389/fendo.2020.600439

Cui, J., Li, F., & Shi, Z.-L. (2019). Origin and evolution of pathogenic coronaviruses. *Nature Reviews Microbiology*, *17*(3), 181–192. https://doi.org/10.1038/s41579-018-0118-9

D'Onofrio, L., Pieralice, S., Maddaloni, E., Mignogna, C., Sterpetti, S., Coraggio, L., Luordi, C., Guarisco, G., Leto, G., Leonetti, F., Manfrini, S., & Buzzetti, R. (2021). Effects of the the COVID -19 lockdown on glycaemic control in subjects with type 2 diabetes: the glycalock study. *Diabetes, Obesity and Metabolism*, *23*(7), 1624–1630. https://doi.org/10.1111/dom.14380

Dailah, H. G. (2024). The Influence of Nurse-Led Interventions on Diseases Management in Patients with Diabetes Mellitus: A Narrative Review. *Healthcare (Switzerland)*, *12*(3). https://doi.org/10.3390/healthcare12030352

Dajani, R., Li, J., Wei, Z., Glessner, J. T., Chang, X., Cardinale, C. J., Pellegrino, R., Wang, T., Hakooz, N., Khader, Y., Sheshani, A., Zandaki, D., & Hakonarson, H. (2015). CNV Analysis Associates AKNAD1 with Type-2 Diabetes in Jordan Subpopulations. *Scientific Reports*, *5*, 1–10. https://doi.org/10.1038/srep13391

Dajani, R., Li, J., Wei, Z., March, M. E., Xia, Q., Khader, Y., Hakooz, N., Fatahallah, R., El-

Khateeb, M., Arafat, A., Saleh, T., Dajani, A. R., Al-Abbadi, Z., Qader, M. A., Shiyab, A. H., Bateiha, A., Ajlouni, K., & Hakonarson, H. (2017). Genome-wide association study identifies novel type II diabetes risk loci in Jordan subpopulations. *PeerJ*, *2017*(8), 1–21. https://doi.org/10.7717/peerj.3618

Das, S., Purkayastha, S., Roy, H., Sinha, A., & Choudhury, Y. (2018). Polymorphisms in DNA repair genes increase the risk for type 2 diabetes mellitus and hypertension. *Biomolecular Concepts*, *9*(1), 80–93. https://doi.org/10.1515/bmc-2018-0008

Davies, M. J., Aroda, V. R., Collins, B. S., Gabbay, R. A., Green, J., Maruthur, N. M., Rosas, S. E., Del Prato, S., Mathieu, C., Mingrone, G., Rossing, P., Tankova, T., Tsapas, A., & Buse, J. B. (2022). Management of Hyperglycemia in Type 2 Diabetes, 2022. A Consensus Report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes Care*, *45*(11), 2753–2786. https://doi.org/10.2337/dci22-0034

De la Fuente Coria, M. C., Cruz-Cobo, C., & Santi-Cano, M. J. (2020). Effectiveness of a primary care nurse delivered educational intervention for patients with type 2 diabetes mellitus in promoting metabolic control and compliance with long-term therapeutic targets: Randomised controlled trial. *International Journal of Nursing Studies*, *101*(August 2022), 103417. https://doi.org/10.1016/j.ijnurstu.2019.103417

De Marinis, Y., Pesola, A.-K., Söderlund Strand, A., Norman, A., Pernow, G., Aldén, M., Yang, R., & Rasmussen, M. (2021). Detection of SARS-CoV-2 by rapid antigen tests on saliva in hospitalized patients with COVID-19. *Infection Ecology & Epidemiology*, *11*(1). https://doi.org/10.1080/20008686.2021.1993535

Dedeilia, A., Papapanou, M., Papadopoulos, A. N., Karela, N. R., Androutsou, A., Mitsopoulou, D., Nikolakea, M., Konstantinidis, C., Papageorgakopoulou, M., Sideris, M., Johnson, E. O., Fitzpatrick, S., Cometto, G., Campbell, J., & Sotiropoulos, M. G. (2023). Health worker education during the COVID-19 pandemic: global disruption, responses and lessons for the future—a systematic review and meta-analysis. *Human Resources for Health*, *21*(1), 1–35. https://doi.org/10.1186/s12960-023-00799-4

del Rio, C., Collins, L. F., & Malani, P. (2020). Long-term Health Consequences of COVID-19. *JAMA*, *324*(17), 1723. https://doi.org/10.1001/jama.2020.19719

Demoz, G. T., Gebremariam, A., Yifter, H., Alebachew, M., Niriayo, Y. L., Gebreslassie, G., Woldu, G., Bahrey, D., & Shibeshi, W. (2019). Predictors of poor glycemic control among patients with type 2 diabetes on follow - up care at a tertiary healthcare setting in Ethiopia. *BMC Research Notes*, 1–7. https://doi.org/10.1186/s13104-019-4248-6

Deng, F., Gao, D., Ma, X., Guo, Y., Wang, R., & Jiang, W. (2021). *Corticosteroids in diabetes patients infected with COVID-19*. 29–31.

Deng, S. Q., & Peng, H. J. (2020). Characteristics of and public health responses to the coronavirus disease 2019 outbreak in China. *Journal of Clinical Medicine*, *9*(2). https://doi.org/10.3390/jcm9020575

Dennis, J. M., Mateen, B. A., Sonabend, R., Thomas, N. J., Patel, K. A., Hattersley, A. T., Denaxas, S., McGovern, A. P., & Vollmer, S. J. (2021). Type 2 diabetes and covid-19–related mortality in the critical care setting: A national cohort study in england, march–july 2020. *Diabetes Care*, *44*(1), 50–57. https://doi.org/10.2337/dc20-1444

Despres, J. P., Lemieux, S., Lamarche, B., Prud'Homme, D., Moorjani, S., Brun, L. D., Gagne, C., & Lupien, P. J. (1995). The insulin resistance dyslipidemic syndrome: Contribution of visceral obesity and therapeutic implications. *International Journal of Obesity*, *19*(SUPPL. 1), S76-86.

Desvars-Larrive, A., Dervic, E., Haug, N., Niederkrotenthaler, T., Chen, J., Di Natale, A., Lasser, J., Gliga, D. S., Roux, A., Sorger, J., Chakraborty, A., Ten, A., Dervic, A., Pacheco, A., Jurczak, A., Cserjan, D., Lederhilger, D., Bulska, D., Berishaj, D., … Thurner, S. (2020). A structured open dataset of government interventions in response to COVID-19. *Scientific Data*, *7*(1), 285. https://doi.org/10.1038/s41597-020-00609-9

DI Dalmazi, G., Maltoni, G., Bongiorno, C., Tucci, L., DI Natale, V., Moscatiello, S., Laffi, G., Pession, A., Zucchini, S., & Pagotto, U. (2020). Comparison of the effects of lockdown due to COVID-19 on glucose patterns among children, adolescents, and adults with type 1 diabetes: CGM study. *BMJ Open Diabetes Research and Care*, *8*(2), 1664. https://doi.org/10.1136/bmjdrc-2020-001664

Dinavari, M. F., Sanaie, S., Rasouli, K., Faramarzi, E., & Gol, R. M. (2023). Glycemic control and associated factors among type 2 diabetes mellitus patients : a cross-sectional study of Azar cohort population. *BMC Endocrine Disorders*, 1–11. https://doi.org/10.1186/s12902-023-01515-y

Dissanayake, H., Soysa, P., Samarathunga, T., De Silva, L., Samaranayake, N., Padmaperuma, C., & Katulanda, P. (2022). Impact of COVID-19 lockdown on people living with diabetes: Experience from a low-middle income country in South Asia. *Primary Care Diabetes*, *16*(1), 127–134. https://doi.org/10.1016/j.pcd.2021.12.003

Dmour, I., Al-Hamaideh, K. D., Qudah, S. A. A.-, & Al-Shawabkeh, J. D. (2023). Self-care interventions among the Jordanians during the COVID-19 lockdown: A cross-sectional study of community pharmacists' observations. *Journal of Applied Pharmaceutical Science*, *13*(08), 212–222. https://doi.org/10.7324/JAPS.2023.143803

Dong, E., Du, H., & Gardner, L. (2020). An interactive web-based dashboard to track COVID-19 in real time. *The Lancet Infectious Diseases*, *20*(5), 533–534. https://doi.org/10.1016/S1473-3099(20)30120-1

Dong, Q., Huang, J., Liu, S., Yang, L., Li, J., Li, B., Zhao, X., Li, Z., & Wu, L. (2019). A survey on glycemic control rate of type 2 diabetes mellitus with different therapies and patients' satisfaction in China. *Patient Preference and Adherence*, *13*, 1303–1310. https://doi.org/10.2147/PPA.S198908

Doyle, J., Smith, E. M. J. S., Gough, C. J. R., Haq, A., Willis, C., Stevenson, T., & Reljic, M. (2020). Mobilising a workforce to combat COVID-19: An account, reflections, and lessons learned. *Journal of the Intensive Care Society*. https://doi.org/10.1177/1751143720971540

Dror, A. A., Eisenbach, N., Taiber, S., Morozov, N. G., Mizrachi, M., Zigron, A., Srouji, S., & Sela, E. (2020). Vaccine hesitancy: the next challenge in the fight against COVID-19. *European Journal of Epidemiology*, *35*(8), 775–779. https://doi.org/10.1007/s10654-020-00671-y

Du, R.-H., Liu, L.-M., Yin, W., Wang, W., Guan, L.-L., Yuan, M.-L., Li, Y.-L., Hu, Y., Li, X.-Y., Sun, B., Peng, P., & Shi, H.-Z. (2020). Hospitalization and Critical Care of 109 Decedents with COVID-19 Pneumonia in Wuhan, China. *Annals of the American Thoracic Society*, *17*(7), 839–846. https://doi.org/10.1513/AnnalsATS.202003-225OC

Duan, L., & Zhu, G. (2020). Psychological interventions for people affected by the COVID-19 epidemic. In *The Lancet Psychiatry* (Vol. 7, Issue 4, pp. 300–302). Elsevier Ltd. https://doi.org/10.1016/S2215-0366(20)30073-0

Dubé, E., Laberge, C., Guay, M., Bramadat, P., Roy, R., & Bettinger, J. A. (2013). Vaccine hesitancy. *Human Vaccines & Immunotherapeutics*, *9*(8), 1763–1773. https://doi.org/10.4161/hv.24657

Dubowitz, N., Xue, W., Long, Q., Ownby, J. G., Olson, D. E., Barb, D., Rhee, M. K., Mohan, A. V., Watson-Williams, P. I., Jackson, S. L., Tomolo, A. M., Johnson, T. M., & Phillips, L. S. (2014). Aging is associated with increased HbA1c levels, independently of glucose levels and insulin resistance, and also with decreased HbA1c diagnostic specificity. *Diabetic Medicine*, *31*(8), 927–935. https://doi.org/10.1111/dme.12459

Duke, L., Fereira de Moura, A., Silvia Gorban de Lapertosa, S., Lucy Hammond L., Jacobs E., Abha Kaundal, A., ... Rivas Gonzalez, M. (2019). IDF Diabetes Atlas 9th edition 2019. In *International Diabetes Federation Diabetes Atlas, Ninth Edition*.

Dyer, T. A., Ahlers, R. S., & Goldstein, S. K. (2021). The impact of COVID-19 on individuals with diabetes: A survey of the psychological and lifestyle changes. *Diabetes Research and Clinical Practice*, *172*, 108570. https://doi.org/https://doi.org/10.1016/j.diabres.2021.108570

Eberle, C., & Stichling, S. (2021). Impact of COVID-19 lockdown on glycemic control in patients with type 1 and type 2 diabetes mellitus: a systematic review. *Diabetology and Metabolic Syndrome*, *13*(1), 1–8. https://doi.org/10.1186/s13098-021-00705-9

Eckstein, M. L., Williams, D. M., O'Neil, L. K., Hayes, J., Stephens, J. W., & Bracken, R. M. (2019). Physical exercise and non-insulin glucose-lowering therapies in the management of Type 2 diabetes mellitus: a clinical review. In *Diabetic Medicine* (Vol. 36, Issue 3, pp. 349–358). Blackwell Publishing Ltd. https://doi.org/10.1111/dme.13865

Edwards, L. E. (2021). *NC Diabetes Advisory Council ADA Standards of Medical Care in Diabetes – 2021 Standards of Medical Care in Diabetes – 2021*.

Ege, F., Mellace, G., & Menon, S. (2023). The unseen toll: excess mortality during covid-19 lockdowns. *Scientific Reports*, *13*(1), 1–9. https://doi.org/10.1038/s41598-023-45934-2

El-Kebbi, I. M., Bidikian, N. H., Hneiny, L., & Nasrallah, M. P. (2021). Epidemiology of type 2 diabetes in the Middle East and North Africa: Challenges and call for action. *World Journal of Diabetes*, *12*(9), 1401–1425. https://doi.org/10.4239/wjd.v12.i9.1401

England, N. (2020). *NHS Improvement. Clinical guide for the management of surge during the coronavirus pandemic: rapid learning. version 2, 2020.* available: https://www.england.nhs.uk/coronavirus/secondary- care/other- [Accessed 14 Dec 2020].

Engler, C., Leo, M., Pfeifer, B., Juchum, M., Chen-Koenig, D., Poelzl, K., Schoenherr, H., Vill, D., Oberdanner, J., Eisendle, E., Middeldorf, K., Heindl, B., Gaenzer, H., Bode, G., Kirchmeyr, K., Ladner, G., Rieger, L., Koellensperger, U., Schwaiger, A., … Ebenbichler, C. (2020). Long-term trends in the prescription of antidiabetic drugs: Real-world evidence from the Diabetes Registry Tyrol 2012-2018. *BMJ Open Diabetes Research and Care*, *8*(1), 1–9. https://doi.org/10.1136/bmjdrc-2020-001279

Enguix, D. M., Cambronero, M. S., Rodríguez, J. C. A., & Rodríguez, A. H. (2022). Impact of

COVID-19 on glycaemic control in a Spanish cohort of patients with type 2 diabetes. *Practical Diabetes*, *39*(1), 7–11. https://doi.org/10.1002/pdi.2373

Ennab, R. M., & Ibdah, R. K. (2021). The impact of COVID-19 on surgical practice in Jordan during the second outbreak: A survey. *Annals of Medicine and Surgery*, *62*(December 2020), 402–405. https://doi.org/10.1016/j.amsu.2021.01.047

Espinosa, M. M., Almeida, V. R. dos S., & Do Nascimento, V. F. (2021). Poor glycemic control and associated factors in diabetic people attending a reference outpatient clinic in Mato Grosso, Brazil. *Investigación y Educación En Enfermería*, *39*(3). https://doi.org/10.17533/udea.iee.v39n3e10

Falcetta, P., Aragona, M., Ciccarone, A., Bertolotto, A., Campi, F., Coppelli, A., Dardano, A., Giannarelli, R., Bianchi, C., & Del Prato, S. (2021). Impact of COVID-19 lockdown on glucose control of elderly people with type 2 diabetes in Italy. *Diabetes Research and Clinical Practice*, *174*, 108750. https://doi.org/10.1016/j.diabres.2021.108750

Fallahi, A., Jamil, D. I., Karimi, E. B., Baghi, V., & Gheshlagh, R. G. (2019). Prevalence of obstructive sleep apnea in patients with type 2 diabetes: A systematic review and meta-analysis. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *13*(4), 2463–2468. https://doi.org/10.1016/j.dsx.2019.06.030

Fan, L., & Sidani, S. (2017). Preferences of Persons with Type 2 Diabetes for Diabetes Self-Management Education Interventions : An Exploration. *Health*, *9*, 1567–1588. https://doi.org/10.4236/health.2017.911115

Fang, F. C., Naccache, S. N., & Greninger, A. L. (2020). The Laboratory Diagnosis of

Coronavirus Disease 2019- Frequently Asked Questions. *Clinical Infectious Diseases : An Official Publication of the Infectious Diseases Society of America*, *71*(11), 2996–3001. https://doi.org/10.1093/cid/ciaa742

Farah, R., Al-Hawari, H., Albtoush, A., Nofal, A., Hyasat, T. B., Abu Jabeh, R. A. H., Suboh, L. T., Toubasi, A. A., Eqrai, T. F., & Abufaraj, M. (2023). Prevalence and risk factors of COVID-19 infection, mortality, and post-infection lung fibrosis in patients with type 2 diabetes: a cross-sectional study. *Journal of International Medical Research*, *51*(9). https://doi.org/10.1177/03000605231198413

