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Advancing healthcare through digital innovation: A bibliometric perspective on Saudi Arabia's vision 2030

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Abstract: This study aims to perform a comprehensive bibliometric analysis of digital health research in Saudi Arabia from 1996 to 2024, identifying key contributors, evolutionary trends, and emerging themes to inform future initiatives aligned with Vision 2030. We analyzed 417 digital health-related documents from the Scopus database using VOSviewer and Biblioshiny tools to examine co-authorship patterns, citation clusters, and keyword associations. This quantitative approach allowed for systematic mapping of the digital health research landscape in Saudi Arabia. The analysis revealed influential authors, robust collaborative networks, and distinct thematic clusters in telemedicine, mHealth, electronic health records, and artificial intelligence applications. Highly cited publications demonstrated research concentration in oncology, aging populations, and diagnostic screening. Saudi Arabia's expanding international collaborations, particularly with the UK and US, reflect its growing prominence in global digital health research. Saudi Arabia has made significant progress in digital health research, with increasing publication output and international collaboration networks that support its Vision 2030 healthcare objectives. The bibliometric data indicates an evolving research focus from basic infrastructure to advanced applications of AI and personalized medicine. This study provides valuable insights for policymakers, researchers, and healthcare administrators by offering a data-driven foundation for strategic planning, resource allocation, and institutional collaborations in digital health initiatives across the Kingdom.

Keywords: *Artificial intelligence, Bibliometric analysis, Digital health, Healthcare innovation, MHealth, Saudi Arabia, Telemedicine, Vision 2030.*

1. Introduction

Digital healthcare systems worldwide represent a convergence of technology and health practices aimed at optimizing patient outcomes, enhancing healthcare services' reach, and increasing health providers' operational efficiency Hassan [1]. These systems encompass a range of technologies such as electronic health records (EHRs), telehealth, mobile health (mHealth), health information technology (IT), wearable devices, and personalized medicine enabled by big data analytics and artificial intelligence (AI).

The importance of digital health within current healthcare paradigms is multifaceted. It facilitates improved patient engagement by enabling individuals to manage their health more proactively through apps and wearable technologies [2]. For healthcare providers, digital tools can streamline workflows, reduce errors, and support clinical decision-making Also, the big data analytics that support digital health systems use the power of very large, complicated datasets to make medical research and personalized medicine possible in ways that have never been seen before [3].

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Given the global push toward more connected and efficient healthcare ecosystems, digital health stands as a cornerstone for future medical innovations. The ongoing COVID-19 pandemic has further underscored the critical role of digital health technologies, such as telemedicine and remote monitoring, in providing care amidst public health crises [4].

In Saudi Arabia, the health sector is undergoing a significant transformation, underpinned by digital health initiatives to improve outcomes and efficiency E-health plans, like the Saudi Health Information Exchange, are very important to these efforts because they aim to link public and private healthcare providers all over the Kingdom to make an all-encompassing and safe electronic patient record system [5]. Moreover, the government's investment in telemedicine has expanded access to health services, particularly those in remote areas, enhancing the reach and equality of healthcare provision [6].

Saudi Arabia's ambitious Vision 2030 plan emphasizes the importance of healthcare and technology integration. One of the plan's primary goals is to transition from a public health system to one based on competition and privatization, where the quality of service is paramount [7]. Vision 2030 recognizes the role of digital health solutions in achieving this transformation, emphasizing preventive care and promoting population well-being. We anticipate that the integration of technology through digital health initiatives will drive efficiency, cut costs, and enhance the effectiveness of health services across the country [8].

The Saudi Data and Artificial Intelligence Authority (SDAIA) spearheads the country's agenda to become a global leader in AI and data-driven industries, with healthcare being a crucial component [9] as part of Vision 2030. Saudi Arabia's goal is to personalize medical treatments, predict public health risks, and optimize healthcare logistics by integrating AI and machine learning algorithms with health data. As Saudi Arabia continues to expand its digital health infrastructure, it is poised to establish a technologically advanced healthcare system that strives to be among the best globally, in line with the aspirations of Vision 2030.

Conducting a bibliometric analysis is critical in scholarly research because it allows for quantitative evaluation of the literature in a specific field, such as digital health in Saudi Arabia. The bibliometric analysis can identify the volume of research activity over time and discern patterns of publication, collaboration, and dissemination of knowledge [10]. It enables researchers to map out the landscape of scientific output, understand the impact of works or authors, and uncover potential gaps in the existing literature.

Understanding the evolutionary trends in digital health in Saudi Arabia offers multiple benefits. Such an analysis can provide insights into the progression and focus areas of digital health initiatives and research within the nation, aligning with the goals set out in Vision 2030. Additionally, it guarantees that future research builds on a robust understanding of the field's trajectory, taking into account the past advancements, challenges, and opportunities [11]. For policymakers and healthcare administrators, this knowledge is crucial in strategizing and promoting evidence-based interventions that can best harness digital technology to meet the country's health aspirations [12].

In the rapidly evolving landscape of Saudi healthcare, a bibliometric study provides a necessary, data-driven foundation to support continued innovation and development in the digital health sphere, ensuring that the Kingdom's healthcare system grows in alignment with global technological advancements while meeting local needs and expectations.

There are several goals for the proposed bibliometric analysis. The main goal is to fully understand the different areas of digital health research in Saudi Arabia. The goals are to quantify academic literature production related to digital health in Saudi Arabia and chart its growth over a defined period [13]. Then, we analyze the most frequently occurring keywords and themes in the literature, which will help us understand the focus areas within the digital health domain in Saudi Arabia [14]. As a result, we investigate collaboration within the research community by examining co-authorship networks, identifying influential institutions and authors driving digital health research in the United Kingdom [15]. Moreover, we measure the impact of the research output using citation analysis, which identifies the most influential papers and authors in the region's digital health sector [16]. We also pinpoint the

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top journals and conferences that publish Saudi digital health research, emphasizing the preferred channels for researchers in this field. By achieving these objectives, the bibliometric analysis will significantly contribute to the body of knowledge on digital health in Saudi Arabia in several ways. It will trace the historical and current trajectory of digital health research, informing policymakers and healthcare stakeholders about trends and the state of play.

Finding key themes will help researchers focus on areas that are in line with Vision 2030's strategic healthcare priorities. This will make sure that the research is relevant and leads to targeted development strategies [7]. So, insights into collaborative networks will encourage cross-institutional and international partnerships, fostering innovation through shared knowledge and expertise [17]. Lastly, understanding the influential work within the field would direct new research endeavours to build upon the most impactful and ground breaking studies rather than duplicating efforts.

The evolution of digital health in Saudi Arabia is part of a broader global trend toward integrating technology into healthcare systems. We can tailor digital health technologies to meet specific healthcare needs in Saudi Arabia by cross-referencing global and regional literature Studies have shown that using digital health tools like AI, mHealth, and telemedicine together can greatly improve healthcare outcomes by lowering medical mistakes, making patients more involved, and making it easier for them to get care [18].

In addition, the combination of AI and big data analytics in healthcare research can help Saudi Arabia improve its healthcare system by using personalized treatment plans and predictive models [19]. Bibliometric reviews of digital health research show how important it is for people from different fields to work together to drive innovation. Saudi Arabia is in a great position to lead the region in digital health advances thanks to partnerships between healthcare providers, academic institutions, and technology companies [11].

This study can help guide future research agendas and inform policy decisions. Therefore, the research objectives of this study are as follows:

R1: Which keywords were used most often in the Scopus database research on digital health in Saudi Arabia?

RQ2: Which authors are most often mentioned in the Scopus database research on digital health in Saudi Arabia?

RQ3: Which nations are most interested in seeing digital health research published in the Scopus database in Saudi Arabia?

RQ4: Which organizations are most interested in the Scopus database research on digital health in Saudi Arabia?

