



## Digital health and mobile health: a bibliometric analysis of the 100 most cited papers and their contributing authors

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## Abstract

**Aim:** This study aimed to identify and analyze the top 100 most cited digital health and mobile health (m-health) publications. It could aid researchers in the identification of promising new research avenues, additionally supporting the establishment of international scientific collaboration between interdisciplinary research groups with demonstrated achievements in the area of interest.

**Methods:** On 30th August, 2023, the Web of Science Core Collection (WOSCC) electronic database was queried to identify the top 100 most cited digital health papers with a comprehensive search string. From the initial search, 106 papers were identified. After screening for relevance, six papers were excluded, resulting in the final list of the top 100 papers. The basic bibliographic data was directly extracted from WOSCC using its “Analyze” and “Create Citation Report” functions. The complete records of the top 100 papers were downloaded and imported into a bibliometric software called VOSviewer (version 1.6.19) to generate an author keyword map and author collaboration map.

**Results:** The top 100 papers on digital health received a total of 49,653 citations. Over half of them ( $n = 55$ ) were published during 2013–2017. Among these 100 papers, 59 were original articles, 36 were reviews, 4 were editorial materials, and 1 was a proceeding paper. All papers were written in English. The University of London and the University of California system were the most represented affiliations. The USA and the UK were the most represented countries. The *Journal of Medical Internet Research* was the most represented journal. Several diseases and health conditions were identified as a focus of these works, including anxiety, depression, diabetes mellitus, cardiovascular diseases, and coronavirus disease 2019 (COVID-19).

**Conclusions:** The findings underscore key areas of focus in the field and prominent contributors, providing a roadmap for future research in digital and m-health.

## Keywords

Digital health, bibliometric, anxiety, depression, diabetes mellitus, cardiovascular diseases, coronavirus disease 2019

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## Introduction

Digital health is a popular topic that crosses the fields of healthcare, engineering, and computer science. There are numerous definitions of digital health, and it can be defined as “the application of software or hardware, often using mobile smartphone or sensor technologies to improve patient or population health and health care delivery” [1]. The World Health Organization (WHO) defined digital health as “the field of knowledge and practice associated with the development and use of digital technologies to improve health” [2]. The evolution of the concept “digital health” is intricately connected with the closely related concept “mobile health (m-health)” [3]. m-health could potentially accelerate the delivery of healthcare services in the case of both communicable and non-communicable diseases, by augmenting the transformation of the current standard healthcare system towards more digital approach and innovations, making it more accessible and affordable on a global scale [4]. Following digital health transformation from traditional medicine, the point-of-care has shifted from the clinic or laboratory to the patient themselves, and with the vast amount of digital health data collected and stored in various databases, the diagnostic procedure can shift from domination by individual experience towards an evidence-based or analytical data-driven practice [5]. In this context, digital health technologies have also shown promise in addressing challenges related to rare conditions such as spinal cord injuries, offering avenues for personalized treatment and rehabilitation [6]. Moreover, the integration of biobanking data with digital health platforms is emerging as a potent tool for translational medicine, enhancing the scope and efficacy of interventions [7]. Currently, the relevance of the implementation of digital health products and services is due to the increasing number of people on the planet, the increasing life expectancy and aging population, the increasing number of patients with chronic and viral diseases, and the increasing cost of diagnostic and treatment measures. Digital medicine has great potential for diagnosing, preventing, and treating diseases, predicting outcomes, increasing access to medical care, and monitoring the condition of patients. Moreover, digital technologies help reduce costs and improve the quality and efficiency of medical care [8, 9]. Artificial intelligence (AI) improves the quality of medical care and increases patient safety through improved clinical decision-making, process optimization, and risk management [10, 11]. Deep machine learning and robotic process automation are used in many areas of medicine, and new technologies are emerging [12, 13]. According to experts, the AI market in healthcare will reach \$1,345.2 billion by 2030 [14]. Big data also has huge potential for digital health development. The global big data market in healthcare is also projected to reach \$794.08 billion in 2030 [15, 16]. According to Statista, in 2030, it is anticipated that there will be close to 30 billion Internet of Things (IoT) devices in use worldwide [17]. IoT technologies are actively used in healthcare [18]. Internet of Medical Things (IoMTs) provide ongoing patient monitoring, promote quality improvement, and reduce the cost of care [19]. Telemedicine is also one of the key tools of digital health care. Its use allows for solving both social and economic problems: increasing the availability and quality of medical care, as well as reducing the costs associated with hospitalization and rehabilitation of patients [20]. There is no doubt that the implementation of AI, big data analysis, IoMTs, telemedicine, and remote patient monitoring in healthcare will contribute to improving the level and quality of life of the population, the formation of highly qualified personnel, and intensifying the national economy. For more detailed information on the definitions and scope of the discussed complex concepts, the readers are referred to the following dedicated references: “digital health” [21], “m-health” [22], “innovation” [23], “big data” [24], and “AI” [25].