Farzaei, M., Shahbazi, S., Gilani, N., Ostadrahimi, A., & Gholizadeh, L. (2023). Nurses' knowledge, attitudes, and practice with regards to nutritional management of diabetes mellitus. *BMC Medical Education*, *23*(1), 192. https://doi.org/10.1186/s12909-023-04178-4

Fathallah, N., Slim, R., Larif, S., Hmouda, H., & Ben Salem, C. (2015). Drug- induced hyperglycaemia and diabetes. *Drug Saf*, *38*(12), 40264– 015– 0339–. https://doi.org/doi. org/ 10. 1007/

Feldman, E. L., Callaghan, B. C., Pop-Busui, R., Zochodne, D. W., Wright, D. E., Bennett, D. L., Bril, V., Russell, J. W., & Viswanathan, V. (2019). Diabetic neuropathy. *Nature Reviews. Disease Primers*, *5*(1), 42. https://doi.org/10.1038/s41572-019-0097-9

Felix, H. C., Andersen, J. A., Willis, D. E., Malhis, J. R., Selig, J. P., & McElfish, P. A. (2021). Control of type 2 diabetes mellitus during the COVID-19 pandemic. *Primary Care Diabetes*, *15*(5), 786–792. https://doi.org/10.1016/j.pcd.2021.06.012

Feng, G., Liu, L., Cui, W., & Wang, F. (2020). Electron beam irradiation on novel coronavirus

(COVID-19): A Monte–Carlo simulation. *Chinese Physics B*, *29*(4), 048703. https://doi.org/10.1088/1674-1056/ab7dac

Fernández, E., Cortazar, A., & Bellido, V. (2020a). Impact of COVID-19 lockdown on glycemic control in patients with type 1 diabetes. *Diabetes Research and Clinical Practice*, *166*(January), 108348. https://doi.org/10.1016/j.diabres.2020.108348

Fernández, E., Cortazar, A., & Bellido, V. (2020b). Impact of COVID-19 lockdown on glycemic control in patients with type 1 diabetes. *Diabetes Research and Clinical Practice*, *166*, 108348. https://doi.org/10.1016/j.diabres.2020.108348

Fina Lubaki, J. P., Omole, O. B., & Francis, J. M. (2022). Glycaemic control among type 2 diabetes patients in sub-Saharan Africa from 2012 to 2022: a systematic review and meta-analysis. In *Diabetology and Metabolic Syndrome* (Vol. 14, Issue 1). BioMed Central. https://doi.org/10.1186/s13098-022-00902-0

Fritschi, C., & Fink, A. M. (2012). Fatigue in adults with type 2 diabetes-An overview of current understanding and management approaches. *US Endocrinology*, *8*(2), 84–87. https://doi.org/10.17925/use.2012.08.02.84

Frost, L. S., Mitchell, C. H., & Boesze-Battaglia, K. (2014). Autophagy in the eye: Implications for ocular cell health. *Experimental Eye Research*, *124*, 56–66. https://doi.org/10.1016/j.exer.2014.04.010

Fu, L., Wang, B., Yuan, T., Chen, X., Ao, Y., Fitzpatrick, T., Li, P., Zhou, Y., Lin, Y.-F., Duan, Q., Luo, G., Fan, S., Lu, Y., Feng, A., Zhan, Y., Liang, B., Cai, W., Zhang, L., Du, X., … Zou, H. (2020). Clinical characteristics of coronavirus disease 2019 (COVID-19) in China:

A systematic review and meta-analysis. *The Journal of Infection*, *80*(6), 656–665. https://doi.org/10.1016/j.jinf.2020.03.041

Fuchsberger, C., Flannick, J., Teslovich, T. M., Mahajan, A., Agarwala, V., Gaulton, K. J., Ma, C., Fontanillas, P., Moutsianas, L., McCarthy, D. J., Rivas, M. A., Perry, J. R. B., Sim, X., Blackwell, T. W., Robertson, N. R., Rayner, N. W., Cingolani, P., Locke, A. E., Tajes, J. F., … McCarthy, M. I. (2016). The genetic architecture of type 2 diabetes. *Nature*, *536*(7614), 41–47. https://doi.org/10.1038/nature18642

Fung, M., Otani, I., Pham, M., & Babik, J. (2021). Zoonotic coronavirus epidemics. *Annals of Allergy, Asthma & Immunology*, *126*(4), 321–337. https://doi.org/10.1016/j.anai.2020.11.021

Gaba, U., Altamish, M., Azharuddin, M., Adil, M., Ghosh, P., Gyawali, B., Yadav, Y., & Sharma, M. (2022). Risk factors and outcomes associated with diabetes mellitus in COVID-19 patients: a meta-analytic synthesis of observational studies. *Journal of Diabetes & Metabolic Disorders*, *21*(2), 1395–1405. https://doi.org/10.1007/s40200-022-01072-6

Gadekar, T., Dudeja, P., Basu, I., Vashisht, S., & Mukherji, S. (2020). Correlation of visceral body fat with waist–hip ratio, waist circumference and body mass index in healthy adults: A cross sectional study. *Medical Journal Armed Forces India*, *76*(1), 41–46. https://doi.org/10.1016/j.mjafi.2017.12.001

Galicia-Garcia, U., Benito-Vicente, A., Jebari, S., Larrea-Sebal, A., Siddiqi, H., Uribe, K. B., Ostolaza, H., & Martín, C. (2020). Pathophysiology of type 2 diabetes mellitus. *International Journal of Molecular Sciences*, *21*(17), 1–34. https://doi.org/10.3390/ijms21176275

Gamal, D. M., Ibrahim, R. A., & Samaan, S. F. (2022). Post COVID-19 syndrome in a prospective cohort study of Egyptian patients. *Egyptian Rheumatology and Rehabilitation*, *49*(1), 12. https://doi.org/10.1186/s43166-021-00104-y

Ganyani, T., Kremer, C., Chen, D., Torneri, A., Faes, C., Wallinga, J., & Hens, N. (2020). Estimating the generation interval for coronavirus disease (COVID-19) based on symptom onset data, March 2020. *Eurosurveillance*, *25*(17), 1–8. https://doi.org/10.2807/1560-7917.ES.2020.25.17.2000257

García-Lara, R. A., Gómez-Urquiza, J. L., Membrive-Jiménez, M. J., Velando-Soriano, A., Granados-Bolivar, M. E., Romero-Béjar, J. L., & Suleiman-Martos, N. (2022). Anxiety, Distress and Stress among Patients with Diabetes during COVID-19 Pandemic: A Systematic Review and Meta-Analysis. *Journal of Personalized Medicine*, *12*(9). https://doi.org/10.3390/jpm12091412

García-Molina, L., Lewis-Mikhael, A. M., Riquelme-Gallego, B., Cano-Ibáñez, N., Oliveras-López, M. J., & Bueno-Cavanillas, A. (2020). Improving type 2 diabetes mellitus glycaemic control through lifestyle modification implementing diet intervention: a systematic review and meta-analysis. *European Journal of Nutrition*, *59*(4), 1313–1328. https://doi.org/10.1007/s00394-019-02147-6

Garfan, S., Alamoodi, A. H., Zaidan, B. B., Al-Zobbi, M., Hamid, R. A., Alwan, J. K., Ahmaro, I. Y. Y., Khalid, E. T., Jumaah, F. M., Albahri, O. S., Zaidan, A. A., Albahri, A. S., Al-qaysi, Z. T., Ahmed, M. A., Shuwandy, M. L., Salih, M. M., Zughoul, O., Mohammed, K. I., & Momani, F. (2021). Telehealth utilization during the Covid-19 pandemic: A systematic review. *Computers in Biology and Medicine*, *138*(January), 104878.

https://doi.org/10.1016/j.compbiomed.2021.104878

Gerganova, A., Assyov, Y., & Kamenov, Z. (2022). Stress Hyperglycemia, Diabetes Mellitus and COVID-19 Infection: Risk Factors, Clinical Outcomes and Post-Discharge Implications. *Frontiers in Clinical Diabetes and Healthcare*, *3*(April), 1–13. https://doi.org/10.3389/fcdhc.2022.826006

Gertz, A. H., Pollack, C. C., Schultheiss, M. D., & Brownstein, J. S. (2022). Delayed medical care and underlying health in the United States during the COVID-19 pandemic: A cross-sectional study. *Preventive Medicine Reports*, *28*(June), 101882. https://doi.org/10.1016/j.pmedr.2022.101882

Ghosal, S., Sinha, B., Majumder, M., & Misra, A. (2020). Estimation of effects of nationwide lockdown for containing coronavirus infection on worsening of glycosylated haemoglobin and increase in diabetes-related complications: A simulation model using multivariate regression analysis. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 319–323. https://doi.org/10.1016/j.dsx.2020.03.014

Ghosh, A., Arora, B., Gupta, R., Anoop, S., & Misra, A. (2020). Effects of nationwide lockdown during COVID-19 epidemic on lifestyle and other medical issues of patients with type 2 diabetes in north India. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(5), 917–920. https://doi.org/10.1016/j.dsx.2020.05.044

Gonzalez, J. S., Peyrot, M., McCarl, L. A., Collins, E. M., Serpa, L., Mimiaga, M. J., & Safren, S. A. (2008). Depression and diabetes treatment nonadherence: A meta-analysis. *Diabetes Care*, *31*(12), 2398–2403. https://doi.org/10.2337/dc08-1341

Grasselli, G., Zangrillo, A., Zanella, A., Antonelli, M., Cabrini, L., Castelli, A., Cereda, D., Coluccello, A., Foti, G., Fumagalli, R., Iotti, G., Latronico, N., Lorini, L., Merler, S., Natalini, G., Piatti, A., Ranieri, M. V., Scandroglio, A. M., Storti, E., … Pesenti, A. (2020). Baseline Characteristics and Outcomes of 1591 Patients Infected with SARS-CoV-2 Admitted to ICUs of the Lombardy Region, Italy. *JAMA - Journal of the American Medical Association*, *323*(16), 1574–1581. https://doi.org/10.1001/jama.2020.5394

Grech, J., Norman, I. J., & Sammut, R. (2024). Exploring the smoking cessation needs of individuals with diabetes using the Information-Motivation-Behavior Skills model. *Tobacco Prevention & Cessation*, *10*(February), 1–13. https://doi.org/10.18332/tpc/181366

Greenberger, C., Dror, Y. F., Lev, I., & Hazoref, R. H. (2014). The inter-relationships between self-efficacy, self-management, depression and glycaemic control in Israeli people with type 2 diabetes. *Journal of Diabetes Nursing*, *18*(8), 333–339.

Greenhalgh, T., Knight, M., A'Court, C., Buxton, M., & Husain, L. (2020). Management of post-acute covid-19 in primary care. *BMJ*, m3026. https://doi.org/10.1136/bmj.m3026

Guan, W.-J., Liang, W.-H., Zhao, Y., Liang, H.-R., Chen, Z.-S., Li, Y.-M., Liu, X.-Q., Chen, R.-C., Tang, C.-L., Wang, T., Ou, C.-Q., Li, L., Chen, P.-Y., Sang, L., Wang, W., Li, J.-F., Li, C.-C., Ou, L.-M., Cheng, B., … He, J.-X. (2020). Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. *The European Respiratory Journal*, *55*(5). https://doi.org/10.1183/13993003.00547-2020

Guan, W., Ni, Z., Hu, Y., Liang, W., Ou, C., He, J., Liu, L., Shan, H., Lei, C., Hui, D. S. C., Du, B., Li, L., Zeng, G., Yuen, K.-Y., Chen, R., Tang, C., Wang, T., Chen, P., Xiang, J., … Zhong, N. (2020). Clinical Characteristics of Coronavirus Disease 2019 in China. *New*

*England Journal of Medicine*, *382*(18), 1708–1720. https://doi.org/10.1056/nejmoa2002032

Guardado-Mendoza, R., Prioletta, A., Jiménez-Ceja, L. M., Sosale, A., & Folli, F. (2013). State of the art paper The role of nateglinide and repaglinide, derivatives of meglitinide, in the treatment of type 2 diabetes mellitus. *Archives of Medical Science*, *5*, 936–943. https://doi.org/10.5114/aoms.2013.34991

Gucuk, S. (2015). Effects of the behavior of elderly type 2 diabetic patients and their relatives as caregivers on diabetes follow-up parameters in Bolu, Turkey. *Geriatrics & Gerontology International*, *16*(2), 182–190. https://doi.org/10.1111/ggi.12449

Guo, W., Li, M., Dong, Y., Zhou, H., Zhang, Z., Tian, C., Qin, R., Wang, H., Shen, Y., Du, K., Zhao, L., Fan, H., Luo, S., & Hu, D. (2020). Diabetes is a risk factor for the progression and prognosis of <scp>COVID</scp> -19. *Diabetes/Metabolism Research and Reviews*, *36*(7), 3319. https://doi.org/10.1002/dmrr.3319

Gupta, A., Madhavan, M. V, Sehgal, K., Nair, N., Mahajan, S., Sehrawat, T. S., Bikdeli, B., Ahluwalia, N., Ausiello, J. C., Wan, E. Y., Freedberg, D. E., Kirtane, A. J., Parikh, S. A., Maurer, M. S., Nordvig, A. S., Accili, D., Bathon, J. M., Mohan, S., Bauer, K. A., … Landry, D. W. (2020). Extrapulmonary manifestations of COVID-19. *Nature Medicine*, *26*(7), 1017–1032. https://doi.org/10.1038/s41591-020-0968-3

Gupta, R., Ghosh, A., Singh, A. K., & Misra, A. (2020). Clinical considerations for patients with diabetes in times of COVID-19 epidemic. *Diabetes & Metabolic Syndrome*, *14*(3), 211–212. https://doi.org/10.1016/j.dsx.2020.03.002

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient

physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health*, *6*(10), e1077–e1086. https://doi.org/10.1016/S2214-109X(18)30357-7

Gvozdanović, Z., Farčić, N., Šimić, H., Buljanović, V., Gvozdanović, L., Katalinić, S., Pačarić, S., Gvozdanović, D., Dujmić, Ž., Miškić, B., Barać, I., & Prlić, N. (2021). The impact of education, covid-19 and risk factors on the quality of life in patients with type 2 diabetes. *International Journal of Environmental Research and Public Health*, *18*(5), 1–14. https://doi.org/10.3390/ijerph18052332

Habib, S. S. (2013). Serum lipoprotein(a) and high sensitivity C reactive protein levels in Saudi patients with type 2 diabetes mellitus and their relationship with glycemic control. *Turkish Journal of Medical Sciences*. https://doi.org/10.3906/sag-1205-75

Hafidh, K., Abbas, S., Khan, A., Kazmi, T., Nazir, Z., & Aldaham, T. (2020). The Clinical Characteristics and Outcomes of COVID-19 Infections in Patients with Diabetes at a Tertiary Care Center in the UAE. *Dubai Diabetes and Endocrinology Journal*, *26*(4), 158–163. https://doi.org/10.1159/000512232

Haghighatpanah, M., Nejad, A. S. M., Haghighatpanah, M., Thunga, G., & Mallayasamy, S. (2018). Factors that correlate with poor glycemic control in type 2 diabetes mellitus patients with complications. *Osong Public Health and Research Perspectives*, *9*(4), 167–174. https://doi.org/10.24171/j.phrp.2018.9.4.05

Hallowell, M. R., & Gambatese, J. A. (2010). Qualitative Research: Application of the Delphi Method to CEM Research. *Journal of Construction Engineering and Management*. https://doi.org/10.1061/(asce)co.1943-7862.0000137

Hamdan, K. M., Zahran, Z., Al-Bashaireh, A. M., Khraisat, O. M., Albqoor, M. A., & Shaheen, A. M. (2022). Jordanian Nurses' Knowledge, Attitudes, and Willingness to Provide Care to Patients with COVID-19. *The Open Nursing Journal*, *16*(1), 1–9. https://doi.org/10.2174/18744346-v16-e2208102

Hammour, K. A., Abdeljalil, M., Manaseer, Q., & Al-Manaseer, B. (2022). Jordanian experience: The internet pharmacy drug delivery platform during the COVID-19. *Health Policy and Technology*, *11*(1), 100596. https://doi.org/10.1016/j.hlpt.2022.100596

Harding, J. L., Pavkov, M. E., Magliano, D. J., Shaw, J. E., & Gregg, E. W. (2019). Global trends in diabetes complications: a review of current evidence. *Diabetologia*, *62*(1), 3–16. https://doi.org/10.1007/s00125-018-4711-2

Harrington, D., & Henson, J. (2021). Physical activity and exercise in the management of type 2 diabetes: where to start? *Practical Diabetes*, *38*(5), 35. https://doi.org/10.1002/pdi.2361

