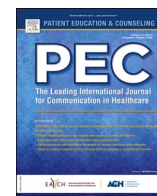


Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Patient Education and Counseling

journal homepage: www.journals.elsevier.com/patient-education-and-counseling

Prostate cancer, online health information and communication technology – Bibliometric analysis of field with research frontiers

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ARTICLE INFO

Keywords:

Prostate

Cancer

Self-education

Internet

Information

Bibliometric

ABSTRACT

Objectives: The purpose of this study is to conduct the first bibliometric analysis which examines eHealth communication technologies in prostate cancer care, and the utilization of internet-based health information and communication technology by men with prostate cancer.

Methods: Original articles were extracted from the Science Citation Index Expanded (SCI-E) on Web of Science (WOS) and analyzed concerning their distributions. Quantitative guidance directed investigation of findings from previous studies and trending issues within the field. The WOS, VOSviewer and CiteSpace IV were used for information analysis.

Results: 302 articles were included in the final analysis. There has been a 165 % increase in productivity over the past decade. The leading country by publication was the USA (145 articles = 48.02 %). Journals which published the highest number of original articles were the Journal of Medical Internet Research (6.95 %), and Patient Education and Counseling (4.64 %).

Discussion and practice implications: The field of research which examines utilization and impacts of internet-based health information on men with prostate cancer is growing and diverse. Research frontiers are 'Information quality and diversity', 'eHealth literacy', 'decision making', and 'survivorship and advanced disease'. Clinicians should be aware of several significant limitations which exist within the current field of research.

1. Introduction

In 1991, the establishment of the World Wide Web created a flood of information exchange and communication. With this growth, patient and clinician use of the internet for healthcare has increased [1–3]. This is occurring with patients engaging with all medical specialties, and growing numbers are using technology as part of their ongoing health care [4–7]. With this shift, the health system becomes more complex and decentralized, with eHealth communication technologies providing opportunity for large scale and cost-effective health interventions to the masses [8]. One area where this can play an important role is global cancer care, where costs are currently estimated to reach \$25.2 trillion (international dollars) by 2050 [9]. Scalable communication technologies provide an opportunity to augment and improve care access for

millions of individuals who are diagnosed with cancer each year.

Prostate cancer care is one example where this may hold great effect. Prostate cancer is the most common cancer diagnosed in men worldwide, affecting more than 1.3 million men each year [10]. It is the most common malignancy and second leading cause of cancer death for men in the United States [10]. For men with prostate cancer, the internet is being signified as a common education, communication, and intervention tool – providing consumer information and education which is utilized as part of screening, treatment, and support [11–13]. It is therefore an opportune time to comprehensively investigate the state of research which explores online health communication technology used in prostate cancer care. A bibliometric review will be undertaken, as this broad literature review methodology is suited to describe the state of this diverse collection of technology and health-based research.

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<https://doi.org/10.1016/j.pec.2023.107887>

Received 9 August 2022; Received in revised form 24 May 2023; Accepted 6 July 2023

Available online 10 July 2023

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1.1. Rationale

Bibliometrics utilizes literature metadata to illustrate and review the state of a research field [14]. It allows macro and micro-analysis, providing a means to demonstrate contributions and relationships within a field. These techniques primarily allow a top-down demonstration of current knowledge, field structures, research frontiers and potential knowledge gaps in research. This can aid clinical and systemic decision making, research, and policy. Bibliometric techniques have been used in medical literature previously, including urological publications, with healthcare stakeholders now demanding bibliometric data to contextualize and aggregate large volumes of research to guide practice [15–17].

Bibliometric review is fitting when considering the complexity of eHealth research [18–20]. Despite the reported benefits of technology, investigation and clinical implementation remains difficult due to several conflicting characteristics [8]. In example, the exponential nature of diverse technological developments, with the costs of investigating and/or implementing these technologies within traditionally inflexible and siloed healthcare systems [8]. A traditional reluctance to share intellectual property is also matched by the resistance of clinicians and policy makers to adopt technologies without a clear evidence base, creating the potential for disparities in care [21,22]. This is intensified by geographic and sociocultural factors which can have significant regional effects on eHealth development and uptake [23,24]. Ultimately, these barriers slow innovation, adoption and diffusion, preventing clinicians from efficiently implementing effective eHealth interventions or strategies for their patients [22]. The broad nature of bibliometric review affords an opportunity for clinicians to appreciate the diverse volume of data which is currently associated with this research body. With improved clarity regarding the meta-structures, strengths and limitations of the field, clinicians and scientists can more efficiently allocate resources to appropriate eHealth interventions, systems and research which can address their patients' needs.

1.2. Objectives

Our broad research question is: “What is known from existing literature about eHealth communication technology and online information sources used in prostate cancer patient care, and what gaps exist in this literature?”.

While demonstrating the broad state of this research, this review has specific aims. By investigating these, clinicians are afforded a greater understanding of eHealth evidence which can aid selection of communication, education, and care interventions for men with prostate cancer. Key objectives are as follows:

Identify and map major research field structures, themes and development, including connections and major contributors to the field.

Identify internet connected eHealth information sources and communication technologies investigated in the literature that are related to care of patients with prostate cancer; and,

Identify those information sources and technologies which are used by men with prostate cancer.

Identify the research methods within literature which investigate this use by men with prostate cancer.

Identify research frontiers and any gaps in literature to allow direction of clinical practice and future research.

2. Methods

2.1. Search strategy

On the 20/2/2020 and 13/3/23, the Web of Science Core Collection of the ISI Web of Science (WOS) (Thomson Reuters, Philadelphia, PA)

was searched without language, date, or categorical restriction. The protocol aimed to identify articles which related prostate cancer to internet-based information sources and the technology platforms used to access this information. Keywords such as “prostat* ” were Boolean linked to terms such as “cancer*”, “carcinoma*” and “tumour*” to identify papers related to prostate cancer. Articles related to internet-based information sources and platforms utilized general terms such as “internet”, “web” and “digital”, with more specific named platforms such as “facebook”, “i-phone”, and “tiktok”. The search protocol may be found in the [supplementary information online](#) (Figure A1 in Appendix).

Non-English works, editorials, meeting abstracts and proceedings, letters, errata, retractions, and corrections were excluded with WOS analysis tools.

2.2. Inclusion criteria

Literature was identified by a single reviewer (SRJ) screening titles, abstracts, and full texts in sequence. If abstracts were vague, full articles were reviewed in more detail prior to the full text stage. Records were considered relevant if:

- Investigating internet-based information/education sources directly related to prostate cancer patient care (e.g. information and news-based websites, social media websites, mobile applications, website forums, online interventions with information/education component); or,
- Investigating internet connected communication technology used by men with prostate cancer.

