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Digital health defined by eHealth and mHealth: A bibliometric Analysis

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Abstract. *Nowadays, there are several mobile applications and disruptive technologies that have significantly changed many traditional practices. One of the sectors positively impacted is healthcare, where various technologies and applications, known as mHealth and eHealth, have been developed. Multiple studies support the fact that health-related devices and technological programs have transformed traditional medicine and many clinical practices, as they provide an essential contribution of information that makes a difference in both the time allocated to activities and decision-making processes. This paper aims to provide an overview of the benefits brought by the extensive integration of technology into the healthcare system. The results have shown, through bibliometric analysis, the impact of disruptive technologies on traditional medicine in the context of the current economy.*

Keywords: digital health, mHealth, eHealth, disruptive technology, wearable, bibliometric analysis.

Introduction

In recent decades, digital technologies have fundamentally reshaped health systems, bringing to the forefront concepts such as digital health, eHealth, and mHealth. This digital transition reflects not only a technological shift but also a profound transformation in the paradigm of delivering and accessing medical services on a global scale. Digital health is now widely recognized as a broad term encompassing the use of advanced information technologies in healthcare, from electronic health records and telemedicine platforms to artificial intelligence, big data, blockchain, and mobile applications, with the purpose of improving both individual and collective health outcomes (WHO, 2021).

According to the World Health Organization (2021), digital health represents a strategic opportunity to achieve global goals for universal health coverage, effective responses to health emergencies, and the promotion of well-being for diverse populations. This strategy advocates for the use of digital technologies in a secure, equitable, sustainable, and person-centered manner, emphasizing the importance of interconnected health systems actors and the protection of sensitive health data. Similarly, eHealth is defined as the use of information and communication technologies in support of health and health-related fields (WHO, 2021), while mHealth focuses specifically on the use of mobile technologies to deliver medical services and health-related information (WHO, 2021; Eysenbach, 2001).

The purpose of this article is to conduct a comprehensive bibliometric analysis to highlight the progress of research in the fields of eHealth and mHealth, by identifying the most influential authors and institutions, mapping emerging themes, and revealing underexplored research directions. Additionally, the study aims to understand how these technologies contribute to

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healthcare innovation, and how they can be leveraged as accessible, sustainable, and efficient tools for the general population and patients alike.

The core elements of this research first focus on identifying the key technologies in digital health, which is essential for understanding the dynamic nature of this field. Applications based on AI, teleconsultation platforms, self-monitoring systems, and wearable devices are just some of the technologies that are redefining access to and delivery of healthcare services (WHO, 2021; Banerjee, 2025).

Secondly, the analysis emphasizes the recurrent trends and topics found in the literature, such as digital mental health, telemedicine, mobile interventions for chronic disease management, and the integration of AI in early diagnostics (Abascal-Peiró et al., 2024).

It also places a strong focus on the scientific credibility of authors, identifying prominent researchers and institutions, and mapping them through bibliometric techniques that allow for an objective evaluation of authoritative sources in the field (Bengana et al., 2025).

At the same time, this article explores research gaps and insufficiently addressed directions in current literature, such as the lack of interoperability standards across eHealth/mHealth applications, the need for ethical regulations concerning AI in healthcare, and the ecological impact of digital waste (WHO, 2021; Eysenbach, 2001). These thematic voids are crucial for shaping future research agendas.

The importance of digital innovation in health is undeniable, not only from the perspective of efficiency and cost reduction, but also in its capacity to expand healthcare coverage to isolated or disadvantaged populations (Amekpor et al., 2025). Therefore, eHealth and mHealth prove to be among the most accessible and democratizing technologies for the general public, offering opportunities for self-monitoring, information access, and direct communication with healthcare professionals (Eysenbach, 2001).

Thus, this bibliometric investigation aims not only to synthesize the current state of knowledge but also to offer a strategic tool for policymakers, researchers, and developers of digital health technologies. Built on a rigorous methodology, the study provides a clear vision of the intersection between research, innovation, and practical application in the digital health ecosystem, with a particular focus on real-world relevance and public health impact.

Literature review

The conceptual evolution of digital technologies in healthcare began to take shape in the late 1990s and early 2000s with the emergence of the term eHealth. According to Gunther Eysenbach (2001), considered one of the pioneers in the field, eHealth is “an emerging term that not only describes a technical development, but also a state of mind, an attitude, and a commitment to networked, global thinking, to improve healthcare locally, regionally, and worldwide by using information and communication technology (ICT)” (Eysenbach, 2001). This extended definition positions eHealth not merely as a technological tool, but also as a cultural transformation in the delivery of healthcare services.

Subsequently, with the advancement of mobile technologies, the term mHealth (mobile health) emerged and gained prominence. It is defined by the World Health Organization (2011) as “medical and public health practice supported by mobile devices, such as mobile phones, wireless devices, and wearable technologies.” Unlike eHealth, which encompasses a broader spectrum, including health information systems, electronic health records (EHRs), and telemedicine, mHealth refers specifically to applications and services delivered through mobile technologies.

The term digital health is the most recent and broadly encompasses both eHealth and mHealth, as well as emerging technologies such as artificial intelligence (AI), blockchain, the Internet of Things (IoT), and virtual reality. According to WHO (2021), digital health is "the use of digital knowledge and technologies to improve people's health and the provision of healthcare services in a way that is equitable and centered on people." As such, digital health is conceptualized as an overarching umbrella under which eHealth and mHealth act as applied subdomains.

Several bibliometric studies, such as the one conducted by Chen et al. (2024), highlight the evolution of research in eHealth from 1999 to 2023, noting a significant increase in scientific output after 2015, driven by accelerated digitalization and the COVID-19 pandemic. Similarly, Tian and Chen (2022) analyze global research networks and identify the United States, China, and the United Kingdom as leading contributors to eHealth-related scientific production.

In the case of mHealth, the literature reflects a growing focus on applications targeting mental health, chronic disease management, and behavioral interventions. The article by Abascal-Peiró et al. (2024) presents a review of mobile apps designed to prevent suicide among adolescents, emphasizing mHealth's potential to deliver real-time interventions in vulnerable contexts. Other studies, such as Jayaraj et al. (2025), confirm the effectiveness of mobile applications in improving university students' mental well-being and reducing symptoms of depression and anxiety.

