

Original Paper

Exploring the Shift in International Trends in Mobile Health Research From 2000 to 2020: Bibliometric Analysis

Jianfei Cao¹, MSc; Yeongjoo Lim², PhD; Shintaro Sengoku³, PhD; Xitong Guo⁴, PhD; Kota Kodama¹, PhD

¹Graduate School of Technology Management, Ritsumeikan University, Ibaraki, Japan

²Department of Business Administration, Ritsumeikan University, Ibaraki, Japan

³Department of Innovation Science, Tokyo Institute of Technology, Tokyo, Japan

⁴Institute at School of Management, Harbin Institute of Technology, Harbin, China

Corresponding Author:

Kota Kodama, PhD

Graduate School of Technology Management

Ritsumeikan University

Ibaraki

Japan

Phone: 81 0726652448

Email: kkodama@fc.ritsumei.ac.jp

Abstract

Background: Smartphones have become an integral part of our lives with unprecedented popularity and a diverse selection of apps. The continuous upgrading of information technology has also enabled smartphones to display great potential in the field of health care.

Objective: We aimed to determine the future research direction of mobile health (mHealth) by analyzing its research trends and latest research hotspots.

Methods: This study collected mHealth-related literature published between 2000 and 2020 from the Web of Science database. Descriptive statistics of publication trends of mHealth research were determined by analyzing the annual number of publications in the literature and annual number of publications by country. We constructed visualization network maps of country (or regional) collaborations and author-provided keyword co-occurrences, as well as overlay visualization maps of the average publication year of author-provided keywords to analyze the hotspots and research trends in mHealth research.

Results: In total, 12,593 mHealth-related research papers published between 2000 and 2020 were found. The results showed an exponential growth trend in the number of annual publications in mHealth literature. JMIR mHealth and uHealth, the Journal of Medical Internet Research, and JMIR Research Protocols were the 3 top journals with respect to number of publications. The United States remained the leading contributor to the literature in this area (5294/12,593, 42.0%), well ahead of other countries and regions. Other countries and regions also showed a clear trend of annual increases in the number of mHealth publications. The 4 countries with the largest number of publications—the United States, the United Kingdom, Canada, and Australia—were found to cooperate more closely. The rest of the countries and regions showed a clear geographic pattern of cooperation. The keyword co-occurrence analysis of the top 100 authors demonstrated 5 clusters, namely, development of mHealth medical technology and its application to various diseases, use of mHealth technology to improve basic public health and health policy, mHealth self-health testing and management in daily life, adolescent use of mHealth, and mHealth in mental health. The research trends revealed a gradual shift in mHealth research from health policy and improving public health care to the development and social application of mHealth technologies.

Conclusions: To the best of our knowledge, the most current bibliometric analysis dates back to 2016. However, the number of mHealth research published between 2017 and 2020 exceeds the previous total. The results of this study shed light on the latest hotspots and trends in mHealth research. These findings provide a useful overview of the development of the field; they may also serve as a valuable reference and provide guidance for researchers in the digital health field.

(JMIR Mhealth Uhealth 2021;9(9):e31097) doi: [10.2196/31097](https://doi.org/10.2196/31097)

KEYWORDS

mobile health; digital health; digital medicine; bibliometric analysis; journalology; data visualization; co-occurrence analysis; research trends; mental health; mHealth; paradigm; innovation; smartphone; research; trend; literature; bibliometric; review; app; cooperation; development; public health; health policy; self-management; adolescent

Introduction

In recent years, smartphones have become popular in many countries; especially in high-income countries such as the United Kingdom and the United States—as of September 2019, the smartphone penetration rate is as high as 80% [1]. With the popularity of smartphones, the richness of smartphone app functions and the anytime-anywhere operability provide more opportunities for health promotion, especially in the medical field [2,3]. Services for medical and public health supported by mobile devices is defined as mobile health (mHealth). The outbreak of coronavirus disease 2019 (COVID-19) in 2020 has exposed the lack of medical resources in many countries [4-7]. In this context, mHealth apps can monitor body information, such as heart rate, as well as behavioral information, such as real-time acceleration, through smartphones, smartwatches, and other mobile devices. This can enable people to check their health status at any time and provide medical staff with more reference data [8-10]. Therefore, the development of mHealth can alleviate the shortage of medical resources to a certain extent [11,12]. The great potential shown by mHealth in the medical field has received attention from researchers in many countries [13]. A focus for an increasing number of researchers is to determine how further developments in the mHealth field can reasonably create more social value; therefore, it is necessary to have an in-depth understanding of current research trends and hot spots in mHealth.