Hartmann-Boyce, J., Morris, E., Goyder, C., Kinton, J., Perring, J., Nunan, D., Mahtani, K., Buse, J. B., Del Prato, S., Ji, L., Roussel, R., & Khunti, K. (2020). Diabetes and COVID-19: Risks, Management, and Learnings From Other National Disasters. *Diabetes Care*, *43*(8), 1695–1703. https://doi.org/10.2337/dc20-1192

Helou, K., El Helou, N., Mahfouz, M., Mahfouz, Y., Salameh, P., & Harmouche Karaki, M. (2017). Validity and reliability of an adapted Arabic version of the long international physical activity questionnaire. *BMC Public Health*, *18*. https://doi.org/10.1186/s12889-017-4599-7

Hernandez, J. D., Li, T., Rau, C. M., LeSuer, W. E., Wang, P., Coletta, D. K., Madura, J. A.,

Jacobsen, E. A., & De Filippis, E. (2021). ω-3PUFA supplementation ameliorates adipose tissue inflammation and insulin-stimulated glucose disposal in subjects with obesity: a potential role for apolipoprotein E. *International Journal of Obesity*, *45*(6), 1331–1341. https://doi.org/10.1038/s41366-021-00801-w

Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (2019). Cochrane Handbook for Systematic Reviews of Interventions. In *Cochrane Handbook for Systematic Reviews of Interventions*. Wiley. https://doi.org/10.1002/9781119536604

Higgins, T., Cembrowski, G., Tran, D., Lim, E., & Chan, J. (2009). Influence of variables on hemoglobin A1c values and nonheterogeneity of hemoglobin A1c reference ranges. *Journal of Diabetes Science and Technology*, *3*(4), 644–648. https://doi.org/10.1177/193229680900300404

Hinnen, D. (2017). Glucagon-Like Peptide 1 Receptor Agonists for Type 2 Diabetes. *Diabetes Spectrum*, *30*(3), 202–210. https://doi.org/10.2337/ds16-0026

Hoffmann, M., Kleine-Weber, H., Schroeder, S., Krüger, N., Herrler, T., Erichsen, S., Schiergens, T. S., Herrler, G., Wu, N.-H., Nitsche, A., Müller, M. A., Drosten, C., & Pöhlmann, S. (2020). SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibitor. *Cell*, *181*(2), 271-280.e8. https://doi.org/10.1016/j.cell.2020.02.052

Holt, R. I. G., Nicolucci, A., Kovacs Burns, K., Escalante, M., Forbes, A., Hermanns, N., Kalra, S., Massi-Benedetti, M., Mayorov, A., Menéndez-Torre, E., Munro, N., Skovlund, S. E., Tarkun, I., Wens, J., & Peyrot, M. (2013). Diabetes Attitudes, Wishes and Needs second

study (DAWN2™): Cross-national comparisons on barriers and resources for optimal care—healthcare professional perspective. *Diabetic Medicine*, *30*(7), 789–798. https://doi.org/10.1111/dme.12242

Hossain, M. S., Arif, A., & Ahsan, M. (2021). Psychological effects of the COVID-19 pandemic on people with diabetes in Bangladesh. *Diabetes & Metabolism*, *47*(1), 101–105. https://doi.org/https://doi.org/10.1016/j.diabet.2020.08.010

Hotamisligil, G. S. (2017). Inflammation, metaflammation and immunometabolic disorders. *Nature*, *542*(7640), 177–185. https://doi.org/10.1038/nature21363

Hu, B., Guo, H., Zhou, P., & Shi, Z. L. (2021). Characteristics of SARS-CoV-2 and COVID-19. *Nature Reviews Microbiology*, *19*(3), 141–154. https://doi.org/10.1038/s41579-020-00459-7

Huang, I., Lim, M. A., & Pranata, R. (2020). Diabetes mellitus is associated with increased mortality and severity of disease in COVID-19 pneumonia – A systematic review, meta-analysis, and meta-regression: Diabetes and COVID-19. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, *14*(4), 395–403. https://doi.org/10.1016/j.dsx.2020.04.018

Hulbert, L. R., Zhang, X., Ng, B. P., Nhim, K., Khan, T., & Cannon, M. J. (2021). Health Care Providers' Knowledge, Attitudes, and Practices and the Association With Referrals to the National Diabetes Prevention Program Lifestyle Change Program. *American Journal of Health Promotion*, 089011712110449. https://doi.org/10.1177/08901171211044937

Hurren, K. M., & Dunham, M. W. (2021). Are thiazolidinediones a preferred drug treatment for type 2 diabetes? *Expert Opinion on Pharmacotherapy*, *22*(2), 131–133. https://doi.org/10.1080/14656566.2020.1853100

Huynh, G., Tran, T. T., Do, T. H. T., Truong, T. T. D., Ong, P. T., Nguyen, T. N. H., & Pham, L. A. (2021). Diabetes-related distress among people with type 2 diabetes in Ho Chi Minh City, Vietnam: Prevalence and associated factors. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *14*, 683–690. https://doi.org/10.2147/DMSO.S297315

Hyassat, D., Al-Saeksaek, S., Naji, D., Mahasneh, A., Khader, Y., Abujbara, M., El-Khateeb, M., & Ajlouni, K. (2022). Dyslipidemia among patients with type 2 diabetes in Jordan: Prevalence, pattern, and associated factors. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.1002466

Iacobellis, G. (2020). COVID-19 and diabetes: Can DPP4 inhibition play a role? *Diabetes Research and Clinical Practice*, *162*(108125), 108125. https://doi.org/10.1016/j.diabres.2020.108125

IDF. (2017). Eighth edition 2017. In *IDF Diabetes Atlas, 8th edition*. file:///Users/ximeneacarballo/Downloads/IDF_DA_8e-EN-final.pdf

IDF. (2019). IDF Diabetes Atlas 9th. In *IDF Diabetes Atlas, 9th edition*. https://diabetesatlas.org/idfawp/resource-files/2019/07/IDF_diabetes_atlas_ninth_edition_en.pdf

IDF. (2021). IDF Diabetes Atlas 2021 – 10th edition. *Diabetes Research and Clinical Practice*, *102*(2), 1–135. https://doi.org/10.1016/j.diabres.2013.10.013

Ipaq Research Committee. (2005). Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire ( IPAQ ) – Short and Long Forms. *Ipaq*, *November*, 1–15.

Islam, S., Islam, T., & Islam, M. R. (2022). New Coronavirus Variants are Creating More Challenges to Global Healthcare System: A Brief Report on the Current Knowledge. *Clinical Pathology*, *15*, 2632010X2210755. https://doi.org/10.1177/2632010X221075584

Jackson, C. B., Farzan, M., Chen, B., & Choe, H. (2022). Mechanisms of SARS-CoV-2 entry into cells. *Nature Reviews Molecular Cell Biology*, *23*(1), 3–20. https://doi.org/10.1038/s41580-021-00418-x

Jackson, D., Bradbury-Jones, C., Baptiste, D., Gelling, L., Morin, K., Neville, S., & Smith, G. D. (2020). Life in the pandemic: Some reflections on nursing in the context of COVID-19. *Journal of Clinical Nursing*, *29*(13–14), 2041–2043. https://doi.org/10.1111/jocn.15257

Jahanlou, A. S., & Alishan, N. K. (2011). The effect of literacy level on health related-quality of life, self-efficacy and self-management behaviors in diabetic patients. *Acta Medica Iranica*, *49*(3), 153–158. http://www.ncbi.nlm.nih.gov/pubmed/21681702

Jelleyman, C., Yates, T., O'Donovan, G., Gray, L. J., King, J. A., Khunti, K., & Davies, M. J. (2015). The effects of high-intensity interval training on glucose regulation and insulin resistance: a meta-analysis. *Obesity Reviews*, *16*(11), 942–961. https://doi.org/10.1111/obr.12317

Jetté, M., Sidney, K., & Blümchen, G. (1990). Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clinical Cardiology*, *13*(8), 555–565. https://doi.org/10.1002/clc.4960130809

Johar, D., Ahmed, S. M., El. Hayek, S., Al-Dewik, N., Bahbah, E. I., Omar, N. H., Mustafa, M., Salman, D. O., Fahmey, A., Mottawea, M., Azouz, R. A. M., & Bernstein, L. (2019).

Diabetes-induced Proteome Changes Throughout Development. *Endocrine, Metabolic & Immune Disorders - Drug Targets*, *19*(6), 732–743. https://doi.org/10.2174/1871530319666190305153810

Jones, M. S., Goley, A. L., Alexander, B. E., Keller, S. B., Caldwell, M. M., & Buse, J. B. (2020). Inpatient Transition to Virtual Care During COVID-19 Pandemic. *Diabetes Technology and Therapeutics*, *22*(6), 444–448. https://doi.org/10.1089/dia.2020.0206

Jordanian Ministry of Health. (2020). *COVID-19 in Jordan.*

Juan, V. S. N., Clark, S. E., Camilleri, M., Jeans, J. P., Monkhouse, A., Chisnall, G., & Vindrola-Padros, C. (2022). Training and redeployment of healthcare workers to intensive care units (ICUs) during the COVID-19 pandemic: A systematic review. *BMJ Open*, *12*(1). https://doi.org/10.1136/bmjopen-2021-050038

Juni, M. H., Othman, M. F., Hairi, N. N., et al. (2021). Impact of physical activity and dietary changes on glycaemic control among type 2 diabetes patients during the COVID-19 lockdown in Malaysia. *BMC Endocrine Disorders*, *21*(1), 1–10. https://doi.org/10.1186/s12902-021-00757-4

Kaddar, R., Tarik, C., Atmani, M., Enakhil, I., Fakhri, N., Khalis, M., Lotfy, A., & El Kadmiri, N. (2022). Effect of COVID-19 lockdown on Moroccan patients with type 1 and type 2 diabetes. *Bulletin of the National Research Centre*, *46*(1). https://doi.org/10.1186/s42269-022-00827-8

Kahn, B. B., & Flier, J. S. (2000). Obesity and insulin resistance. *Journal of Clinical Investigation*, *106*(4), 473–481. https://doi.org/10.1172/JCI10842

Kahn, J. S., & McIntosh, K. (2005). History and Recent Advances in Coronavirus Discovery. *Pediatric Infectious Disease Journal*, *24*(11), S223–S227. https://doi.org/10.1097/01.inf.0000188166.17324.60

Kamalam, & Angelina, J. T. T. (2021). Significant Nursing Practices for the Management of Diabetes. *Journal of Nursing.*, *1(1): 18–2*.

Kannan, S. R., Spratt, A. N., Cohen, A. R., Naqvi, S. H., Chand, H. S., Quinn, T. P., Lorson, C. L., Byrareddy, S. N., & Singh, K. (2021). Evolutionary analysis of the Delta and Delta Plus variants of the SARS-CoV-2 viruses. *Journal of Autoimmunity*, *124*, 102715. https://doi.org/10.1016/j.jaut.2021.102715

Karatas, S., Yesim, T., & Beysel, S. (2020). Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information. *Primary Care Diabetes J*, *15*(January), 424–427.

Karatas, S., Yesim, T., & Beysel, S. (2021). Impact of lockdown COVID-19 on metabolic control in type 2 diabetes mellitus and healthy people. *Primary Care Diabetes*, *0*(0). https://doi.org/10.1016/j.pcd.2021.01.003

Kautzky-Willer, A., Kosi, L., Lin, J., & Mihaljevic, R. (2015). Gender-based differences in glycaemic control and hypoglycaemia prevalence in patients with type 2 diabetes: Results from patient-level pooled data of six randomized controlled trials. *Diabetes, Obesity and Metabolism*, *17*(6), 533–540. https://doi.org/10.1111/dom.12449

Khan, H., Lasker, S. S., & Chowdhury, T. A. (2011). Exploring reasons for very poor glycaemic

control in patients with Type 2 diabetes. *Primary Care Diabetes*, *5*(4), 251–255. https://doi.org/10.1016/j.pcd.2011.07.001

Khan, M. A. B., Hashim, M. J., King, J. K., Govender, R. D., Mustafa, H., & Al Kaabi, J. (2019). Epidemiology of Type 2 Diabetes – Global Burden of Disease and Forecasted Trends. *Journal of Epidemiology and Global Health*, *10*(1), 107. https://doi.org/10.2991/jegh.k.191028.001

Khare, J., & Jindal, S. (2021). Observational study on effect of lock down due to COVID 19 on HBA1c levels in patients with diabetes: Experience from Central India. *Primary Care Diabetes*, *0*(0). https://doi.org/10.1016/j.pcd.2020.12.003

Khassawneh, A. H., Alzoubi, A., Khasawneh, A. G., Abdo, N., Abu-Naser, D., Al-Mistarehi, A. H., Albattah, M. F., & Kheirallah, K. A. (2021). The relationship between depression and metabolic control parameters in type 2 diabetic patients: A cross-sectional and feasibility interventional study. *International Journal of Clinical Practice*, *75*(4), 1–11. https://doi.org/10.1111/ijcp.13777

Khatatbeh, M. (2020). Efficacy of Nationwide Curfew to Encounter Spread of COVID-19: A Case From Jordan. *Frontiers in Public Health*, *8*(August), 19–21. https://doi.org/10.3389/fpubh.2020.00394

Khatatbeh, M., Khasawneh, A., Hussein, H., Altahat, O., & Alhalaiqa, F. (2021). Psychological Impact of COVID-19 Pandemic Among the General Population in Jordan. *Frontiers in Psychiatry*, *12*(April), 1–7. https://doi.org/10.3389/fpsyt.2021.618993

Khattab, M., Khader, Y. S., Al-Khawaldeh, A., & Ajlouni, K. (2010). Factors associated with

poor glycemic control among patients with Type 2 diabetes. *Journal of Diabetes and Its Complications*, *24*(2), 84–89. https://doi.org/10.1016/j.jdiacomp.2008.12.008

Khawaja, N., Abu-Shennar, J., Saleh, M., Dahbour, S. S., Khader, Y. S., & Ajlouni, K. M. (2018). The prevalence and risk factors of peripheral neuropathy among patients with type 2 diabetes mellitus; The case of Jordan. *Diabetology and Metabolic Syndrome*, *10*(1), 1–10. https://doi.org/10.1186/s13098-018-0309-6

Khrais, H., Alsadi, M., Oweidat, I., & Ahmad, M. (2023). Determinants of missed nursing care in Jordanian hospitals during COVID-19 pandemic. *Nursing Open*, *10*(3), 1565–1573. https://doi.org/10.1002/nop2.1407

Khunti, K., Aroda, V. R., Aschner, P., Chan, J. C. N., Del Prato, S., Hambling, C. E., Harris, S., Lamptey, R., McKee, M., Tandon, N., Valabhji, J., & Seidu, S. (2022). The impact of the COVID-19 pandemic on diabetes services: planning for a global recovery. *The Lancet Diabetes & Endocrinology*, *10*(12), 890–900. https://doi.org/10.1016/S2213-8587(22)00278-9

Kim, H. R., & Kim, J. S. (2022). Stress, Depression, and Unhealthy Behavior Changes among Patients with Diabetes during COVID-19 in Korea. *Healthcare (Switzerland)*, *10*(2), 1–10. https://doi.org/10.3390/healthcare10020303

Kirwan, J. P., Sacks, J., & Nieuwoudt, S. (2017). The essential role of exercise in the management of type 2 diabetes. *Cleveland Clinic Journal of Medicine*, *84*(7 suppl 1), S15–S21. https://doi.org/10.3949/ccjm.84.s1.03

Kofahi, H. M., Swedan, S. F., Khabour, O. F., & Nimer, R. M. (2022). Predictors of COVID-19

severity and hospitalization: A survey-based study from Jordan. *Informatics in Medicine Unlocked*, *31*(June), 100994. https://doi.org/10.1016/j.imu.2022.100994

Krause, P. R., & Gruber, M. F. (2020). Emergency Use Authorization of Covid Vaccines — Safety and Efficacy Follow-up Considerations. *New England Journal of Medicine*, *383*(19), e107. https://doi.org/10.1056/NEJMp2031373

Kumar, Y., & Nachankar, A. (2022). Effect of COVID-19 lockdown on glycemic status of patients with T2DM and effects of various factors involved. *Journal of Marine Medical Society*, *0*(0), 0. https://doi.org/10.4103/jmms.jmms_71_21

Kyrou, I., Tsigos, C., Mavrogianni, C., Cardon, G., Van Stappen, V., Latomme, J., Kivelä, J., Wikström, K., Tsochev, K., Nanasi, A., Semanova, C., Mateo-Gallego, R., Lamiquiz-Moneo, I., Dafoulas, G., Timpel, P., Schwarz, P. E. H., Iotova, V., Tankova, T., Makrilakis, K., & Manios, Y. (2020). Sociodemographic and lifestyle-related risk factors for identifying vulnerable groups for type 2 diabetes: A narrative review with emphasis on data from Europe. *BMC Endocrine Disorders*, *20*(Suppl 1), 1–13. https://doi.org/10.1186/s12902-019-0463-3

Lee, P. H., Macfarlane, D. J., Lam, T., & Stewart, S. M. (2011). Validity of the international physical activity questionnaire short form. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(115), 1–11.