State entities and international health bodies have underscored their support and called for action to enhance the use of digital health in contemporary healthcare systems during the last decades. In 2020, WHO released a global strategy on digital health for 2020–2025, focusing on capacity building, implementation of national digital health strategies, and access to digital health applications (apps) [2]. In 2023, the United States Agency for International Development (USAID) published a digital health vision for action, underlining strategic priorities for the integration of the existing USAID digital health policy into the global health sector [26]. During the coronavirus disease 2019 (COVID-19) pandemic, the European Union (EU) accelerated the launch of the European Health Union (EHU), a policy initiative intending to strengthen the EU's capacity to respond to health crises and improve the resilience of national healthcare systems. In this frame, the European Health Data Space (EHDS) is a health data-sharing framework with clear rules, common standards, and practices allowing individuals to access and control their personal health data across the EU. This platform leverages interoperability between healthcare and research infrastructure in Europe while providing a paradigm of patient-centeredness and empowerment [27].

In the context of the paradigm shift towards digitalization of healthcare, a rapidly increasing number of studies have been conducted to introduce or evaluate digital health interventions [28, 29]. Although bibliometric studies of the applied categories (i.e., analyses of a specific topic, authors, countries, journals, etc.) were found to have a generally lower citation impact than those studies that actually analyzed author behavior or discussed bibliometric methods, the former group of studies enabled readers to quickly understand the literature landscape of their concerned fields [30]. Moreover, bibliometric analysis may assess the “international influence of scientific work in a reliable, transparent, and objective way” [31]. Subsequently, many bibliometric studies have been published to assess the recurring themes of digital health research, such as digital health behavior change technology [32], the use of AI in digital health [33, 34], digital health literacy [35], the use of digital technology in cognitive assessment and cardiology [36, 37], the use of m-health apps [38], and the app of digital health in pediatric dentistry [39], among others. These previous works clearly demonstrate the merit of bibliometrics research in the target area. Through analysis of large-scale literature data, bibliometrics has a unique role in quantifying scientific knowledge production, at the same time providing a reliable reference for fostering further advancements and a better understanding of future trends in digital health and its related subcategories worldwide [40].

Since so many publications on digital health have been published, it might be difficult for the general audience and researchers alike to quickly identify the most relevant topics and the most influential and cited publications in the field, and who wrote them. As a guide for beginners and the curious, a bibliometric study reporting these pieces of information would be a convenient introduction to the most impactful research in this area. Hence, this work aimed to reveal the top 100 most cited digital health papers and the most productive authors contributing to them. The conducted analysis can be regarded as a compilation highlighting the most impactful (in terms of obtained citations) work in this field that can be a reference for those who wish to understand the types of studies that are conducted and have been highly referenced by the scientific community. Moreover, bibliometric analysis of highly cited articles in the scope of digital health could facilitate researchers to identify promising new research avenues, and establish international scientific collaboration between interdisciplinary research groups with demonstrated achievements in the area of interest, thus providing additional opportunities for the development of new research studies in the field of digital healthcare [41]. The recurring diseases or medical conditions associated with these papers were also identified in this work in order to provide readers with a better understanding of the potential clinical implications associated with the research landscape of this field.