A critical issue discussed in the literature involves the inequities in access to digital technologies, often referred to as the digital determinants of health. According to Jahnel et al. (2022), factors such as digital literacy, socioeconomic status, and language barriers can significantly influence the extent to which individuals benefit from digital health innovations.

Additionally, Kruse et al. (2016), in a systematic review of barriers to telemedicine adoption, identify persistent challenges such as cultural resistance to technology, high initial implementation costs, and lack of interoperability between systems as major obstacles to the scalable deployment of eHealth and mHealth solutions.

Complementing this, Khan et al. (2025) demonstrate that, despite high levels of digital technology usage among healthcare professionals, there remains a clear lack of formal training and institutional support for the sustainable integration of these technologies into everyday clinical practice.

This body of literature confirms that, despite remarkable progress in the digitalization of healthcare, there are still numerous conceptual and practical challenges. Therefore, the distinction between digital health, eHealth, and mHealth is not only terminological but also functional, with direct implications for public policy design, app development strategies, and digital literacy initiatives among populations (Norman & Skinner, 2006).

Methodology

To explore the scientific landscape of the fields of digital health, eHealth, and mHealth, this study employed a comprehensive bibliometric approach, a well-established method used for mapping and quantifying the structure, dynamics, and evolution of scientific research. Rooted in the foundational work of Pritchard (1969), who introduced the term bibliometrics, and further developed by scholars such as Broadus (1987), this methodology enables the analysis of publication patterns, citations, collaborations, and thematic developments across large corpora of scientific literature.

For the data collection and processing phase, datasets were extracted from the Web of Science Core Collection (WoS), one of the most widely used multidisciplinary databases, known

for its rigorous indexing and quality-controlled content. Two advanced searches were conducted using the Topic Search (TS) function to retrieve literature relevant to the domains under investigation:

TS = "eHealth"

TS = "mHealth"

The search results were exported in "Plain Text File" format, compatible with the bibliometric software tools used in the analysis. The datasets were cleaned by removing duplicates and standardizing author names, institutional affiliations, and journal titles to ensure metadata consistency. Following data processing, a total of 25,830 documents were analyzed, covering the period from 2000 to 2024 and the beginning of 2025. The dataset included research articles, reviews, conference papers, editorials, and other relevant publication types.

One of the main tools used in this analysis was the Bibliometrix package in the RStudio environment, an open-source and powerful instrument for science mapping and bibliometric analysis (Aria & Cuccurullo, 2017). This package enabled detailed examination of metadata such as author distribution, source journals, institutional affiliations, and contributions at the country level. The Biblioshiny graphical interface was used to facilitate interactive exploration of results.

To generate additional visual representations of bibliographic networks, the VOSviewer software was employed, following the recommendations of Van Eck and Waltman (2010). This program was essential for building co-authorship maps, keyword co-occurrence networks, citation maps, and cluster visualizations based on bibliographic coupling and co-citation analysis. Minimum thresholds were applied to ensure statistical relevance and clarity of graphical outputs.

The methodology was structured around three major analytical dimensions, drawing inspiration from recent research such as Hegerty & Weresa (2024), who conducted a bibliometric study of digital innovation in healthcare. In the first phase, a descriptive statistical analysis was performed to examine annual scientific output, the most prolific authors, top journals, and the geographic distribution of publications. This stage offered a general overview of productivity trends and key contributors in the field.

The second phase focused on collaboration networks, by constructing co-authorship graphs and institutional linkages to identify research clusters and influential centers. These networks provided insights into the structure of academic partnerships and the degree of internationalization of research.

The third analytical dimension explored thematic and conceptual structures, examined through keyword co-occurrence analysis and thematic mapping. This analysis enabled the identification of core research areas and emerging frontiers. The thematic evolution function in Bibliometrix was used to track how specific research themes changed and evolved over time.

It was observed that although the Web of Science provides a robust and high-quality foundation, one known limitation is its partial coverage of publications from emerging countries or in non-English languages, which may lead to underrepresentation of certain regional perspectives. Furthermore, the analysis is based solely on metadata, and not on the full content of articles, which may limit the depth of semantic interpretation.

Nevertheless, the combination of Bibliometrix for statistical analysis and VOSviewer for visual clarity provides a robust and reproducible methodological architecture. This facilitates a transparent, data-driven understanding of how digital technologies are conceptualized, researched, and applied in medical sciences and related fields.

Results and discussions

To provide a wide overview of the two key concepts that fall under the broader umbrella of digital health, namely eHealth and mHealth, the results have been structured in a parallel and comparative format. This approach allows for a clearer understanding of each term individually, while also highlighting their similarities, differences, and respective contributions to the evolution of digital innovation in healthcare.

Based on Web of Science (WoS) outputs, after the data cleaning and standardization, the comparison between the eHealth and mHealth datasets reveals distinct patterns in research productivity, collaboration, and scholarly impact. Between 2000 and 2025, the eHealth dataset includes a total of 12,201 documents published across 3,270 sources, while the mHealth dataset consists of 13,630 documents from 3,215 sources. Although both fields exhibit substantial publication activity, mHealth demonstrates a slightly higher research output in terms of volume. More notably, the annual growth rate for mHealth literature stands at 25.81%, surpassing the 15.5% growth rate observed in the eHealth field. This accelerated development may be attributed to the widespread adoption of mobile technologies and their integration into various healthcare systems.

Table 1. Indicators of database quality

Indicator	eHealth	mHealth
Timespan	2000–2025	2000–2025
Sources	3,270	3,215
Documents	12,201	13,630
Annual Growth Rate (%)	15.5%	25.81%
Authors	43,565	50,493
Single-authored Documents	635	480
International Co-Authorship (%)	27.06%	30.85%
Co-Authors per Document	5.62	6.28
Author's Keywords (EN)	18,347	17,996
Document Average Age (years)	6.01	4.88
Average Citations per Document	17.3	16.57

Source: Own compilation based on results from R Studio - Bibliometrix, exported WoS Database.