Lee, Y., Kirubarajan, A., Patro, N., Soon, M. S., Doumouras, A. G., & Hong, D. (2021). Impact of hospital lockdown secondary to COVID-19 and past pandemics on surgical practice: A living rapid systematic review. *The American Journal of Surgery*, *222*(1), 67–85. https://doi.org/10.1016/j.amjsurg.2020.11.019

Leite, N. J. C., Raimundo, A. M. M., Mendes, R. D. C., & Marmeleira, J. F. F. (2022). Impact of COVID-19 Pandemic on Daily Life, Physical Exercise, and General Health among Older People with Type 2 Diabetes: A Qualitative Interview Study. *International Journal of Environmental Research and Public Health*, *19*(7). https://doi.org/10.3390/ijerph19073986

LeRoith, D., Biessels, G. J., Braithwaite, S. S., Casanueva, F. F., Draznin, B., Halter, J. B., Hirsch, I. B., McDonnell, M. E., Molitch, M. E., Murad, M. H., & Sinclair, A. J. (2019). Treatment of Diabetes in Older Adults: An Endocrine Society* Clinical Practice Guideline. *The Journal of Clinical Endocrinology & Metabolism*, *104*(5), 1520–1574. https://doi.org/10.1210/jc.2019-00198

Li, B., Yang, J., Zhao, F., Zhi, L., Wang, X., Liu, L., Bi, Z., & Zhao, Y. (2020). Prevalence and impact of cardiovascular metabolic diseases on COVID-19 in China. *Clinical Research in Cardiology*, *109*(5), 531–538. https://doi.org/10.1007/s00392-020-01626-9

Li, G., Zhang, P., Wang, J., Gregg, E. W., Yang, W., Gong, Q., Li, H., Li, H., Jiang, Y., An, Y., Shuai, Y., Zhang, B., Zhang, J., Thompson, T. J., Gerzoff, R. B., Roglic, G., Hu, Y., & Bennett, P. H. (2008). The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. *Lancet (London, England)*, *371*(9626), 1783–1789. https://doi.org/10.1016/S0140-6736(08)60766-7

Li, T., Quan, H., Zhang, H., Lin, L., Lin, L., Ou, Q., & Chen, K. (2021). Type 2 diabetes is more predictable in women than men by multiple anthropometric and biochemical measures. *Scientific Reports*, *11*(1), 1–10. https://doi.org/10.1038/s41598-021-85581-z

Li, X., Mi, Z., Liu, Z., & Rong, P. (2024). SARS-CoV-2: pathogenesis, therapeutics, variants, and vaccines. *Frontiers in Microbiology*, *15*(June), 1–16.

https://doi.org/10.3389/fmicb.2024.1334152

Lim, S., Bae, J. H., Kwon, H.-S., & Nauck, M. A. (2020). COVID-19 and diabetes mellitus: from pathophysiology to clinical management. *Nature Reviews Endocrinology*, *17*(1), 11–30. https://doi.org/10.1038/s41574-020-00435-4

Lima, J. E. B. F., Moreira, N. C. S., & Sakamoto-Hojo, E. T. (2022). Mechanisms underlying the pathophysiology of type 2 diabetes: From risk factors to oxidative stress, metabolic dysfunction, and hyperglycemia. *Mutation Research - Genetic Toxicology and Environmental Mutagenesis*, *874–875*(December 2021), 503437. https://doi.org/10.1016/j.mrgentox.2021.503437

Little, R. R., & Rohlfing, C. L. (2013). The long and winding road to optimal HbA1c measurement. *Clinica Chimica Acta*, *418*, 63–71. https://doi.org/10.1016/j.cca.2012.12.026

Liu, L., Wei, W., Yang, K., Li, S., Yu, X., Dong, C., & Zhang, B. (2021). Glycemic control before admission is an important determinant of prognosis in patients with coronavirus disease 2019. *Journal of Diabetes Investigation*, *12*(6), 1064–1073. https://doi.org/10.1111/jdi.13431

Liu, P., Chen, W., & Chen, J.-P. (2019). Viral Metagenomics Revealed Sendai Virus and Coronavirus Infection of Malayan Pangolins (Manis javanica). *Viruses*, *11*(11), 979. https://doi.org/10.3390/v11110979

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the Depression Anxiety Stress Scales (2nd ed.). Sydney: Psychology Foundation of Australia.*

Lovibond, P. F. (1995). *Pergamon THE STRUCTURE OF NEGATIVE EMOTIONAL STATES :*

*SCALES ( DASS ) WITH THE BECK DEPRESSION AND*. *33*(3), 335–343.

Luo, X., Lv, M., Zhang, X., Estill, J., Yang, B., Lei, R., Ren, M., Liu, Y., Wang, L., Liu, X., Wang, Q., Meng, M., & Chen, Y. (2022). Clinical manifestations of COVID-19: An overview of 102 systematic reviews with evidence mapping. *Journal of Evidence-Based Medicine*, *15*(3), 201–215. https://doi.org/10.1111/jebm.12483

Lustman, P. J., Anderson, R. J., Freedland, K. E., de Groot, M., Carney, R. M., & Clouse, R. E. (2000). Depression and poor glycemic control: a meta-analytic review of the literature. *Diabetes Care*, *23*(7), 934–942. https://doi.org/10.2337/diacare.23.7.934

Lytras, T., & Tsiodras, S. (2021). Lockdowns and the COVID-19 pandemic: What is the endgame? *Scandinavian Journal of Public Health*, *49*(1), 37–40. https://doi.org/10.1177/1403494820961293

Ma, Q., Liu, J., Liu, Q., Kang, L., Liu, R., Jing, W., Wu, Y., & Liu, M. (2021). Global Percentage of Asymptomatic SARS-CoV-2 Infections among the Tested Population and Individuals with Confirmed COVID-19 Diagnosis: A Systematic Review and Meta-analysis. *JAMA Network Open*, *4*(12), 1–18. https://doi.org/10.1001/jamanetworkopen.2021.37257

Madanat, H., & Merrill, R. M. (2006). Motivational factors and stages of change for physical activity among college students in Amman, Jordan. *Promotion & Education*, *13*(3), 185–190.

Maddah, M., & Attarpour, L. (2016). Glycemic control and its predictors among Iranian diabetic patients. *Mediterranean Journal of Nutrition and Metabolism*, *9*(1), 1–6.

https://doi.org/10.3233/mnm-160053

Mahgoub, M. O., Ali, I. I., Adeghate, J. O., Tekes, K., Kalász, H., & Adeghate, E. A. (2023). An Update on the Molecular and Cellular Basis of Pharmacotherapy in Type 2 Diabetes Mellitus. *International Journal of Molecular Sciences*, *24*(11), 1–26. https://doi.org/10.3390/ijms24119328

Mahmud, R., Rahman, M. M., Rassel, M. A., Monayem, F. B., Sayeed, S. K. J. B., Islam, M. S., & Islam, M. M. (2021). Post-COVID-19 syndrome among symptomatic COVID-19 patients: A prospective cohort study in a tertiary care center of Bangladesh. *PLOS ONE*, *16*(4), e0249644. https://doi.org/10.1371/journal.pone.0249644

Makki, I., Alnoon, N., Rahmani, N., Almulla, J., Alamiri, A., Alfalasi, A., & Zidan, M. (2021). Impact of COVID-19 Lockdown on Glycemic Control in Patients with Type 2 Diabetes Mellitus in Dubai. *Current Diabetes Reviews*, *18*(8), 88–92. https://doi.org/10.2174/1573399818666211208102729

Malini, H., Zhahara, S., Lenggogeni, D. P., & Putri, Z. M. (2022). SELF-CARE AND QUALITY OF LIFE PEOPLE WITH TYPE 2 DIABETES DURING THE COVID-19: CROSS-SECTIONAL STUDY. *Journal of Diabetes and Metabolic Disorders*, *21*(1), 785–790. https://doi.org/10.1007/s40200-022-01055-7

Mamo, Y., Bekele, F., Nigussie, T., & Zewudie, A. (2019). Determinants of poor glycemic control among adult patients with type 2 diabetes mellitus in Jimma University Medical Center, Jimma zone, south west Ethiopia: A case control study. *BMC Endocrine Disorders*, *19*(1), 91. https://doi.org/10.1186/s12902-019-0421-0

Manios, Y., Androutsos, O., Lambrinou, C.-P., Cardon, G., Lindstrom, J., Annemans, L., Mateo-Gallego, R., de Sabata, M. S., Iotova, V., Kivela, J., Martinez, R., Moreno, L. A., Rurik, I., Schwarz, P., Tankova, T., Liatis, S., & Makrilakis, K. (2018). A school- and community-based intervention to promote healthy lifestyle and prevent type 2 diabetes in vulnerable families across Europe: design and implementation of the Feel4Diabetes-study. *Public Health Nutrition*, *21*(17), 3281–3290. https://doi.org/10.1017/S1368980018002136

Mansour, A. A., Alibrahim, N. T. Y., Alidrisi, H. A., Alhamza, A. H., Almomin, A. M., Zaboon, I. A., Kadhim, M. B., Hussein, R. N., Nwayyir, H. A., Mohammed, A. G., Al-Waeli, D. K. J., & Hussein, I. H. (2020). Prevalence and correlation of glycemic control achievement in patients with type 2 diabetes in Iraq: A retrospective analysis of a tertiary care database over a 9-year period. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(3), 265–272. https://doi.org/10.1016/j.dsx.2020.03.008

Mansour, A., Mousa, M., Abdelmannan, D., Tay, G., Hassoun, A., & Alsafar, H. (2023). Microvascular and macrovascular complications of type 2 diabetes mellitus: Exome wide association analyses. *Frontiers in Endocrinology*, *14*(March), 1–11. https://doi.org/10.3389/fendo.2023.1143067

Marín-Peñalver, J. J., Martín-Timón, I., Sevillano-Collantes, C., & Cañizo-Gómez, F. J. del. (2016). Update on the treatment of type 2 diabetes mellitus. *World Journal of Diabetes*, *7*(17), 354. https://doi.org/10.4239/wjd.v7.i17.354

Martinez-Ferran, M., Guía-Galipienso, F. de la, Sanchis-Gomar, F., & Pareja-Galeano, H. (2020). Metabolic Impacts of Confinement during the COVID-19 Pandemic Due to Modified Diet and. *Journal Nutrient*, *12*, 3–17.

Mashal, S., Khanfar, M., Al-Khalayfa, S., Srour, L., Mustafa, L., Hakooz, N. M., Zayed, A. A., Khader, Y. S., & Azab, B. (2021). SLC30A8 gene polymorphism rs13266634 associated with increased risk for developing type 2 diabetes mellitus in Jordanian population. *Gene*, *768*(November 2020), 145279. https://doi.org/10.1016/j.gene.2020.145279

Massey, C. N., Feig, E. H., Duque-Serrano, L., Wexler, D., Moskowitz, J. T., & Huffman, J. C. (2019). Well-being interventions for individuals with diabetes: A systematic review. In *Diabetes Research and Clinical Practice* (Vol. 147, pp. 118–133). Elsevier Ireland Ltd. https://doi.org/10.1016/j.diabres.2018.11.014

Matias, T., Dominski, F. H., & Marks, D. F. (2020). Human needs in COVID-19 isolation. *Journal of Health Psychology*, *25*(7), 871–882. https://doi.org/10.1177/1359105320925149

Mayyas, F. A., & Ibrahim, K. S. (2021). Predictors of mortality among patients with type 2 diabetes in Jordan. *BMC Endocrine Disorders*, *21*(1), 200. https://doi.org/10.1186/s12902-021-00866-8

Mazahreh, T. S., Aleshawi, A. J., Al-Zoubi, N. A., Hatamleh, M., & Hmedat, A. (2020). The impact of COVID-19 on the surgical operations. *Annals of Medicine and Surgery*, *57*, 49–51. https://doi.org/10.1016/j.amsu.2020.06.042

Mcdonald, H. I., Nitsch, D., Millett, E. R. C., Sinclair, A., & Thomas, S. L. (2014). New estimates of the burden of acute community-acquired infections among older people with diabetes mellitus: A retrospective cohort study using linked electronic health records. *Diabetic Medicine*, *31*(5), 606–614. https://doi.org/10.1111/dme.12384

McIntosh, K., Hirsch, M. S., & Bloom, A. (2020). Coronavirus disease 2019 (COVID-19).

UpToDate Hirsch MS, Bloom A (Eds) Accessed Mar. 2020;5. *UpToDate*, *2019*, 1–27. https://www.cmim.org/PDF_covid/Coronavirus_disease2019_COVID-19_UpToDate2.pdf

Medvedev, O. N. (2023). Depression Anxiety Stress Scales (DASS-21) in International Contexts. *International Handbook of Behavioral Health Assessment*, 1–15. https://doi.org/10.1007/978-3-030-89738-3_15-1

Megahed, F. I. A.-L., & Farg, H. K. (2020). Most Effiecnt Factors Affecting Glycemic Control of Type II Diabetic Patients Attending Suez Canal University Hospitals in Egypt Applying Stepwise Regression. *LOJ Medical Sciences*, *4*(5). https://doi.org/10.32474/lojms.2020.04.000200

Minari, T. P., Tácito, L. H. B., Yugar, L. B. T., Ferreira-Melo, S. E., Manzano, C. F., Pires, A. C., Moreno, H., Vilela-Martin, J. F., Cosenso-Martin, L. N., & Yugar-Toledo, J. C. (2023). Nutritional Strategies for the Management of Type 2 Diabetes Mellitus: A Narrative Review. *Nutrients*, *15*(24), 1–27. https://doi.org/10.3390/nu15245096

Mirahmadizadeh, A., Khorshidsavar, H., Seif, M., & Sharifi, M. H. (2020). Adherence to Medication, Diet and Physical Activity and the Associated Factors Amongst Patients with Type 2 Diabetes. *Diabetes Therapy*, *11*(2), 479–494. https://doi.org/10.1007/s13300-019-00750-8

Mitiku, Y., Belayneh, A., Tegegne, B. A., Kebede, B., Abebe, D., Biyazin, Y., Bahiru, B., Abebaw, A., Mengist, H. M., & Getachew, M. (2022). Prevalence of Medication Non-Adherence and Associated Factors among Diabetic Patients in A Tertiary Hospital at Debre Markos, Northwest Ethiopia. *Ethiopian Journal of Health Sciences*, *32*(4), 755–764. https://doi.org/10.4314/ejhs.v32i4.12

Modesti, P., Reboldi, G., & Cappuccio, F. (2016). NEWCASTLE-OTTAWA QUALITY ASSESSMENT SCALE (adapted for cross sectional studies). *PLoS One*, 1–2.