2. Materials and Methods

2.1. Preamble

This bibliometric analysis utilizes various tools and methods to assess and interpret data from digital health-related publications in Saudi Arabia. VOSviewer, Bibliometrics, and Biblioshiny in R represent the core technologies applied in this study. VOSviewer facilitates the construction and visualization of bibliometric networks. These networks can include journals, researchers, or individual publications, and they can be based on citations, bibliographic coupling, co-citations, or co-authorship relationships [20, 21]. VOSviewer offers a means to analyze trends and patterns, providing visual insights into the structure and dynamics of scientific fields.

Bibliometrics, with the aid of the 'bibliometrix' R package, is a comprehensive tool for performing quantitative research in scientific and bibliometrics. This tool can analyze data extracted from scientific publications to give various indicators, such as the most prolific authors or institutions, the most cited articles, and the most influential journals in a specific research domain [14, 22]. Biblioshiny, which is the web interface of the 'bibliometrix' R package, is a web-based platform to conduct bibliometric analysis without requiring advanced coding skills. It can produce extensive reports and graphs, facilitating the examination of complex bibliometric data [14, 23].

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For this study, the sources of literature and data include scientific papers, conference proceedings, and reviews obtained from comprehensive databases such as Scopus. We selected these databases for their extensive coverage of quality peer-reviewed literature in healthcare and technology. The search strategy will involve varying combinations of keywords pertinent to digital health topics and contextually relevant to Saudi Arabia's healthcare landscape. We will establish inclusion criteria to ensure the data's relevance and quality, including publication between specific years, relevance to digital health, and a clear connection to the Saudi Arabian context.

We clean and filter the resulting dataset to eliminate duplicates and irrelevant entries Bibliometric indicators, like citation analysis, co-authorship network analysis, keyword occurrence, and thematic mapping, are used to look at data. The extracted data contains a wealth of information that, once processed, will reveal Saudi Arabia's digital health arena's evolution, interconnectedness, and current focal points.

The described methodology is very helpful in reaching the study goals; it gives us a structured way to look at and understand the academic landscape of digital health research in Saudi Arabia. The numerical and visual results from VOSviewer and bibliometric/biblioshiny analyses help to paint a more complex picture of how the country's digital health research fits in with global trends and the country's overall healthcare development goals.

2.2. Bibliometric Data

A wide variety of scientific domains and fields of knowledge relate to the problem of digital health. Because of the volume, multiplicity, and ramifications of these studies included in the Scopus database, the researcher must carefully choose the keywords for the study.

The Scopus database's search for *"digital health" and TITLE-ABS-KEY to ("Digital AND health") and (Limit-To(Subjarea, "Medi") Or Limit-To(Subjarea, "Heal") Orlimit-To(Subjarea,"Bioc")Or Limit-To(Subjarea, "Nurs")and (Limit-To(Affilcountry, "Saudiarabia")and (Limit-To(Language, "English"))* returned 417 documents, which were categorized as follows: Article 277; Review 87; Conference Paper 28; Book Chapter 10; Note 6: Editorial 2; Letter 2, Retracted 1; Book 1; Erratum 1; and Short Survey 1. The following graph shows the 28 years (1996–2024):

Figure 1 illustrates that R outputs indicate a growing trend in Saudi Arabia's annual scientific production of digital health-related articles, with a notable increase in publications from 2017 to 2022. The year 2022 marks the highest output with 123 articles, showing a substantial leap compared to previous years. This increase might signify a greater focus on digital health initiatives, possibly because of the COVID-19 pandemic's effects on digital healthcare delivery and the advancement of Vision 2030's digital transformation objectives. However, 2023 saw a slight decline with 96 articles, likely due to incomplete data or a temporary plateau in research activities. The consistent increase over the years showcases a heightened interest and investment in digital health research, aligning with global trends for integrating technology into healthcare systems. It's also indicative of a maturing research field within the nation. The data suggest a positive trajectory and a solid foundation for future research and development in digital health in Saudi Arabia.

2.3. Bibliometric Analysis Methods

The study used bibliometric analysis [24] in five main ways to create networks, overlays, and densities that display the most significant authors, references, research institutions, and countries in the field of digital health for publications in the Scopus database. These were co-occurrence, citation, co-citation, co-authorship, and bibliographic coupling. We used the statistical tools VOSviewer, Bibliometrics, and BiblioShiny in R to analyze the publications.

3. Results

3.1. Keywords Analysis Results

Figure 2 (Appendix) depicts the most commonly recurring words in various digital health studies

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and investigations. Figures 2 (Appendix) and 3 present the most frequently occurring words within the analyzed digital health-related articles, providing insight into the focus of the scientific research. The prevalence of general terms such as "human," "humans," "female," "male," "adult," and "aged" indicates that the studies encompass a wide demographic range, suggesting a focus on human-based research relevant to various population groups in the context of healthcare. Terms such as "Saudi Arabia" highlight the geographical specificity of the study, confirming the country as a focal point of the research corpus. Words like "article" may indicate the type of documents under analysis or frequently appear in the paper's methodology sections.

The presence of "controlled studies and "cross-sectional studies" among the most frequent words points to the prevalent study designs used in the research This suggests a methodological approach that focuses on observational and comparative analysis within the Saudi Arabian healthcare context. The data shows how methodically sound the research was, and it's possible that future studies will build on these basic designs to make the field of digital health in the region even better.

Figure 4 (Appendix) shows topics that are popular right now and suggests that Saudi Arabian researchers should focus on a few key areas, such as oncology, older populations, and diagnostic screening. Topics such as "prostatic neoplasms," "cancer screening," and "prostate cancer" are significant, with median years highlighting a persistent research interest extending well over a decade. The spread of years also indicates that while interest in these topics began in the early 2000s, attention has continued or increased through 2020 and 2021, marking them as enduring areas of concern. The focus on "digital rectal examination" and "transrectal ultrasonography", with high frequencies and a wide range of years, demonstrates the ongoing improvement of cancer diagnostic methods. This is in line with global trends and may also be a sign of a higher awareness of these health issues in the area. As for "university hospitals," the term's recurrence could denote the role these institutions play in Saudi Arabia's research landscape, possibly correlating with academic-led studies or the development of university-affiliated medical practices.

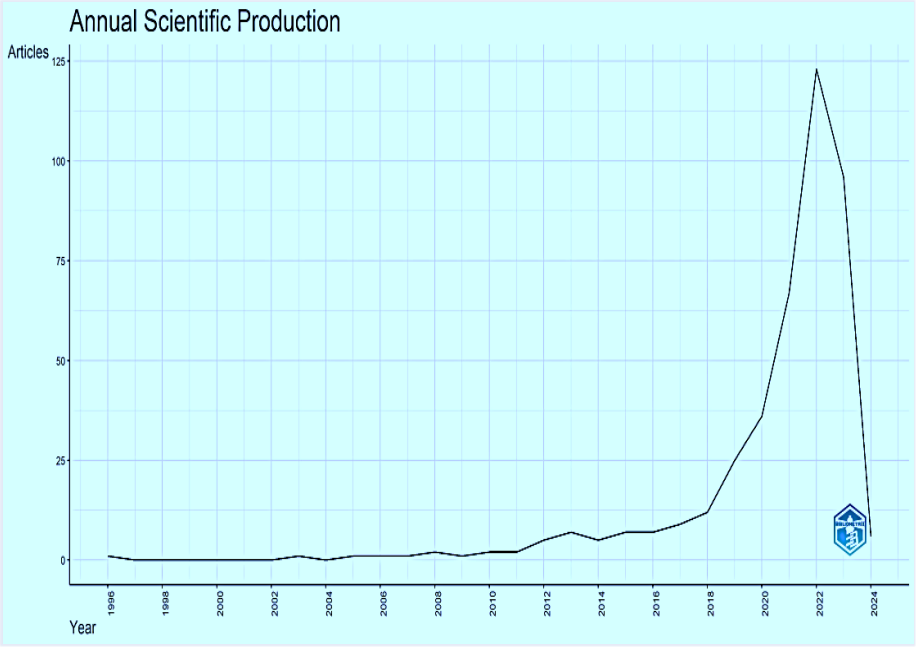

Figure 1.
Annual Scientific Production.