Moreover, the mHealth dataset shows a greater degree of international research engagement, with 30.85% of publications involving international co-authorship, compared to 27.06% in eHealth. The average number of co-authors per document is also higher in mHealth (6.28) than in eHealth (5.62), suggesting more extensive collaboration networks. However, despite the faster growth and broader collaboration observed in mHealth, the eHealth field maintains a slightly higher average citation count per publication (17.3 compared to 16.57), indicating a potentially greater maturity or visibility of its core literature. Additionally, the average age of

documents is higher in eHealth (6.01 years) than in mHealth (4.88 years), further supporting the notion that eHealth research has been established earlier and continues to evolve steadily.

Figure 1 illustrates the evolution of annual scientific production in the fields of eHealth and mHealth, covering the period from 2000 to 2024. The data shows a consistent and notable increase in the number of published articles for both domains, particularly after 2010, reflecting a growing academic and institutional interest in digital health solutions. For eHealth, the number of publications rose steadily from under 100 articles per year in the early 2000s to a peak of over 1,400 articles around 2021. Similarly, mHealth experienced even more rapid growth, reaching a peak of nearly 1,800 publications around the same period.

This exponential growth observed between 2015 and 2021 can be attributed to several factors, including the accelerated adoption of mobile and telehealth technologies, especially during the COVID-19 pandemic. Moreover, the surge in digital innovation initiatives and the increasing integration of AI, remote monitoring, and mobile apps into healthcare services have likely driven the rising scholarly output. Notably, both lines show a slight decline in publication volume after the peak years, which may reflect publication lags or post-pandemic normalization trends.

Although both fields show similar trajectories, mHealth exhibits a steeper rise and higher volume of annual outputs in recent years, suggesting a more dynamic pace of research activity. Conversely, eHealth, while maintaining strong momentum, reflects a more established and stable scholarly development. The data for 2025 has been excluded from this interpretation, as the year is still ongoing and incomplete for scientific indexing purposes.

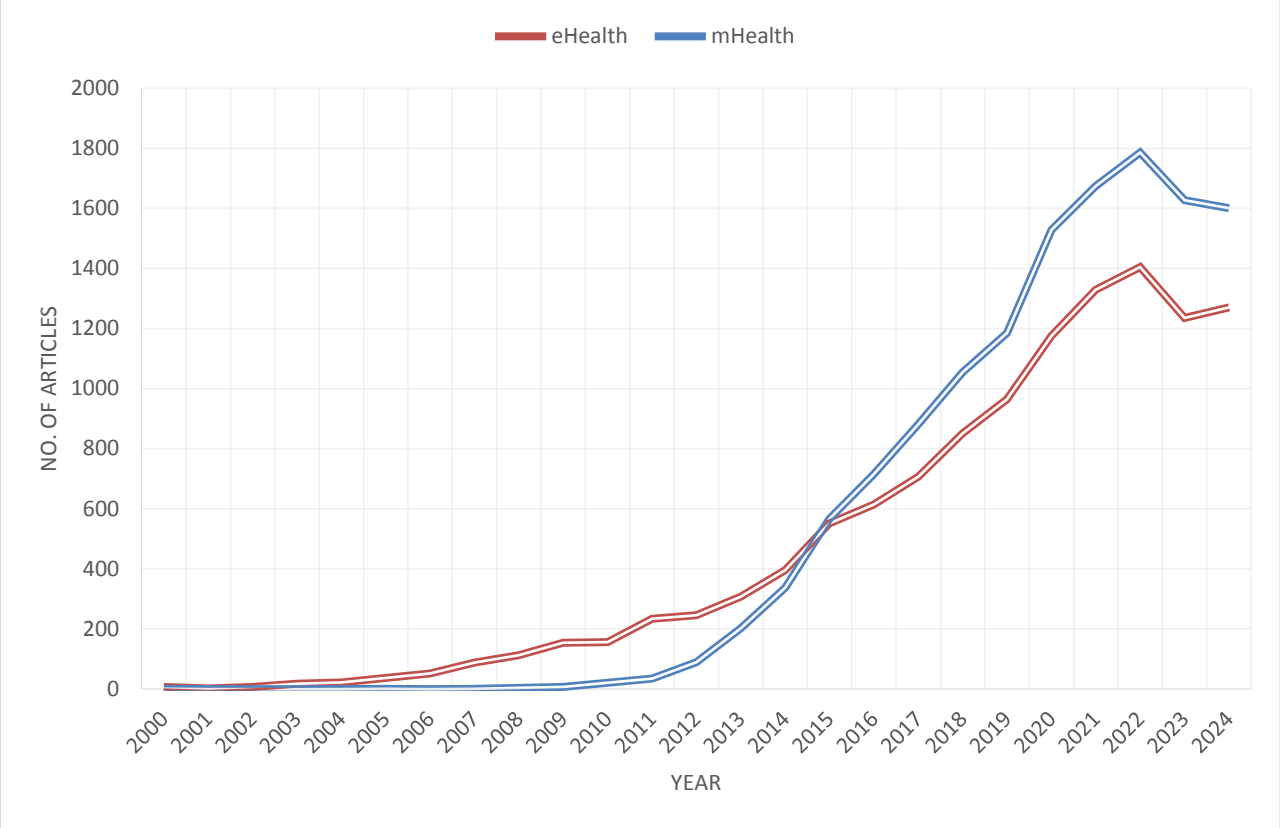


Figure 1. Number of articles per year (annual data, 2000-2024)

Source: Own compilation based on results from R Studio – Bibliometrix, exported WoS Database.

On figures 2 and 3 is presented the distribution of scientific publications across the most active countries in the fields of eHealth and mHealth, based on the affiliation of the corresponding authors. It also highlights the distinction between articles written solely within a country (SCP – Single Country Publications) and those produced through international collaborations (MCP – Multiple Country Publications). The data clearly shows that the United States leads scientific output in both domains, with nearly 2,000 eHealth articles and an even higher number (nearly 5,000) in mHealth, dominating the global landscape. In both cases, the USA also displays a substantial volume of internationally co-authored papers.