Mogre, V., Ansah, G. A., Marfo, D. N., & Garti, H. A. (2015). Assessing nurses' knowledge levels in the nutritional management of diabetes. *International Journal of Africa Nursing Sciences*, *3*, 40–43. https://doi.org/10.1016/j.ijans.2015.07.003

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., Estarli, M., Barrera, E. S. A., Martínez-Rodríguez, R., Baladia, E., Agüero, S. D., Camacho, S., Buhring, K., Herrero-López, A., Gil-González, D. M., Altman, D. G., Booth, A., … Whitlock, E. (2016). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Revista Espanola de Nutricion Humana y Dietetica*. https://doi.org/10.1186/2046-4053-4-1

Mohseni, M., Ahmadi, S., Azami-Aghdash, S., Mousavi Isfahani, H., Moosavi, A., Fardid, M., Etemadi, M., & Ghazanfari, F. (2021). Challenges of routine diabetes care during COVID-19 era: A systematic search and narrative review. *Primary Care Diabetes*, *15*(6), 918–922. https://doi.org/10.1016/j.pcd.2021.07.017

Mokdad, A. (2016). Global non-communicable disease prevention: Building on success by addressing an emerging health need in developing countries. *Journal of Health Specialties*, *4*(2), 92. https://doi.org/10.4103/1658-600X.179820

Momani, M., Haddad, F., Barham, M., & Aldarawasheh, J. (2020). *Current Practice in the Management of Type 2 Diabetes Mellitus in Jordan : Results of the Jordanian Diabetes Management Practices Study*. *9*(1), 12–22. https://doi.org/10.5923/j.diabetes.20200901.03

Monaghesh, E., & Hajizadeh, A. (2020). The role of telehealth during COVID-19 outbreak: A systematic review based on current evidence. *BMC Public Health*, *20*(1), 1–9. https://doi.org/10.1186/s12889-020-09301-4

Moradi-Lakeh, M., Forouzanfar, M. H., El Bcheraoui, C., Daoud, F., Afshin, A., Hanson, S. W., Vos, T., Naghavi, M., Murray, C. J. L., & Mokdad, A. H. (2017). High Fasting Plasma Glucose, Diabetes, and Its Risk Factors in the Eastern Mediterranean Region, 1990–2013: Findings From the Global Burden of Disease Study 2013. *Diabetes Care*, *40*(1), 22–29. https://doi.org/10.2337/dc16-1075

Mosleh, R. S., Abd Aziz, N., Ali, S. M., Manan, M. M., Zyoud, S., Shah, I. M., & Jarrar, Y. B. (2017). Predictors of good glycemic control among type II diabetes patients in Palestine. *Asian Journal of Pharmaceutical and Clinical Research*, *10*(9), 341–347. https://doi.org/10.22159/ajpcr.2017.v10i9.19453

Mousavi, S. S., Namayandeh, S. M., Fallahzadeh, H., Rahmanian, M., & Mollahosseini, M. (2023). Comparing the effectiveness of metformin with lifestyle modification for the primary prevention of type II diabetes: a systematic review and meta-analysis. *BMC Endocrine Disorders*, *23*(1), 1–11. https://doi.org/10.1186/s12902-023-01445-9

Moussa, M. T., Lovibond, P., Laube, R., & Megahead, H. A. (2017). Psychometric Properties of an Arabic Version of the Depression Anxiety Stress Scales (DASS). *Research on Social Work Practice*, *27*(3), 375–386. https://doi.org/10.1177/1049731516662916

Moynihan, A. B., van Tilburg, W. A. P., Igou, E. R., Wisman, A., Donnelly, A. E., & Mulcaire, J. B. (2015). Eaten up by boredom: consuming food to escape awareness of the bored self. *Frontiers in Psychology*, *6*, 369. https://doi.org/10.3389/fpsyg.2015.00369

Mozaffarian, D., Hao, T., Rimm, E. B., Willett, W. C., & Hu, F. B. (2011). Changes in Diet and Lifestyle and Long-Term Weight Gain in Women and Men. *New England Journal of Medicine*, *364*(25), 2392–2404. https://doi.org/10.1056/NEJMoa1014296

Muchiri, J. W., Gericke, G. J., & Rheeder, P. (2016). Effect of a nutrition education programme on clinical status and dietary behaviours of adults with type 2 diabetes in a resource-limited setting in South Africa: A randomised controlled trial. *Public Health Nutrition*, *19*(1), 142–155. https://doi.org/10.1017/S1368980015000956

Mukona, D. M., & Zvinavashe, M. (2020). Self- management of diabetes mellitus during the Covid-19 pandemic: Recommendations for a resource limited setting. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(6), 1575–1578. https://doi.org/10.1016/j.dsx.2020.08.022

Muniyappa, R., & Gubbi, S. (2020). COVID-19 pandemic, coronaviruses, and diabetes mellitus. *American Journal of Physiology-Endocrinology and Metabolism*, *318*(5), E736–E741. https://doi.org/10.1152/ajpendo.00124.2020

Nachimuthu, S., Vijayalakshmi, R., Sudha, M., & Viswanathan, V. (2020). *Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information*. *January*. https://doi.org/10.1016/j.dsx.2020.04.053

Nakayama, R., Bunya, N., Tagami, T., Hayakawa, M., Yamakawa, K., Endo, A., Ogura, T., Hirayama, A., Yasunaga, H., Uemura, S., & Narimatsu, E. (2023). Associated organs and system with COVID-19 death with information of organ support: a multicenter

observational study. *BMC Infectious Diseases*, *23*(1), 814. https://doi.org/10.1186/s12879-023-08817-5

Naous, E., Boulos, M., Sleilaty, G., Achkar, A. A., & Gannagé-Yared, M. H. (2022). Quality of life and other patient-reported outcomes in adult Lebanese patients with type 2 diabetes during COVID-19 pandemic. *Journal of Endocrinological Investigation*, *45*(4), 763–772. https://doi.org/10.1007/s40618-021-01701-6

Naseri, H., Jahanbakhsh, H., Hosseini, P., & Moghadas Nejad, F. (2020). Designing sustainable concrete mixture by developing a new machine learning technique. *Journal of Cleaner Production*, *258*, 120578. https://doi.org/10.1016/j.jclepro.2020.120578

Nathan, D. M. (2015). Diabetes: Advances in Diagnosis and Treatment. *JAMA*, *314*(10), 1052–1062. https://doi.org/10.1001/jama.2015.9536

Neelam, K., Duddu, V., Anyim, N., Neelam, J., & Lewis, S. (2021). Pandemics and pre-existing mental illness: A systematic review and meta-analysis. *Brain, Behavior, and Immunity - Health*, *10*(October 2020). https://doi.org/10.1016/j.bbih.2020.100177

Nemeh A, A.-A., Yousef S, K., & Aysha M, A. (2011). Glycemic Control and Its Determinants among Patients with type 2 Diabetes Mellitus Attending a Teaching Hospital. *Journal of Diabetes & Metabolism*, *02*(04). https://doi.org/10.4172/2155-6156.1000129

Ng, F., Trauer, T., Dodd, S., Callaly, T., Campbell, S., & Berk, M. (2007). The validity of the 21-item version of the Depression Anxiety Stress Scales as a routine clinical outcome measure. *Acta Neuropsychiatrica*, *19*(5), 304–310. https://doi.org/10.1111/j.1601-5215.2007.00217.x

Ng, S. C., & Tilg, H. (2020). COVID-19 and the gastrointestinal tract: more than meets the eye. *Gut*, *69*(6), 973–974. https://doi.org/10.1136/gutjnl-2020-321195

Nguyen, V. B., Thi, K. H. P., Nguyen, T. X., Pham, N. T. L., Nguyen, V. V. H., & Van Le, C. (2022). Diabetes self-management and its associated factors among patients with diabetes in central Vietnam: A cross-sectional study. *PLOS ONE*, *17*(7), e0270901. https://doi.org/10.1371/journal.pone.0270901

Niederberger, M., & Spranger, J. (2020). Delphi Technique in Health Sciences: A Map. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2020.00457

Nofal, A. K., Abu Jabeh, R. A., Alrafayia, D. B., Hyasat, T. B., Suboh, L. T., Aljabiri, R. N., Al Ryalat, S. A., Alhawari, H. H., & Jaber, R. M. (2023). Glycemic Control Improvement amongst Patients with Diabetes Mellitus during a COVID-19 Lockdown in Jordan. *Jordan Medical Journal*, *57*(1), 43–53. https://doi.org/10.35516/jmj.v57i1.1101

Nouhjah, S., Shahbazian, H., & Ghodrati, N. (2022). Changes in self-care behaviors of Iranian patients with type 2 diabetes using insulin pens during COVID-19 pandemic. *Obesity Medicine*, *33*(April), 100418. https://doi.org/10.1016/j.obmed.2022.100418

Noureddine, H., Nakhoul, N., Galal, A., Soubra, L., & Saleh, M. (2014). Level of A1C control and its predictors among Lebanese type 2 diabetic patients. *Therapeutic Advances in Endocrinology and Metabolism*, *5*(3), 43–52. https://doi.org/10.1177/2042018814544890

O'Neill, H. M. (2013). AMPK and Exercise: Glucose Uptake and Insulin Sensitivity. *Diabetes & Metabolism Journal*, *37*(1), 1–21. https://doi.org/10.4093/dmj.2013.37.1.1

Ojo, O., Wang, X. H., Ojo, O. O., Orjih, E., Pavithran, N., Adegboye, A. R. A., Feng, Q. Q., &

McCrone, P. (2022). The Effects of COVID-19 Lockdown on Glycaemic Control and Lipid Profile in Patients with Type 2 Diabetes: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health*, *19*(3). https://doi.org/10.3390/ijerph19031095

Okon, E. B., Chung, A. W. Y., Zhang, H., Laher, I., & van Breemen, C. (2007). Hyperglycemia and hyperlipidemia are associated with endothelial dysfunction during the development of type 2 diabetes. *Canadian Journal of Physiology and Pharmacology*, *85*(5), 562–567. https://doi.org/10.1139/Y07-026

Olausson, J. M., Brady, V. J., & Storey, S. (2023). Effect of COVID-19 on Type 2 Diabetes Self-Care Behaviors: A Rapid Review. *Diabetes Spectrum*, *36*(1). https://doi.org/10.2337/DS22-0060

Oli, J., Pant, V. P., Niraula, A., & Lamsal, M. (2022). Poor Glycemic Control in Type 2 Diabetes Mellitus Patients in Two Tertiary Care Centers during COVID-19 Lockdown: A Descriptive Cross-sectional Study. *Journal of the Nepal Medical Association*, *60*(247), 268–273. https://doi.org/10.31729/jnma.6998

Ong, K. L., Stafford, L. K., McLaughlin, S. A., Boyko, E. J., Vollset, S. E., Smith, A. E., Dalton, B. E., Duprey, J., Cruz, J. A., Hagins, H., Lindstedt, P. A., Aali, A., Abate, Y. H., Abate, M. D., Abbasian, M., Abbasi-Kangevari, Z., Abbasi-Kangevari, M., ElHafeez, S. A., Abd-Rabu, R., … Vos, T. (2023). Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021. *The Lancet*, *402*(10397), 203–234. https://doi.org/10.1016/S0140-6736(23)01301-6

Önmez, A., Gamsızkan, Z., Özdemir, Ş., Kesikbaş, E., Gökosmanoğlu, F., Torun, S., & Cinemre, H. (2020). The effect of COVID-19 lockdown on glycemic control in patients with type 2 diabetes mellitus in Turkey. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(6), 1963–1966. https://doi.org/10.1016/j.dsx.2020.10.007

Ooi, C. P., & Loke, S. C. (2014). Colesevelam for Type 2 diabetes mellitus: an abridged Cochrane review. *Diabetic Medicine*, *31*(1), 2–14. https://doi.org/10.1111/dme.12295

Oran, D. P., & Topol, E. J. (2021). The Proportion of SARS-CoV-2 Infections That Are Asymptomatic : A Systematic Review. *Annals of Internal Medicine*, *174*(5), 655–662. https://doi.org/10.7326/M20-6976

Østergaard, L. (2021). SARS CoV-2 related microvascular damage and symptoms during and after COVID-19: Consequences of capillary transit-time changes, tissue hypoxia and inflammation. *Physiological Reports*, *9*(3). https://doi.org/10.14814/phy2.14726

Padilla-Rojas, C., Jimenez-Vasquez, V., Hurtado, V., Mestanza, O., Molina, I. S., Barcena, L., Morales Ruiz, S., Acedo, S., Lizarraga, W., Bailon, H., Cáceres, O., Galarza, M., Rojas-Serrano, N., Vargas-Herrera, N., Lope-Pari, P., Huayra, J., & Solari, L. (2021). Genomic analysis reveals a rapid spread and predominance of lambda (C.37) SARS-COV-2 lineage in Peru despite circulation of variants of concern. *Journal of Medical Virology*, *93*(12), 6845–6849. https://doi.org/10.1002/jmv.27261

Pan, A., Wang, Y., Talaei, M., Hu, F. B., & Wu, T. (2015). Relation of active, passive, and quitting smoking with incident type 2 diabetes: a systematic review and meta-analysis. *The Lancet Diabetes & Endocrinology*, *3*(12), 958–967. https://doi.org/10.1016/S2213-8587(15)00316-2

Panda, N., Sinyard, R. D., Henrich, N., Cauley, C. E., Hannenberg, A. A., Sonnay, Y., Bitton, A., Brindle, M., & Molina, G. (2021). Redeployment of Health Care Workers in the COVID-19 Pandemic: A Qualitative Study of Health System Leaders' Strategies. *Journal of Patient Safety*, *17*(4), 256–263. https://doi.org/10.1097/PTS.0000000000000847

Parums, D. V. (2021). Editorial: Revised World Health Organization (WHO) Terminology for Variants of Concern and Variants of Interest of SARS-CoV-2. *Medical Science Monitor*, *27*, e933622. https://doi.org/10.12659/MSM.933622

Patti, A. M., Rizvi, A. A., Giglio, R. V., Stoian, A. P., Ligi, D., & Mannello, F. (2020). Impact of Glucose-Lowering Medications on Cardiovascular and Metabolic Risk in Type 2 Diabetes. *Journal of Clinical Medicine*, *9*(4), 912. https://doi.org/10.3390/jcm9040912

Patton, M. (1990). *Qualitative evaluation and research methods*. Sage Publications, Newbury Park, California.

Paulsamy, P., Ashraf, R., Alshahrani, S. H., Periannan, K., Qureshi, A. A., Venkatesan, K., Manoharan, V., Govindasamy, N., Prabahar, K., Arumugam, T., Venkatesan, K., Chidambaram, K., Kandasamy, G., Vasudevan, R., & Krishnaraju, K. (2021). Social support, self-care behaviour and self-efficacy in patients with type 2 diabetes during the COVID-19 pandemic: A cross-sectional study. *Healthcare (Switzerland)*, *9*(11), 1–10. https://doi.org/10.3390/healthcare9111607

Peek, N., Sujan, M., & Scott, P. (2020). Digital health and care in pandemic times: impact of COVID-19. *BMJ Health & Care Informatics*, *27*(1), e100166. https://doi.org/10.1136/bmjhci-2020-100166

Peimani, M., Bandarian, F., Namazi, N., Larijani, B., & Nasli-esfahani, E. (2022). *Physical Activity Behavior During the COVID-19 Outbreak in Individuals with Type 2 Diabetes : Role of Social Support and Other Covariates Physical Activity Behavior During the COVID-19 Outbreak in Individuals with Type 2 Diabetes : Role of Social Support . June*. https://doi.org/10.5812/ijem-120867

Peiris, J. S. M., Guan, Y., & Yuen, K. Y. (2004). Severe acute respiratory syndrome. *Nature Medicine*, *10*(12 Suppl), S88-97. https://doi.org/10.1038/nm1143

Pekar, J., Worobey, M., Moshiri, N., Scheffler, K., & Wertheim, J. O. (2021). Timing the SARS-CoV-2 index case in Hubei province. *Science*, *372*(6540), 412–417. https://doi.org/10.1126/science.abf8003originally

Peric, S., & Stulnig, T. M. (2020). Diabetes and COVID-19 : Disease-Management-People. *Wiener Klinische Wochenschrift*, *132*(13–14), 356–361. https://doi.org/10.1007/s00508-020-01672-3

Perseghin, G., Price, T. B., Petersen, K. F., Roden, M., Cline, G. W., Gerow, K., Rothman, D. L., & Shulman, G. I. (1996). Increased Glucose Transport–Phosphorylation and Muscle Glycogen Synthesis after Exercise Training in Insulin-Resistant Subjects. *New England Journal of Medicine*, *335*(18), 1357–1362. https://doi.org/10.1056/nejm199610313351804

Phadke, V. K., Bednarczyk, R. A., Salmon, D. A., & Omer, S. B. (2016). Association Between Vaccine Refusal and Vaccine-Preventable Diseases in the United States. *JAMA*, *315*(11), 1149. https://doi.org/10.1001/jama.2016.1353

Pinchevsky, Y., Butkow, N., Raal, F., Chirwa, T., & Rothberg, A. (2020). *Demographic And*

*Clinical Factors Associated With Development Of Type 2 Diabetes: A Review Of The Literature. International Journal Of General Medicine*. 121–129. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7127847/pdf/ijgm-13-121.pdf

Piparva, K., Singh, A., & Joshi, N. (2022). Compliance of Appointment, Antidiabetic Treatment, and Diet in Type 2 Diabetes Mellitus Patients at Private Diabetes Clinic. *Dubai Diabetes and Endocrinology*, *28*(3), 112–118. https://doi.org/10.1159/000525373

Pla, B., Arranz, A., Knott, C., Sampedro, M., Jiménez, S., Hernando, I., & Marazuela, M. (2020). Impact of COVID-19 Lockdown on Glycemic Control in Adults with Type 1 Diabetes Mellitus. *Journal of the Endocrine Society*, *4*(12), 1–8. https://doi.org/10.1210/jendso/bvaa149

Planas, D., Veyer, D., Baidaliuk, A., Staropoli, I., Guivel-Benhassine, F., Rajah, M. M., Planchais, C., Porrot, F., Robillard, N., Puech, J., Prot, M., Gallais, F., Gantner, P., Velay, A., Le Guen, J., Kassis-Chikhani, N., Edriss, D., Belec, L., Seve, A., … Schwartz, O. (2021). Reduced sensitivity of SARS-CoV-2 variant Delta to antibody neutralization. *Nature*, *596*(7871), 276–280. https://doi.org/10.1038/s41586-021-03777-9

Poonoosamy, J., Lopes, P., Huret, P., Dardari, R., Penfornis, A., Thomas, C., & Dardari, D. (2023). Impact of Intensive Glycemic Treatment on Diabetes Complications—A Systematic Review. *Pharmaceutics*, *15*(7), 1–14. https://doi.org/10.3390/pharmaceutics15071791

Prime Ministry of Jordan. (2020). *Official Reports.*

Puntmann, V. O., Carerj, M. L., Wieters, I., Fahim, M., Arendt, C., Hoffmann, J., Shchendrygina, A., Escher, F., Vasa-Nicotera, M., Zeiher, A. M., Vehreschild, M., &

Nagel, E. (2020). Outcomes of Cardiovascular Magnetic Resonance Imaging in Patients Recently Recovered From Coronavirus Disease 2019 (COVID-19). *JAMA Cardiology*, *5*(11), 1265–1273. https://doi.org/10.1001/jamacardio.2020.3557

Qin, Y. Y., Zhou, Y. H., Lu, Y. Q., Sun, F., Yang, S., & Harypursat, V. (2020). Effectiveness of glucocor- ticoid therapy in patients with severe corona- virus disease 2019: protocol of a randomized controlled trial. *China Med J*, *133*(9), 1080–6.

