Trends in Remote Healthcare and the Future of Telemedicine: A bibliometric Analysis

*Komalpreet Kaur[1], Bharti Kapur[2]

[1]University School of Business, Chandigarh University, Mohali, Punjab, India
[2]University School of Business, Chandigarh University, Mohali, Punjab, India
komalpreetb02@gmail.com

Abstract. The telemedicine and telehealth sectors have seen significant expansion in recent years, primarily propelled by technological advancements and the widespread adoption of wearable devices. This study seeks to conduct an extensive evaluation of research on telemedicine and telehealth over the past 33 years to track their evolution and growth through bibliometric analysis using R-Studio and VOS-viewer. Detailed information for the selected papers has been gathered from the Scopus database. The study highlights the annual production of research undertaken in this study. The data indicates a growing trend in the overall publications for both authors and articles. The study examines the thematic analysis using thematic evolution, thematic map, co-word, and co-citation network analysis. The results indicated that Krupinski E.A. (8), and Weinstein R.S. (7), are the top two authors in the production of documents. Further, a paper by Joseph Kvedar (2014), titled "Connected Health: A Review of Technologies and Strategies to Improve Patient Care with Telemedicine and Telehealth" received the highest citation 403 followed by Ronald S. Weinstein (2014), titled "Telemedicine, Telehealth, and Mobile Health Applications That Work: Opportunities and Barriers" which received 398 citations thus indicating the most influential publications. Key terms like "telemedicine" and "telehealth", are the most prominent themes. Thematic evolution shows a shift from general medical themes to healthcare quality. This highlights the growing importance of digital health solutions in improving healthcare delivery. The study will be helpful for researchers, funding agencies, and policymakers to use the findings to prioritize their work to advance telemedicine and telehealth.

Keywords: Telemedicine, Telehealth, Human, E-Health, Healthcare Delivery

1 Introduction

The term "telemedicine" was introduced to refer to the remote delivery of medical services [1]. It was designed specially to meet the health needs of vulnerable and inaccessible areas and to provide equal treatment regardless of location [2][3]. Telemedicine relies on advanced communication technologies to overcome barriers of distance and become an essential part of the modern system of healthcare. Careful

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consideration of technological, legal, and ethical considerations is necessary for its successful implementation, as well as collaboration between healthcare professionals, patients, and technologists [4]. Technological advancements have increased the adoption of wearable devices. For example, in Shark Tank season one, an entrepreneur presented an innovative product to the panel of sharks. The device, called Ayusynk, is a device that converts a standard hearing aid into a digital hearing aid, eliminating background noise and allowing data to be transferred from one location to another. The device is designed for use by U.S. patients [5]. Telemedicine utilizes electronic communication tools like video conferencing to enable remote consultations between patients and healthcare professionals who aren't physically present in the exact same location [6]. The use of this approach holds promise for improving treatment delivery, improving access, reducing healthcare costs, and improving overall care. It enables health professionals to connect with patients in remote or underserved areas, thus expanding their reach and impact [7].

Telemedicine is an important part of the digital transformation of conventional medicine. With the advent of new technologies in the past decades, telemedicine is continuously evolving and expanding its application scope [8]. With the growing use of telemedicine, the concept of 'telehealth' has emerged, with a broad range of health-related activities such as services and education [9]. This enlargement allows the adoption of a comprehensive approach to healthcare delivery, as it allows for the provision of various health services remotely via telecommunication technologies [10]. When referring to the electronic delivery of healthcare services, the words "telemedicine" and "telehealth" are often used interchangeably [11]. The phrase "e-health" describes the practice of offering healthcare through information and communication technologies (ICTs) [12]. It involves integrating clinical records, electronic health records, and telemedicine services to improve patient care and health outcomes [13]. Although telemedicine, telehealth, and e-health are distinct concepts, they are frequently used interchangeably by way of healthcare specialists and clients [9]. It is essential to remember that the words "telemedicine" only applies to the delivery of medical care through digital communication technologies, Although the term "telehealth" is broader that includes an extensive range of healthcare services and information delivery techniques. In contrast, eHealth describes how health information and services are controlled using digital technologies [14]. Despite the variations, these terms are regularly used interchangeably, causing confusion among healthcare specialists and sufferers.