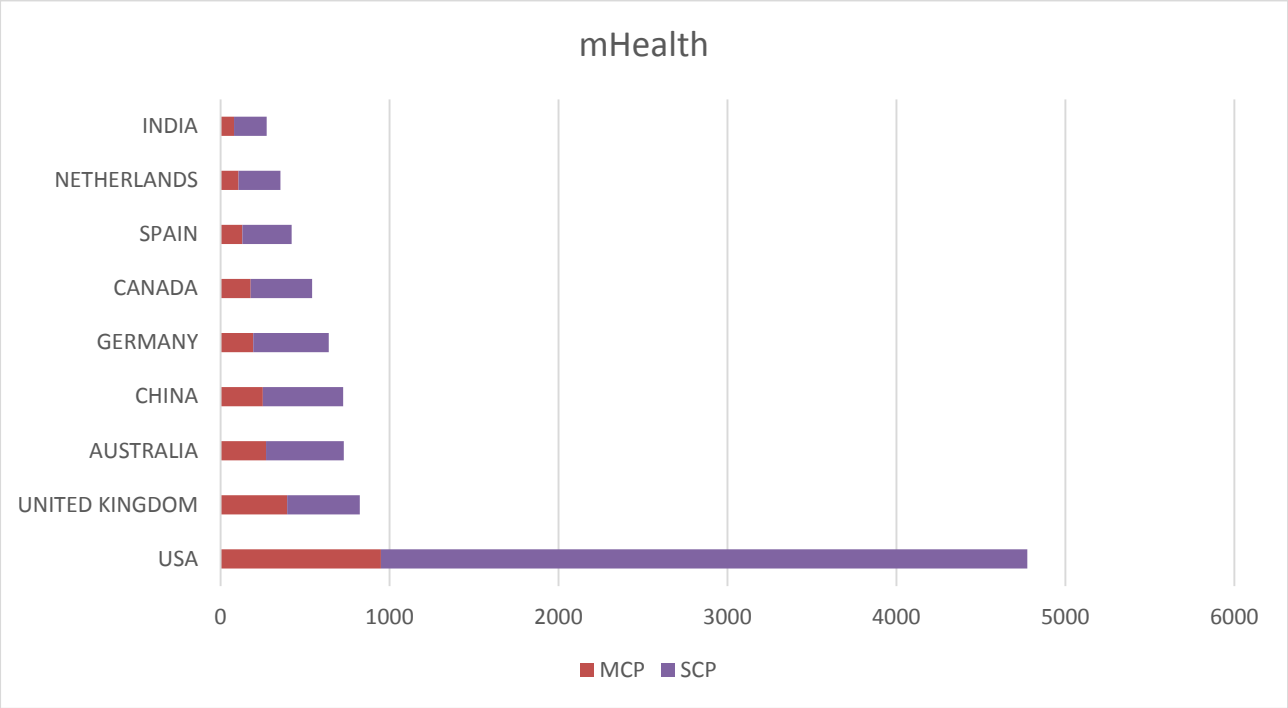


Figure 2. Number of published mHealth documents by type (SCP/MCP) and per country
Source: Own compilation based on results from R Studio – Bibliometrix, exported WoS Database.

Following the US, countries like the Netherlands, Germany, Australia, and Canada appear as strong contributors to both eHealth and mHealth research. However, the Netherlands demonstrates an especially high proportion of international collaboration (MCP), suggesting a strong integration into global research networks. Within Europe, the United Kingdom, Sweden, Italy, Spain, and France all maintain consistent presence among the top contributors. Notably, China also ranks among the top ten countries in both domains, although its publications are predominantly national (SCP).

When comparing the two graphs, mHealth appears to foster a slightly higher rate of international collaboration across countries, which is consistent with earlier indicators of its higher international co-authorship percentage (31.29%). On the other hand, eHealth (MCP – 27.54%) remains rooted in more nationally oriented efforts in several countries. Overall, the data suggests that while most countries continue to prioritize internal production, the global health research community increasingly values and engages in cross-border collaboration—particularly in areas with rapid technological integration such as mHealth.