Bibliometrics can quantify comprehensive textual information to provide numerical statistics on the development process of a particular topic [14]. The quantified numerical information can also help scholars identify the future trends of a subject [15]. Bibliometrics is widely used in academics, specifically for the in-depth analysis of journal papers [16,17]. Recently, researchers have developed many tools that meet the needs of bibliographic analysis and enrich the bibliographic treatment, such as for the analysis of co-authors' countries (or regions) and research institutions to elucidate the collaboration between different regions or research institutions [18-20], the extraction of keywords for co-occurrence analysis to identify research hotspots [21,22], and keyword clustering to identify the main research directions in a field [23,24]. Thus, bibliometrics plays an important role, both in providing an overview of the past and to provide predictive information.

Currently, there are only a few papers on bibliometric analyses of mHealth literature. Sweileh et al [13] searched Scopus for mHealth papers between 2006 and 2016 and found that most keywords were related to diabetes, medication adherence, and obesity. This study also found an exponential growth in mHealth literature.

Shen et al [25] collected 2704 papers related to mHealth from the Web of Science database as of 2016. Although different from the database searched by Sweileh et al [13], the results of

the 2 studies were similar in that both found the United States to be the most active country in mHealth research worldwide; they also showed an exponential growth trend in publications on mHealth in the Web of Science. By identifying the keywords, Shen et al [25] classified the research hotspots in mHealth research into the following 4 main areas: (1) patient engagement and patient intervention, (2) health monitoring and self-care, (3) mobile device and mobile computing, and (4) security and privacy.

Another bibliometric analysis [26] of mHealth literature, published in 2020, focused on papers related to mHealth apps. A total of 2802 papers published between 2000 and 2019 were collected from the Web of Science. The current state of research, research trends, hotspots, and coauthorship networks showed that the United States, England, Australia, and Canada were the most productive countries for mHealth apps research and the hot topics of mHealth apps research formed 5 clusters: (1) technology and system development of mobile health apps, (2) mobile health apps used in mental health, (3) mobile health apps used as mobile health tools in telemedicine, chronic disease, and medication adherence management, (4) mobile health apps used in health behavior and health promotion, and (5) mobile health apps used in disease prevention via the internet.

However, a gap—between 2017 and 2020—in bibliometric analysis of mHealth research remains. Both Sweileh et al [13] and Shen et al [25] found that there was an exponential growth trend up until 2016; therefore, it can be expected that the number would have grown substantially from 2017 to 2020. In fact, the number of publications in the mid-2017 to 2020 period surpasses the previous total. Therefore, a renewed bibliometric analysis of mHealth research from 2000 to 2020 was necessary. The period 2000 to 2020, instead of only 2017 to 2020, was chosen to facilitate the calculation of logical growth curves for publications and the visualization of trends in research hotspots.