Telemedicine has undergone significant expansion over two decades. The current services include remote physician consultations, mental health monitoring, intensive care services, and management of chronic diseases [15]. Telemedicine is a promising strategy to address the challenge of insufficient medical resources in underserved areas, with achieving the ultimate goal of universal healthcare services [16]. By use of telemedicine, healthcare providers can diagnose and deal with patients in live communication, no matter where they are, enhancing access to quality medical care, especially in faraway and rural regions [17]. This technology permits globally virtual medical consultations, remote monitoring, and can be especially useful for patients with chronic conditions [6]. With its capability to transmit information in real-time,

telemedicine technology may help the medical professionals to make better decisions and more accurate diagnoses, decreasing the need for in-individual visits while improving overall healthcare delivery [18]. Telemedicine gaining momentum due to its proven ability to improve health outcomes and medical efficiency [19]. Recent data confirm its effectiveness in improving health outcomes for patients, making it a more desirable choice for healthcare providers [20]. Telehealth not only enhances patient results but also lowers the cost of hospitalization and other healthcare services [21]. Implementation of telemedicine comes with its own set of challenges like security risks, establishing a virtual care system requires significant administrative support to overcome these types of barriers [22].

Due to the outbreak of COVID-19, governments implemented globally social distancing policies, which have ended in tremendous lockdowns. This measure had been taken to control the spread of the virus and protect the public [23]. These regulations seek to reduce the strain on the hospital system and improve the delivery of healthcare through the use of telecommunications technology [10]. The integration of AI, robotics, and other advanced technologies facilitates telemedicine and reinforces our potential to cope with pandemics [24][25]. The rapid growth of telemedicine, also known as telehealth or virtual care, is critical to the sustainable growth of the healthcare industry. Telemedicine uses technology to deliver healthcare services remotely, offering the potential to contribute to several Sustainable Development Goals (SDGs). These include but are not limited to access to universal healthcare, reduction of maternal and child mortality and prevention of common diseases [26].

The field of telemedicine is growing rapidly, and it can be hard to keep up with the latest discoveries and trends. However, bibliometric analysis provides the solution for assessing large literature and identify the most productive authors, documents and keywords. By integrating existing literature, bibliometric analysis facilitates define relevant studies results and identify key topics that may be valuable for information decision-making processes [27]. This makes it simpler for experts to keep up with the latest findings in telemedicine research and make informed decisions based on the most relevant information available [28]. Citation analysis the use of bibliometrics methods is an effective method that enables the evaluation of publication trends and the identify the high-impact journals. The methodology has proven highly effective in presenting valuable insights into the research context and impact of examine findings. Bibliometric analysis is an effective tool for knowledge mapping, yielding a body of literature on telemedicine, telehealth, and the impact of e-health [29].

2 Objective:

The authors of the present study conducted a bibliometric analysis on “Telemedicine” AND “Telehealth” with the aim of identifying current research trends and the futuristic trends, relevant to the development of this area. Hence, this study seeks to look for answers to the research questions stated below:

1. What is the present state of the study in the field of "Telemedicine" AND "Telehealth"?
2. Who are the most productive authors and their Fractionalized Contribution and the most cited articles regarding telemedicine and telehealth?
3. To identify and analyse the prominent themes and topics in the study.

3 Methodology

The Prisma framework was used to facilitate the overall evaluation process shown in Figure 1. This figure shows the detailed process by which the original text was transformed into the final document using specific factors including language and source characteristics and other. Firstly, the SCOPUS database was utilized for obtaining the documents related to the keywords "telemedicine" AND "telehealth". The total number of documents obtained after searching process was 14,425 documents and these documents were up to May 11, 2024. Subsequently, a filtration procedure was implemented, wherein various filters were applied to the total article's title and the total articles titles left after this process were 161 documents in all. The funnelization was done by using these criteria: Subject area – Medicine (119), Social Sciences (14), Business, Accounting and Management (5), Psychology (3) Economics, Econometrics and Finance (3), and Environmental Science (2). Similarly, the types of documents were also selected to clear the irrelevant articles and, in that case, only articles (56), Review (28), conference papers (13), Book chapter (13), Short survey (6), Note (4), Editorial (4), Letter (2), Erratum (2), Book (2) and Conference review (1) were chosen. After the selection of the document type, total 127 documents. Only 126 published documents were considered after the publication stage was chosen. The study makes uses biblioshiny, a configurable web interface packages from bibliometrix of the R programming language, that provides the capabilities of bibliometric analyses [30]. Authors utilized for various analyses including country scientific production, Annual scientific production, most productive authors, Most global cited documents, word Treemap, thematic evolution analysis, thematic map analysis, and Co-citation network analysis. In addition, authors use VOSviewer, use for visualizing and conducting cluster analysis to identify the co-occurrence of keywords [31].