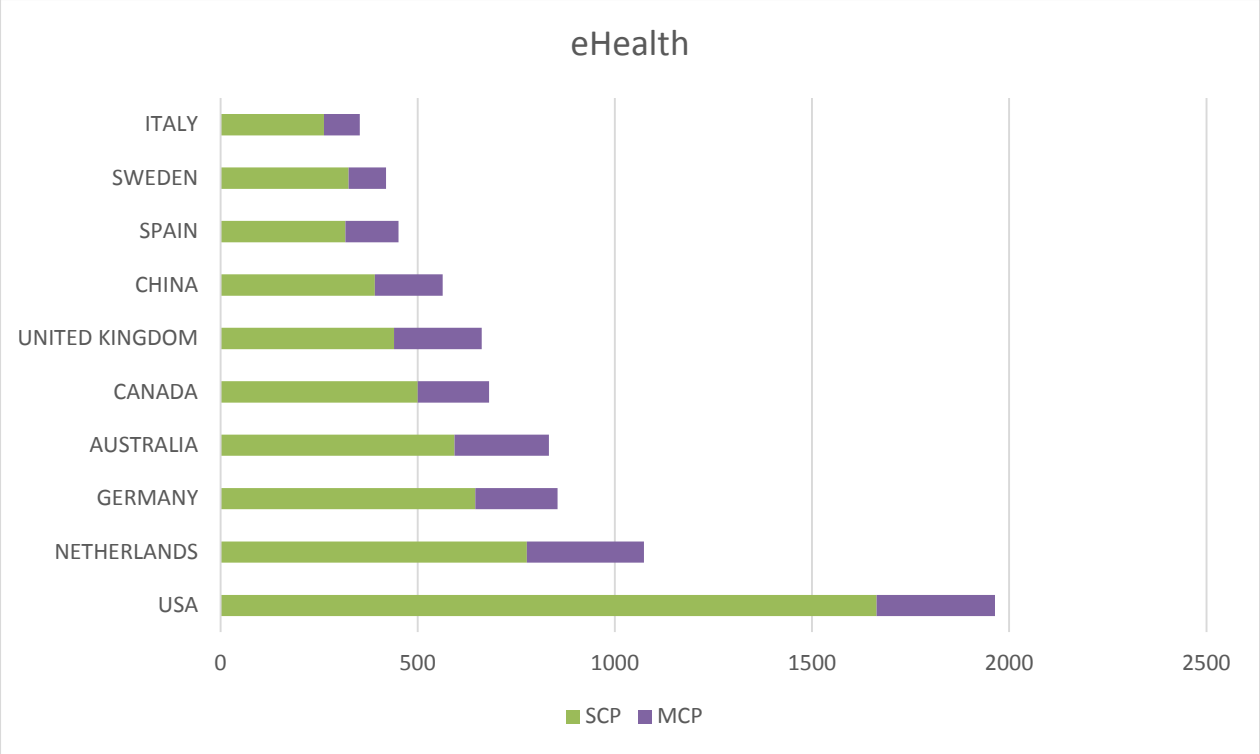


Figure 3. Number of published eHealth documents by type (SCP/MCP) and per country
Source: Own compilation based on results from R Studio – Bibliometrix, exported WoS Database.

Using VOSviewer software, two co-authorship networks were generated to illustrate the scientific collaboration patterns among countries in the fields of eHealth and mHealth (Figure 4).. The maps are structured by both the volume of co-authored publications and the recency of contributions, as indicated by the color gradient (from purple for older publications to yellow for more recent ones). In both networks, the United States occupies a central and dominant position, highlighting its pivotal role in driving global research in digital health. The size of the nodes confirms its high output and strong collaborative links with a diverse range of countries across all continents.

In the mHealth collaboration network, the clustering suggests a broader inclusion of low- and middle-income countries (LMICs) such as South Africa, Kenya, Nigeria, Ghana, Bangladesh, and Uganda, alongside traditional research leaders like the UK, Germany, China, Canada, and Australia. This reflects the global applicability and urgency of mobile health solutions, especially in regions with limited access to traditional healthcare infrastructure. The presence of countries from Africa and Southeast Asia in this cluster indicates a growing research emphasis on scalable mHealth interventions in resource-constrained settings.

Conversely, the eHealth collaboration map appears more compact and concentrated in terms of nodes, showing a denser network within the European Union and North America. Countries like the Netherlands, Germany, Sweden, and the UK form a highly interconnected core of eHealth collaboration, with substantial involvement also from Canada, Australia, and China. The visual density and proximity of European countries in the eHealth map suggest a more established and institutionalized pattern of cooperation, likely shaped by shared policies, funding mechanisms, and health system structures.

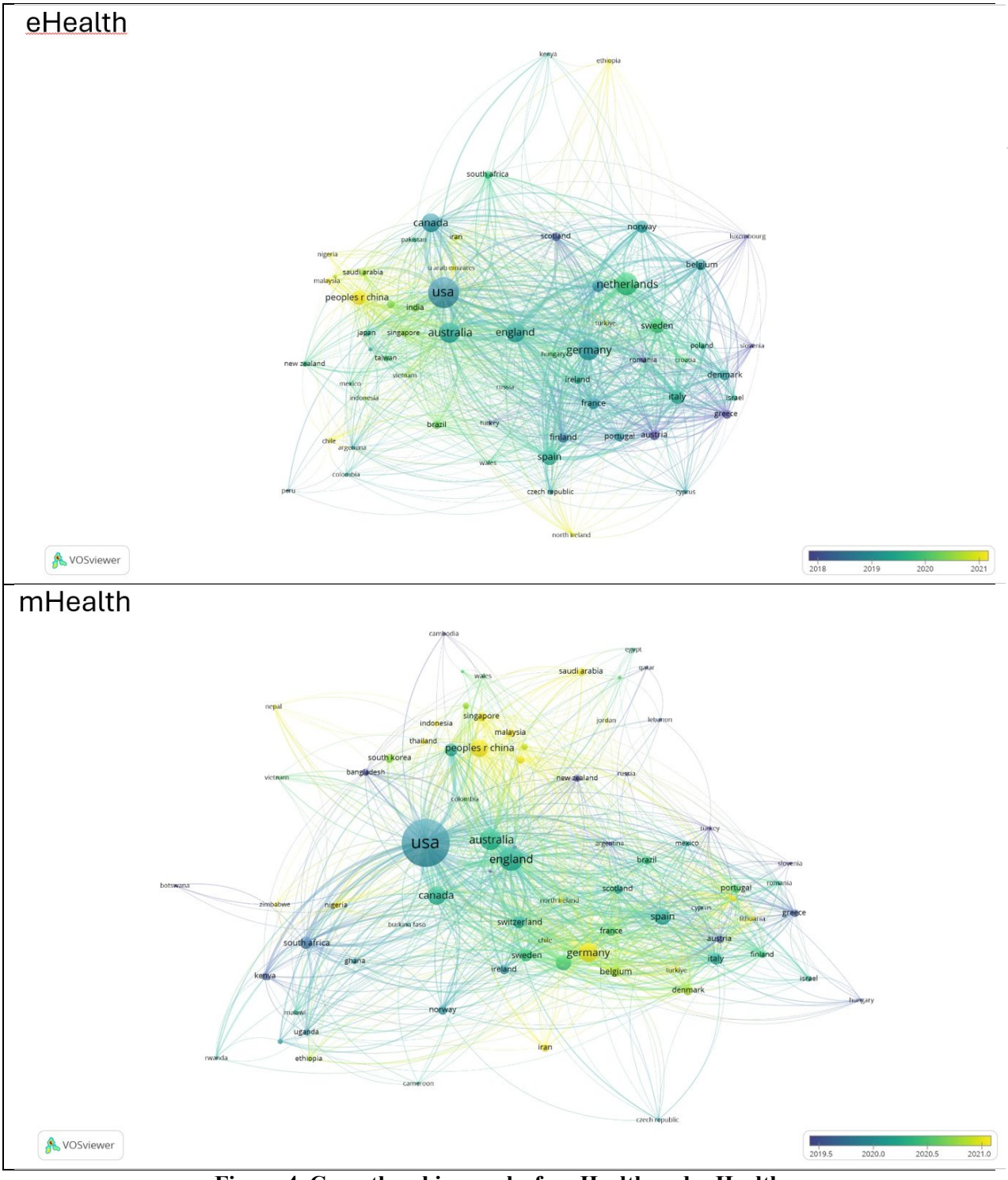


Figure 4. Co-authorship graphs for eHealth and mHealth

Source: Own compilation, generated in VosViewer based on WoS database.