Original articles were included in the bibliometric analysis, including level 1–4 research, systematic review and meta-analysis, narrative review, and case reports/series. Animal based studies, protocols, and those matching WOS analysis restriction categories were excluded.

Empiric studies underwent data charting (by SRJ) with the following extracted and tabulated: year of publication, research methods, analytical approaches, population/s sampled, internet-based health information sources used, digital technologies used, variables and/or measures used, and relevant results/findings. If a description of, or type of website, was documented within a study, relevant website and social media types were sub-categorized as part of tabulation. Online information sources and technologies were considered ‘used’ by men with prostate cancer if use was reported by men included in a study or the use of this occurred within the study itself.

2.3. Results synthesis and analysis

Evidence was summarized in narrative form, with tables, illustrations and bibliometric analysis following established guidelines [25]. WOS ‘analyze results’ tools were utilized to record identified articles and citations, countries, authors, institutions, journals, annual publications, and impact factor. Number of research articles and citations of each article were used to quantify research productivity and impact respectively, allowing ranking of primary outcomes: country, journal, institution, and author. Top 10 rankings are described for these by productivity. Top co-cited authors and references are also ranked. The top 10 articles of the field by impact, are listed. VOSviewer (Leiden University, Leiden, Netherlands) was utilized to identify thematic clusters, temporal field development, and co-authorship networks. As citation bursts indicate research community attention to an underlying construct, CiteSpace V (Chaomei Chen, Mountain View, CA, USA) analytic system was used to identify notable keyword, author and articles of the last 10 years [26].

Descriptive statistics were used to analyse online information sources and technology investigated in available literature, and that have been used by men with prostate cancer. If prostate cancer patient health care

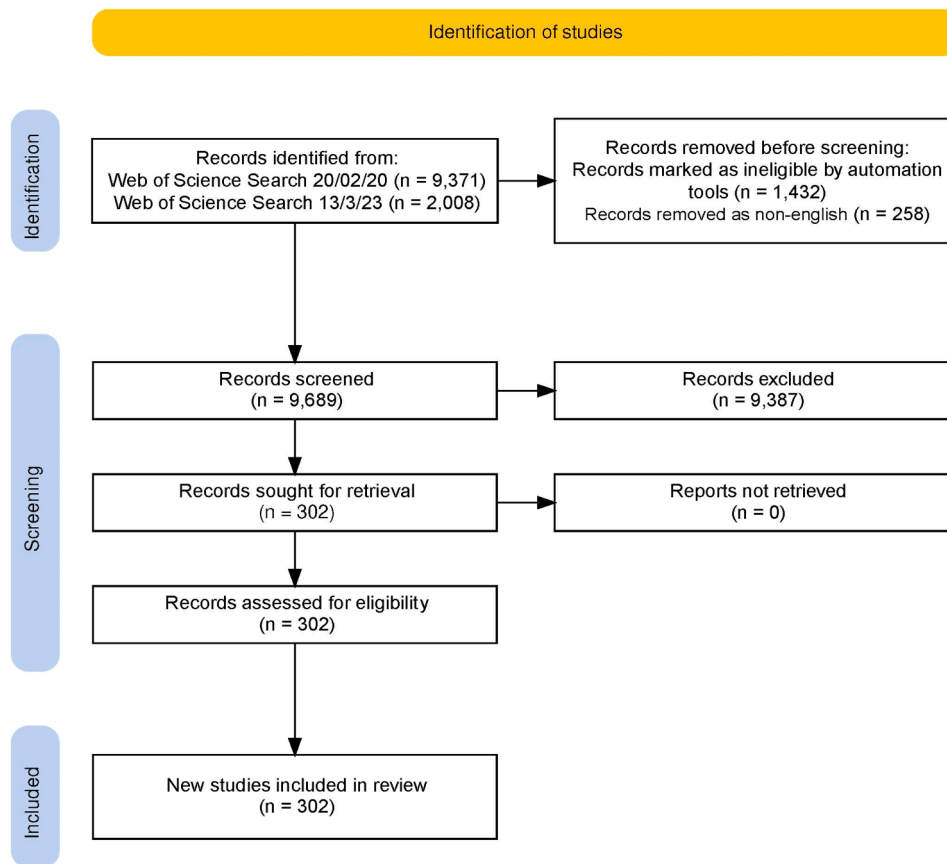


Fig. 1. PRISMA flow diagram.

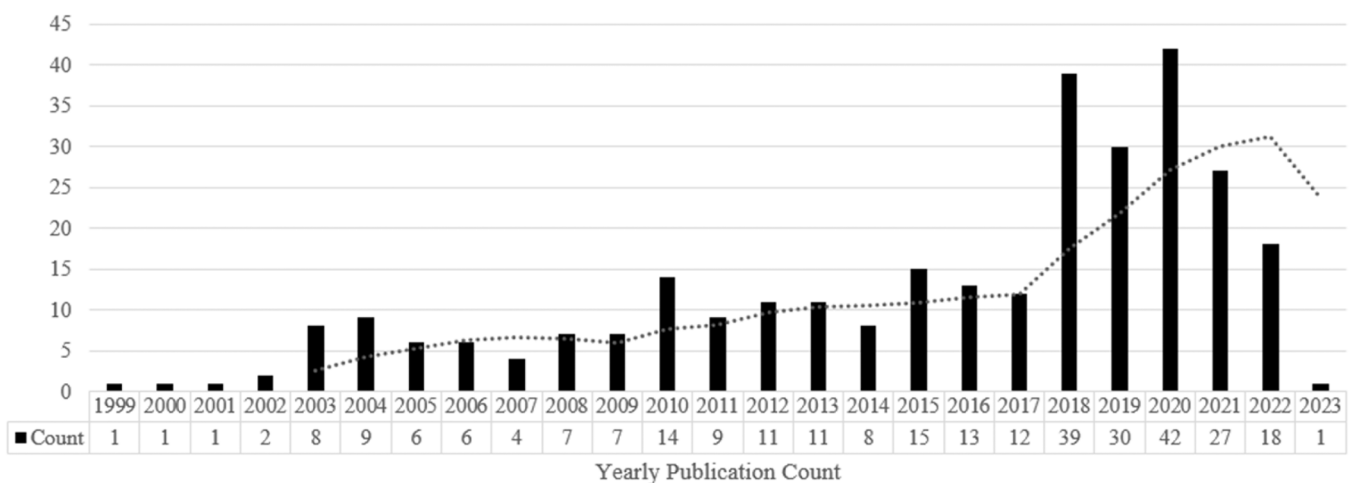


Fig. 2. Annual number of publications with 5-year moving average trendline, 1999–2023.

outcomes, information use, or technology use were unable to be delineated from other included study populations (e.g. general population, other cancer patients, prostate cancer carers, etc), then these findings were excluded from the portion of data synthesis exploring empiric prostate cancer research methodology. This was elected as it is unclear whether mixed results truly reflect the prostate cancer patients sampled. Narrative conclusions were drawn from and based on cumulative inspection of all tabulated data, bibliometric outputs, and review of literature identified.