Methods

Data Collection

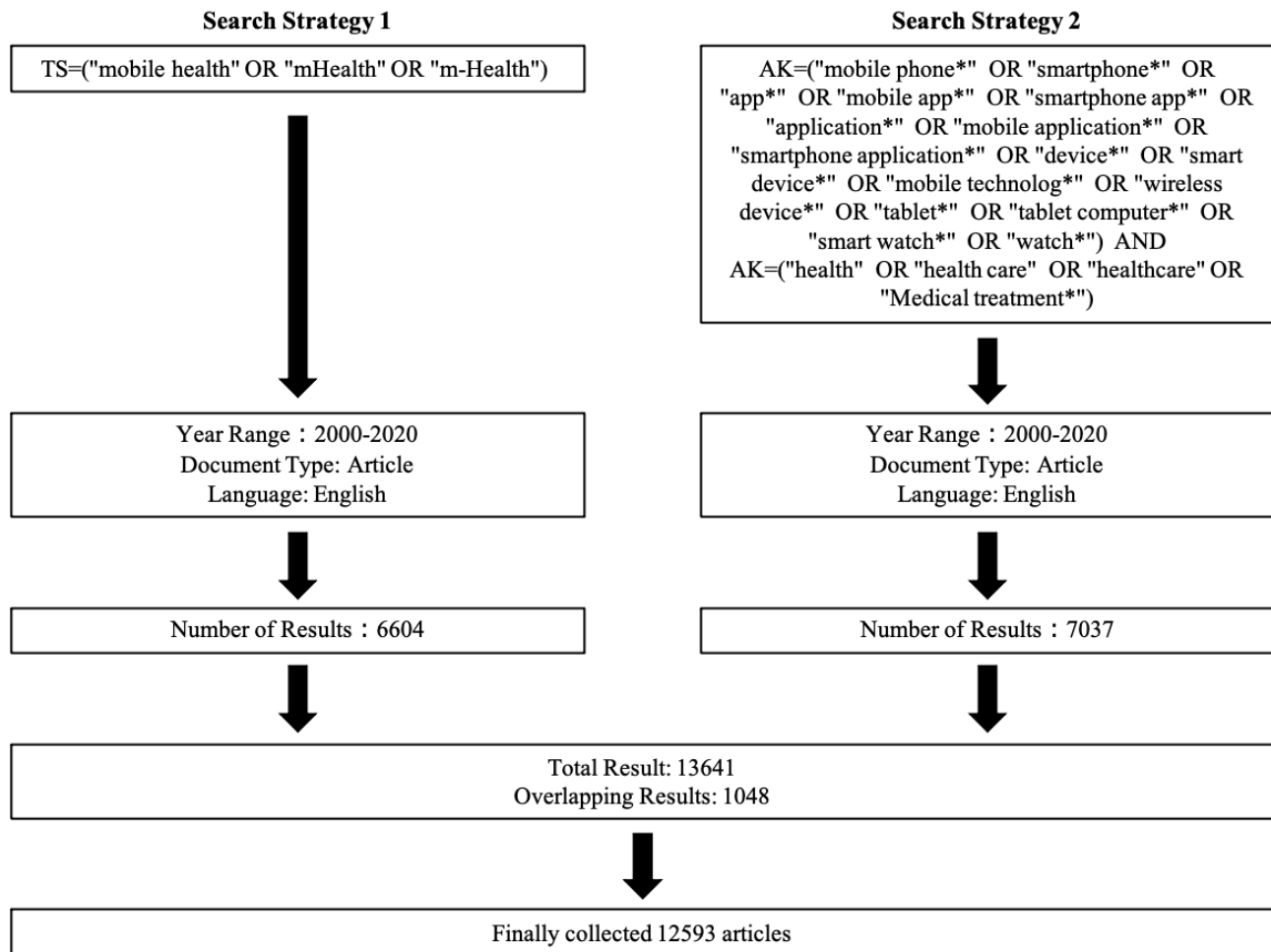
We collected metadata (paper title, abstract, author keywords, author information, country, and references [27]) on papers related to mHealth published between 2000 and 2020 from the Web of Science database. The Web of Science database was chosen because it covers a wide range of fields of study and includes 21,000 peer reviewed and high-quality journals. In addition, the Web of Science includes 6 high-impact citation databases, the Science Citation Index extension, Social Science Citation Index, and many regional databases [28] in its core collection. Thus, the Web of Science database was considered to be appropriate for the bibliometric analysis.

We conducted searches using mHealth and its synonyms as search-topic keywords (in titles, abstracts, and author-provided keywords) to find potential publications related to mHealth;

however, this simple approach has a major limitation. As Sweileh et al [13] suggested, many researchers might not identify their papers as focusing on mHealth though the papers are mHealth-related. Therefore, a second search strategy was also used. Given that mHealth depends on mobile devices, we searched for author-provided keywords related to both mobile devices and mHealth (smartphone, mobile phone, etc) and general health (health, health care, etc). Author-provided keyword searches were used instead of topic searches because the latter may have led to the inclusion of papers that did not

emphasize the study of mobile devices and health, whereas the former represents keywords chosen by authors to highlight the contents of their papers. Thus, we determined that searching for author-provided keywords would be more appropriate to collect articles related to mHealth. Both search strategies were conducted for the period from 2000 to 2020, and only papers published in English were retrieved (Figure 1). We implemented the search on March 2, 2021. The results from both strategies were aggregated, and duplicates were removed.