Moreover, the mHealth visualization exhibits a wider geographic dispersion of collaboration lines and a more vibrant distribution of recent activity (lighter colors), indicating a

fresher and faster-growing area of research. In contrast, eHealth collaborations appear slightly more mature and evenly spread over time, as reflected by a more balanced color distribution across the map.

Overall, these visual outputs reinforce the earlier quantitative findings: while eHealth research is deeply rooted in traditional academic systems, mHealth fosters broader and more inclusive global partnerships, reflecting the practical necessity and adaptability of mobile health technologies across a wide range of socio-economic contexts.

To identify the primary thematic directions and conceptual density within the eHealth and mHealth research landscapes, a keyword co-occurrence analysis was conducted using VOSviewer (Figure 5). This analysis reveals how frequently keywords appear together across documents, highlighting the central focus areas of scholarly discourse in each domain.

In the case of eHealth, the term itself forms the dominant node, surrounded by highly connected concepts such as "telemedicine," "health care," "technology," "internet," "management," "chronic disease," and "self-management". A strong cluster also revolves around "health literacy", "eHealth literacy", and "internet use", emphasizing the role of patient engagement and access to digital health information. In parallel, themes related to mental health—including keywords like anxiety, depression, quality of life, randomized controlled trial, and intervention—are frequently co-associated, reflecting a clinical and outcomes-based research orientation. Terms like "electronic health records," "privacy," "interoperability," and "adoption" suggest a continued emphasis on systemic and infrastructure challenges in digital health implementation.

In contrast, the mHealth network places greater emphasis on mobile-based interventions, with keywords such as "mobile health," "smartphone," "mobile phone," "adherence," "text messaging," "engagement," and "behavioral change" appearing prominently. Notably, the mHealth map shows tighter clustering around public health intervention themes, such as "pregnancy," "diabetes," "HIV," and "maternal health," suggesting that mobile solutions are widely applied to disease-specific or population-targeted contexts. Concepts like "monitoring," "reminder systems," and "accessibility" reinforce the application-driven nature of mHealth in low-resource or remote settings.

While both networks display shared intersections with concepts like "telehealth," "usability," "acceptance," and "artificial intelligence", their positioning and strength of connection differ—indicating that while mHealth is more operational and intervention-focused, eHealth maintains a broader systemic and informational scope. Additionally, color gradients indicate a recent shift (2020–2021) toward topics like "COVID-19", "digital literacy", and "online health communication", underlining the rapid adaptation of digital health tools during the pandemic.

These co-occurrence maps offer a strategic insight into the evolving priorities of digital health research, revealing both the technological drivers (e.g., AI, telehealth, mobile platforms) and societal needs (e.g., literacy, access, chronic disease management) shaping the global eHealth and mHealth agendas.