3. Results

3.1. General

11,379 articles were identified. 1690 articles were excluded with application of WOS analysis tools. 9689 articles underwent title and abstract review (Fig. 1). 302 articles were included in the final field analysis, published from 1999 until March 2023 (Fig. 2), with an average of 12.6 articles published per year. Comparing the most recent decades (2003–2012 vs 2013–2022), there has been a 165% increase in productivity. Strength of interest in the field is further demonstrated

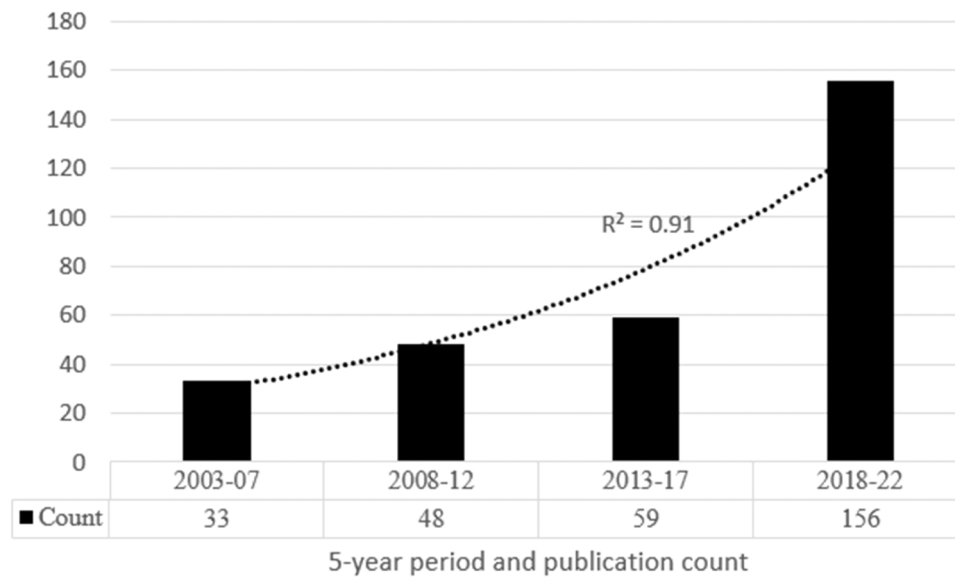


Fig. 3. 5-year publication rate with exponential trend line, 2003–2022.

Table 1
Top 10 journal, country and institutional ranking by citation count.

	Rank	Name	Citation Count	% of papers
Journal	1	JOURNAL OF MEDICAL INTERNET RESEARCH	21	6.95 %
	2	PATIENT EDUCATION AND COUNSELING	14	4.64 %
	3	JOURNAL OF CANCER EDUCATION	11	3.64 %
	4	SUPPORTIVE CARE IN CANCER	11	3.64 %
	5	JOURNAL OF UROLOGY	10	3.31 %
	6	JMIR CANCER	10	3.31 %
	7	PSYCHO ONCOLOGY	10	3.31 %
	8	UROLOGY	10	3.31 %
	9	BJU INTERNATIONAL	9	2.98 %
	10	AMERICAN JOURNAL OF MENS HEALTH	7	2.32 %
Country	1	USA	145	48.01 %
	2	ENGLAND	43	14.24 %
	3	CANADA	34	11.26 %
	4	AUSTRALIA	30	9.93 %
	5	GERMANY	19	6.29 %
	6	NETHERLANDS	19	6.29 %
	7	SWEDEN	16	5.30 %
	8	ITALY	7	2.32 %
	9	SPAIN	7	2.32 %
	10	PEOPLES R CHINA	5	1.66 %
Institution	1	UNIVERSITY OF CALIFORNIA SYSTEM	23	7.62 %
	2	HARVARD UNIVERSITY	20	6.62 %
	3	DANA FARBER CANCER INSTITUTE	17	5.63 %
	4	KAROLINSKA INSTITUTET	13	4.31 %
	5	UNIVERSITY OF MELBOURNE	13	4.31 %
	6	UNIVERSITY OF TORONTO	13	4.31 %
	7	UNIVERSITY OF LONDON	12	3.97 %
	8	UNIVERSITY OF BRITISH COLUMBIA	11	3.64 %
	9	UNIVERSITY OF CALIFORNIA (SAN FRAN.)	10	3.31 %
	10	UNIVERSITY OF OXFORD	10	3.31 %

with productivity of the most recent 5-year period (2018–22) outweighing all output prior (Figs. 2 and 3). Average citation per article was 30.14, with 11.25 % (n = 34) of articles demonstrating a ≤ 1 citation rate. Top articles by impact are listed in the supplementary information (Fig. A2).

3.2. Journal distribution

130 academic journals were identified in the analysis (Table 1). Top 5 journals, ranked according to productivity were: Journal of Medical Internet Research (21 papers = 6.95 %; IF 2021 = 7.08), Patient Education and Counselling (14 papers = 4.64 %; IF 2021 = 3.467); Journal of Cancer Education (11 papers = 3.64 %; IF 2021 = 1.771); Supportive Care in Cancer (11 papers = 3.64 %; IF 2021 = 3.359); and, Journal of Urology (10 papers = 3.31 %; IF 2021 = 7.64). 80 % (n = 104) of all journals in the analysis published ≤ 2 papers.

3.3. Countries and institutions

Articles were published by authors from 32 countries. The United States of America (USA; 145 articles = 48.02 %) was most represented, followed by England (43 articles = 14.24 %; Table 1). 574 institutions were represented in the research output. The institutions with most publications were University of California (System; 23 articles = 7.62 %), and Harvard University (20 articles = 6.62 %; Table 1). Visual analysis demonstrated centralised collaboration between relevant nations (Fig. 3), with institutes of the top 7 countries forming primary collaboration clusters across the institutional network.