Figure 1. Data collection strategy for mHealth research bibliometric analysis. AK: author-provided keywords; TS: topic search.



Data Analysis

We used VOSviewer (version 1.6.15) for data analysis. In bibliometric analysis, mapping and clustering techniques can provide insight into network structure and are usually used together [28,29]; however, these 2 techniques were developed independently and rely upon different ideas and assumptions. Waltman et al [30] proposed a unified mapping approach and clustering, which is used in VOSviewer [31]. This tool has been used in bibliometric analyses in many fields [32,33].

The annual number of publications, the annual growth rate, *AGR*; relative growth rate, *RGR*; doubling time, *DT*; and the growth curve of publications were calculated to observe publication trends in mHealth literature using Excel (version 2013; Microsoft Inc). In the growth curve, *x* is the number of years of growth since 2000, and *y* is the cumulative number of

publications. We examined the coefficient of determination (R^2) to confirm the explanatory power of the growth curve. *AGR* was defined as the percentage change in the number of publications per year and is calculated with the following formula: $AGR = [(N_2 - N_1) / N_1] * 100$, where *N* is the annual number of publications. *RGR* was defined as the growth rate of the cumulative number of publications per unit of time and was calculated with the following formula [13,34]: $RGR = [(lnTN_2 - lnTN_1) / (T_2 - T_1)] * 100$, where *T* is the year and *TN* is the cumulative number of publications. *DT* was defined as the number of times the number of publications double in 1 year and was calculated with the following formula [13,34]: $DT = 0.693/RGR$.

In addition, we analyzed the publication trends by country (or region) and the distribution of publications by journal. Using

VOSviewer, we created bibliometric maps for social networks, based on countries and regions, to identify international partnerships in the mHealth field.

In this study, we did a co-occurrence analysis using author-provided keywords in VOSviewer to elucidate research hotspots in the mHealth field. We set the minimum number of co-occurrences to 50. The keywords *mHealth* and *smartphone* (as well as keywords with a similar meaning) appeared more frequently because of the search strategy and took up a large weight in the co-occurrence network graph. Such keywords were considered to influence the distribution of the remaining keywords; hence, we removed the keywords used in the search strategy that appeared in the results, to focus the results on valuable research-topic buzzwords. We then extracted the top 100 keywords and mapped them into a keyword co-occurrence network. The top 100 author-provided keywords were superimposed and visualized according to the average publication year to determine the changes in research hotspots of mHealth over time. The node size indicates the number of times the author's keyword appeared, and the color of the node changes gradually, according to the average publication year.

Results

mHealth Research Publications

Through the first search strategy, 6604 search results were obtained, and through the second strategy, 7037 search results were obtained. After removing 1048 documents; there were 12,593 remaining (Figure 1). The number of publications related to mHealth has been increasing since 2004 (Table 1, Figure 2, and Figure 3) and has demonstrated an approximately exponential growth trend. By fitting an exponential function equation, the growth curve can be represented by $y=37e^{0.3062x}$, with $R^2=0.9935$. Specifically, the year 2015 was a flashpoint. The number of documents published in 2015 increased by 366 compared to 2014, and the annual growth rate reached 61%, becoming the highest annual growth rate in 20 years. *RGR* dropped from 58% in 2001 to 30% in 2003 and then stabilized at 28% (SD 5%). *DT* increased from 1.2 in 2001 to 2.3 in 2003 and then stabilized at 2.6 (SD 0.5). The stability of *RGR* and *DT* demonstrates the exponential growth trend [13,34] of the number of publications and confirms that the curve in Figure 3 is exponential, which indicates that the field of mHealth is increasingly receiving attention from scholars.

Table 1. Descriptive statistics of the collected mHealth literature.