## Materials and methods

On 30th August, 2023, the Web of Science Core Collection (WOSCC) electronic database was queried to identify the top 100 most cited digital health papers. The search strategy was adopted from the previous publication of Yang et al. [35]. In brief, the title, abstract, and keywords fields [topic (TS)] of papers indexed in WOSCC were searched. The #1 search string was: TS = (“digital health” OR “digital health care” OR “digital medicine” OR “eHealth” OR “eHealth care” OR “e-medicine” OR “telehealth” OR “tele-health” OR

“telehealthcare” OR “tele-healthcare” OR “telemedicine” OR “tele-medicine” OR “mHealth” OR “m-health” OR “mHealthcare” OR “m-healthcare” OR “mobile health” OR “mobile healthcare” OR “mobile medicine” OR “online health” OR “online healthcare” OR “online medicine”). The #2 search string was: TS = (“digital” OR “mobile” OR “app” OR “apps” OR “information technology” OR “Internet technology” OR “artificial intelligence” OR “big data” OR “Internet of Things” OR “IoT” OR “Internet of Thing” OR “blockchain” OR “machine learning” OR “digital learning” OR “deep learning” OR “wearable” OR “robotic” OR “robot” OR “robotics” OR “augmented reality” OR “virtual reality”). The #3 search string was: TS = (“health\*”) (\* represents any group of characters, including no character). The search was completed as: #1 OR (#2 AND #3). The search yielded 31,555 papers, which were sorted by descending order of citation count. Papers that did not explicitly focus on digital health or m-health were excluded. WOSCC was chosen over Scopus because the former was a more popular choice of literature database to be consulted by researchers [42]. Two authors (AWKY and AGA) independently screened the list to exclude the irrelevant papers, and any disagreements were resolved by mutual discussion to reach a consensus. Subsequently, six papers were excluded from the top 106, to form the final list of top 100 papers.

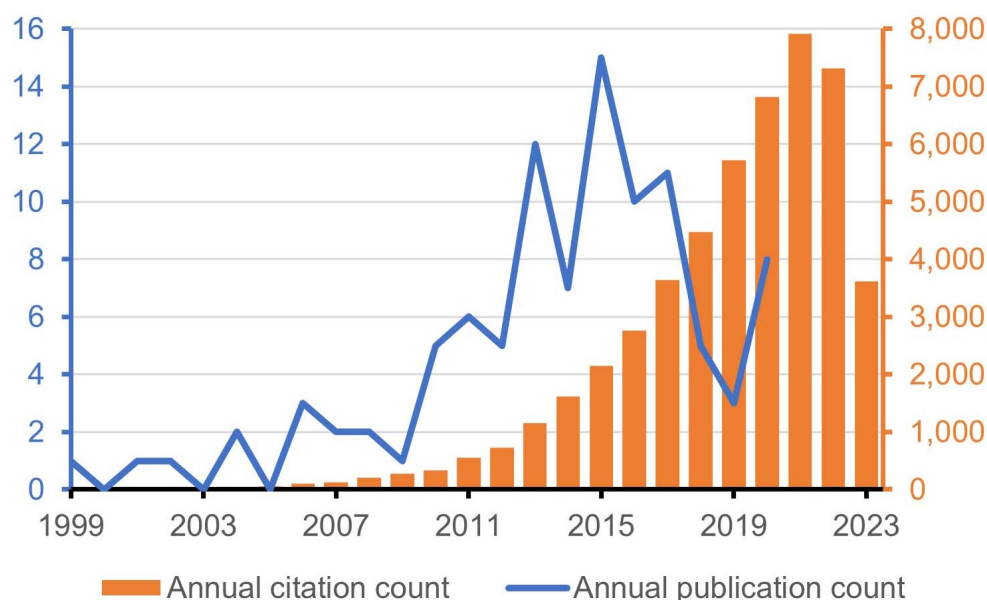
The basic bibliographic data was directly exported from WOSCC via its Analyze and Create Citation Report functions. The full records of the top 100 papers were exported into bibliometric software, VOSviewer (version 1.6.19), with default settings recommended by the user manual of the software, to generate author keyword maps and author collaboration maps [43]. In short, the function of “Create a map based on bibliographic data” was used. Then, the analysis of “co-occurrence > author keywords” was used for the former and the “co-authorship > authors” analysis was used for the latter. “Full counting” method was applied. For both maps, a threshold of 2 was applied, meaning that only author keywords appearing in at least 2 papers or authors contributing at least 2 papers were considered, respectively. In each map, the node size represents the number of papers, and the inter-node distance represents the frequency of co-occurrence in the same papers by the nodes. The node color represents the citations per paper (CPP) for the author keyword map and different clusters for the author collaboration map. Moreover, the list of author names from the top 100 papers was compiled and the gender of the authors was identified by genderize.io (<https://genderize.io/>).