Qteishat, R. R., & Ghananim, A. rahman al. (2016). Comprehensive assessment of variables affecting metabolic control in patients with type 2 diabetes mellitus in Jordan. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *10*(1), S56–S59. https://doi.org/10.1016/j.dsx.2015.09.014

Ra, S. H., Lim, J. S., Kim, G. U., Kim, M. J., Jung, J., & Kim, S. H. (2021). Upper respiratory viral load in asymptomatic individuals and mildly symptomatic patients with SARS-CoV-2 infection. *Thorax*, *76*(1), 61–63. https://doi.org/10.1136/thoraxjnl-2020-215042

Radwan, M., Elsous, A., Al-Sharif, H., & Abu Mustafa, A. (2017). Glycemic control among primary care patients with type 2 diabetes mellitus in the Gaza Strip, Palestine. *Therapeutic Advances in Endocrinology and Metabolism*, *9*(1), 3–14. https://doi.org/10.1177/2042018817742070

Radwan, M., Elsous, A., Al-Sharif, H., & Abu Mustafa, A. (2018). Glycemic control among primary care patients with type 2 diabetes mellitus in the Gaza Strip, Palestine. *Therapeutic Advances in Endocrinology and Metabolism*, *9*(1), 3–14. https://doi.org/10.1177/2042018817742070

Rahman, M. E., Islam, M. S., Bishwas, M. S., Moonajilin, M. S., & Gozal, D. (2020). Physical inactivity and sedentary behaviors in the Bangladeshi population during the COVID-19 pandemic: An online cross-sectional survey. *Heliyon*, *6*(10), e05392. https://doi.org/10.1016/j.heliyon.2020.e05392

Rajput, R., Rajput, M., Bairwa, M., Singh, J., Saini, O., & Shankar, V. (2014). Waist height ratio: A universal screening tool for prediction of metabolic syndrome in urban and rural population of Haryana. *Indian Journal of Endocrinology and Metabolism*, *18*(3), 394–399. https://doi.org/10.4103/2230-8210.131201

Rana, J. S., Li, T. Y., Manson, J. A. E., & Hu, F. B. (2007). Adiposity compared with physical inactivity and risk of type 2 diabetes in women. *Diabetes Care*, *30*(1), 53–58. https://doi.org/10.2337/dc06-1456

Rando, H. M., MacLean, A. L., Lee, A. J., Lordan, R., Ray, S., Bansal, V., Skelly, A. N., Sell, E., Dziak, J. J., Shinholster, L., McGowan, L. D., Guebila, M. Ben, Wellhausen, N., Knyazev, S., Boca, S. M., Capone, S., Qi, Y., Park, Y., Sun, Y., … Greene, C. S. (2021). Pathogenesis, Symptomatology, and Transmission of SARS-CoV-2 through Analysis of Viral Genomics and Structure. *ArXiv*, 55. http://www.ncbi.nlm.nih.gov/pubmed/33594340

Redondo-Sendino, Á., Guallar-Castillón, P., Banegas, J. R., & Rodríguez-Artalejo, F. (2006). Gender differences in the utilization of health-care services among the older adult population of Spain. *BMC Public Health*, *6*(1), 155. https://doi.org/10.1186/1471-2458-6-155

Reed, J., Bain, S., & Kanamarlapudi, V. (2021). A review of current trends with type 2 diabetes epidemiology, aetiology, pathogenesis, treatments and future perspectives. *Diabetes,*

*Metabolic Syndrome and Obesity: Targets and Therapy*, *14*, 3567–3602. https://doi.org/10.2147/DMSO.S319895

Reshad, R. A. I., Riana, S. H., Chowdhury, M. A., Moin, A. T., Miah, F., Sarkar, B., & Jewel, N. A. (2021). ر ك س ا ى ل ا ف ي د ي ف ا ك ي ل ا ق م ي ا ع ا ل ق ف و ل ح Diabetes in COVID-19 patients: challenges and possible management strategies. *The Egyptian Journal of Bronchology*, *15*(1). https://doi.org/10.1186/s43168-021-00099-2

Reynolds, N. R., Baker, D., D'Aoust, R., Docal, M., Goldstein, N., Grubb, L., Hladek, M. D., Koirala, B., Kverno, K., Ling, C., Lukkahatai, N., McIltrot, K., Pandian, V., Regier, N. G., Sloand, E., Tomori, C., & Wenzel, J. (2023). COVID-19: Implications for Nursing and Health Care in the United States. *Journal of Nursing Scholarship*, *55*(1), 187–201. https://doi.org/10.1111/jnu.12853

Richardson, S., Hirsch, J. S., Narasimhan, M., Crawford, J. M., McGinn, T., Davidson, K. W., Barnaby, D. P., Becker, L. B., Chelico, J. D., Cohen, S. L., Cookingham, J., Coppa, K., Diefenbach, M. A., Dominello, A. J., Duer-Hefele, J., Falzon, L., Gitlin, J., Hajizadeh, N., Harvin, T. G., … Zanos, T. P. (2020). Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. *JAMA*, *323*(20), 2052. https://doi.org/10.1001/jama.2020.6775

Roca-Ho, H., Riera, M., Palau, V., Pascual, J., & Soler, M. (2017). Characterization of ACE and ACE2 Expression within Different Organs of the NOD Mouse. *International Journal of Molecular Sciences*, *18*(3), 563. https://doi.org/10.3390/ijms18030563

Röckl, K. S. C., Witczak, C. A., & Goodyear, L. J. (2008). Signaling mechanisms in skeletal muscle: Acute responses and chronic adaptations to exercise. *IUBMB Life*, *60*(3), 145–153.

https://doi.org/10.1002/iub.21

Rodríguez-Gutiérrez, R., & Montori, V. M. (2016). Glycemic Control for Patients With Type 2 Diabetes Mellitus: Our Evolving Faith in the Face of Evidence. *Circulation: Cardiovascular Quality and Outcomes*, *9*(5), 504–512. https://doi.org/10.1161/CIRCOUTCOMES.116.002901

Romero-Castillo, R., Pabón-Carrasco, M., Jiménez-Picón, N., & Ponce-Blandón, J. A. (2022). Effects of Nursing Diabetes Self-Management Education on Glycemic Control and Self-Care in Type 1 Diabetes: Study Protocol. *International Journal of Environmental Research and Public Health*, *19*(9), 5079. https://doi.org/10.3390/ijerph19095079

Roncon, L., Zuin, M., Rigatelli, G., & Zuliani, G. (2020). Diabetic patients with COVID-19 infection are at higher risk of ICU admission and poor short-term outcome. *Journal of Clinical Virology*, *127*(January), 104354. https://doi.org/10.1016/j.jcv.2020.104354

Ruissen, M. M., Regeer, H., Landstra, C. P., Schroijen, M., Jazet, I., Nijhoff, M. F., Pijl, H., Ballieux, B. E. P. B., Dekkers, O., Huisman, S. D., & de Koning, E. J. P. (2021). Increased stress, weight gain and less exercise in relation to glycemic control in people with type 1 and type 2 diabetes during the COVID-19 pandemic. *BMJ Open Diabetes Research & Care*, *9*(1). https://doi.org/10.1136/bmjdrc-2020-002035

Saad, A. M. J., Younes, Z. M. H., Ahmed, H., Brown, J. A., Al Owesie, R. M., & Hassoun, A. A. K. (2018). Self-efficacy, self-care and glycemic control in Saudi Arabian patients with type 2 diabetes mellitus: A cross-sectional survey. *Diabetes Research and Clinical Practice*, *137*, 28–36. https://doi.org/10.1016/j.diabres.2017.12.014

Saadeh, R., Alsmadi, H., Batieha, A., Khader, Y., & Jaddou, H. (2023). *Quality of care for type 2 diabetes in Jordan : A national study*. 1–11. https://doi.org/10.3892/mi.2023.87

Saberiyan, M., Karimi, E., Khademi, Z., Movahhed, P., Safi, A., & Mehri-Ghahfarrokhi, A. (2022). SARS-CoV-2: phenotype, genotype, and characterization of different variants. *Cellular and Molecular Biology Letters*, *27*(1). https://doi.org/10.1186/s11658-022-00352-6

Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., Colagiuri, S., Guariguata, L., Motala, A. A., Ogurtsova, K., Shaw, J. E., Bright, D., & Williams, R. (2019). Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Research and Clinical Practice*, *157*, 107843. https://doi.org/10.1016/j.diabres.2019.107843

Saghir, S. A. M., Alhariri, A. E. A., Alkubat, S. A., Almiamn, A. A., Aladaileh, S. H., & Alyousefi, N. A. (2019). Factors associated with poor glycemic control among type-2 diabetes mellitus patients in Yemen. *Tropical Journal of Pharmaceutical Research*, *18*(7), 1539–1546. https://doi.org/10.4314/tjpr.v18i7.26

Saha, S., & Schwarz, P. E. H. (2017). Impact of glycated hemoglobin (HbA1c) on identifying insulin resistance among apparently healthy individuals. *Journal of Public Health (Germany)*, *25*(5), 505–512. https://doi.org/10.1007/s10389-017-0805-4

Samancioglu, S., Donmez, R. O., Surucu, H. A., & Cevik, A. B. (2017). Experiences of Clinic Nurses Regarding Diabetes Education in Turkey' Health System. *Health Systems and Policy Research*, *4*(3). https://doi.org/10.21767/2254-9137.100078

Samancioglu Sevgin, R. N. P., Surucu Hamdiye Arda, R. N. P., Donmez Renginar Ozturk, R. N. P., & Cevik Ayfer Bayindir, R. N. P. (2017). Factors Affecting Glycemic Control in Type 2 Diabetics and Diabetics' Attitude towards the Disease. *International Journal of Caring Sciences*, *10*(2), 889–896.

Samara, M., Horoub, A., Ibaidi, N., & Sweileh, W. M. (2017). Prevalence of Glycemic Control and Factors Associated With Increasing Levels of Hba1c Among A Sample of Palestinian Patients With Type 2 Diabetes Mellitus. *Palestinian Medical and Pharmaceutical Journal*, *2*(2). https://doi.org/10.59049/2790-0231.1064

Sánchez Conejero, M., González de Buitrago Amigo, J., Tejado Bravo, M. L., & de Nicolás Jiménez, J. M. (2022). Impact of COVID-19 lockdown on glucemic control in children and adolescents with type 1 diabetes mellitus. *Anales de Pediatría (English Edition)*, *97*, 22–29. https://doi.org/10.1016/j.anpede.2020.12.022

Sanyaolu, A., Okorie, C., Marinkovic, A., Patidar, R., Younis, K., Desai, P., Hosein, Z., Padda, I., Mangat, J., & Altaf, M. (2020). Comorbidity and its Impact on Patients with COVID-19. *SN Comprehensive Clinical Medicine*, *2*(8), 1069–1076. https://doi.org/10.1007/s42399-020-00363-4

Sardu, C., D'Onofrio, N., Balestrieri, M. L., Barbieri, M., Rizzo, M. R., Messina, V., Maggi, P., Coppola, N., Paolisso, G., & Marfella, R. (2020). Outcomes in Patients With Hyperglycemia Affected by COVID-19: Can We Do More on Glycemic Control? *Diabetes Care*, *43*(7), 1408–1415. https://doi.org/10.2337/dc20-0723

Saxena, S. K., Kumar, S., Ansari, S., Paweska, J. T., Maurya, V. K., Tripathi, A. K., & Abdel-Moneim, A. S. (2022). Characterization of the novel SARS-CoV-2 Omicron (B.1.1.529)

variant of concern and its global perspective. *Journal of Medical Virology*, *94*(4), 1738–1744. https://doi.org/10.1002/jmv.27524

Schäfer, I., Tajdar, D., Walther, L., Bittner, L., Lühmann, D., & Scherer, M. (2023). Impact of two COVID-19 lockdowns on HbA1c levels in patients with type 2 diabetes and associations with patient characteristics: a multicentre, observational cohort study over three years. *Frontiers in Public Health*, *11*(January), 1–10. https://doi.org/10.3389/fpubh.2023.1272769

Schoen, K., Horvat, N., Guerreiro, N. F. C., De Castro, I., & De Giassi, K. S. (2019). Spectrum of clinical and radiographic findings in patients with diagnosis of H1N1 and correlation with clinical severity. *BMC Infectious Diseases*, *19*(1), 1–8. https://doi.org/10.1186/s12879-019-4592-0

Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie*, *69*(Suppl 2), 107–131. https://doi.org/10.1007/s11577-017-0454-1

Schorr, M., Dichtel, L. E., Gerweck, A. V., Valera, R. D., Torriani, M., Miller, K. K., & Bredella, M. A. (2018). Sex differences in body composition and association with cardiometabolic risk. *Biology of Sex Differences*, *9*(1), 1–10. https://doi.org/10.1186/s13293-018-0189-3

Seda-Gombau, G., Montero-Alía, J. J., Moreno-Gabriel, E., & Torán-Monserrat, P. (2021). Impact of the COVID-19 Pandemic on Burnout in Primary Care Physicians in Catalonia. *International Journal of Environmental Research and Public Health*, *18*(17), 9031. https://doi.org/10.3390/ijerph18179031

Selvin, E., & Juraschek, S. P. (2020). Diabetes epidemiology in the covid-19 pandemic. *Diabetes Care*, *43*(8), 1690–1694. https://doi.org/10.2337/dc20-1295

Shah, S., Bhattarai, S. R., Basnet, K., Adhikari, Y. R., Adhikari, T. B., Bhatta, N., Chamlagain, R., Aryal, S., Sah, S. K., Bhandari, G., Bhandari, B., Poudel, S., Pant, P., & Das, S. K. (2022). Post-COVID syndrome: A prospective study in a tertiary hospital of Nepal. *PLOS ONE*, *17*(8), e0272636. https://doi.org/10.1371/journal.pone.0272636

Shahani, S., & Shahani, L. (2015). Use of insulin in diabetes: a century of treatment. *Hong Kong Medical Journal = Xianggang Yi Xue Za Zhi*, *21*(6), 553–559. https://doi.org/10.12809/hkmj154557

Sharma, S., Ray, A., & Sadasivam, B. (2020). Metformin in COVID-19: A possible role beyond diabetes. *Diabetes Research and Clinical Practice*, *164*, 108183. https://doi.org/10.1016/j.diabres.2020.108183

Shaw, J. E., Sicree, R. A., & Zimmet, P. Z. (2010). Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice*, *87*(1), 4–14. https://doi.org/10.1016/j.diabres.2009.10.007

Sherwani, S. I., Khan, H. A., Ekhzaimy, A., Masood, A., & Sakharkar, M. K. (2016). Significance of HbA1c Test in Diagnosis and Prognosis of Diabetic Patients. *Biomarker Insights*, *11*, BMI.S38440. https://doi.org/10.4137/BMI.S38440

Shi, S., Qin, M., Shen, B., Cai, Y., Liu, T., Yang, F., Gong, W., Liu, X., Liang, J., Zhao, Q., Huang, H., Yang, B., & Huang, C. (2020). Association of Cardiac Injury With Mortality in Hospitalized Patients With COVID-19 in Wuhan, China. *JAMA Cardiology*, *5*(7), 802.