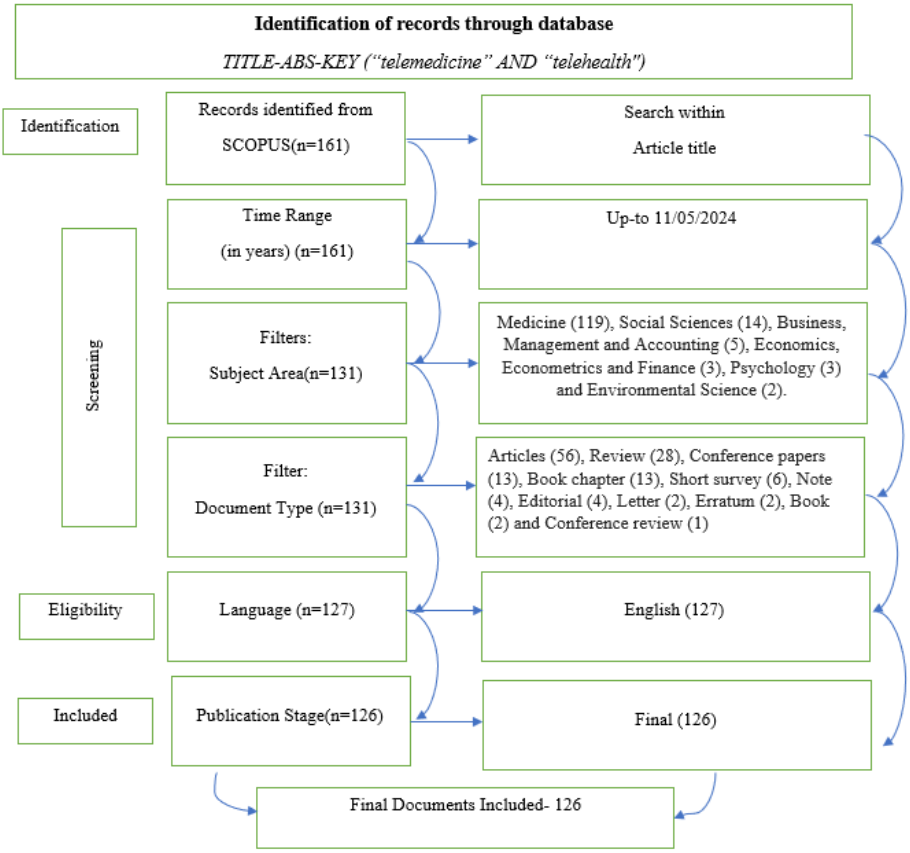

Fig. 1. Prisma Article Selection Guidelines adopted for the study.

4 Result And Analysis

In this study, a bibliometric analysis is performed on telemedicine and telehealth literature. The sections that follow provide an explanation of the research questions that the study attempts to address.

4.1 The present state of the study in the field of "Telemedicine" AND "Telehealth".

Annual Scientific Production

The graph in Figure 2 illustrates the growth of the research publications in the field of "telemedicine" and "telehealth" from May 1991 to 2024. Despite slow growth in the early years, there has been a substantial increase in scholarly output, with a total of 15 publications in 2020, marking a significant rise compared to previous years. The data

shows a notable increase in scholarly publications over the years, especially starting from 2014, with a significant peak in scholarly interest, particularly in 2020 (15 articles), 2022 (12 articles), and 2023 (11 articles). This data underscores the escalating scholarly focus on telemedicine research. The majority of documents focused on "telemedicine" and "telehealth". The data indicates a limited interest of scholars in the initial years, specifically during the mid-90s (1992-1996), with certain years lacking any documented articles. The volume of articles fluctuates on an annual basis, mirroring fluctuations in research output. Despite occasional declines, recent years have shown increased activity, indicating an overall trend of growing research and publication efforts over the last thirty years in this domain.