## Results

The top digital health 100 papers (Table S1) received a total of 49,653 citations as of 30th August, 2023. Over half of them ( $n = 55$ ) were published during 2013–2017 (Figure 1). Meanwhile, the annual citation count of these papers experienced stable growth, and collectively they received 7,923 citations in the year 2021 alone. Among these 100 papers, 59 were original articles (CPP = 527.9), 36 were reviews (CPP = 437.6), 4 were editorial materials (CPP = 585.5), and 1 was a proceeding paper (CPP = 414.0). All of them were written in English.

The top 5 most represented authors, affiliations, countries, journals, and journal categories among the top 100 digital health papers are listed in Table 1. University of London ( $n = 11$ , CPP = 550.3) and the University of California system ( $n = 10$ , CPP = 439.4) were the most productive affiliations. Accordingly, the USA ( $n = 58$ , CPP = 513.2) and the UK ( $n = 20$ , CPP = 513.5) were the most productive countries. The *Journal of Medical Internet Research* ( $n = 21$ , CPP = 459.1) was by far the most productive journal, while both medical informatics ( $n = 35$ , CPP = 469.7) and health care sciences & services ( $n = 33$ , CPP = 476.4) were the most productive journal categories.

Name analysis from genderize.io indicated that the top 100 papers were authored by 327 men and 184 women (approximately 1.8:1, 36.0% women). The most productive authors among the top 100 digital health papers were examined more closely. The author collaboration map showed that there were 44 authors, each with at least 2 papers among the top 100, distributed in 12 clusters (Figure 2). The most productive authors (Table 1) were clustered as demonstrated in Figure 2. The most productive author, Mohr DC was in the yellow cluster with Schueller SM, a cluster with authors mainly working in the USA. Meanwhile, Spring BJ, Riley WT, West R, and Yardley L were in the red cluster, a cluster with authors based in the USA and the UK. The orange cluster had Chau PYK and Hu PJH showing a collaboration between



**Figure 1.** Annual publication and citation counts of the top 100 digital health papers

**Table 1.** Top 5 most represented authors, affiliations, countries, journals, and journal categories

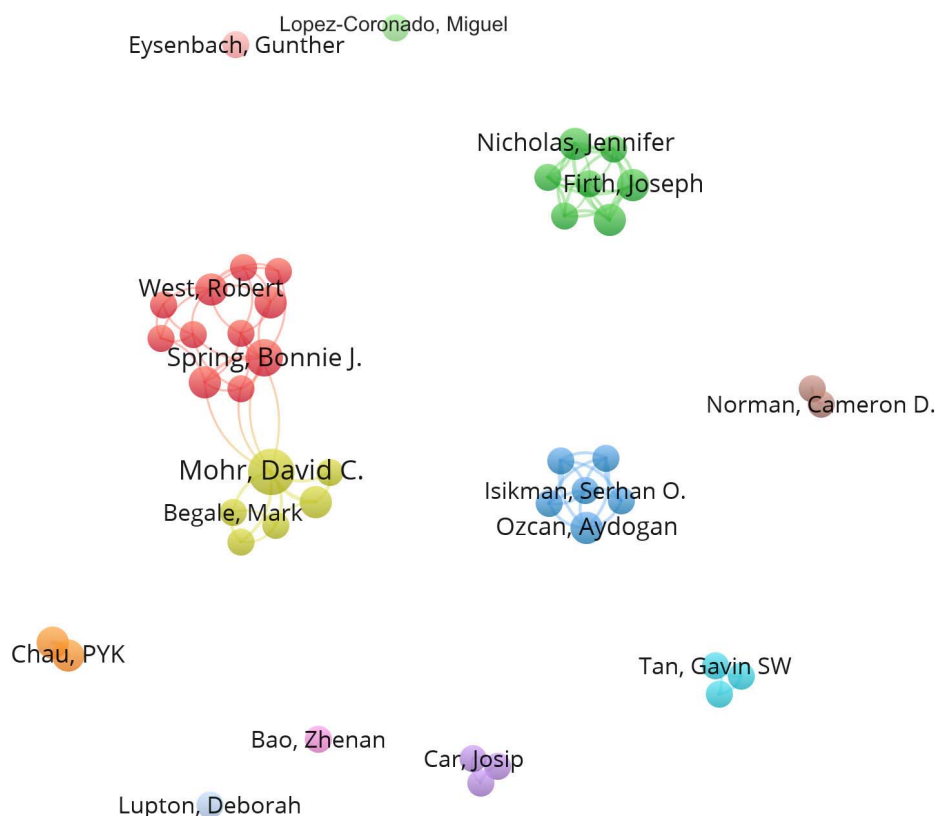
Entity	Number of publications	CPP
<b>Authors</b>		
Mohr, David C.	6	378.3
Spring, Bonnie J.	4	528.3
Chau, Patrick Y. K.	3	706.3
Firth, Joseph	3	362.0
Hu, Paul J. H.	3	706.3
Nicholas, Jennifer	3	362.0
Ozcan, Aydogan	3	404.7
Riley, William T.	3	506.3
Schueller, Stephen M.	3	353.0
Torous, John	3	362.0
West, Robert	3	392.3
Yardley, Lucy	3	471.3
<b>Affiliations</b>		
University of London	11	550.3
University of California system	10	439.4
Northwestern University	9	425.3
University College London	9	476.3
Harvard University	8	578.0
<b>Countries</b>		
USA	58	513.2
UK	20	513.5
Australia	12	432.2
Canada	9	631.8
China	9	556.4
<b>Journals</b>		
<i>Journal of Medical Internet Research</i>	21	459.1
<i>International Journal of Medical Informatics</i>	5	440.4
<i>American Journal of Preventive Medicine</i>	3	444.3
<i>JMIR mHealth and uHealth</i>	3	728.0
<i>Healthcare Informatics Research</i>	2	355.0
<i>JAMA</i>	2	735.0