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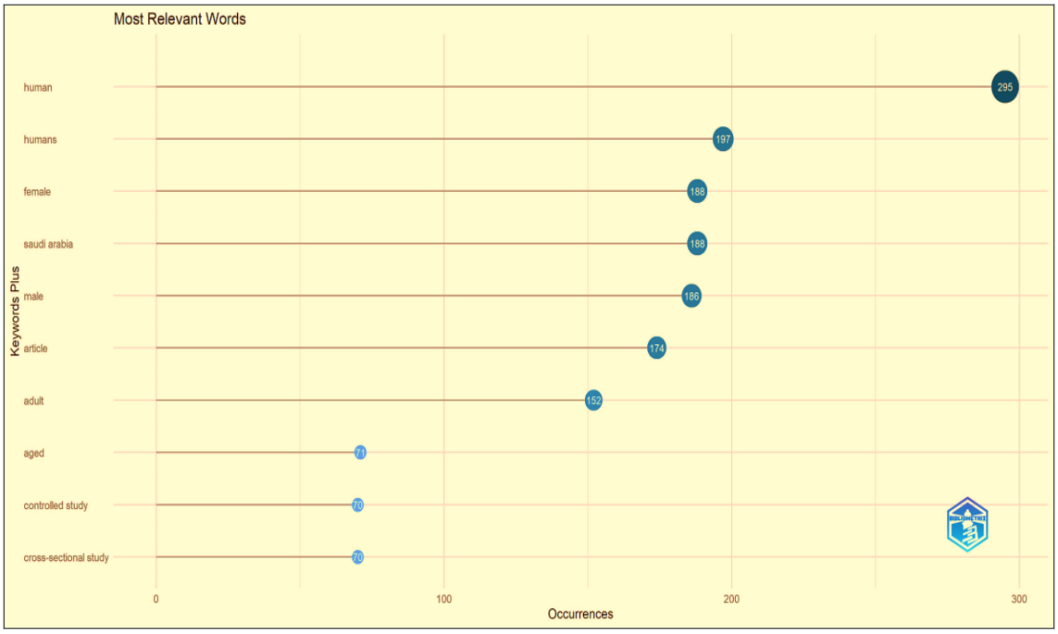

Figure 2.
Most relevant words.

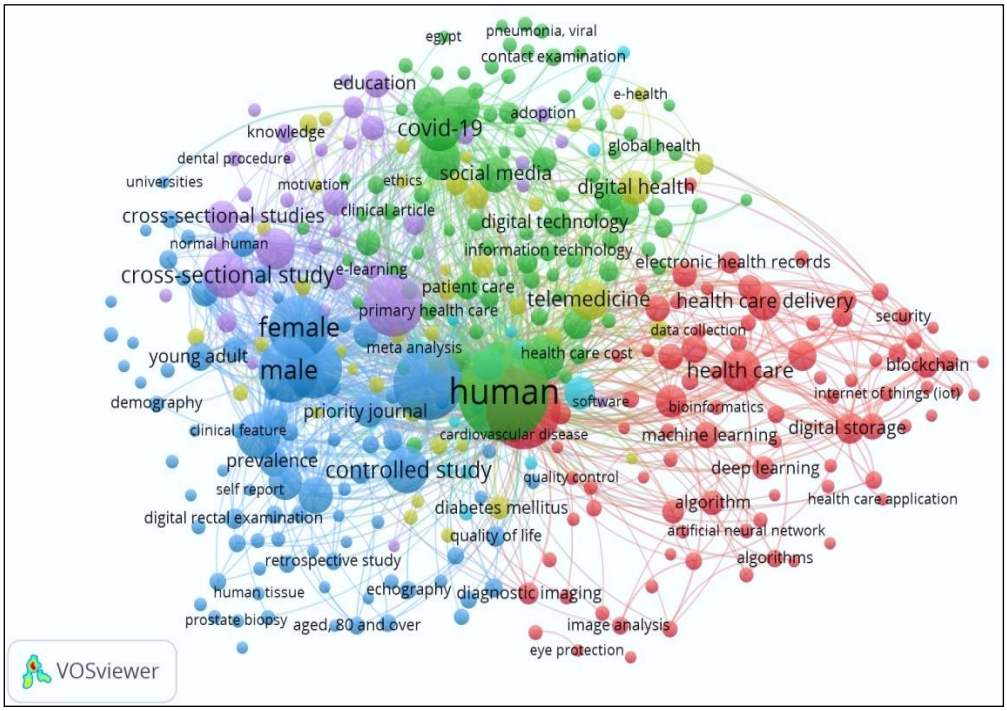

Figure 3.
Network of keywords.

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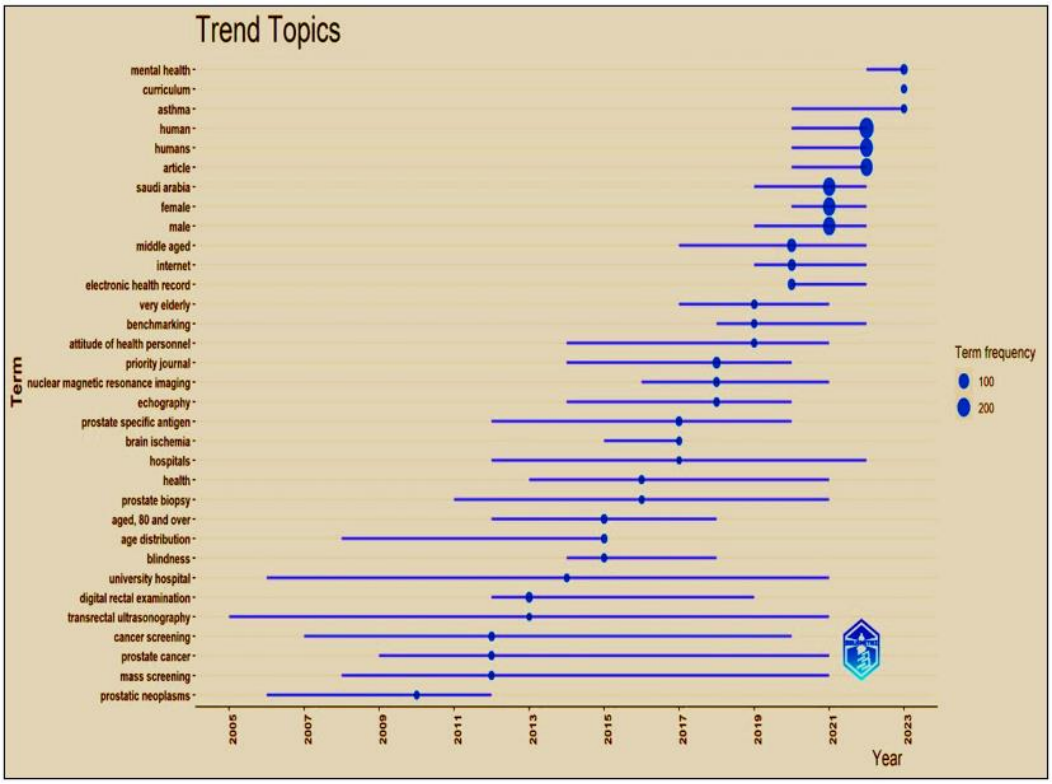

Figure 4.
Trend topic.