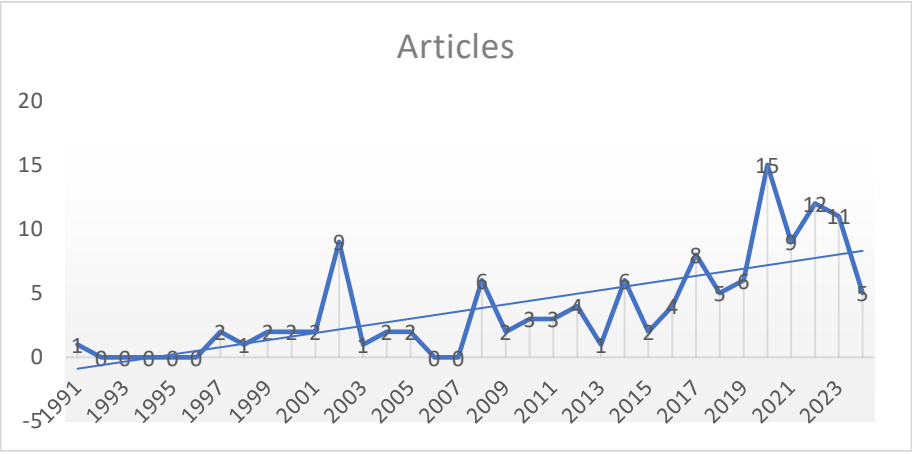

Fig. 2. Trends In Telemedicine and Telehealth from January 1991 to May 2024 (N = 126)

Country Scientific Production

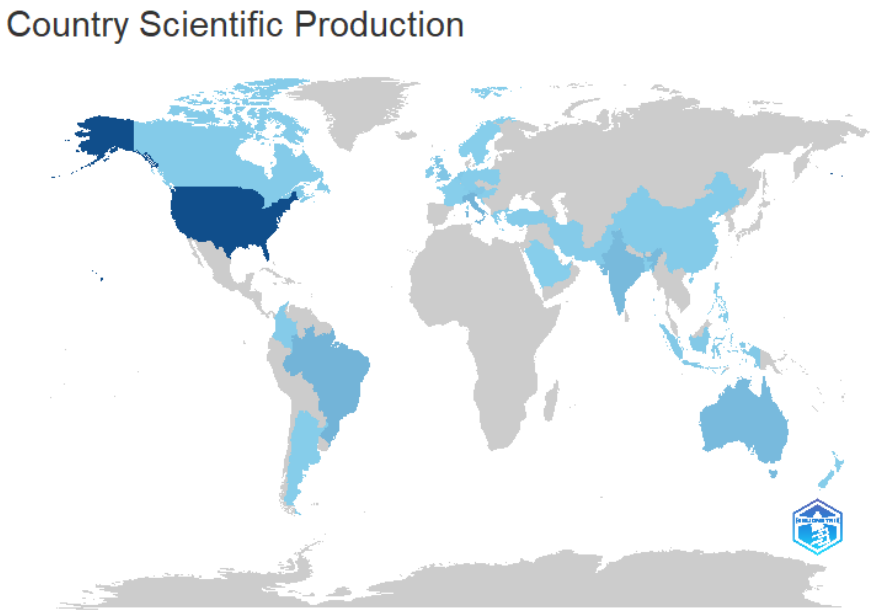

Fig. 3. Concentrated Worldwide Distribution of Telemedicine and Telehealth

Fig.3 shows the country's scientific production. The geographical locations of the authors were explored to see whether or not there is a concentration of academic interest in telemedicine and telehealth research. Most of the telemedicine and telehealth articles used in this study had authors from only five countries: USA (203), Brazil (39), Italy (39), India (31), and Australia (30). The fact that this type of work has been produced in most of the different countries worldwide demonstrates the widespread interest in the topic.

4.2 The most productive authors and their fractionalized contribution and the most cited articles regarding telemedicine and telehealth?

The Most Productive Authors and Their Fractionalized Contribution

The bibliometrix study aims to identify authors who have made significant study in the field of telemedicine and telehealth research. The most productive authors are displayed in Table 1 according to their fractionalized and complete contributions. At the outset, researchers observed 126 articles listed in this review database (not tabled). "Articles" refers to the total count of articles that each author has contributed to, while "Articles Fractionalized" denotes the proportional credit that each author has received based on co-authorship. For example, Krupinski E.A. has co-authored 8 articles with a fractional contribution of 1.97, indicating shared credit among co-authors. On the other hand, Doarn C.R. has published 5 articles with a higher fractional contribution of 2.41, signifying significant individual contribution to a smaller number of co-

authored papers. These findings suggest a strong academic interest in this particular field of study. Authors such as Blanchet K.D. are assigned a fractional contribution score equivalent to the total number of their articles, which indicates sole or major authorship. These authors are focused on areas of interest spanning from telemedicine to telehealth. The outcomes indicate that the total number of publications as well as the level of individual input in collaborative telemedicine and telehealth work are indicative of a growing sector focused on long-term sustainability. This work is authored by individuals with diverse interests and viewpoints.