**Table 1.** Top 5 most represented authors, affiliations, countries, journals, and journal categories (*continued*)

Entity	Number of publications	CPP
JMIR Mental Health	2	486.5
Lab on a Chip	2	370.5
PLOS Medicine	2	1104.5
Scientific Data	2	385.0
Translational Behavioral Medicine	2	552.5
Journal categories		
Medical informatics	35	469.7
Health care sciences & services	33	476.4
Medicine general internal	13	605.2
Public environmental occupational health	12	430.7
Computer science information systems	11	547.6

More than 5 names are displayed for authors and journals, due to the equal number of publications for several authors or journals that were ranked in 5th place

China and the USA. The green cluster had Firth J, Nicholas J, and Torous J, who had affiliations with the USA, the UK, and Australia. Finally, the blue cluster had Ozcan A, and authors within this cluster were mostly based at the University of California Los Angeles. Besides those authors listed in Table 1, there were two 3-author clusters: the Singaporean cluster (cyan) and the UK cluster (purple). Other five clusters had 1 or 2 authors each.



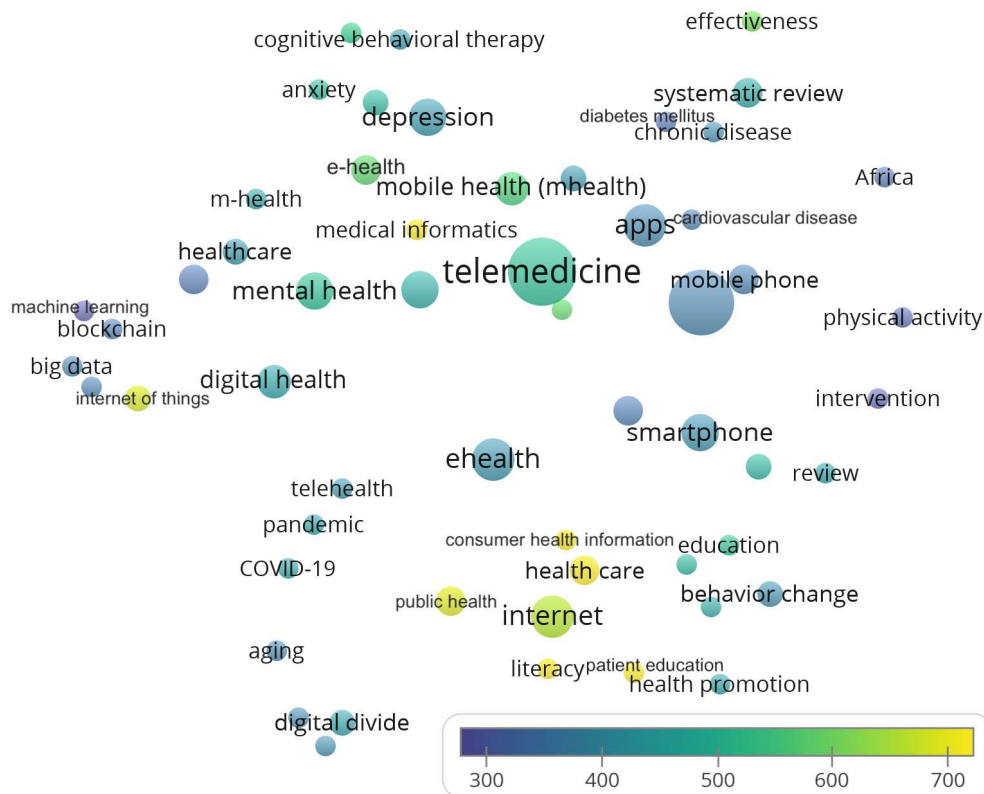
**Figure 2.** Author collaboration map

At the country level, the extent of international collaboration was explored. For the 69 papers with authors based in the USA and the UK, international collaborations were observed with China ( $n = 8$ ), and to a lesser extent with the following: Australia and Germany (each  $n = 4$ ); Canada, Singapore, and Sweden (each  $n = 3$ ); Brazil, India, Netherlands, South Korea, and Switzerland (each  $n = 2$ ). Fourteen collaborators with  $n = 1$  were not listed here. Meanwhile, for the 9 papers with authors based in China, international



collaborations were observed with the USA ( $n = 8$ ), and to a lesser extent with the UK, Singapore, and Sweden (each  $n = 2$ ). Similarly, seven collaborators with  $n = 1$  were not listed here.