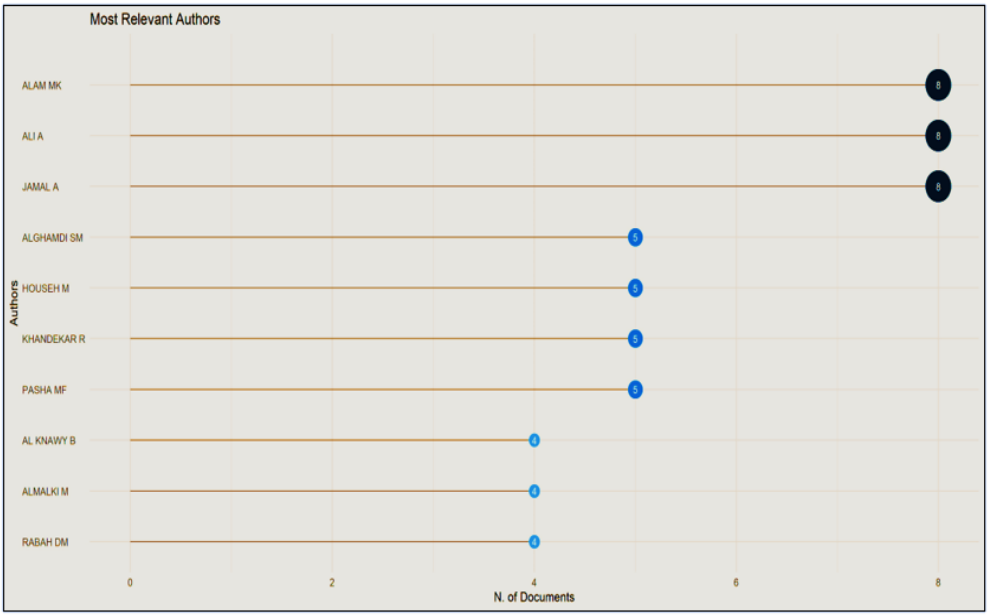

Figure 5.
Most Relevant Authors.

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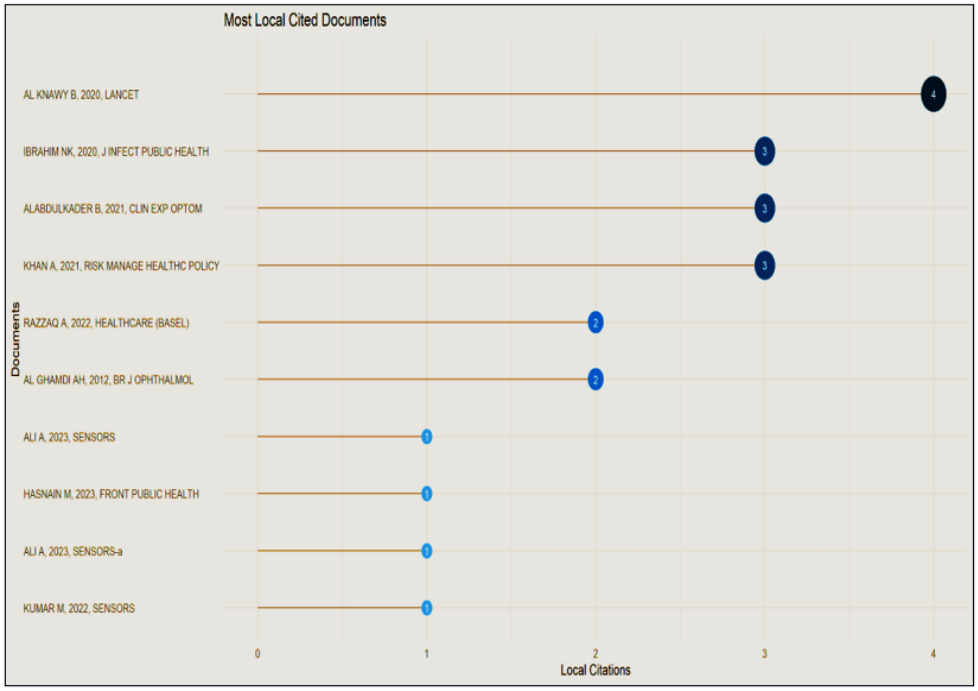

Figure 6.
Most Local Cited Authors.

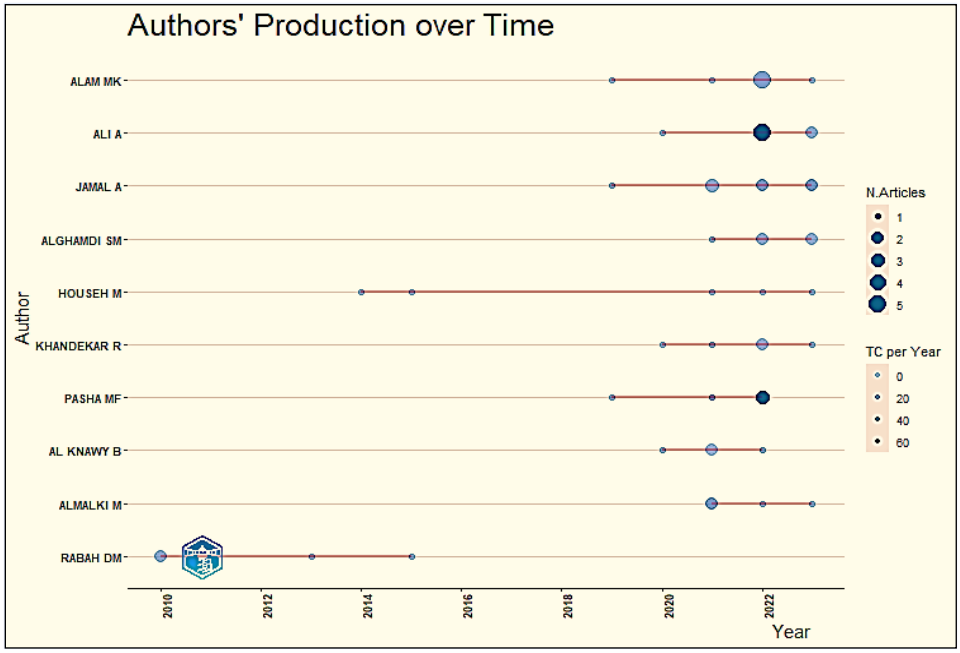

Figure 7.
Authors' Production over Time.

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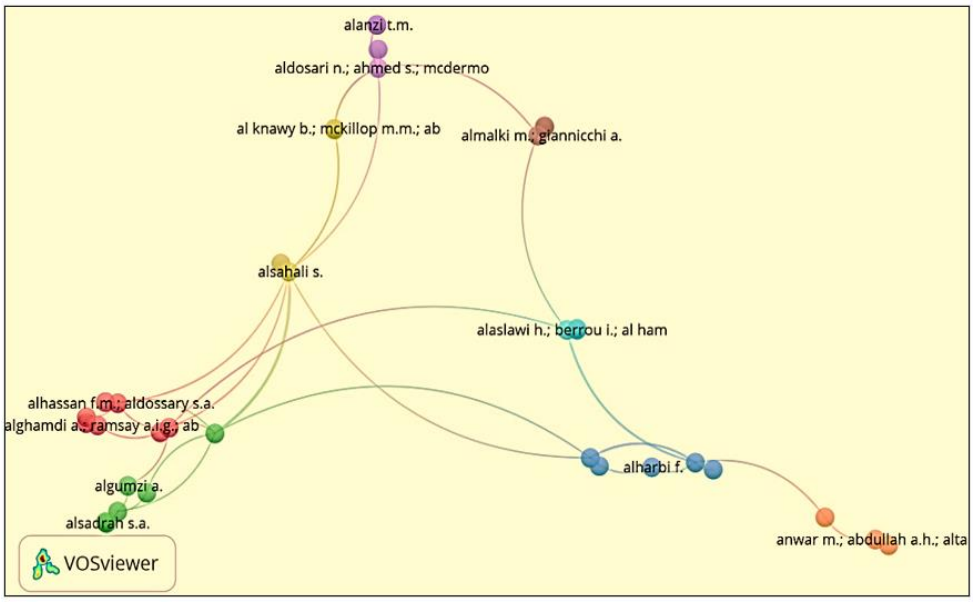

Figure 8.
Authors' Network.