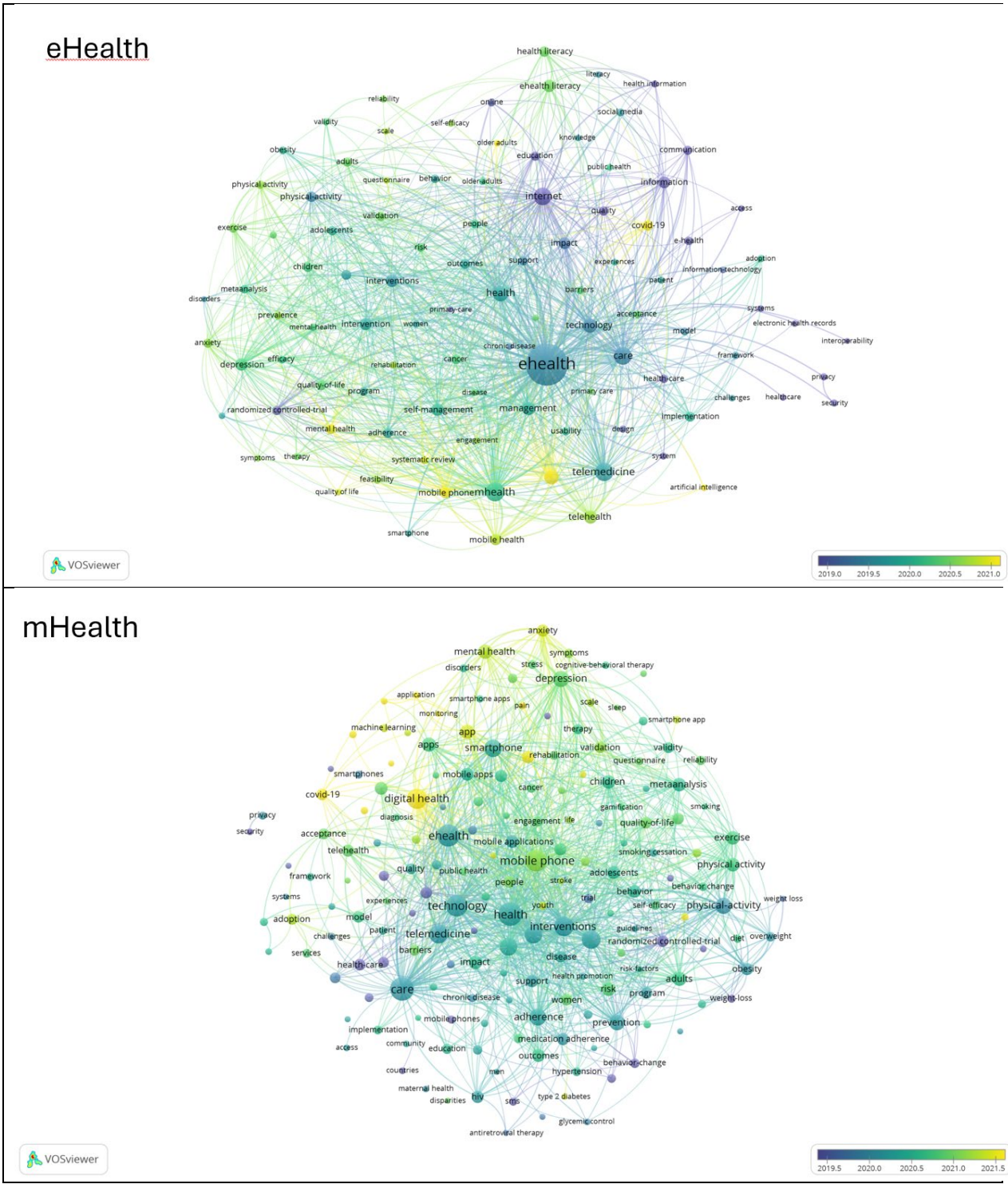


Figure 5. Keywords co-occurrence network by field

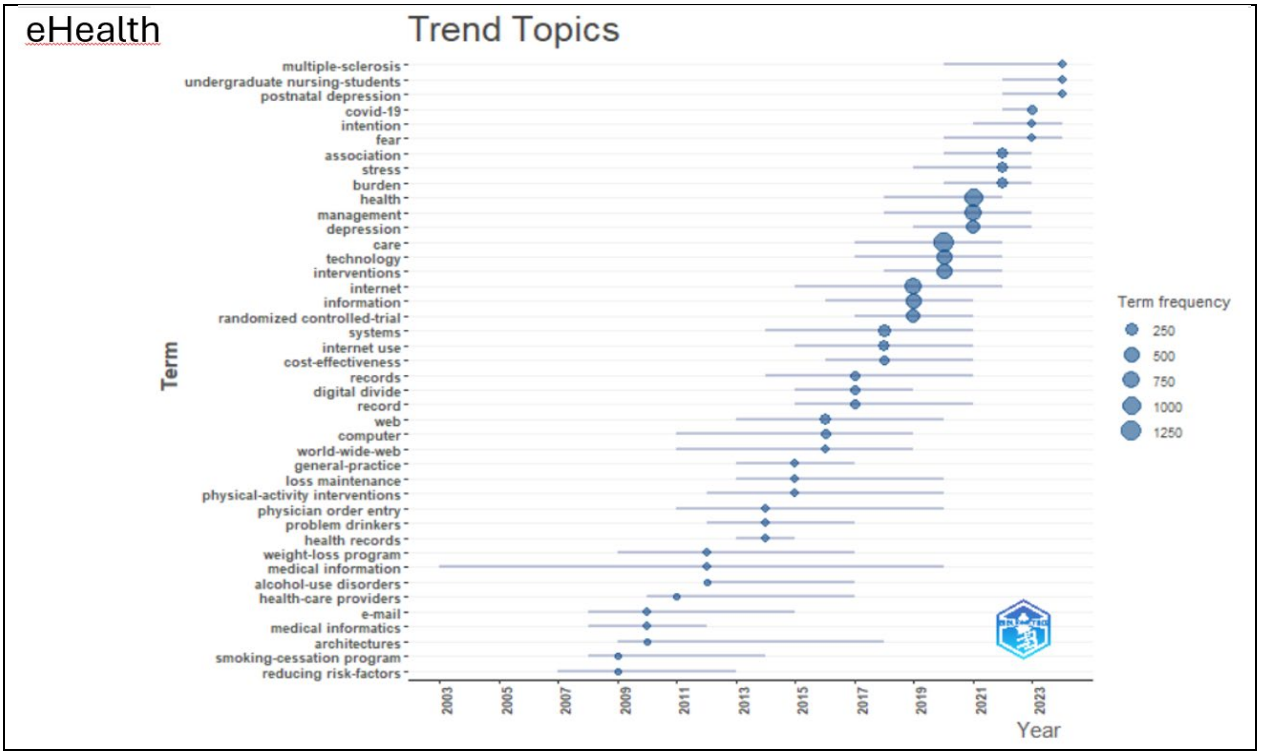
Source: Own compilation, generated in VosViewer based on WoS database.

As part of the bibliometric analysis, a Trend Topics visualization was generated for both eHealth and mHealth, capturing the temporal dynamics of term emergence and frequency within

the literature (Figure 6). This approach helps to reveal not only when certain topics became academically prominent, but also the trajectory of conceptual development across years.

In the case of eHealth, early terms such as "medical informatics", "e-mail", and "web" began appearing as far back as 2003–2007, reflecting the foundational technological pillars of digital transformation in healthcare. Between 2010 and 2017, a noticeable academic shift took place toward topics such as "electronic health records," "internet use," "randomized controlled trial," "health literacy," and "interventions"—marking a move toward applied, patient-centered, and evidence-based research. A peak in term frequency is observed for "health," "technology," "care," and "management", particularly during the 2018–2020 period. Post-2020, emergent topics like "COVID-19", "stress," "fear," "burden", and "intention" signal a surge in research addressing pandemic-induced challenges and mental health in digital contexts.

The mHealth trend map, although structurally similar, indicates a distinct thematic focus. Early research (pre-2010) was sparse and often exploratory, but after 2014, a rapid expansion is observed with keywords such as "text messaging," "mobile phones," "smartphone applications," and "diabetes management" becoming prominent. The term "mHealth" itself gained critical mass around 2015–2017. From 2018 onward, new clusters of interest began to emerge, with high-frequency terms including "self-management," "pregnancy," "maternal health," "behavior change," and "accessibility." This aligns with the practical orientation of mobile health interventions, especially in underserved or remote populations.