Then, the author's keywords were examined to identify recurring themes among the top 100 digital health papers. Several common diseases and health conditions could be observed, such as anxiety ( $n = 2$ , CPP = 486.5), depression ( $n = 6$ , CPP = 413.3), diabetes mellitus ( $n = 2$ , CPP = 342.5), cardiovascular diseases ( $n = 2$ , CPP = 360.5), and COVID-19 ( $n = 2$ , CPP = 445.5) (Figure 3). Among the recurring authors, keywords were also "public health" ( $n = 4$ , CPP = 674.5), "literacy" ( $n = 2$ , CPP = 850), "patient education" ( $n = 2$ , CPP = 857.0), "consumer health information" ( $n = 2$ , CPP = 743.0), and "internet" ( $n = 8$ , CPP = 640.0), which all fit into the theme of "digital health literacy", underling the high significance of digital media as an important source of health information for patients with chronic diseases and other health conditions.



**Figure 3.** Author keywords map

## Discussion

This bibliometric analysis identified the top 100 digital health publications. The article-to-review ratio was approximately 1.6:1. More than half of the publications ( $n = 55$ ) were published during the middle of the 2010s. The annual citation count of these papers grew steadily, and collectively they received nearly 8,000 citations in the year 2021 alone. The majority of these 100 papers are original articles and reviews. All of them were written in English.

It is noteworthy that the majority of these top-cited papers were published between 2013 and 2017, indicating a surge in interest and research output during this period. This could be reflective of technological advancements and increased funding in digital health research. Furthermore, the *Journal of Medical Internet Research* emerged as the most productive journal, suggesting that it serves as a central platform for high-impact research in this field. Interestingly, numerous journals with high Journal Citation Reports (JCR) impact factor, which are cherished by the scientific community in the area of digital health (e.g., *Nature Biotechnology*, *Lancet Digital Health*, *Nature Medicine*, *npj Digital Medicine*), were not highly represented in the list of the 100 most cited publications (Table 1). These findings might be due, at least in part, to the larger number of papers published in journals such as the *Journal of Medical Internet Research*

in combination with the poor prediction power of journal editors, manuscript reviewers, and submitting authors to judge the future citation-potential of manuscripts at the time of manuscript submission or during peer-review process.