https://doi.org/10.1001/jamacardio.2020.0950

Shipchandler, T. Z., Nesemeier, B. R., Schmalbach, C. E., & Ting, J. Y. (2020). Otolaryngologists' Role in Redeployment During the COVID-19 Pandemic: A Commentary. *Otolaryngology - Head and Neck Surgery (United States)*, *163*(1), 94–95. https://doi.org/10.1177/0194599820926982

Shoaib, M. H., Ahmed, F. R., Sikandar, M., Yousuf, R. I., & Saleem, M. T. (2021). A Journey From SARS-CoV-2 to COVID-19 and Beyond: A Comprehensive Insight of Epidemiology, Diagnosis, Pathogenesis, and Overview of the Progress into Its Therapeutic Management. *Frontiers in Pharmacology*, *12*(February), 1–24. https://doi.org/10.3389/fphar.2021.576448

Shperling, T., & Danon, D. (1990). Age population distribution of erythrocytes in young and old healthy donors. *Experimental Gerontology*, *25*(5), 413–422. https://doi.org/10.1016/0531-5565(90)90030-6

Sigal, R. J., Armstrong, M. J., Colby, P., Kenny, G. P., Plotnikoff, R. C., Reichert, S. M., & Riddell, M. C. (2013). Physical activity and diabetes. *Canadian Journal of Diabetes*, *37 Suppl 1*, S40-4. https://doi.org/10.1016/j.jcjd.2013.01.018

Silva, F. M., Duarte-Mendes, P., Teixeira, A. M., Soares, C. M., & Ferreira, J. P. (2024). The effects of combined exercise training on glucose metabolism and inflammatory markers in sedentary adults: a systematic review and meta-analysis. *Scientific Reports*, *14*(1), 1936. https://doi.org/10.1038/s41598-024-51832-y

Simonnet, A., Chetboun, M., Poissy, J., Raverdy, V., Noulette, J., Duhamel, A., Labreuche, J., Mathieu, D., Pattou, F., & Jourdain, M. (2020). High Prevalence of Obesity in Severe Acute

Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) Requiring Invasive Mechanical Ventilation. *Obesity (Silver Spring, Md.)*, *28*(7), 1195–1199. https://doi.org/10.1002/oby.22831

Smith, R. J., Koenig, R. J., & Binnerts, A. (1982). Regulation of hemoglobin A(I)(c) formation in human erythrocytes in vitro. Effects of physiologic factors other than glucose. *Journal of Clinical Investigation*, *69*(5), 1164–1168. https://doi.org/10.1172/JCI110552

Smyth, A., Jenkins, M., Dunham, M., Kutzer, Y., Taheri, S., & Whitehead, L. (2020). Systematic review of clinical practice guidelines to identify recommendations for sleep in type 2 diabetes mellitus management. *Diabetes Research and Clinical Practice*, *170*, 108532. https://doi.org/10.1016/j.diabres.2020.108532

Sobers-Grannum, N., Murphy, M. M., Nielsen, A., Guell, C., Samuels, T. A., Bishop, L., & Unwin, N. (2015). Female gender is a social determinant of diabetes in the Caribbean: A systematic review and meta-analysis. *PLoS ONE*, *10*(5), e0126799. https://doi.org/10.1371/journal.pone.0126799

Sondrup, N., Termannsen, A.-D., Eriksen, J. N., Hjorth, M. F., Færch, K., Klingenberg, L., & Quist, J. S. (2022). Effects of sleep manipulation on markers of insulin sensitivity: A systematic review and meta-analysis of randomized controlled trials. *Sleep Medicine Reviews*, *62*, 101594. https://doi.org/10.1016/j.smrv.2022.101594

Soulimane, S., Simon, D., Herman, W. H., Lange, C., Lee, C. M. Y., Colagiuri, S., Shaw, J. E., Zimmet, P. Z., Magliano, D., Ferreira, S. R. G., Dong, Y., Zhang, L., Jorgensen, T., Tuomilehto, J., Mohan, V., Christensen, D. L., Kaduka, L., Dekker, J. M., Nijpels, G., … Balkau, B. (2014). HbA1c, fasting and 2 h plasma glucose in current, ex- and never-

smokers: A meta-analysis. *Diabetologia*, *57*(1), 30–39. https://doi.org/10.1007/s00125-013-3058-y

Souza, E. de, Meneses-Santos, D., Santos, J. C., Aidar, F. J., Carvalho, C. R. de O., Santos, J. L. dos, & Marçal, A. C. (2023). "Does Physical Exercise Promote Health Benefits for Diabetic Patients during the COVID-19 Pandemic?": A Systematic Review. *Sports*, *11*(10), 1–20. https://doi.org/10.3390/sports11100192

Stefan, N. (2022). Metabolic disorders, COVID-19 and vaccine-breakthrough infections. *Nature Reviews Endocrinology*, *18*(2), 75–76. https://doi.org/10.1038/s41574-021-00608-9

Suleiman, Y. A., Abdel-Qader, D. H., Suleiman, B. A., Suleiman, A. H., Hamadi, S., & Al Meslamani, A. Z. (2022). Evaluating the impact of COVID-19 on mental health of the public in Jordan: A cross-sectional study. *Journal of Pharmacy and Pharmacognosy Research*, *10*(2), 196–205. https://doi.org/10.56499/jppres21.1191_10.2.196

Sürücü, H. A., Büyükkaya Besen, D., & Erbil, E. Y. (2017). Empowerment and Social Support as Predictors of Self-Care Behaviors and Glycemic Control in Individuals With Type 2 Diabetes. *Clinical Nursing Research*, *27*(4), 395–413. https://doi.org/10.1177/1054773816688940

Taha, A. R. (2022). How the Middle East is facing COVID-19. In *COVID-19 Pandemic*. Elsevier Inc. https://doi.org/10.1016/b978-0-323-82860-4.00008-2

Takahara, M., Watanabe, H., Shiraiwa, T., Maeno, Y., Yamamoto, K., Shiraiwa, Y., Yoshida, Y., Nishioka, N., Katakami, N., & Shimomura, I. (2022). Lifestyle changes and their impact on glycemic control and weight control in patients with diabetes during the coronavirus disease

2019 pandemic in Japan. *Journal of Diabetes Investigation*, *13*(2), 375–385. https://doi.org/10.1111/jdi.13555

Tamiru, S., Dugassa, M., Amsalu, B., Bidira, K., Bacha, L., & Tsegaye, D. (2023). Effects of Nurse-Led diabetes Self-Management education on Self-Care knowledge and Self-Care behavior among adult patients with type 2 diabetes mellitus attending diabetes follow up clinic: A Quasi-Experimental study design. *International Journal of Africa Nursing Sciences*, *18*(August 2022), 100548. https://doi.org/10.1016/j.ijans.2023.100548

Tang, X., Du, R.-H., Wang, R., Cao, T.-Z., Guan, L.-L., Yang, C.-Q., Zhu, Q., Hu, M., Li, X.-Y., Li, Y., Liang, L.-R., Tong, Z.-H., Sun, B., Peng, P., & Shi, H.-Z. (2020). Comparison of Hospitalized Patients With ARDS Caused by COVID-19 and H1N1. *Chest*, *158*(1), 195–205. https://doi.org/10.1016/j.chest.2020.03.032

Tang, X., Wu, C., Li, X., Song, Y., Yao, X., Wu, X., Duan, Y., Zhang, H., Wang, Y., Qian, Z., Cui, J., & Lu, J. (2020). On the origin and continuing evolution of SARS-CoV-2. *National Science Review*, *7*(6), 1012–1023. https://doi.org/10.1093/nsr/nwaa036

Tanharo, D., Ghods, R., Pourrahimi, M., Abdi, M., Aghaei, S., & Vali, N. (2018). Adherence to Treatment in Diabetic Patients and Its Affecting Factors. *Pajouhan Scientific Journal*, *17*(1), 37–44. https://doi.org/10.21859/psj.17.1.37

Tanji, Y., Sawada, S., Watanabe, T., & Mita, T. (2020). *Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information . January*.

Tao, J., Gao, L., Liu, Q., Dong, K., Huang, J., Peng, X., Yang, Y., Wang, H., & Yu, X. (2020). Factors contributing to glycemic control in diabetes mellitus patients complying with home quarantine during the coronavirus disease 2019 (COVID-19) epidemic. *Diabetes Research and Clinical Practice*, *170*(January), 108514. https://doi.org/10.1016/j.diabres.2020.108514

Taylor, L. (2021). Covid-19: Researchers find higher than expected reinfections with P.1 variant among the Brazilian Amazon. *BMJ*, *373*, n1353. https://doi.org/10.1136/bmj.n1353

TeachMideast. (2020). *Middle East Countries*.

Tegally, H., Wilkinson, E., Giovanetti, M., Iranzadeh, A., Fonseca, V., Giandhari, J., Doolabh, D., Pillay, S., San, E. J., Msomi, N., Mlisana, K., von Gottberg, A., Walaza, S., Allam, M., Ismail, A., Mohale, T., Glass, A. J., Engelbrecht, S., van Zyl, G., … de Oliveira, T. (2020). Emergence and rapid spread of a new severe acute respiratory syndrome-related coronavirus 2 (SARS-CoV-2) lineage with multiple spike mutations in South Africa. *MedRxiv*, *2*. https://doi.org/10.1101/2020.12.21.20248640

Tesfaye, S., & Selvarajah, D. (2012). Advances in the epidemiology, pathogenesis and management of diabetic peripheral neuropathy. *Diabetes/Metabolism Research and Reviews*, *28*(S1), 8–14. https://doi.org/10.1002/dmrr.2239

The National News. (2021). *Jordan's health minister forced out of government after seven Covid-19 patients die from lack of oxygen".* 13 March 2021. Archived from the original on 14 March 2021. Retrieved 14 March 2021.The National News. 13 March 2021. Archived from the original on 14 March 2021. Retrieved 14 March 2021.

Theodoropoulou, K. T., Dimitriadis, G. D., Tentolouris, N., Darviri, C., & Chrousos, G. P.

(2020). Diabetes distress is associated with individualized glycemic control in adults with type 2 diabetes mellitus. *Hormones*, *19*(4), 515–521. https://doi.org/10.1007/s42000-020-00237-3

Thirunavukkarasu, R., Asirvatham, A. J., Chitra, A., & Jayalakshmi, M. (2019). SLC30A8 Gene rs13266634 C/T Polymorphism in Children with Type 1 Diabetes in Tamil Nadu, India. *Journal of Clinical Research in Pediatric Endocrinology*, *11*(1), 55–60. https://doi.org/10.4274/jcrpe.galenos.2018.2018.0195

Thompson, A., & Kanamarlapudi, V. (2013). Type 2 Diabetes Mellitus and Glucagon Like Peptide-1 Receptor Signalling. *Clinical & Experimental Pharmacology*, *03*(04). https://doi.org/10.4172/2161-1459.1000138

Thunander Sundbom, L., & Bingefors, K. (2012). Women and men report different behaviours in, and reasons for medication non-adherence: a nationwide Swedish survey. *Pharmacy Practice (Internet)*, *10*(4), 207–221. https://doi.org/10.4321/S1886-36552012000400005

Timpel, P., Soz, D., Oswald, S., & Schwarz, P. E. H. (2020). *Mapping the Evidence on the Effectiveness of Telemedicine Interventions in Diabetes , Dyslipidemia , and Hypertension : An Umbrella Review of Systematic Reviews and Meta-Analyses Corresponding Author : 22*. https://doi.org/10.2196/16791

Toh. (2011). Association of Younger Age With Poor Glycemic and Cholesterol Control in Asians With Type 2 Diabetes Mellitus in Singapore. *Journal of Endocrinology and Metabolism*. https://doi.org/10.4021/jem13e

Tol, A., Baghbanian, A., Sharifirad, G., Shojaeizadeh, D., Eslami, A., Alhani, F., & Tehrani, M.

M. (2012). Assessment of diabetic distress and disease related factors in patients with type 2 diabetes in Isfahan: A way to tailor an effective intervention planning in Isfahan-Iran. *Journal of Diabetes & Metabolic Disorders*, *11*(1). https://doi.org/10.1186/2251-6581-11-20

Toobert, D. J., & Glasgow, R. E. (1994). Assessing diabetes self-management: the summary of diabetes self- care activities questionnaire. In *In Handbook of Psychology and Diabetes. Bradley C, Ed. Chur, Switzerland, Harwood Academic* (pp. 351–375).

Toobert, D. J., Hampson, S. E., & Glasgow, R. E. (2000). The Summary of Diabetes Self-Care Activities Measure. *Diabetes Care Journal*, *23*(7), 943–950.

Tornese, G., Ceconi, V., Monasta, L., Carletti, C., Faleschini, E., & Barbi, E. (2020). Glycemic Control in Type 1 Diabetes Mellitus During COVID-19 Quarantine and the Role of In-Home Physical Activity. *Diabetes Technology & Therapeutics*, *22*(6), 462–467. https://doi.org/10.1089/dia.2020.0169

Troughton, J., Kearney, P. M., & Moore, M. (2021). The impact of COVID-19 on diabetes management: A review of the literature. *Diabetes & Metabolism*, *47*(4), 101–110. https://doi.org/https://doi.org/10.1016/j.diabet.2021.03.012

Tuso, P. (2014). Prediabetes and Lifestyle Modification: Time to Prevent a Preventable Disease. *The Permanente Journal*, *18*(3), 88–93. https://doi.org/10.7812/TPP/14-002

Tuttle, K. R., Bakris, G. L., Bilous, R. W., Chiang, J. L., de Boer, I. H., Goldstein-Fuchs, J., Hirsch, I. B., Kalantar-Zadeh, K., Narva, A. S., Navaneethan, S. D., Neumiller, J. J., Patel, U. D., Ratner, R. E., Whaley-Connell, A. T., & Molitch, M. E. (2014). Diabetic Kidney

Disease: A Report From an ADA Consensus Conference. *Diabetes Care*, *37*(10), 2864–2883. https://doi.org/10.2337/dc14-1296

Udugama, B., Kadhiresan, P., Kozlowski, H. N., Malekjahani, A., Osborne, M., Li, V. Y. C., Chen, H., Mubareka, S., Gubbay, J. B., & Chan, W. C. W. (2020). Diagnosing COVID-19: The Disease and Tools for Detection. *ACS Nano*, *14*(4), 3822–3835. https://doi.org/10.1021/acsnano.0c02624

Ugwueze, C. V., Ezeokpo, B. C., Nnolim, B. I., Agim, E. A., Anikpo, N. C., & Onyekachi, K. E. (2020). COVID-19 and Diabetes Mellitus: The Link and Clinical Implications. *Dubai Diabetes and Endocrinology Journal*, *26*(2), 69–77. https://doi.org/10.1159/000511354

Usher, K., Bhullar, N., & Jackson, D. (2020). Life in the pandemic: Social isolation and mental health. *Journal of Clinical Nursing*, *29*(15–16), 2756–2757. https://doi.org/10.1111/jocn.15290

Van Der Kooy, K., Leenen, R., Seidell, J. C., Deurenberg, P., Droop, A., & Bakker, C. J. G. (1993). Waist-hip ratio is a poor predictor of changes in visceral fat. *American Journal of Clinical Nutrition*, *57*(3), 327–333. https://doi.org/10.1093/ajcn/57.3.327

Van Grondelle, S. E., Van Bruggen, S., Rauh, S. P., Van der Zwan, M., Cebrian, A., Seidu, S., Rutten, G. E. H. M., Vos, H. M. M., Numans, M. E., & Vos, R. C. (2023). The impact of the covid-19 pandemic on diabetes care: the perspective of healthcare providers across Europe. *Primary Care Diabetes*, *17*(2), 141–147. https://doi.org/10.1016/j.pcd.2023.02.002

Vazquez, G., Duval, S., Jacobs, D. R., & Silventoinen, K. (2007). Comparison of body mass index, waist circumference, and waist/hip ratio in predicting incident diabetes: A meta-

analysis. *Epidemiologic Reviews*, *29*(1), 115–128. https://doi.org/10.1093/epirev/mxm008

Venkatasamy, V. V., Pericherla, S., Manthuruthil, S., Mishra, S., & Hanno, R. (2013). Effect of Physical activity on Insulin Resistance, Inflammation and Oxidative Stress in Diabetes Mellitus. *Journal of Clinical and Diagnostic Research : JCDR*, *7*(8), 1764–1766. https://doi.org/10.7860/JCDR/2013/6518.3306