3.4. Authors, references and keywords

1573 authors contributed to the field. Teams ranged in size from 1 to 25, with a median of 5. The overall network is displayed in Fig. 4, with key co-authorship clusters demonstrating high output collaborative stakeholders. Loeb (9 publications) was found to have the highest rank based on productivity (Table 2). Analysis of co-citations (Table 2) and keyword co-occurrence with VosViewer allowed subnetwork visualisation of highly cited authors and articles. Among authors, Eysenbach (73 co-citations) and Chambers SK (58) were ranked highest. Keyword mapping identified 6 clusters, assigned titles: ‘social media and cancer’, ‘eHealth survivorship’, ‘prostate cancer decision making’, ‘quality of life’, ‘mhealth’ and ‘online communication’ (Fig. 5). Temporal overlay

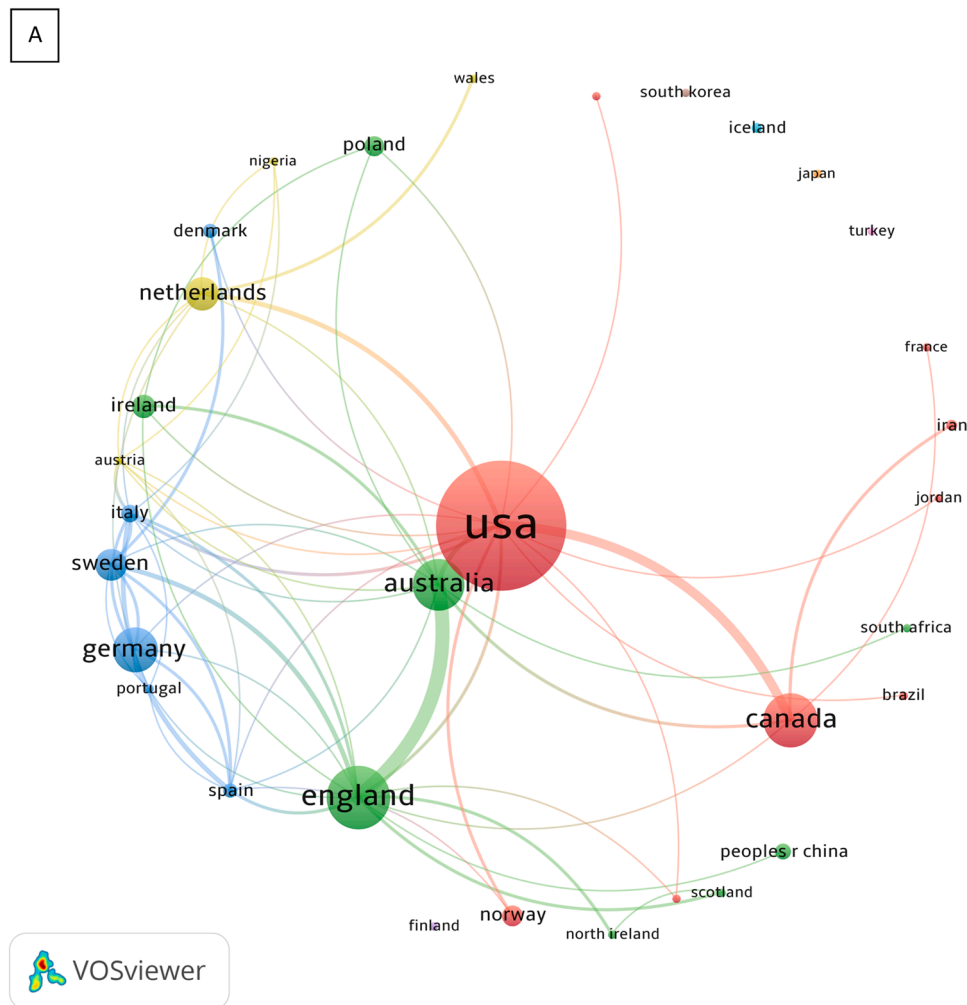


Fig. 4. Distribution of national (A) and institutional (B) co-authorship clusters.

demonstrates development of the field with early literature progressing from a focus of information quality and experience to impact of internet-based information and technology on survivorship and patient quality of life.

3.5. Citation burst detection

Top 10 keywords, authors and cited articles within the 2012–2023 time slice were ranked by strength of burst (Table 3). Keywords which demonstrated strong citation bursts included: ‘patient education’, ‘quality’, ‘cancer survivorship’, ‘shared decision making’ and ‘consumer health information’.

3.6. Online information sources and technology

The most common website addressed by empiric articles of the field were basic information sites (26.61 %; Fig. A3; characteristics and results of included articles in Fig. A4). If available, the most common sub-categorisation of these were private and public/government healthcare provider websites, and not-for-profit/charity. Articles addressing social media-based websites (26.23 %) are similar in number to those investigating basic information websites. However, when able to sub-categorize social media-based sites, they were largely comprised of online cancer support groups and forums, appearing in 33 and 17 articles respectively. Articles investigating named ‘social media networks’ are low (9.13 %). Restricted web portals requiring log in access for health

information or interventions were common (28.5 %), as were articles evaluating search engine results (14.4 %). eHealth information sources or technology was often investigated in general as ‘the internet’, with computers, email, and mHealth technologies (where indicated) as primary technological engagement platforms. Articles addressing fitness trackers, tablet-based technology, video-based telehealth technologies, virtual/augmented reality, video game platforms, audio-based streaming, eReaders, and smart watches, are few.

Articles ($n = 143$) where use is specifically reported/demonstrated by men with prostate cancer (Fig. A3) are lower in volume. The most referred source or technology is ‘the internet’ (92.31 %), rather than specific website types or access platforms. Non-social media information sites use is documented in 17.48 % of articles, while social media use is represented in 18.2 %. This social media use is almost entirely limited to online cancer support groups/forums, with few articles documenting use of named social networks (2.10 %). A sizable portion of this article cohort includes an intervention component (64.34 %), with web-portals again restricting access to specific users. In example, while several articles explored use of online decision aids (6.29 %), the ability to access these (for free and without geographic restriction), was limited to two. More precise reporting of specific online information sources used by men with prostate cancer is significantly lacking. Technology use demonstrated in literature is again largely restricted to computer, email, and mHealth platforms, with multiple communication technology platforms or capabilities with little or no apparent knowledge base.

Table 2
Top 20 authors, co-cited authors, and co-cited references.