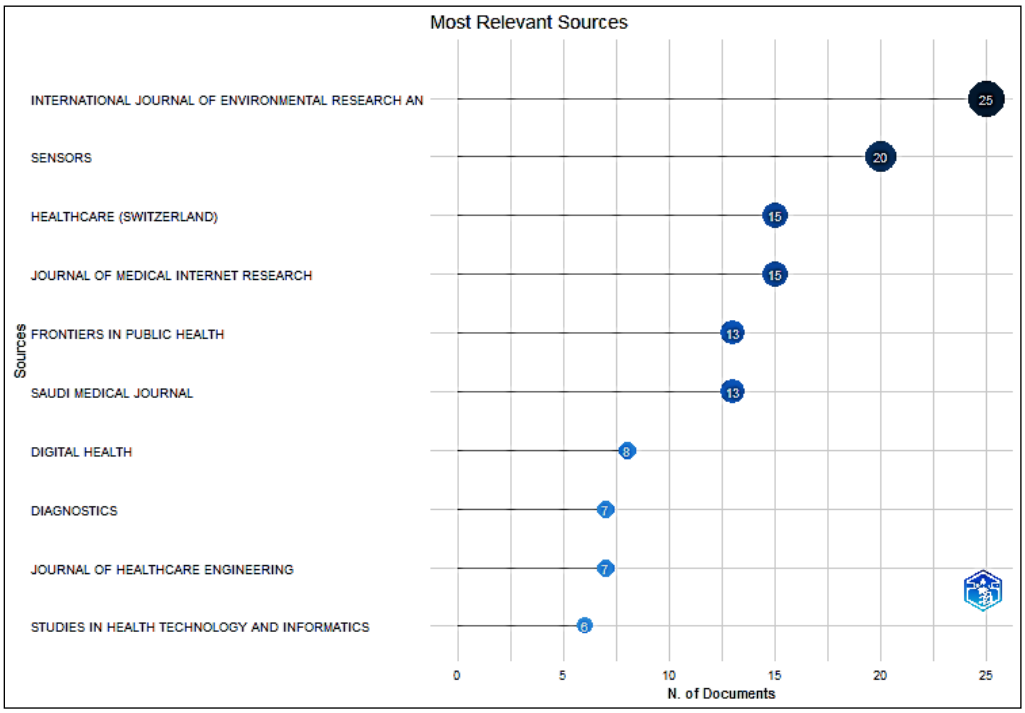

Figure 9.
Most Relevant Sources.

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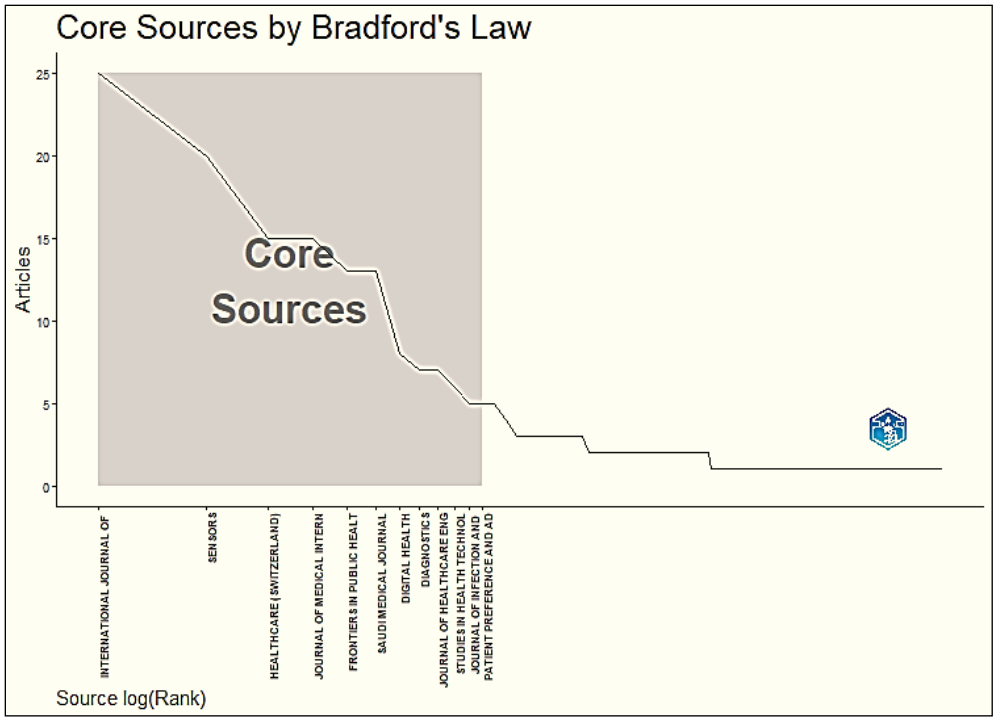

Figure 10.
Core Sources by Bradford's Law.

The high frequency of attention given to "aged 80 and over" and "age distribution" aligns with global aging demographics, as well as the growing importance of geriatric medicine and age-related disease management. "Blindness" remains a focus, with research seemingly peaking around 2015, aligning with health initiatives aimed at reducing the prevalence and impact of this condition. These topics not only represent the direct interests and concerns addressed by the scientific community in Saudi Arabia but also inform healthcare policy and priority settings. The alignment of these topics with the Kingdom's broader healthcare objectives, such as those outlined in Vision 2030, suggests that these areas may receive continued focus moving forward. The findings provide a constructive outlook on the Kingdom's commitment to tackling crucial health issues pertinent to its population, which could drive future initiatives and collaborations for healthcare improvements.

3.2. Authors' Analysis Results

Several authors have multiple publications in well-known databases, such as Scopus, and among them are those who are more influential than others in terms of publications, citations, co-citation, co-authorship, and bibliographic coupling. Figures 5 and 6 illustrate this.

Figure 5, which profiles the leading authors in Saudi Arabia's digital health research, shows [25] emerge as prolific contributors, each with eight articles to their credit. Their fractionalized article counts suggest collaborative efforts spanning multiple studies. Alghamdi, et al. [26] stands out with an elevated fractionalized count over five contributions, signifying primary or singular authorship roles. Househ, et al. [27] also mark their significance with pronounced publication numbers, tailored to their collaborative engagements. These scholars are likely pivotal figures within the digital health academic terrain of Saudi Arabia, setting potential avenues for joint endeavors in future explorations. The breadth of their work enriches the regional knowledge base, potentially guiding policy formation and healthcare service advancement.

Figure 6 (Appendix) illuminates key research-making waves within the Saudi digital health sector.

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Vol. 9, No. 3: 96-115, 2024
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With its pronounced regional citation rate, the article by Al Knawy, et al. [28] in The Lancet from 2020 captures attention, a testament to its substantial local influence. In contrast, Ibrahim, et al. [29] piece has seen extensive international recognition despite a lower local-to-global citation ratio. Fresh off the press, works by Alabdulkader, et al. [30] have swiftly garnered local academic acknowledgment, heralding the immediate relevance of their research. The high LC/GC ratio of Razzaq and Ajaz [31] publication indicates salience in local contexts. Additionally, Ali [32] outputs have already resonated locally, indicating swift integration into Saudi research circles, perhaps awaiting global traction as they mature in dissemination. The local citation metrics, illuminated by the LC/GC ratios, offer insights into the research's resonating impact at national and international levels, suggesting priorities and influential work shaping Saudi Arabia's digital health narrative.

According to Figure 7, it displays the production of different authors over some time. In Nawy, et al. [33] had a total word count (TC) of 21. In 2021, their TC decreased to 1, and in 2022, it increased to 18. In 2019, Alam, et al. [34] published one book with a TC of 1. In 2021, another book with a TC of 1 was published. Their production peaked in 2022 with a TC of 32, but in 2023, it dropped to 0. In 2021, Alghamdi and Hoehndorf [35] had a TC of 17, which decreased to 10 in 2022. Their production remained the same in 2023, with a TC of 0. These numbers provide an overview of the total word count of each author's publications in different years, reflecting their output over time.