In regard to the analyzed countries with the highest productive output, findings from previous similar studies also indicate that articles from the USA are often among the most cited, although this tendency seems to be changing with the growing publication rates from up-and-coming countries like China and India, depending on the specific domains investigated [44]. Meanwhile, there seemed to be gender disparity in the authorship of the top 100 papers, as 36.0% of authors were women, consistent with previous findings from cardiology-related COVID-19 literature (29.9%) [45] and neuroscience (35.3%) [46]. It was suggested that historical numerical imbalance, socio-psychological factors, and cultural reasons contributed to the gender disparity, and policies to establish a more egalitarian and heterogeneous scientific community should be advocated [47].

Several diseases and health conditions were found among the recurring author keywords, such as anxiety, depression, diabetes mellitus, cardiovascular diseases, and COVID-19. Regarding anxiety and depression, Firth et al. [48] conducted a meta-analysis of randomized controlled trials for each. They found that smartphone interventions could significantly reduce the total anxiety scores compared to control conditions across samples with sub-clinical or diagnosed anxiety disorders (publication ranked 81st in Table S1, 322 citations). They also found that depressive symptoms were reduced significantly more from smartphone apps than control conditions, and cognitive training apps had a significantly smaller effect size on depression outcomes than those focusing on mental health [49] (publication ranked 38th in Table S1, 461 citations). Meanwhile, the most cited randomized controlled trial on anxiety and depression was conducted by Fitzpatrick et al. [50] (publication ranked 20th in Table S1, 599 citations), which found that young adults who received a text-based conversational agent significantly reduced their symptoms of both depression and anxiety over a 2-week study period, whereas those who received a mental health electronic book (eBook) significantly reduced their anxiety but not depression.

The authors of the article “The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis”, which ranks second in the citation (1,440 citations) in Table S1, note the modest advantages of using mobile technologies and the need for further research [51]. The high citation of the publication confirms further research in this area and represents the experience of using digital technologies in medicine and their social and economic effectiveness. Further publications citing the work discuss the need for safety and the proven effectiveness of new digital healthcare products.

In the third most cited publication (1,286 citations) in Table S1, an analysis of the security and privacy of the IoT and their impact on the economy and society was carried out [52]. The high citation of this publication confirms the relevance of these issues at this time. It is necessary to conduct clinical research on digital medical devices and services. An increasing number of digital health products are being developed to help reduce morbidity and mortality and increase patient satisfaction with the quality and availability of care.

In the context of diabetes, Ting et al. [53] (publication ranked 7th in Table S1, 1,039 citations) developed a deep learning system that could reliably identify diabetic retinopathy and related eye diseases to facilitate better patient screening. Meanwhile, Cafazzo et al. [54] (publication ranked 50th in Table S1, 392 citations) developed a mobile app to facilitate the self-management of adolescents with diabetes. They found that participants enjoyed the reward system and the microblogging community: the former meant that a user would be awarded “game points” to redeem mobile apps and music if he/she adhered to the preset goals (e.g., 3 or more daily blood glucose tests), whereas the latter meant that users could communicate with one another through a social platform resembling Twitter (recently renamed X).

For cardiovascular disease, Chow et al. [55] (publication ranked 41st in Table S1, 431 citations) found that the use of a lifestyle-focused text messaging service among patients with coronary artery disease led to a modest improvement in low-density lipoprotein cholesterol levels and greater improvement in other

cardiovascular disease risk factors such as an increase in physical activity and decrease in smoking, compared with usual care. Meanwhile, the American Heart Association has reviewed and acknowledged the studies on using m-health to manage numerous risk factors of cardiovascular disease, such as weight management, increased physical activity, and smoking cessation [56] (publication ranked 75th in Table S1, 332 citations).

Last but not least, COVID-19 was among the most represented diseases. For instance, the use of telemedicine and virtual care for remote treatment of patients during the COVID-19 pandemic was summarized from 35 research studies [57] (publication ranked 60th in Table S1, 364 citations). Meanwhile, the conceptual framework of telemedicine integration and implementation into the national healthcare system during the COVID-19 pandemic has been discussed and its app was examined for numerous countries [58] (publication ranked 27th in Table S1, 514 citations).