Year	Publications, n	Annual growth, n	AGR ^a (%)	RGR ^b (%)	DT ^c	Cumulative total, n
2000	37	N/A ^d	N/A	N/A	N/A	37
2001	29	-8	-22	58	1.2	66
2002	41	12	41	48	1.4	107
2003	37	-4	-10	30	2.3	144
2004	50	13	35	30	2.3	194
2005	77	27	54	33	2.1	271
2006	86	9	12	28	2.5	357
2007	96	10	12	24	2.9	453
2008	123	27	28	24	2.9	576
2009	158	35	28	24	2.9	734
2010	184	26	16	22	3.1	918
2011	236	52	28	23	3.0	1154
2012	302	66	28	23	3.0	1456
2013	437	135	45	26	2.6	1893
2014	603	166	38	28	2.5	2496
2015	970	367	61	33	2.1	3466
2016	1206	236	24	30	2.3	4672
2017	1383	177	15	26	2.7	6055
2018	1725	342	25	25	2.8	7780
2019	2132	407	24	24	2.9	9912
2020	2681	549	26	24	2.9	12,593

^aAGR: annual growth rate.

^bRGR: relative growth rate.

^cDT: doubling time.

^dN/A: not applicable.

Figure 2. Number of publications in mHealth literature between 2000 and 2020.

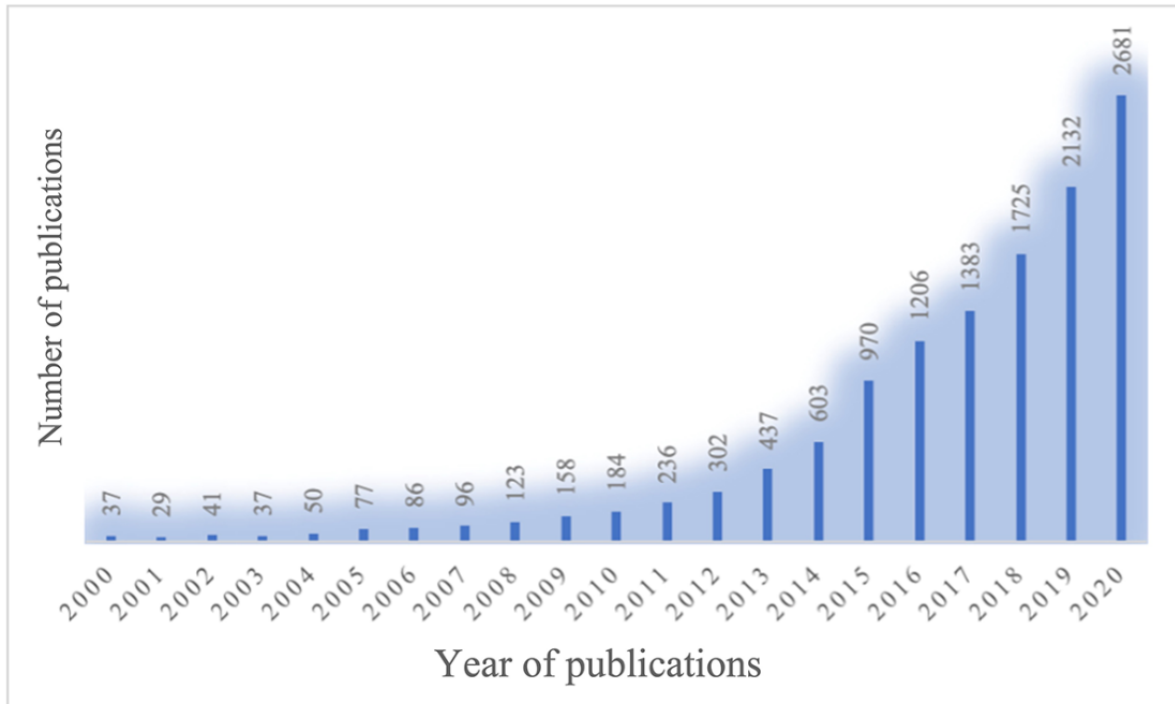
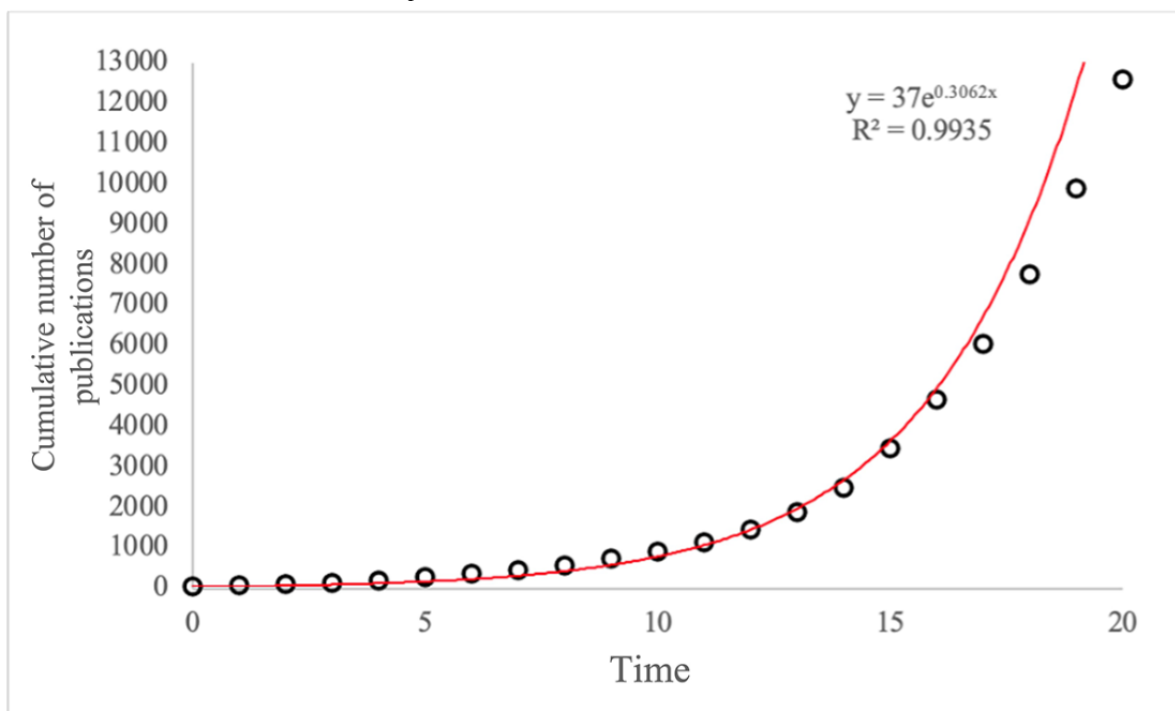