In the study, the United States, with authors Krupinski E.A., Weinstein R.S., Doarn C.R., Lopez A.M., Bashshur R.L., Blanchet K.D., Erps K.A., Latifi R., and Brazil, with authors Savaris A., Von Wangenheim A., emerged as the most productive countries and authors. The researchers carried out an extensive investigation of the capabilities of telemedicine, telehealth, wireless personal communication, and electronic health (eHealth) services. They specifically focused on the potential of wireless telemedicine for facilitating telehealth services.

Table 1. The Most Productive Authors and Their Fractionalized Contribution on Telemedicine and Telehealth (N=126**)**

Ranks	Authors	Articles	Articles Fractionalized
1.	KRUPINSKI EA	8	1.97619048
2.	WEINSTEIN RS	7	1.67619048
3.	DOARN CR	5	2.41666667
4.	LOPEZ AM	4	2.26785714
5.	SAVARIS A	4	0.81666667
6.	VON WANGENHEIM A	4	1.15
7.	BASHSHUR RL	3	1.47619048
8.	BLANCHET KD	3	3
9.	ERPS KA	3	0.46785714
10.	LATIFI R	3	0.58333333

The Most Influential Authors and their Articles contributions.

In analysing the most relevant article by the most influential author researchers use the total citations and total citations per year as it indicates the most contributed research Table 2 presents a list of authors and their publication years along with article titles and publication sources. This information highlights the important contributions made to telemedicine and telehealth. In 2014, Kvedar J. authored "Connected Health: A Review of Technologies and Strategies to Improve Patient Care with Telemedicine and Telehealth" in “Health Affairs”, which received the

Table 2. The Most Influential Authors and Articles on Telemedicine and Telehealth (N=126)

Authors	Year	Title	Source Title	Total Citations	Total Citation per year
Kvedar J.	2014	Connected Health: A Review of Technologies and Strategies to Improve Patient Care with Telemedicine and Telehealth [32]	Health Affairs	403	36.64
Weinstein R.S.	2014	Telemedicine, Telehealth, and Mobile Health Applications That Work: Opportunities and Barriers [33]	The American Journal of Medicine	398	36.18
Chaet D.	2017	Ethical practice in Telehealth and Telemedicine [34]	Society of General Internal Medicine	185	23.13
Novara G.	2020	Telehealth in Urology: A Systematic Review of the Literature. How Much Can Telemedicine Be Useful During and After the COVID-19 Pandemic? [35]	European Association of Urology	153	30.60
Kaplan B.	2020	Revisiting Health Information Technology Ethical, Legal, And Social Issues and Evaluation: Telehealth/Telemedicine and Covid-19 [36]	International Journal of Medical Informatics	147	29.40
Ahmad R.W.	2021	The role of blockchain technology in telehealth and	International Journal of Medical Informatics	132	33.00

		telemedicine [37]			
Fatehi F.	2012	Telemedicine, telehealth or e-health? A bibliometric analysis of the trends in the use of these terms [38]	Journal Of Telemedicine Telecare	116	8.92
Weinstein R.S.	2018	Clinical Examination Component of Telemedicine, Telehealth, mHealth, and Connected Health Medical Practices [39]	The Medical Clinics of North America	106	15.14
Stowe S.	2010	Telecare, telehealth and telemedicine [40]	European Geriatric Society	105	7.00
Kaplan B.	2008	Ethical Challenges of Telemedicine and Telehealth [41]	Cambridge Quarterly of Healthcare Ethics	102	6.00

highest number of citations 403 in the field. Following closely is Weinstein R.S.'s work in the same year, titled "Telemedicine, Telehealth, and Mobile Health Applications," published in The American Journal of Medicine, which garnered 398 Citations. In 2014, these two authors demonstrated outstanding performance in their field with a source publication.

The results presents the leading authors in the telemedicine and telehealth field are Kvedar J. with 403 Scopus citations (36.64 per year), Weinstein R.S. whose 2014 publication has acquired 398 citations (36.18 per year) and whose 2018 work has 106 citations (15.14 per year), Chaet D. with 185 citations (23.13 per year), Novara G. with 153 citations (30.60 per year), Kaplan B. whose 2020 publication has amassed 147 citations (929.40 per year) and whose 2008 work has 102 citations (6.00 per year), Ahmad R.W. with 132 citations (33.00 per year), Fatehi F. with 116 citations (8.92 per year), and Stowe S. with 105 citations (7.00 per year). The study's criteria mandated a minimum of three publications per author.