While informative, this study has several inherent limitations. The dynamic character of citation counts is one of them. Because citations build over time, the rankings of the most cited articles are susceptible to change, making these findings reflective of the current research scene. Total citation numbers are also a time-dependent phenomenon that might favor older papers, which had more time to accumulate citations. Furthermore, the specific collection and citation count of the WOSCC database influence the results. Hence, other databases, such as Scopus or Dimensions, may yield different findings. Last but not least, while citation counts were used as a measure of scientific attention, it is important to note that many citations do not always speak to a paper's scientific quality or real-world influence. In essence, papers can be referenced for various reasons, and not all of them will reflect well on the work's content.

This bibliometric research highlights the changing environment of digital health, which is characterized by a convergence of advanced technologies and patient-centered care paradigms. The analysis corroborates the notion that the introduction of digital technologies in healthcare improves access to medical services and their quality, optimizes the use of healthcare resources, and improves patient safety. The prevalence of themes such as anxiety, depression, diabetes mellitus, cardiovascular diseases, and especially COVID-19 demonstrates the versatility and necessity of digital health treatments in treating both chronic and emergent health challenges. Notably, institutions such as the University of London and the University of California are pioneering the way, reflecting worldwide contributions, with the USA and the UK being especially active in this arena. The dominance of journals such as the *Journal of Medical Internet Research* highlights the importance of dedicated channels for disseminating digital health research. As the digital health industry expands, it is critical to evaluate and analyze its bibliometric environment regularly to comprehend evolving paradigms and ensure that technical improvements fit with healthcare demands.

## Abbreviations

AI: artificial intelligence

apps: applications

COVID-19: coronavirus disease 2019

CPP: citations per paper

EU: European Union

IoT: Internet of Things

m-health: mobile health

WOSCC: Web of Science Core Collection

## Supplementary materials

The supplementary material for this article is available at: [https://www.explorationpub.com/uploads/Article/file/101113\\_sup\\_1.pdf](https://www.explorationpub.com/uploads/Article/file/101113_sup_1.pdf).

## Declarations

### Author contributions

AWKY: Conceptualization, Investigation, Writing—original draft, Writing—review & editing. AGA: Conceptualization, Investigation, Writing—review & editing. OL, NLB, YK, MMR, ZS, RSHI, AK, AOA, JMF, NR, SMSI, DT, GV, GO, JN, AGG, MRS, DH, YY, MAI, HC, EBS, HPD, MAL, JGM, NTT, MM, OA, SVK, FPH, FBM, BNS, DW, JS, JOH, MK, EP, IB, A Józwik, NK, BZK, BS, GP, DB, TYW, BSG, MB, C Tomasik, SK, STW, RL, FAN, RKS, AM, HM, A Juhi, SM, M Cenanovic, AZ, C Tsagkaris, R De, SSC, R Damaševičius, MN, AS, OE, M Cascella, and HW: Writing—review & editing. All authors read and approved the submitted version.

### Conflicts of interest

Atanas G. Atanasov is an Advisory Board member of QluPod AG, a health-tech company aiming for the development of innovative telehealth solutions, and Editor-in-Chief of *Exploration of Digital Health Technologies*. Andy Wai Kan Yeung, Nicola Luigi Bragazzi, Yousef Khader, Md. Mostafizur Rahman, Zafar Said, Robert S. H. Istepanian, Anastasios Koulaouzidis, Adeyemi Oladapo Aremu, James M. Flanagan, Navid Rabiee, Sheikh Mohammed Shariful Islam, Devesh Tewari, Ganesh Venkatachalam, Giustino Orlando, Josef Niebauer, Alexandros G. Georgakilas, Mohammad Reza Saeb, Yufei Yuan, Muhammad Ali Imran, Huanyu Cheng, Eliana B. Souto, Hari Prasad Devkota, Maurizio Angelo Leone, Jamballi G. Manjunatha, Nikolay T. Tzvetkov, Dongdong Wang, Jivko Stoyanov, Emil Parvanov, Gaurav Pandey, Maciej Banach, Seifedine Kadry, Aleksandra Zielińska, and Marco Cascella are Editorial Board members of *Exploration of Digital Health Technologies*. Atanas G. Atanasov and all the Editorial Board members mentioned above had no involvement in the decision-making or the review process of this manuscript. The other authors declare that they have no conflicts of interest.

### Ethical approval

Not applicable.

### Consent to participate

Not applicable.

### Consent to publication

Not applicable.

### Availability of data and materials

The dataset analyzed for this study are included in the manuscript and the Supplementary materials.

### Funding

Not applicable.

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