Figure 3. Growth curve of the cumulative number of publications in mHealth literature.



Publishing Trends and Cooperation Among Countries and Regions

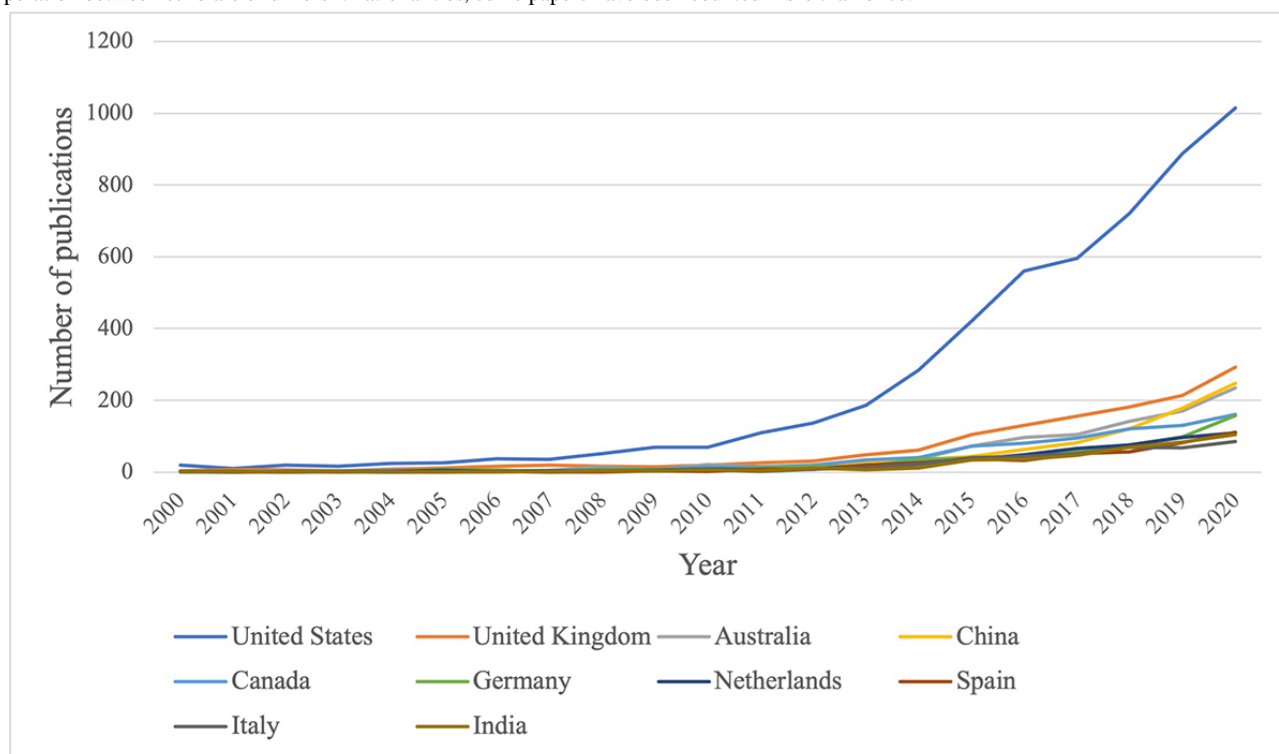
We found that scholars from 166 countries and regions contributed to publications on mHealth (Multimedia Appendix 1). The United States had the largest number of publications (5294/12,593, 42.0%), followed by the United Kingdom (1372/12,593, 10.9%), and then Australia (979/12,593, 7.8%),