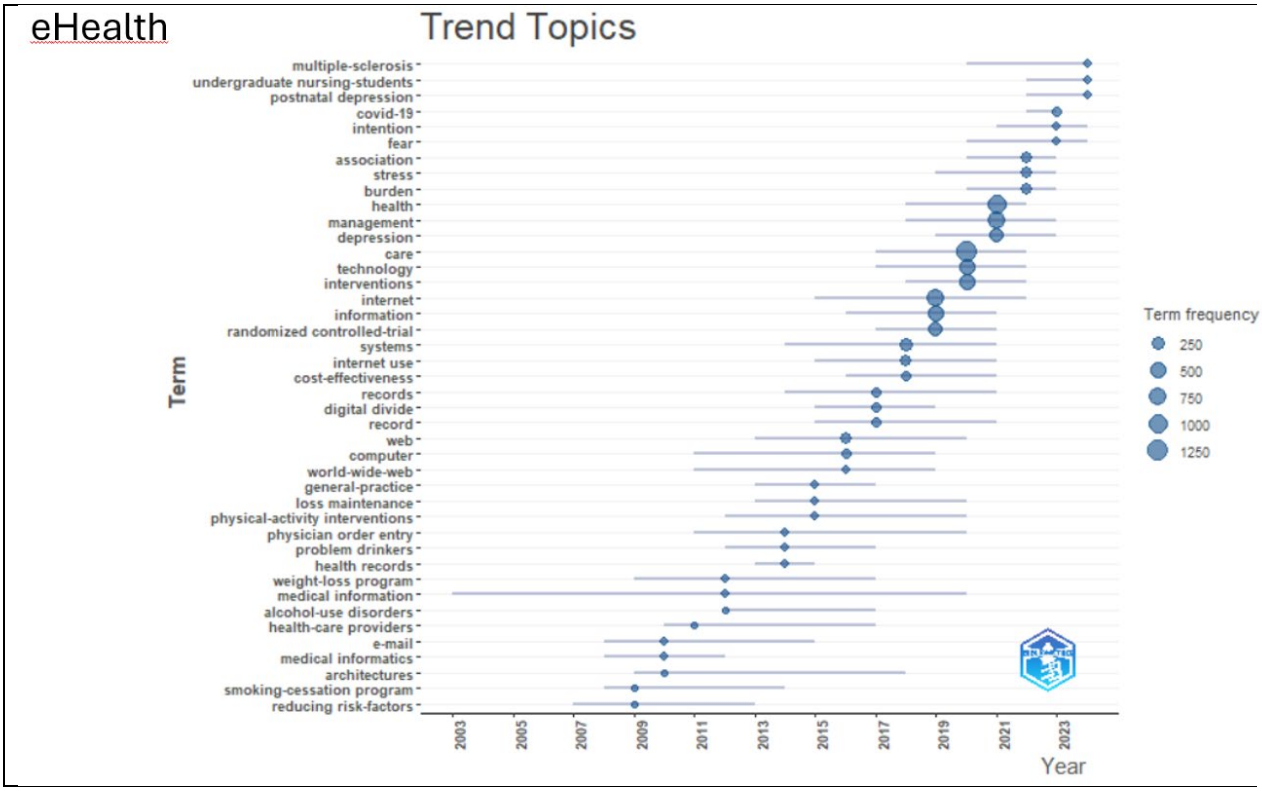


Figure 6. Trend Topic by year
Source: Own compilation, generated in R Studio – Bibliometrix based on WoS database.

What differentiates the two visualizations is the health systems vs. intervention logic: eHealth trend topics often highlight systemic, policy, and infrastructure concerns (e.g., "cost-effectiveness," "interoperability," "digital divide"), whereas mHealth centers more strongly on population-specific interventions, chronic disease management, and mobile usability. Both domains show post-2019 shifts aligned with the COVID-19 pandemic, reflecting the increased relevance of remote healthcare and digital resilience in times of crisis.

In summary, the trend topic analysis reveals a maturing field in eHealth, marked by steady growth in complexity and institutionalization, while mHealth exhibits a more agile, intervention-based trajectory, closely tracking global health needs and technological adoption curves.

Results and discussions

This study provides an integrated overview of the scientific evolution of eHealth and mHealth, two of the most prominent components of the broader digital health ecosystem. Building on both existing literature and advanced bibliometric analysis, we have traced the development of these fields in terms of publication trends, thematic focuses, author productivity, international collaborations, and emerging research clusters. eHealth appears as a well-established domain grounded in systemic, technological, and infrastructural transformations, whereas mHealth shows a more dynamic, application-driven trajectory, with strong links to public health interventions and mobile accessibility.

One of the key contributions of this study lies in addressing several important gaps in the current academic discourse. While previous studies have explored digital health through either technological lenses or clinical outcomes, few have provided a side-by-side bibliometric comparison of eHealth and mHealth, particularly regarding their conceptual overlap, key contributors, collaboration networks, and evolving trends. By applying bibliometric methods such as co-authorship analysis, co-word mapping, and trend topic identification, this study maps the knowledge structure of the field and identifies underexplored yet high-potential areas of inquiry.

At the same time, the research fills critical gaps by differentiating and contextualizing eHealth and mHealth in terms of their respective research maturity, topic clusters, and strategic influence. On the second hand contributes by highlighting overlooked areas such as interoperability standards, digital equity, environmental sustainability of digital infrastructures, and ethical implications of AI in health. The study is offering insight into geographic participation and disparities in research output and collaboration and is presenting a consolidated baseline for scholars, practitioners, and policymakers seeking to orient future investigations and investments in digital health innovation.

Beyond scholarly relevance, the findings reinforce the need for increased public awareness and digital literacy regarding digital health technologies. As healthcare systems worldwide face increasing pressure to become more patient-centered, cost-effective, and scalable, digital health, eHealth, and mHealth emerge not only as technological solutions but also as social enablers, enhancing equity, access, and empowerment. Their intuitive use, scalability, and adaptability make them uniquely positioned to serve marginalized or geographically isolated populations, especially when paired with educational strategies that improve users' confidence and digital engagement.

In conclusion, by offering a comprehensive and comparative understanding of the eHealth and mHealth research landscapes, this study not only synthesizes the current state of knowledge but also provides a strategic vision for the evolution of digital healthcare. The insights gained here can support more targeted, inclusive, and interdisciplinary efforts, laying the groundwork for impactful, evidence-based, and ethically sound innovations in global health.

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