Verma, A. K., Ali Beg, M. M., Bhatt, D., Dev, K., Alsahli, M. A., Rahmani, A. H., & Goyal, Y. (2021). عالقهAssessment and management of diabetic patients during the COVID-19 pandemic. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *14*, 3131–3146. https://doi.org/10.2147/DMSO.S285614

Voloch, C. M., da Silva Francisco, R., de Almeida, L. G. P., Cardoso, C. C., Brustolini, O. J., Gerber, A. L., Guimarães, A. P. de C., Mariani, D., da Costa, R. M., Ferreira, O. C., Cavalcanti, A. C., Frauches, T. S., de Mello, C. M. B., Leitão, I. de C., Galliez, R. M., Faffe, D. S., Castiñeiras, T. M. P. P., Tanuri, A., & de Vasconcelos, A. T. R. (2021). Genomic Characterization of a Novel SARS-CoV-2 Lineage from Rio de Janeiro, Brazil. *Journal of Virology*, *95*(10), e00119-21. https://doi.org/10.1128/JVI.00119-21

Vranas, K. C., Golden, S. E., Mathews, K. S., Schutz, A., Valley, T. S., Duggal, A., Seitz, K. P., Chang, S. Y., Nugent, S., Slatore, C. G., Sullivan, D. R., & Hough, C. L. (2021). The Influence of the COVID-19 Pandemic on ICU Organization, Care Processes, and Frontline Clinician Experiences: A Qualitative Study. *Chest*, *160*(5), 1714–1728. https://doi.org/10.1016/j.chest.2021.05.041

Vujkovic, M., Keaton, J. M., Lynch, J. A., Miller, D. R., Zhou, J., Tcheandjieu, C., Huffman, J. E., Assimes, T. L., Lorenz, K., Zhu, X., Hilliard, A. T., Judy, R. L., Huang, J., Lee, K. M.,

Klarin, D., Pyarajan, S., Danesh, J., Melander, O., Rasheed, A., … Program, V. A. M. V. (2020). Discovery of 318 new risk loci for type 2 diabetes and related vascular outcomes among 1.4 million participants in a multi-ancestry meta-analysis. *Nature Genetics*, *52*(7), 680–691. https://doi.org/10.1038/s41588-020-0637-y

Wafa, I. A., Pratama, N. R., Sofia, N. F., Anastasia, E. S., Konstantin, T., Wijaya, M. A., Rifqi Wiyono, M., Djuari, L., & Novida, H. (2022). Impact of COVID-19 Lockdown on the Metabolic Control Parameters in Patients with Diabetes Mellitus: A Systematic Review and Meta-Analysis. *Diabetes and Metabolism Journal*, *46*(2), 260–272. https://doi.org/10.4093/dmj.2021.0125

Walker, E. A., Molitch, M., Kramer, M. K., Kahn, S., Ma, Y., Edelstein, S., Smith, K., Johnson, M. K., Kitabchi, A., & Crandall, J. (2006). Adherence to preventive medications: Predictors and outcomes in the diabetes prevention program. *Diabetes Care*, *29*(9), 1997–2002. https://doi.org/10.2337/dc06-0454

Wang, A., Zhao, W., Xu, Z., & Gu, J. (2020). Timely blood glucose management for the outbreak of 2019 novel coronavirus disease (COVID-19) is urgently needed. *Diabetes Research and Clinical Practice*, *162*(January). https://doi.org/10.1016/j.diabres.2020.108118

Wang, C.-H., & Wei, Y.-H. (2017). Role of mitochondrial dysfunction and dysregulation of Ca2+ homeostasis in the pathophysiology of insulin resistance and type 2 diabetes. *Journal of Biomedical Science*, *24*(1), 70. https://doi.org/10.1186/s12929-017-0375-3

Wang, H., Li, X., Li, T., Zhang, S., Wang, L., Wu, X., & Liu, J. (2020). The genetic sequence, origin, and diagnosis of SARS-CoV-2. *European Journal of Clinical Microbiology &*

*Infectious Diseases : Official Publication of the European Society of Clinical Microbiology*, *39*(9), 1629–1635. https://doi.org/10.1007/s10096-020-03899-4

Wang, H., Paulson, K. R., Pease, S. A., Watson, S., Comfort, H., Zheng, P., Aravkin, A. Y., Bisignano, C., Barber, R. M., Alam, T., Fuller, J. E., May, E. A., Jones, D. P., Frisch, M. E., Abbafati, C., Adolph, C., Allorant, A., Amlag, J. O., Bang-Jensen, B., … Murray, C. J. L. (2022). Estimating excess mortality due to the COVID-19 pandemic: a systematic analysis of COVID-19-related mortality, 2020–21. *The Lancet*, *399*(10334), 1513–1536. https://doi.org/10.1016/S0140-6736(21)02796-3

Wang, Y., Ji, J., Liu, Y. jian, Deng, X., & He, Q. qiang. (2013). Passive Smoking and Risk of Type 2 Diabetes: A Meta-Analysis of Prospective Cohort Studies. *PLoS ONE*, *8*(7), e69915. https://doi.org/10.1371/journal.pone.0069915

Wang, Z., Du, Z., & Zhu, F. (2020). Glycosylated hemoglobin is associated with systemic inflammation, hypercoagulability, and prognosis of COVID-19 patients. *Diabetes Research and Clinical Practice*, *164*, 108214. https://doi.org/10.1016/j.diabres.2020.108214

Wang, Z., Tang, Y., Cui, Y., Guan, H., Cui, X., Liu, Y., Liu, Y., Kang, Z., Wu, Q., Hao, Y., & Liu, C. (2023). Delay in seeking health care from community residents during a time with low prevalence of COVID-19: A cross-sectional national survey in China. *Frontiers in Public Health*, *11*. https://doi.org/10.3389/fpubh.2023.1100715

Wei, M., Dong, L., Wang, F., & Cui, K. (2021). *The Prevalence and Control of Type 2 Diabetes Mellitus in Residents of a Rural Town , Shandong*. *October*.

Weisman, A., Fazli, G. S., Johns, A., & Booth, G. L. (2018). Evolving Trends in the

Epidemiology, Risk Factors, and Prevention of Type 2 Diabetes: A Review. *Canadian Journal of Cardiology*, *34*(5), 552–564. https://doi.org/10.1016/j.cjca.2018.03.002

Weiss, S. R. (2020). Forty years with coronaviruses. *Journal of Experimental Medicine*, *217*(5), 2–5. https://doi.org/10.1084/jem.20200537

Welch, V. A. (2019). Cochrane Handbook for Systematic Reviews of Interventions. In *Cochrane Handbook for Systematic Reviews of Interventions*. Wiley. https://doi.org/10.1002/9781119536604

Wells, G., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., & Tugwell, P. (2014). *Newcastle-Ottawa quality assessment scale cohort studies.* Visual Communication Quarterly.

WHO. (2010). *A healthy lifestyle - WHO recommendations*. https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle---who-recommendations

WHO. (2018). *World Health Organization.* http://www.who.int/topics/obesity/en/. Accessed 22 Jan 2018

WHO. (2019). *World Health Organization. Middle East respiratory syndrome coronavirus (MERS-CoV). November 2019.* https://www.who.int/health-topics/middle-east-respiratory-syndrome-coronavirus-mers#tab=tab_1

WHO. (2020). *WHO Director- General's remarks at the media briefing on 2019- nCoV on 11 February 2020. https://www .who.int/dg/speeches/detail/who- director- general- s-remarks- at- the- media- briefing- on- 2019- ncov- on- 11- february- 2020No Title*. https://doi.org/https://www.who.int/director-general/speeches/detail/who-director-general-s-

remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020

WHO. (2021a). *WHO Coronavirus (COVID-19) Dashboard With Vaccination*. World Health Organization. https://covid19.who.int/ https://covid19.who.int/%0Ahttps://covid19.who.int/region/searo/country/bd

WHO. (2021b). *World Health Organization. The top 10 causes of death.* https://doi.org/World Health Organization. The top 10 causes of death. [cited 26 Jan 2021]. In: World Health Organization [Internet]. Available from: https://www.who.int/news-room/fact-sheets/detail/the-top- 10-causes-of-death

WHO. (2022a). *COVID-19 July Situation Report No.38 Regional Office for Eastren Mediterranean* (pp. 1–6).

WHO. (2022b). *Weekly epidemiological update on COVID-19 - 8 June 2022*. World Health Organization. https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19---8-june-2022

WHO. (2023). COVID-19 epidemiological update – 22 December 2023. *World Health Organization*, *December 2023*, 26. https://www.who.int/publications/m/item/covid-19-epidemiological-update---22-december-2023

Wicaksana, A. L., Hertanti, N. S., Ferdiana, A., & Pramono, R. B. (2020). Diabetes management and specific considerations for patients with diabetes during coronavirus diseases pandemic: A scoping review. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(5), 1109–1120. https://doi.org/10.1016/j.dsx.2020.06.070

Wiener, K., & Roberts, N. B. (1999). Age does not influence levels of HbA(1c) in normal

subject. *QJM - Monthly Journal of the Association of Physicians*, *92*(3), 169–173. https://doi.org/10.1093/qjmed/92.3.169

Wiersinga, W. J., Rhodes, A., Cheng, A. C., Peacock, S. J., & Prescott, H. C. (2020). Pathophysiology, Transmission, Diagnosis, and Treatment of Coronavirus Disease 2019 (COVID-19). *JAMA*, *324*(8), 782. https://doi.org/10.1001/jama.2020.12839

Woc-Colburn, L., & Godinez, D. (2022). Lockdown as a public health measure. In *COVID-19 Pandemic*. Elsevier Inc. https://doi.org/10.1016/b978-0-323-82860-4.00013-6

Wojcik, G. L., Graff, M., Nishimura, K. K., Tao, R., Haessler, J., Gignoux, C. R., Highland, H. M., Patel, Y. M., Sorokin, E. P., Avery, C. L., Belbin, G. M., Bien, S. A., Cheng, I., Cullina, S., Hodonsky, C. J., Hu, Y., Huckins, L. M., Jeff, J., Justice, A. E., … Carlson, C. S. (2019). Genetic analyses of diverse populations improves discovery for complex traits. *Nature*, *570*(7762), 514–518. https://doi.org/10.1038/s41586-019-1310-4

Wondmkun, Y. T. (2020). Obesity, insulin resistance, and type 2 diabetes: Associations and therapeutic implications. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *13*, 3611–3616. https://doi.org/10.2147/DMSO.S275898

Woolf, S. H., Chapman, D. A., & Lee, J. H. (2021). COVID-19 as the Leading Cause of Death in the United States. *JAMA*, *325*(2), 123. https://doi.org/10.1001/jama.2020.24865

World Health organization. (2016). *Diabetes country profiles: explanatory notes*. *April*, 8.

World Health Organization (WHO). (2020). *Obesity and overweight*.

World Health Organization (WHO). (2022). . *Eastern mediterranean regional office COVID- 19*

*dashboard 2022*.

Wu, Z., & McGoogan, J. M. (2020). Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA*, *323*(13), 1239–1242. https://doi.org/10.1001/jama.2020.2648

Xiang, Y. T., Yang, Y., Li, W., Zhang, L., Zhang, Q., Cheung, T., & Ng, C. H. (2020). Timely mental health care for the 2019 novel coronavirus outbreak is urgently needed. In *The Lancet Psychiatry* (Vol. 7, Issue 3, pp. 228–229). Elsevier Ltd. https://doi.org/10.1016/S2215-0366(20)30046-8

Xu, B., Li, S., Kang, B., & Zhou, J. (2022). The current role of sodium-glucose cotransporter 2 inhibitors in type 2 diabetes mellitus management. *Cardiovascular Diabetology*, *21*(1), 1–21. https://doi.org/10.1186/s12933-022-01512-w

Xu, H., Zhong, L., Deng, J., Peng, J., Dan, H., Zeng, X., Li, T., & Chen, Q. (2020). High expression of ACE2 receptor of 2019-nCoV on the epithelial cells of oral mucosa. *International Journal of Oral Science*, *12*(1), 8. https://doi.org/10.1038/s41368-020-0074-x

Yacoub, M. I., Demeh, W. M., Darawad, M. W., Barr, J. L., Saleh, A. M., & Saleh, M. Y. (2014). An assessment of diabetes-related knowledge among registered nurses working in hospitals in <scp>J</scp> ordan. *International Nursing Review*, *61*(2), 255–262. https://doi.org/10.1111/inr.12090

Yacoub, S. E., Mansur, M. H., & Raheem, Y. A. (2011). Effect of Frequent Self-Monitoring of Blood Glucose on HbA1c Level Among Type 2 Diabetic Patients. *Research Journal of*

*Medical Sciences*, *5*(3), 145–149. https://doi.org/10.3923/rjmsci.2011.145.149

Yang, X. (2021). Does city lockdown prevent the spread of COVID-19? New evidence from the synthetic control method. *Global Health Research and Policy*, *6*(1). https://doi.org/10.1186/s41256-021-00204-4

Yang, Y., Cai, Z., & Zhang, J. (2021). Insulin Treatment May Increase Adverse Outcomes in Patients With COVID-19 and Diabetes: A Systematic Review and Meta-Analysis. *Frontiers in Endocrinology*, *12*(July), 1–10. https://doi.org/10.3389/fendo.2021.696087

Yosef, T., Nureye, D., & Tekalign, E. (2021). Poor glycemic control and its contributing factors among type 2 diabetes patients at adama hospital medical college in east Ethiopia. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *14*, 3273–3280. https://doi.org/10.2147/DMSO.S321756

Zahedi, M., Kordrostami, S., Kalantarhormozi, M., & Bagheri, M. (2023). A Review of Hyperglycemia in COVID-19. *Cureus*, *15*(4), 15–21. https://doi.org/10.7759/cureus.37487

Zayed, R. A., Omran, D., & Zayed, A. A. (2021). *COVID-19 clinical and laboratory diagnosis overview*.

Zhang, H., Zhou, P., Wei, Y., Yue, H., Wang, Y., Hu, M., Zhang, S., Cao, T., Yang, C., Li, M., Guo, G., Chen, X., Chen, Y., Lei, M., Liu, H., Zhao, J., Peng, P., Wang, C.-Y., & Du, R. (2020). Histopathologic Changes and SARS-CoV-2 Immunostaining in the Lung of a Patient With COVID-19. *Annals of Internal Medicine*, *172*(9), 629–632. https://doi.org/10.7326/M20-0533

Zhao, X., Liu, B., Yu, Y., Wang, X., Du, Y., Gu, J., & Wu, X. (2020). The characteristics and

clinical value of chest CT images of novel coronavirus pneumonia. *Clinical Radiology*, *75*(5), 335–340. https://doi.org/10.1016/j.crad.2020.03.002

Zhao, Z., Zhang, F., Xu, M., Huang, K., Zhong, W., Cai, W., Yin, Z., Huang, S., Deng, Z., Wei, M., Xiong, J., & Hawkey, P. M. (2003). Description and clinical treatment of an early outbreak of severe acute respiratory syndrome (SARS) in Guangzhou, PR China. *Journal of Medical Microbiology*, *52*(Pt 8), 715–720. https://doi.org/10.1099/jmm.0.05320-0

Zheng, F., Liu, S., Liu, Y., & Deng, L. (2019). Effects of an outpatient diabetes self-management education on patients with type 2 diabetes in China: A randomized controlled trial. *Journal of Diabetes Research*, *2019*, 1–7. https://doi.org/10.1155/2019/1073131

Zheng, Y., Ley, S. H., & Hu, F. B. (2017). Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. *Nature Publishing Group*, *14*(2), 88–98. https://doi.org/10.1038/nrendo.2017.151

Zheng, Y., Ley, S. H., & Hu, F. B. (2018). Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. In *Nature Reviews Endocrinology*. https://doi.org/10.1038/nrendo.2017.151

Zhou, F., Yu, T., Du, R., Fan, G., Liu, Y., Liu, Z., Xiang, J., Wang, Y., Song, B., Gu, X., Guan, L., Wei, Y., Li, H., Wu, X., Xu, J., Tu, S., Zhang, Y., Chen, H., & Cao, B. (2020). Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet*, *395*(10229), 1054–1062. https://doi.org/10.1016/S0140-6736(20)30566-3

Zhu, M., Liu, X., Liu, W., Lu, Y., Cheng, J., & Chen, Y. (2021). *β cell aging and age-related*

*diabetes*. *13*(5), 7691–7706.

Zhu, T., Li, L., Feng, L., & Ren, M. (2020). StABI5 involved in the regulation of chloroplast development and photosynthesis in potato. *International Journal of Molecular Sciences*, *21*(3), 1–18. https://doi.org/10.3390/ijms21031068