4.3 To identify and analyse the prominent themes and topics in the study

Analyses of Themes and Topics in the Study

One of the primary goals of the study is to analyse and identify the prominent themes and topics in the study. For this, the authors use analysis techniques such as "Thematic map" (Fig.5) "Thematic Evolution" (Fig.6), "Co-word analysis" (Fig. 7), and "co-citation network" (Fig. 8). For thematic analysis, Authors employ keywords for the analysis Fig. 4 presents the "word tree map" analysis using Biblioshiny to analyse the frequently used keywords highlighted in the documents. Author keywords were used to generate the word "Tree Map". The map's size and color indicate the frequency of keywords occurring; a greater box size denotes more keyword repetitions. The top five terms that appear frequently in the articles are telemedicine (46 occurrences, 26%), telehealth (29, 22%), covid-19 (12, 7%), ehealth (5, 3%), and healthcare (5, 3%). Other keywords include digital health, Latin America, and mhealth. The findings indicate that telehealth research is dominated by Latin America and focuses mostly on mhealth and telemedicine. Themes, patterns and trends in research can be found by the use of thematic map analysis represent by Fig. 5. Authors identify telemedicine systems, costs, quality control, patient safety, physical examination, and mlown as emerging themes. Societies, medical privacy, adult, male, female, telemedicine, humans, United States, and healthcare delivery are motor themes. To determine the thematic concentration of research work in telemedicine and telehealth, authors use co-citation network analysis (Fig. 8). The red cluster, which focuses on diabetes care and related telemedicine applications, is one of the four thematic clusters that study results produce, along with green, blue, purple and green. This cluster highlights significant research and publications dealing with how telemedicine is applied to the management and care of diabetes, indicating that this is a major area of study within telemedicine. Whereas, documents in the green cluster focus on telemedicine applications in general healthcare and health informatics signifies that extensive research in health informatics and digital health, shows the broad implementation of telemedicine across

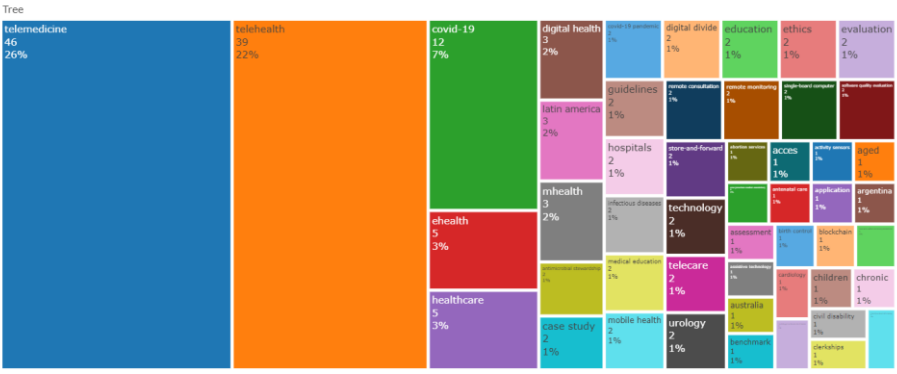

Fig. 4. Word TreeMap

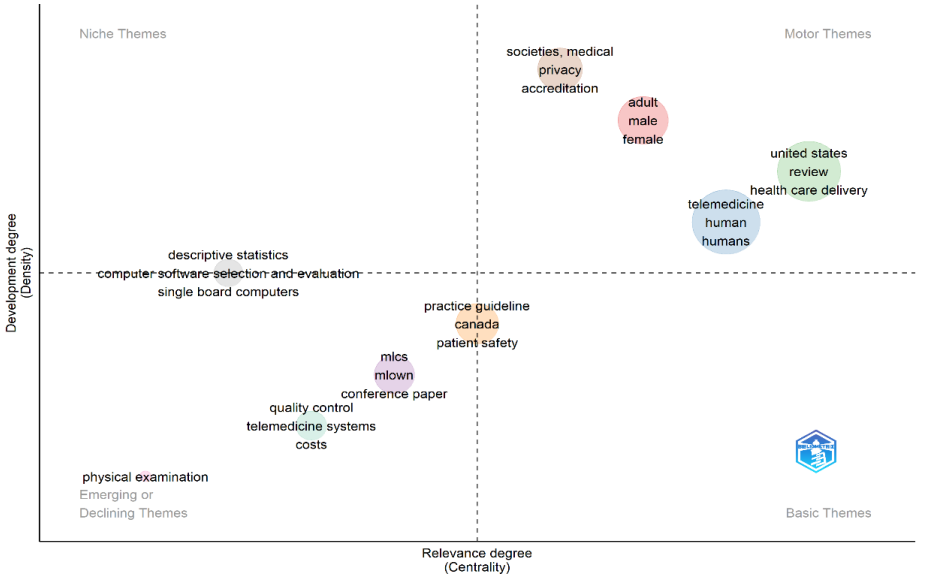

Fig. 5. Thematical Map Analysis.
Note: Field: Keywords Plus, Min Cluster Frequency (per thousand docs): 5, Number of Labels: 3, Walktrap: Cluster alagorithm