Rank	Author	Count	Co-Cited Author	Count	Co-Cited Reference	Count
1	Loeb S	9	Eysenbach G	73	Pautler, et al. (2001). Use of the internet for self-education by patients with prostate cancer. <i>Urology</i> , 57(2), 230–233.	18
2	Huber J	8	Chambers SK	58	Hellawell, et al. (2000). Urology and the Internet: an evaluation of Internet use by urology patients and of information available on urological topics. <i>Bju International</i> , 86(3), 191–194	16
3	Van De Poll-franse LV	7	Davison BJ	46	Eysenbach, G. (2003). The impact of the Internet on cancer outcomes. <i>CA Cancer J Clin</i> , 53(6), 356–371.	15
4	Borgmann H	6	Berry DL	38	Wei, et al. (2000). Development and validation of the expanded prostate cancer index composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. <i>Urology</i> , 56(6), 899–905.	14
5	Ihrig A	6	Feldman-Stewart D	38	Huber, et al. (2011). Decision-making in localized prostate cancer: lessons learned from an online support group. <i>Bju International</i> , 107(10), 1570–1575.	13
6	Lawrentschuk N	6	Fox S	33	Klemm, P. (1999). Cyber Solace. <i>CIN: Computers, Informatics, Nursing</i> , 17(2), 65.	13
7	Cuypers M	5	Huber J	32	Ziebland, et al. (2004). How the internet affects patients' experience of cancer: a qualitative study. <i>Bmj-British Medical Journal</i> , 328(7439), 564–+.	13
8	De Vries M	5	Seale C	32	Black, P. C., & Penson, D. F. (2006). Prostate cancer on the Internet - Information or misinformation? <i>Journal of Urology</i> , 175(5), 1836–1842.	12
9	Forbes CC	5	Gustafson DH	31	Charnock, et al. (1999). DISCERN: an instrument for judging the quality of written consumer health information on treatment choices. <i>Journal of Epidemiology and Community Health</i> , 53(2), 105.	12
10	Gray SW	5	Elwyn G	31	Schover, et al. (2012). A randomized trial of internet-based versus traditional sexual counseling for couples after localized prostate cancer treatment. <i>Cancer</i> , 118(2), 500–509.	12
11	Lamers RED	5	Loeb S	26	Smith, et al. (2003). Internet use by patients with prostate cancer undergoing radiotherapy. <i>Urology</i> , 62(2), 273–277.	12
12	Seale C	5	Volk RJ	25	Eysenbach, G., & Köhler, C. (2002). How do consumers search for and appraise health information on the world wide web? Qualitative study using focus groups, usability tests, and in-depth interviews. <i>BMJ (Clinical research ed.)</i> , 324(7337), 573.	11
13	Short CE	5	Klemm P	25	O'Connor, A. M. (1995). Validation of a decisional conflict scale. <i>Medical Decision Making</i> , 15(1), 25–30.	11
14	Sundberg K	5	O'Connor AM	25	Volk, et al. (2007). Trials of decision aids for prostate cancer screening: a systematic review. <i>Am J Prev Med</i> , 33(5), 428–434.	11
15	Bolton D	4	Stacey D	25	Andriole, et al. (2009). Mortality Results from a Randomized Prostate-Cancer Screening Trial. <i>New England Journal of Medicine</i> , 360(13), 1310–1319.	10
16	Byrne N	4	Winters-Stone KM	24	Berland, et al. (2001). Health Information on the Internet: Accessibility, Quality, and Readability in English and Spanish. <i>JAMA</i> , 285(20), 2612–2621.	10
17	Chen RC	4	Frosch DL	23	Rutten, et al. (2005). Information needs and sources of information among cancer patients: a systematic review of research (1980–2003). <i>Patient Education & Counseling</i> , 57(3), 250–261.	10
18	Chambers SK	4	Ziebland S	23	Chen, X., & Siu, L. L. (2001). Impact of the media and the internet on oncology: survey of cancer patients and oncologists in Canada. <i>J Clin Oncol</i> , 19(23), 4291–4297.	10
19	Dale J	4	Lambert SD	22	Eysenbach, et al. (2002). Empirical studies assessing the quality of health information for consumers on the world wide web: a systematic review. <i>JAMA</i> , 287(20), 2691–2700.	10
20	Diefenbach MA	4	Ruland CM	22	Loeb, et al. (2019). Dissemination of Misinformative and Biased Information about Prostate Cancer on YouTube. <i>European Urology</i> , 75(4), 564–567.	10

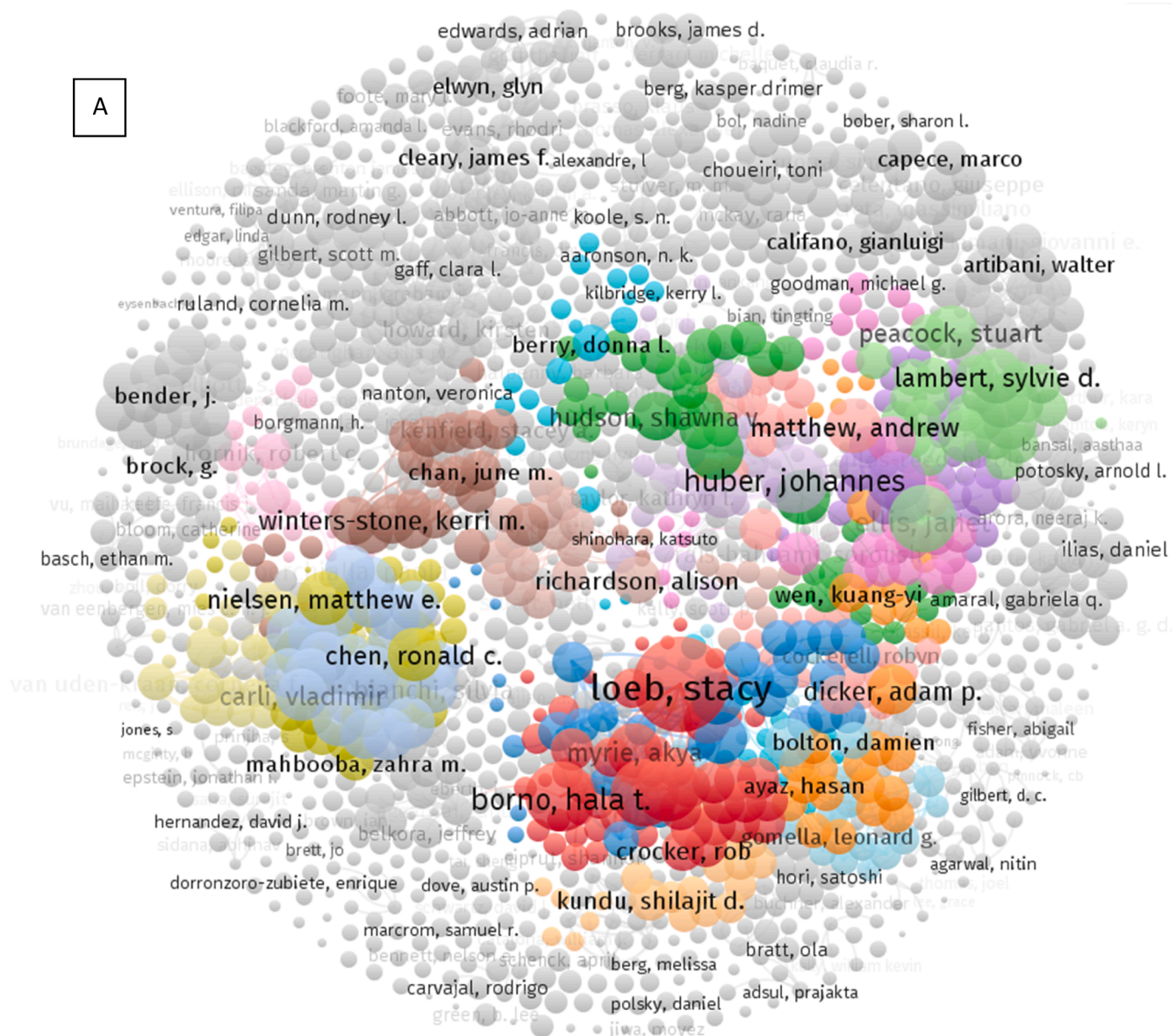


Fig. 5. Field distribution of all authors (A), and key author co-authorship clusters (B).