Figure 8 Authors' Network provides information about authors, their respective documents, citations, and total link strength. Here are some observations: The authors are Al Ghamdi, et al. [36]. This group of authors has contributed to one document, zero citations, and total link strength. Ali, et al. [37]. This group of authors has one document with 10 citations and a total link strength of 4. The authors are Almaiah, et al. [38]. This group of authors has one document with zero citations and a total link strength of four. Almathami, et al. [39]. This group of authors has one document with zero citations and total link strength. The authors are Anwar, et al. [40]. This group of authors has one document with six citations and zero total link strength. The information shows the document contribution, citations, and total link strength associated with each author or group of authors.

3.3. Source and Document the Analysis Results

There are several references and sources on digital health, but the following are the most relevant ones. Figure 9 (Appendix) presents a list of the most relevant sources in terms of the number of articles published in them. The International Journal of Environmental Research and Public Health tops the list with 25 articles. Sensors follows closely behind with 20 articles, while Healthcare (Switzerland) and Journal of Medical Internet Research tie with 15 each. Frontiers in Public Health and SAUDI Medical Journal share the next spot, with 13 articles each. Digital Health, Diagnostics, Journal of Health Care Engineering, and Studies in Health Technology and Information round out the list with 8, 7, and 6 articles, respectively. These sources are considered important within their respective fields and can serve as valuable resources for researchers and professionals looking for information in those areas.

Figure 10 highlights the core sources determined by Bradford's Law, which predicts the distribution of scientific articles in various research areas. Furthermore, Bradford's Law identifies the rank, frequency (Freq), cumulative frequency (cumFreq), and associated zones for each source. All of the sources that were talked about, like the Sensors, Healthcare (Switzerland), Journal of Medical Internet Research, Frontiers in Public Health, Saudi Medical Journal, Digital Health, Diagnostics, Journal of Healthcare Engineering, Studies in Health Technology and Information, and Journal of Infection and Public Health all belong to Zone 1. This indicates that these sources represent the core literature in their respective fields and are likely to contribute to most of the articles published in those areas. Researchers can rely on these sources for comprehensive coverage and valuable insights in their research domains.

Figure 11 (Appendix) presents a list of the most globally cited documents, including their respective DOIs, total citations (TC), citations per year (TC per year), and normalized TC values. The top-ranked

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document is Khan and Mukhtar [41] accumulating a total of 376 citations. It averages 34.18 citations per year and has a normalized TC value of 3.68.

The following documents, such as Almathami, et al. [42] and Dooley, et al. [43] also received high citation counts, with TC values of 338 and 172, respectively. They have notable TC per year and normalized TC values. These highly cited documents reflect their significant impact and influence within their respective fields. Researchers often turn to these papers for reference and insight when conducting their own research.

Figure 12 provides a detailed analysis of various sources, their corresponding documents, citations, and total link strength. The "Journal of Medical Internet Research" stands out prominently with an impressive 723 citations, showcasing its substantial impact and influence in the field. Similarly, the "International Journal of Environmental Research and Public Health" and "Sensors" have significant importance, with 136 and 365 citations, respectively, indicating their influence in their respective domains. "Healthcare (Switzerland)" emerges as a reputable source with 15 documents and 173 citations, highlighting its significance in the healthcare field. "Digital Health" and the "Journal of Infection and Public Health" reveal moderate and distinctive patterns, offering valuable insights into their relevance and influence. The figure provides a consolidated view of sources, shedding light on their potential prominence, but it emphasizes the importance of considering factors like article quality and impact when evaluating source significance. The network analysis of the documents in the figure also shows interesting patterns in the number of citations and the strength of the links. This shows that we need to learn more about the context and content of these documents.

3.4. Institutions and Countries' Results

The following figure shows the network of research institutions and countries most cited on the topic of digital health. Figure 13 offers a comprehensive overview of various organizations, presenting data on the number of documents, total citations, and total link strength within each institution. The College of Medicine at King Saud University in Riyadh, Saudi Arabia, has a big impact, with 51 citations and a strong link strength of 29, which means it has a research network that is well connected. Conversely, the Department of Computer Engineering, despite citations, demonstrates a lack of interconnectivity (link strength 0), warranting further exploration. The Department of Computer Science and Software Engineering in Islamabad, Pakistan, reveals focused research with a low citation count but strong link strength (51). The findings underscore collaborative patterns and research influence, prompting a call for deeper exploration of specific research areas and collaboration dynamics within these institutions.

Moreover, Figure 13 presents a global perspective on research productivity, citations, and link strength across different countries. Notably, Saudi Arabia stands out with a substantial number of documents (414), citations (5322), and an impressive total link strength (26115), reflecting a highly interconnected research landscape. Other countries, such as Australia, Canada, India, and the United Kingdom, also demonstrate significant research output and impact. The data underscores the diverse and dynamic nature of global research efforts, with variations in citation impact and interconnectivity. Further analysis of collaboration patterns and specific research areas within each country could provide valuable insights into the global research landscape.

Figure 14 illustrates the collaborations between countries and the frequency of those collaborations. Saudi Arabia appears to have several active collaborations with different countries. The most frequent collaborations involving Saudi Arabia are with the United Kingdom (54) and the United States (46). This indicates a strong research partnership between Saudi Arabia and these two countries. There are also notable collaborations with Pakistan (39), India (38), and Egypt (33), highlighting the diverse international research collaborations of Saudi Arabia. Other countries, such as Canada (25), Australia (21), Malaysia (19), Jordan (18), and Korea (16), exhibit significant collaborations with Saudi Arabia as well.

Edelweiss Applied Science and Technology
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Collaborations between countries play a crucial role in promoting knowledge exchange, fostering global research networks, and driving scientific advancements. These collaborations allow researchers to leverage expertise and resources from different nations, leading to the development of innovative solutions and discoveries.

3.5. Wordcloud

Figure 15 highlights Saudi Arabia's wordcloud. We can see that some of the most commonly used terms include "human," "humans," "female," "Saudi Arabia," and "male." It suggests that discussions in Saudi Arabia often revolve around topics related to gender and the human population.

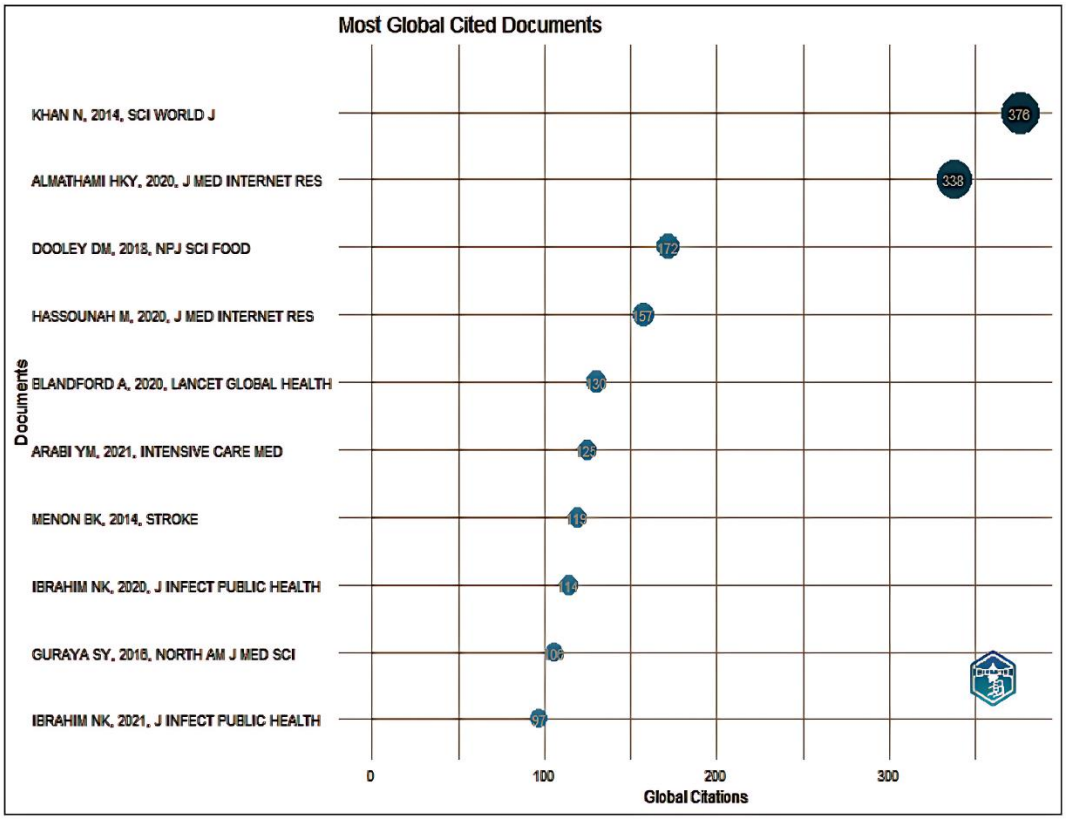

Figure 11.
Most Global Cited Documents.