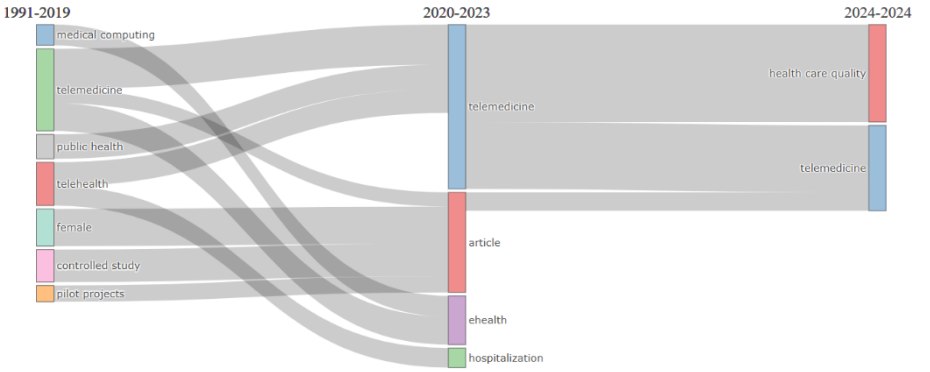

Fig. 6. Thematic Evolution Map

various medical fields and their technological advancements. Important studies on health policy and the effect of telemedicine on healthcare systems are shown by blue color cluster. This cluster signifies that discussion around the policy implications, regulatory frameworks, and overall impact of telemedicine on healthcare delivery systems, highlighting how telemedicine is influencing health policy and

administration. Purple Cluster represents the niche or emerging areas within telemedicine. This isolated node represents a unique aspect of telemedicine that is not heavily connected to the other clusters, possibly indicating an emerging research area or a specialized topic within the field. Biblioshiny and VOSviewer are two visualization approaches authors employ to illustrate the thematic pathway and potential future scope studies in "telemedicine" and "telehealth": a thematic evaluation map and co-word analysis. A thematic progression map created with the author's keywords is displayed in Fig 6. The intern's cutoff point for figuring out what keywords are the newest as of 2020. The author's findings indicate that in the early phase, Research focused on keywords medical computing, telemedicine, public health, telehealth, and female. From 2020 to 2023 focus shifted significantly towards telemedicine, with other relevant areas being articles, ehealth, and hospitalization. Moving into the 2024 period, the primary areas of research have narrowed down to healthcare quality and telemedicine. This visualization underscores the growing prominence and sustained interest in telemedicine over time, reflecting its critical role in modern healthcare advancements and research. (Figs. 5, Figs. 6 and 7)