China (842/12,593, 6.7%), and Canada (828/12,593, 6.6%) (Table 2). Compared with that of other countries, the growth curve of the United States shows explosive growth (Figure 4); mHealth received more attention, early on, from scholars in the United States which continued throughout the period. All countries and regions show growth, though not as high as that of the United States.

Table 2. Top 10 contributing countries in mHealth literature between 2000 and 2020.

Rank	Country and territory	Publications (n=12,593), n (%) ^a
1	United States	5294 (42.0)
2	United Kingdom	1372 (10.9)
3	Australia	979 (7.8)
4	China	842 (6.7)
5	Canada	828 (6.6)
6	Germany	583 (4.6)
7	The Netherlands	526 (4.2)
8	Spain	445 (3.5)
9	Italy	426 (3.4)
10	India	424 (3)

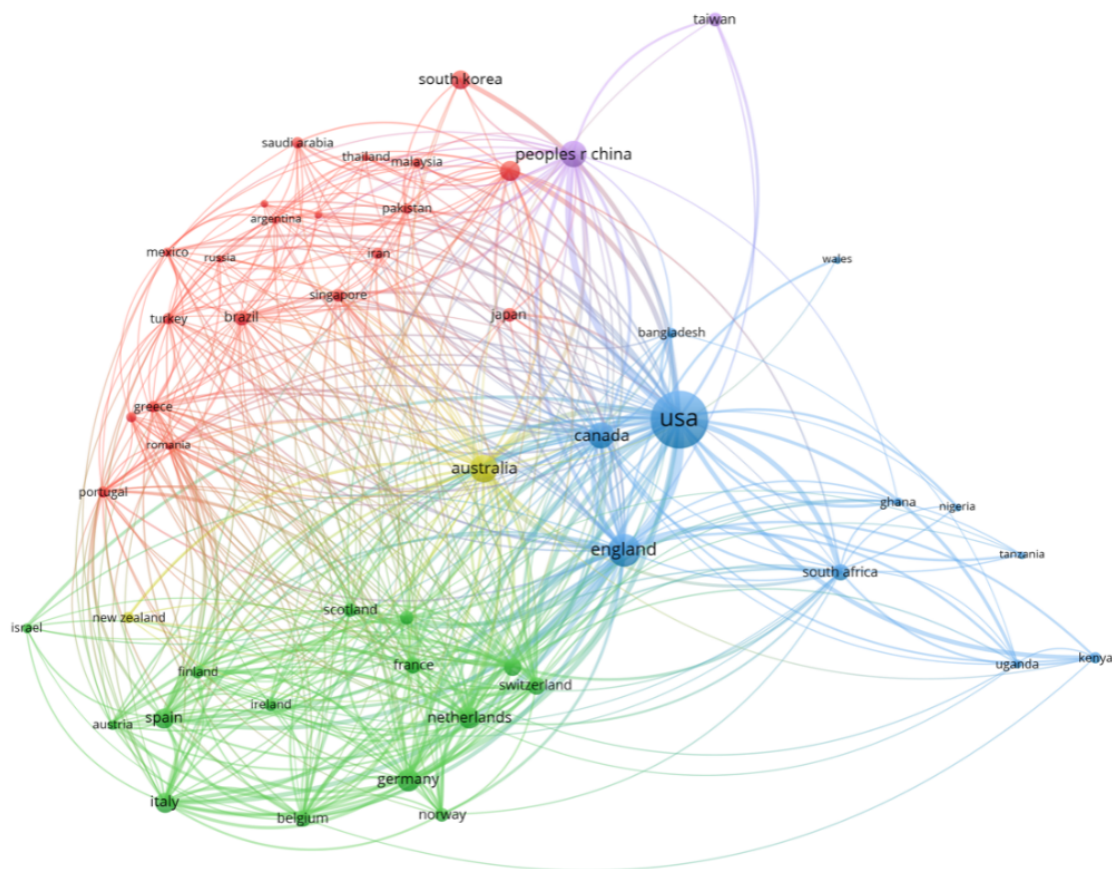
^aDue to research cooperation between scholars of different nationalities, some papers have been counted more than once.