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Vol. 9, No. 3: 96-115, 2024
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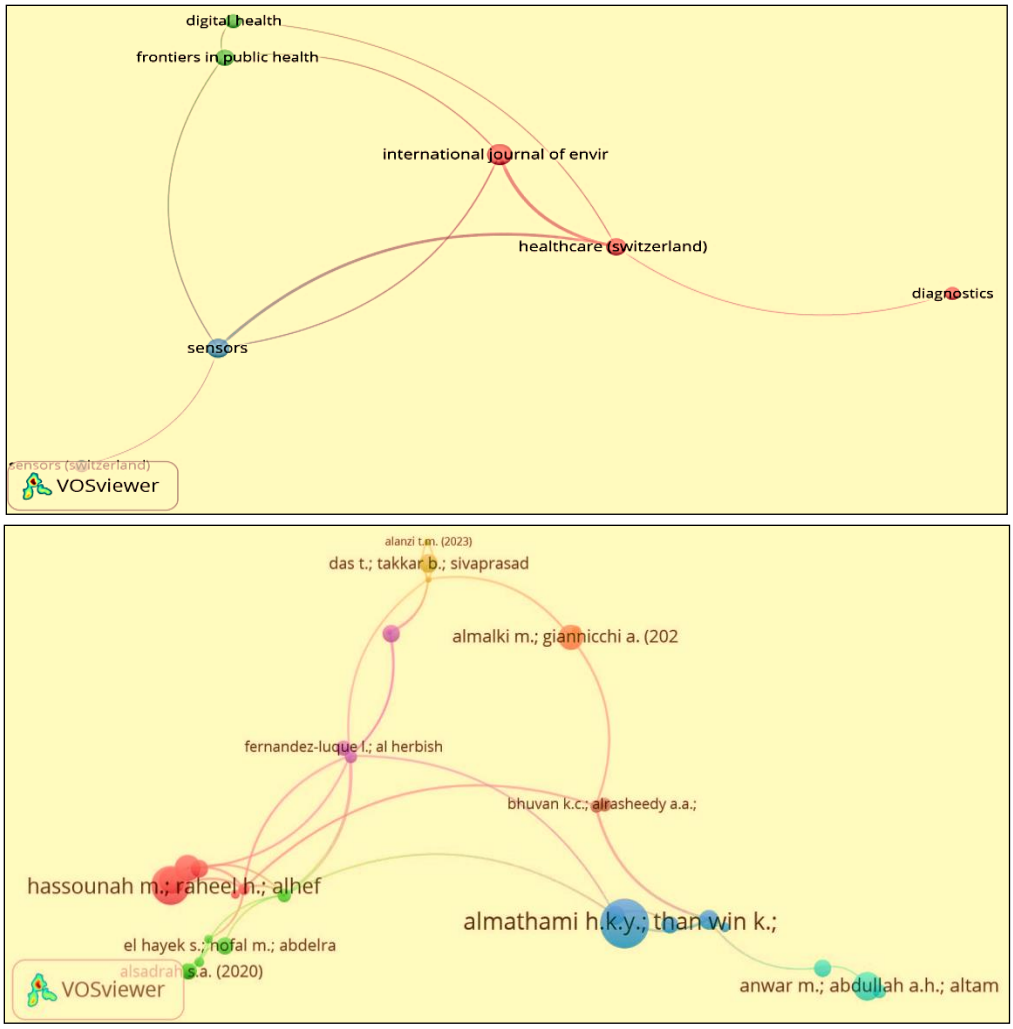

Figure 12.
Sources and documents Networks.

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ISSN: 2576-8484
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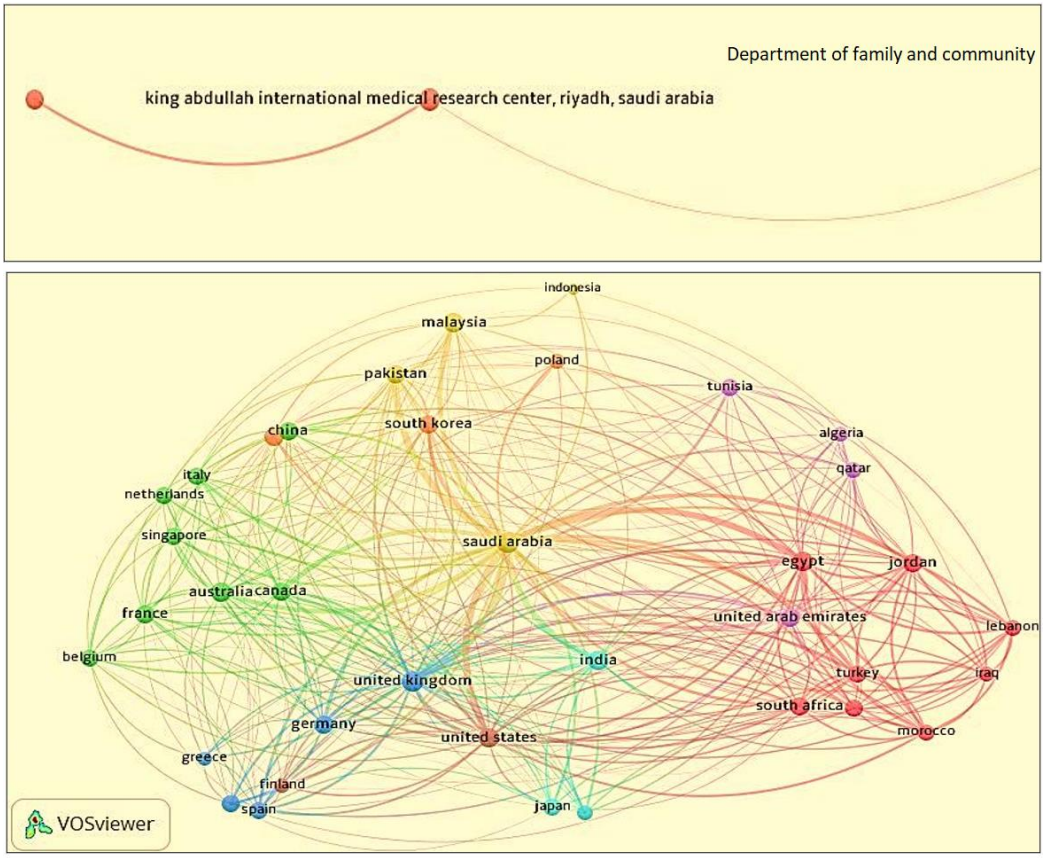

Figure 13.
Institutions and countries Networks.