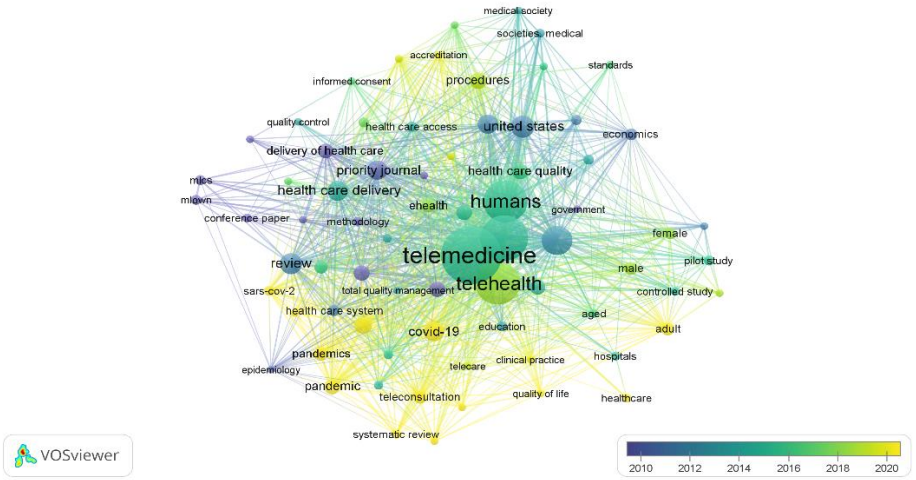

Fig. 7. Co-word Analysis

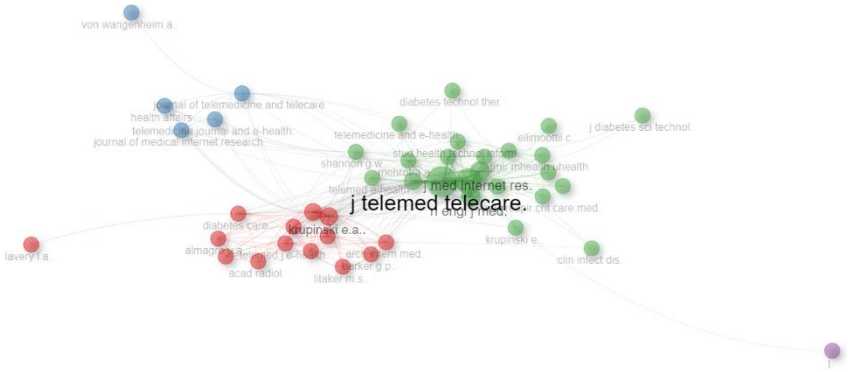

Fig. 8. Co-citation Network

5 Conclusion

In this bibliometric research experienced significant growth in the field of "Telemedicine" and "Telehealth", especially in the past years, as indicated by the increasing number of annual scientific publications. Over the period spanning from 1991 to 2024, the number of papers on telemedicine has been rising for a long time, with a spectacular rise in the past few years. The U.S.A and Brazil lead in research contributions, with substantial input from countries across Europe and Asia, reflecting a global interest in these technologies. Key research contributors included Krupinski E.A. and Weinstein R.S., Doarn C.R. have made substantial contributions to the literature, highlighting key areas such as patient care improvement, technological integration, and ethical considerations. Most of them are the most frequently cited study indicate significant progress in telemedicine research, particularly those by Kvedar (2014) and Weinstein (2014). The study also highlights the primary collaborators and essential concepts, demonstrating the collaborative trends and central topics in telemedicine research. Key terms like "telemedicine" and "telehealth", are the most prominent themes, with significant attention to "COVID-19", "ehealth", and "healthcare". Thematic analysis reveals major research themes including technology integration, and the pandemic impact, indicating shifting priorities and emerging trends. Thematic evolution shows a shift from general medical themes to healthcare quality. This highlights the growing importance of digital health solutions in improving healthcare delivery.

Telemedicine's potential to increase the availability of healthcare services, particularly in underdeveloped regions, makes it a promising tool for advancing a number of sustainable development goals (SDGs). One of the most important impacts

of telemedicine on the SDGs is its potential for the development of the availability of health services in underserved and remote regions. In keeping with Sustainable Development Goal (SDG) 3, which aims to ensure universal access to high-quality healthcare and enhance the well-being of all [42]. Telemedicine is essential to support SDG 5, Through virtual obstetric and gynecological care, telemedicine can play an important role in reducing maternal mortality rates and enhancing overall maternal health, especially in regions with restricted access to specialized healthcare services [43]. In addition, telemedicine promotes innovation and strengthens infrastructure, contributing to SDG 9 by promoting innovation and improving infrastructure [44]. In the pursuit of the SDGs, the incorporation of telemedicine into healthcare infrastructures is imperative for accelerating advancements toward universal health coverage and enhancing health results for diverse global populations [45].

Bibliometric analysis facilitates the identification of new research and development opportunities. A significant advantage of employing the bibliometric technique is its capacity to consolidate a large body of literature.

6 Future Recommendations

Future studies should focus on telemedicine's challenges such as patient involvement, ethical and legal concerns, and technology integration. Increasing worldwide collaboration may provide solutions for diverse populations, particularly those residing in remote regions. Using AI and data analytics. Employing AI and data analytics together can provide insightful information for practice and policy. The long-term effects of telemedicine on health outcomes and cost-effectiveness must be assessed through longitudinal research. Fostering collaboration among academic institutions, government bodies, and commercial associates can effectively bridge the knowledge gap between research and policy, thereby increasing the efficacy of policy. Future research should evaluate the caliber and significance of telemedicine research using a variety of databases and comprehensive techniques. Research ought to examine the efficacy of telemedicine in various healthcare environments and patient populations, incorporating advanced technologies like artificial intelligence and machine learning. Policy and regulatory framework analysis, opportunity and barrier identification, and demographic and geographic differences in adoption and impact might reveal areas that require targeted interventions. To contribute to the industry's steady expansion, longitudinal studies can identify trends and forecast future events.

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