of included variables within the corpus of this literature. A narrowed examination was undertaken to increase the likelihood of broad findings, however the level of variability between articles regarding prostate cancer patients solely was still large enough to hinder this process.

4. Discussion and conclusion

4.1. Discussion

Considering more than 2 decades of online technological development in this area, it was necessary that a bibliometric review be completed to outline the state of available research. This study was concerned with illustrating the structure and conduct of the field, using top-down methodology to determine whether there were any gaps in the research. Of particular importance was identifying which online information sources and technologies are being investigated in the literature, and which of these are documented as being used by men with prostate cancer. It is critical to understand these characteristics as technological innovation takes us into a new era of patient communication and

education. We are no longer simply in the era of ‘the internet’ as singular, but rather, an era of decentralized, complementary, and diverse digital communication solutions.

4.1.1. General

Research productivity in the discipline is lower than other urological fields [15–17]. We suggest that this is due to: 1) aforementioned barriers to technology research and implementation 2) early narrow focus on ‘the internet’ and content quality; and, 3) the field’s modern survivorship focus – as an area of study which is unfortunately characterized by a lack of evidence, measurement variability, and opinion [27]. Prostate cancer survivorship research is known to be historically low in volume compared to other cancer groups, e.g. breast [28].

Nevertheless, this review does demonstrate growth and diversification of the field in recent years. A hypothesis is that recent advances and diffusion of Web 2.0 capable and accessible internet-based technologies (e.g. social media, smart phones, mobile applications) is driving interest. Our analysis supports this, though it cannot be ignored that the overall evidence base for many information sources and technologies is lacking.

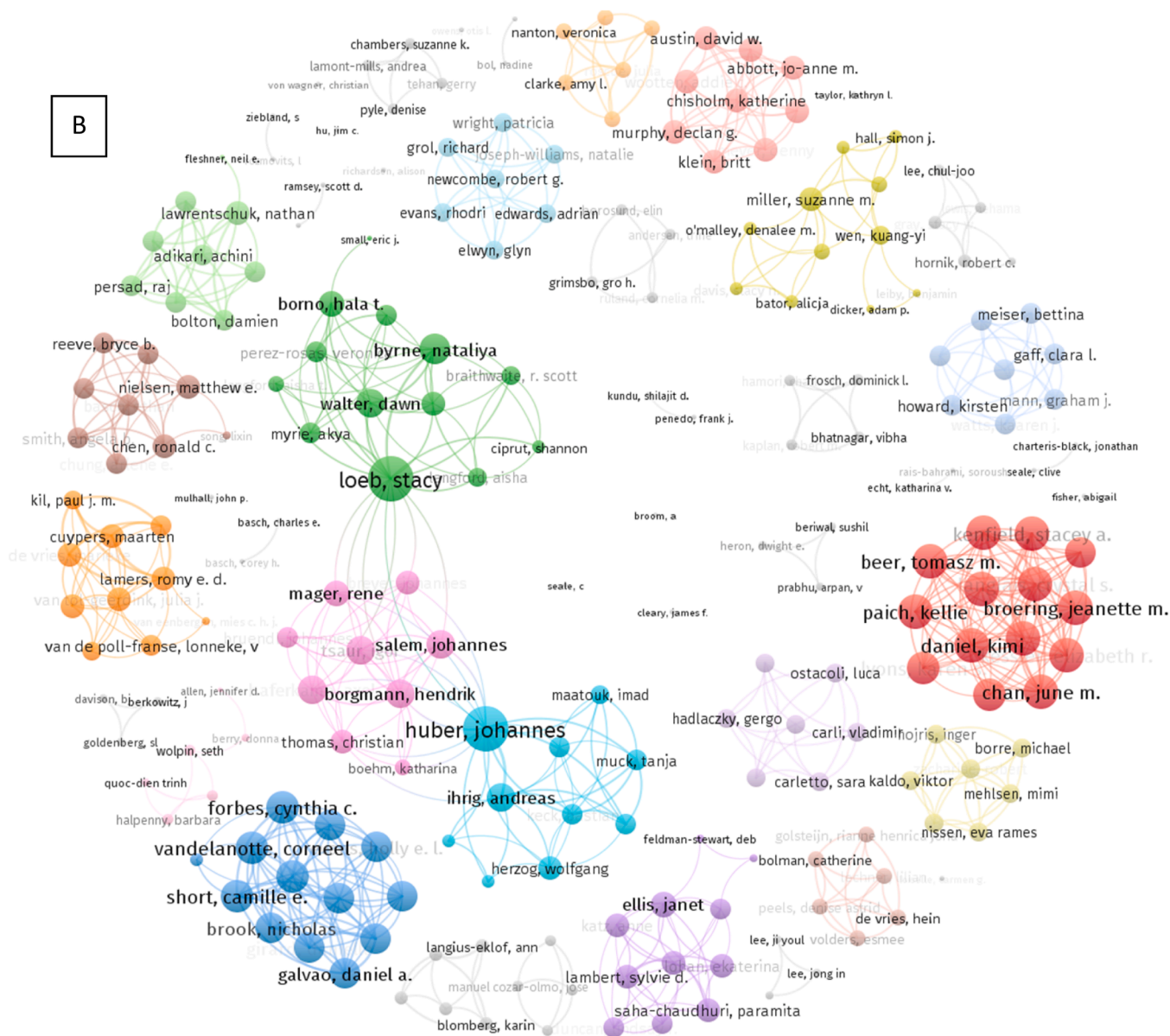


Fig. 5. (continued).

Perhaps unsurprisingly, this appears to have a temporal relationship, with evidence for some ‘newer’ consumer technologies and (web 2.0/3.0) information sources yet to be sufficiently investigated. Surprisingly, there do not appear to be modern studies which seek to comprehensively canvas or compare which online resources and technologies are being utilized by prostate cancer patients, nor investigate the potential for their varying effects.