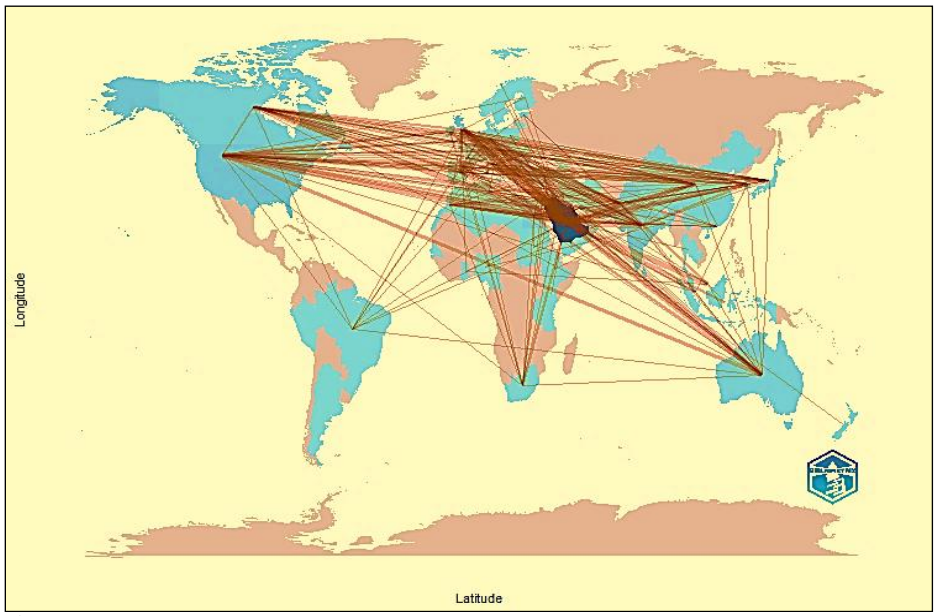

Figure 14.
Countries' Collaboration World Map.

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Figure 15.
Wordcloud.

Additionally, the word cloud highlights the terms "article," "controlled study," and "cross-sectional study," which indicate that research and scholarly articles are prevalent in discussions about Saudi Arabia. This suggests that academics and researchers in Saudi Arabia are actively conducting studies and contributing to knowledge in various fields.

The mention of "adult" and "aged" indicates that discussions often touch upon different age groups within the population, likely related to social and demographic studies. It is important to note that this word cloud reflects the frequency of terms mentioned in discussions about Saudi Arabia; it does not provide context or indicate the positive or negative sentiment associated with these terms.

4. Discussion

An in-depth bibliometric analysis uncovered evolutionary trends, revealing that Saudi Arabia is at the forefront of a transformative journey in the field of digital health [44]. This examination delves into the intricacies of digital health dynamics, unravelling the multifaceted dimensions that shape the landscape of research, collaboration, and knowledge dissemination within the Kingdom. Previous bibliometric reviews of global digital health trends have found similar results. These reviews show that digital health technologies are becoming more important in shaping modern healthcare systems [3, 45].

The keyword analysis serves as a compass, guiding us through the thematic contours of digital health studies. A striking feature is the demographic inclusivity evident in the prevalence of terms such as "human," "humans," "female," "male," "adult," and "agedis a striking feature of demographic inclusivity." This underscores a commitment to addressing health concerns across diverse population groups [11]. The geographical specificity that "Saudi Arabia" encapsulates reaffirms the Kingdom's crucial contribution to the global discussion on digital health [5]. Furthermore, the prominence of methodological terms like "controlled study" and "cross-sectional study" reflects a commitment to robust research practices, forming a solid foundation for evidence-based healthcare strategies. This is in line with global trends in digital health research that emphasize rigorous research methodologies [10, 18, 46].

Trend analysis sheds light on specific areas of research, such as the long-term interest in oncology, aging populations, and diagnostic screening [7]. The constant focus on cancer-related topics shows a strong desire to improve diagnostic methods and advance oncological research. This is in line with previous bibliometric studies that identified oncology as a global priority in healthcare research [2].

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These trends align cohesively with broader healthcare objectives, echoing the Vision 2030 initiative [9]. The emphasis on geriatric medicine and age-related disease management, mirrored by the attention given to "aged 80 and over" and "age distribution," underscores the Kingdom's proactive stance in addressing global aging demographics. This is also consistent with international trends, where aging populations are a growing focus of health research and policy [3, 6, 47].

Authors emerge as key architects in shaping Saudi Arabia's digital health narrative. Prolific contributors like Alam, et al. [48] made significant strides, fostering collaborative efforts and enriching the regional knowledge base [45]. The local citation metrics spotlight the immediate impact of research within Saudi circles, providing a nuanced understanding of the resonance and relevance of specific authors and their publications. This observation contrasts with studies in other regions where international collaboration plays a more dominant role in citation impact. Temporal analyses demonstrate the fluctuations in scholarly productivity, providing valuable insights into the dynamic nature of contributions over time [18].

In the tapestry of sources and documents, certain journals, such as the International Journal of Environmental Research and Public Health, Sensors, and the Journal of Medical Internet Research, emerge as pivotal hubs of knowledge dissemination [12]. Bradford's Law identifies core sources, acting as beacons for researchers seeking comprehensive coverage in the digital health domain [11]. The most globally cited documents, including Khan and Mukhtar [41] and Almathami, et al. [42] underscore their influential impact on the broader research community. These findings are in line with global bibliometric studies that also show how important key journals are for moving digital health research forward [4].

The institutional and country-level analyses vividly depict interconnected research landscapes. The College of Medicine at King Saud University in Riyadh emerges as a nexus of impactful research, with a substantial citation count and strong link strength [45]. Saudi Arabia stands out for its prolific research output and notable global collaborations, particularly with the United Kingdom and the United States [49]. The collaborative world map illustrates the Kingdom's expansive network, fostering knowledge exchange and scientific advancement. Previous research on global digital health networks has shown that working together with people from other countries is a great way to improve the quality and impact of research [9].

The word cloud encapsulates the essence of discussion in Saudi Arabia, highlighting recurrent terms like "human," "Saudi Arabia," "article," and "controlled study" [10]. This visual representation signifies a focus on gender-related discussions, rigorous scholarly endeavors, and a commitment to evidence-based practices. This observation is consistent with global trends in digital health research that emphasize inclusivity and rigorous research designs [11, 18].

Finally, this in-depth bibliometric analysis serves as a compass, guiding stakeholders through the dynamic landscape of digital health in Saudi Arabia [44]. The uncovered evolutionary trends underscore the Kingdom's commitment to addressing diverse health challenges, fostering collaborative research endeavors, and contributing significantly to global knowledge [45]. As Saudi Arabia continues its journey toward digital health excellence, these insights pave the way for informed decision-making, strategic investments, and transformative advancements that align with the Kingdom's healthcare vision and global benchmarks. These results are in line with global bibliometric analyses that show how strategic investments in digital health can help improve healthcare systems around the world [3, 7].

5. Conclusion and Recommendations

This bibliometric analysis demonstrates that Saudi Arabia is a rising leader in the field of digital health, contributing significantly to global research and innovation. The Kingdom's focus on oncology, aging populations, and the implementation of evidence-based research methodologies supports its vision for a technologically advanced and inclusive healthcare system. The growing body of literature, coupled with the nation's increasing collaborations with international research entities, positions Saudi Arabia as a key player in the global digital health narrative.

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However, for continued success, several recommendations are evident. First, increased collaboration with global research institutions, particularly in under-explored areas like AI in healthcare, could further enhance Saudi Arabia's research capacity and impact. Second, sustained investment in digital health infrastructure and workforce development is critical to maintaining research productivity momentum and ensuring successful integration of digital health technologies into the healthcare system. Finally, we should complement the focus on aging populations and oncology with expanded research in preventive medicine and public health to address emerging health issues related to lifestyle diseases and global pandemics.

Accordingly, Saudi Arabia can continue its journey toward becoming a global leader in digital health, aligned with the broader goals of Vision 2030. The insights gained from this bibliometric analysis provide a roadmap for informed decision-making, strategic investments, and the continued advancement of healthcare through digital innovation.

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Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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