Global investigation is evident, though most publications are driven by authors of 7 nations. This is a low representation of research diffusion, and a highly centralized example of global research output [15–17]. Clinicians should thus be aware that applicability of available research findings is currently limited to regions and populations which share similar technological diffusion rates and/or sociocultural healthcare practices or systems. There is opportunity to characterize utility and impacts on men with prostate cancer globally, though particularly in Asia, Africa, and South America. This is critical considering the vast differences in socioeconomic, health care, and digital health utilization which exist around the world.

Publication disciplines should be noted for the field (e.g. urology, oncology, medical informatics, psychology, and computer science). This

breadth is not the norm in technology based scientometric analyses, where new or emerging technologies often have highly specific application/s [16]. The broad range may certainly be a result of the scope of our analysis, though we suggest it reveals major field characteristics which researchers and clinicians should be aware: the ubiquity internet-based technology and information sources have established within modern healthcare social models; the necessary convergence of interest from health and information technology stakeholders in applying digital health technologies to patient care; the necessity of interdisciplinary collaboration as a result of discipline specific expertise and networks; and, the broad applications these technologies can hold for clinicians and patients throughout the prostate cancer care continuum.

4.1.2. Trends and future research agenda

Considering field limitations, the following section briefly highlights 4 major frontiers of research for clinicians, with research priorities summarized in [Textbox 1](#).

4.1.2.1. Information quality and diversity. The quality of information

Table 3
Top 10 Keyword, author and citation bursts 2010–2021.

		Strength	Begin	End	2010–2020
Keywords	PATIENT EDUCATION	2.98	2012	2015	
	QUALITY	2.88	2013	2014	
	CANCER SURVIVORSHIP	2.71	2020	2021	
	EXERCISE	2.71	2020	2021	
	SURVIVORS	2.66	2019	2023	
	SUPPORT	2.56	2015	2019	
	PHYSICAL ACTIVITY	2.42	2019	2021	
	ANDROGEN DEPRIVATION THERAPY	2.21	2020	2021	
	SHARED DECISION MAKING	2.17	2019	2020	
	CONSUMER HEALTH INFORMATION	2.1	2012	2017	
Authors	HUBER J	2.03	2017	2018	
	BORGMANN H	1.79	2016	2018	
	MYRIE AKYA	1.78	2022	2023	
	LAWRETSCHUK N	1.77	2018	2018	
	BOLTON D	1.66	2018	2018	
	SHORT CE	1.59	2021	2021	
	CHAMBERS SK	1.59	2021	2021	
	KICHENADASSE G	1.59	2021	2021	
	BROOK N	1.59	2021	2021	
	GALVAO DA	1.59	2021	2021	
References	Wei, J. T., Dunn, R. L., Litwin, M. S., Sandler, H. M., & Sanda, M. G. (2000). Development and validation of the expanded prostate cancer index composite (EPIC) for comprehensive assessment of health-related quality of life in men with prostate cancer. <i>Urology</i> , 56(6), 899–905.	4.11	2021	2023	
	Stacey, D., Légaré, F., Lewis, K., Barry, M. J., Bennett, C. L., Eden, K. B., Holmes-Rovner, M., Llewellyn-Thomas, H., Lyddiatt, A., Thomson, R., & et al. (2017). Decision aids for people facing health treatment or screening decisions. <i>Cochrane Database of Systematic Reviews</i> (4).	3.09	2018	2019	
	Trinh, L., Arbour-Nicitopoulos, K. P., Sabiston, C. M., Berry, S. R., Loblaw, A., Alibhai, S. M. H., Jones, J. M., & Faulkner, G. E. (2018). RiseTx: testing the feasibility of a web application for reducing sedentary behavior among prostate cancer survivors receiving androgen deprivation therapy. <i>International Journal of Behavioral Nutrition and Physical Activity</i> , 15(1), 49.	2.95	2020	2021	
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Textbox 1

Research priorities.

1. Sociocultural specific investigation of digital information and eHealth engagement practices of patients and familial stakeholders across the cancer care continuum.
2. Development of predictive models to explain the influence of e-health literacy for patients and their familial stakeholders on patient behaviours and outcomes.
3. Co-design of cost effective and contemporary e-health education and decision support solutions for men with prostate cancer that are personalized and connected to men's health outcome goals/needs, illness stage, and sociocultural specific patterns of engagement.
4. Co-design of scalable and effective men-centred survivorship e-health interventions that respond to needs of men across the illness continuum with a particular focus on men with advanced or metastatic disease who are at risk of poorer survivorship outcomes.
5. Development of artificial intelligence and machine learning models which provide institutional and/or consumer feedback on digital information resource quality and reliability.

provided on (Web 1.0 + limited Web 2.0) information sites is criticized across most prostate cancer-based research studies [29–31]. This should raise concern for clinicians who do not regularly direct their patients to appropriate online education resources. Concern for prostate cancer information quality will no doubt remain an ongoing theme in both research and clinical care due to technological progression. This is evident in recent analyses of several subcategorized website types – these are expanding in recognition of the personalized and socially diverse internet user experience [32–35]. Greater consideration of technology platforms is still required, e.g. m-health, Web 2.0–3.0 technologies, or artificial intelligence/natural language processing models such as ChatGPT [32]. Clinicians are also in desperate need of up to date and discrete measurements of technology and information use by prostate cancer sub-populations to help guide this process. Greater understanding of the willingness of patients to use new or previously unused eHealth communication technologies is also crucial to this process.

As is evident in the recent public release of ChatGPT, emerging interest in artificial intelligence and machine learning algorithms specifically presents an opportunity for interdisciplinary collaboration to identify, collect and analyse the swathes of ‘big data’ which is currently available in the public domain [36,37]. This has the potential to encourage much-needed self-regulation of information outputs by online health information stakeholders through provision of ‘single-click’ quality and reliability scores, or elevation/punishment in search results. This may also allow development of a much needed, simplified form of feedback for consumers using online information sources as part of their self-education – something which is currently lacking for patients who search for information online. Clinicians must reflect on our future with this technology prior to publishing online information and educational content for their patients.

Practitioners should currently direct their patients to appropriate online clinical resources which have been vetted for their quality. If patients are to ‘Google’ for information, they should be advised to remain on the first page of results for information which is suggested to be more reliable [38]. Advising patients to restrict themselves to resources supplied by government departments and well-known health-care not-for-profit/charity organizations is likely to result in more reliable and balanced information if they do choose to search online [31]. If deciding to implement new eHealth communication strategies in local prostate cancer patient care, we strongly advise clinicians first canvas their patients locally for information sources and technologies which they are using and/or willing to use.

4.1.2.2. Digital health (eHealth) literacy. Despite perpetual concerns about online information quality and complexity, there are few studies within the field which examine the effects of patient literacy. This is despite low literacy having been directly and indirectly associated with poorer prostate cancer outcomes [39]. Current studies which consider the digital portion of this construct are limited to rudimentary measures of digital technology use, and thus there is a limited understanding of eHealth literacy’s multidimensional effects on prostate cancer care [40]. No studies appear to have explored how eHealth literacy may affect clinical outcomes of treatment or disease progression for prostate cancer patients. In spite of this, it is clear that online information is still being utilized by prostate cancer patients for self-education, emotional support and treatment decisions [41–43].

Investigations of eHealth literacy across the prostate cancer care continuum are necessary to clearly understand the impacts of high vs low eHealth literacy, and to tailor future digital patient education and treatment interventions to individual needs. Future research must also consider the impact of eHealth literacy for patients’ familial or care stakeholders, who have historically influenced decisions and quality of life post treatment [44–46].

Clinicians must be aware that most prostate cancer information online is currently presented at written language literacy levels much

higher than those recommended in traditional medical education materials [47]. Additional issues with technology navigation, virality, information accuracy, bias and commercial interests also exist [33,47]. Not all patients will have the skills to access, understand, integrate, and utilize online health information or technology interventions [48]. As a result of this, practitioners should currently tailor online information and education materials to individual patient abilities, and (if able) provide a variety of media options to suit their needs [7].

4.1.2.3. Decision making. The effects which online information sources can have on decision-making and patient-practitioner interaction are yet to be clearly defined. Online resources have been credited with contributions to the current trend to shared and informed decision-making [32,34,49]. It is known that many men with prostate cancer do share this desire to be involved as a primary decision maker in their care [48–50]. Specific information sought on the internet by men to assist this decision-making process has been demonstrated regularly – including treatments options, side effects, and prognosis [50,51]. However, recent evidence suggests that men with prostate cancer who rely on online information as their most influential information source for treatment decisions have significantly higher rates of treatment regret and negative treatment perception [52]. Current evidence also demonstrates incongruity of men’s desired treatment decision making role, and the decision process experienced with their clinicians [50,53]. It is suspected that a combination of diagnosis related distress and information overload may contribute to this pattern [54,55].

To address these complexities, decision aids have arisen as tools which are designed to summarize current best evidence for patients and support shared decision making with clinicians [56]. Unfortunately, this review demonstrated that there is currently a dearth of data regarding online decisions aids outside of primary treatment purposes, with studies largely limited to PSA testing [56]. Whilst online patient decision aids have demonstrated generally positive but mixed results, further investigation is required to improve efficacy and acceptance by patients in routine clinical practice [57]. Despite the suggested accessibility benefit of online information formats, access to online decision aids with an evidence base within the literature is also clearly limited.

These findings support our previous assertions that clinicians should recommend only vetted online information sources at this current time. Clinicians are encouraged to enquire with patients how they would like to come to treatment decisions as part of their care, and to use valid decision aids available in other media if suitable online resources are unavailable in their region.

4.1.2.4. Survivorship and advanced disease. Most men with prostate cancer survive for extended periods post treatment. The ‘survivorship’ period may extend for months or years after intervention – often with physical, emotional, economic and social impact [27]. Current survivorship literature surrounding online information demonstrates intervention initiatives in effort to address both physical (e.g. incontinence, sexual dysfunction, lethargy) and mental health-oriented survivorship outcomes – though with mixed results [58,59]. Online information sources are most often provided as post-treatment education, interactive encouragement (such as physical activity reminders/tracking), or psychological support (e.g. CBT, and couples/sexual therapy) [43,58]. While positive results exist, the area of study is hindered by lack of public availability for many of these interventions. A lack of investigation and understanding of how online information sources and technologies may be utilized by patients and stakeholders as part of personal agency and care during this period also exists. The lack of investigation regarding impacts for men with advanced or metastatic disease is stark, with much lower specific investigation rates of these subgroups to date.

In light of this current environment, clinicians should currently refer to local survivorship guidelines and frameworks to guide their practice, particularly those informed by patient experience [60].

4.1.3. Limitations

A limitation of this work is the use of single author for screening, data extraction and synthesizing of results. Involvement of additional author/s for these stages may result in varied bibliometric outputs and/or conclusions and would increase internal validity of findings. The review used a single WOS database search – however, previous work has demonstrated that WOS metadata and citation content accurately reflects fields due to the high number of indexed journals, and the WOS remains the dominant database used for research assessment globally [61–63]. Keyword changes for data collection may have resulted in additional data or a broader selection of research frontiers for the field. Analysis is restricted to journals in the database, with books, other article types and non-English works not considered. As is the nature of bibliometrics, there is opportunity for innumerable specific data subsets of the analysis to be further explored and compared with and within the field, though which was outside the limitations of this study. As citations are influenced by recency, both clusters and rankings may change according to differing scientometric tools if applying an alternative such as the h-index [64]. The analysis is limited by the software ability to transform and analyse data, with individuals/institutions with name changes or errors, possibly underrepresented (Fig. 6).

4.2. Conclusion

To our knowledge, this is the first bibliometric analysis to investigate internet-based eHealth information sources and communication technology which are used as part of prostate cancer patient care. Despite the importance of research in this area, the current review has identified that research concerning this use is unfortunately marked by several limitations. As a result of these limitations, broad findings are difficult to discern. Research frontiers are highlighted to assist clinicians' understanding of the limitations which exist within this data set, whilst providing recommendations for current practice and future inquiry. There is ample opportunity for researchers to take advantage of the field. Numerous eHealth technologies require investigation throughout the prostate cancer care continuum with consideration of modern online communication technologies and the eHealth literacy of patients.

4.3. Practice implications

From this review, prostate cancer care providers should be keenly aware that online information sources used by men with prostate cancer are highly variable in quality. These resources are characteristically outdated, biased, hard for patients to understand, or lacking in key information. Nevertheless, these factors likely influence the decision-making and survivorship outcomes of prostate cancer patients. Unfortunately there is an extremely limited understanding of these effects. Current best practice is to direct patients to reliable online resources which are suitable for individual patient education level and needs. Practitioners should not limit these resources to the diagnostic and primary treatment stage of a man's care, but rather the entire prostate cancer care continuum.

CRediT authorship contribution statement

Stuart Robert Jackson: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing – original draft, Writing – review and editing. **Suzanne Chambers:** Writing - Review & Editing. **Scott Leslie:** Writing - Review & Editing, Supervision. **Manish I. Patel:** Writing - Review & Editing, Supervision.

Declaration of Competing Interest

None to declare by any authors.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.pec.2023.107887](https://doi.org/10.1016/j.pec.2023.107887).

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