Figure 4. Comparison of the growth trends of mHealth-related research publications in various countries between 2000 and 2020. Due to research cooperation between scholars of different nationalities, some papers have been counted more than once.

Usually, the closer the two circles, the thicker the links and the stronger the relationship (between the countries). Different colors indicate different clusters, and circles belonging to the same cluster usually have similar properties or characteristics [31]. All countries had a cooperative relationship with the United States (Figure 5). Of the top 5 countries, in terms of the number

of publications, United States, the United Kingdom, Canada, and Australia occupy the center of the network diagram with similar distances between the nodes; these 4 productive countries have strong collaborative relationships. Furthermore, it is evident from the location of the countries' nodes that the cooperation between countries and regions have geographic characteristics.

Figure 5. Visual network diagram of cooperation between countries or regions. The size of the circles indicates the number of publications. The larger the circle, the greater the number of publications. The length and thickness of the links between the circles indicate the strength of partnerships between countries. Asian countries and regions represented by the red cluster and the European countries and regions represented by the green cluster.



Journal Distribution

Literature related to mHealth was distributed among 3268 journals (Table 3). The Canadian *Journal of Medical Internet Research* and its sister journals *JMIR mHealth and uHealth*,

JMIR Research Protocols, and *JMIR Mental Health* were in the top 10 journals, with respect to number of publications, and together represented 14% of all publications (1763/12,593). In addition, all of the top 10 journals, except *JMIR Research Protocols*, have an impact factor above 2.

Table 3. Top 10 journals, in terms of the number of mHealth publications, between 2000 and 2020.

Rank	Journal	Country	2-year impact factor (in 2019)	Publications (n=12,593), n (%)
1	JMIR mHealth and uHealth	Canada	4.31	956 (7.6)
2	Journal of Medical Internet Research	Canada	5.03	463 (3.7)
3	JMIR Research Protocols	Canada	— ^a	235 (1.9)
4	Telemedicine and Health	The United States	2.841	202 (1.6)
5	International Journal of Environmental Research and Public Health	Switzerland	2.849	145 (1.2)
6	BMC Public Health	The United Kingdom	2.69	139 (1.1)
7	JMIR Mental Health	Canada	3.54	109 (0.87)
8	International Journal of Medical Informatics	Ireland	3.025	106 (0.84)
9	BMC Medical Informatics and Decision Making	The United Kingdom	2.317	101 (0.80)
10	Sensors	Switzerland	3.275	99 (0.79)

^aNot available.

Author Keywords Co-occurrence Analysis

The top 100 keywords (Multimedia Appendix 2) were classified into 5 clusters using keyword clustering analysis (Figure 6), and the top 10 keywords by co-occurrence frequency are shown (Table 4). The average year of publication for the keywords

shown in Table 4 ranged from 2015.26 to 2017.90, and the average number of citations ranged from 10.75 to 17.98. The most frequently occurring keyword was *mental health*, with a co-occurrence frequency of 449, followed by *physical activity*, with a co-occurrence frequency of 285.

Figure 6. Co-occurrence network diagram of the top 100 author keywords in mHealth research between 2000 and 2020.

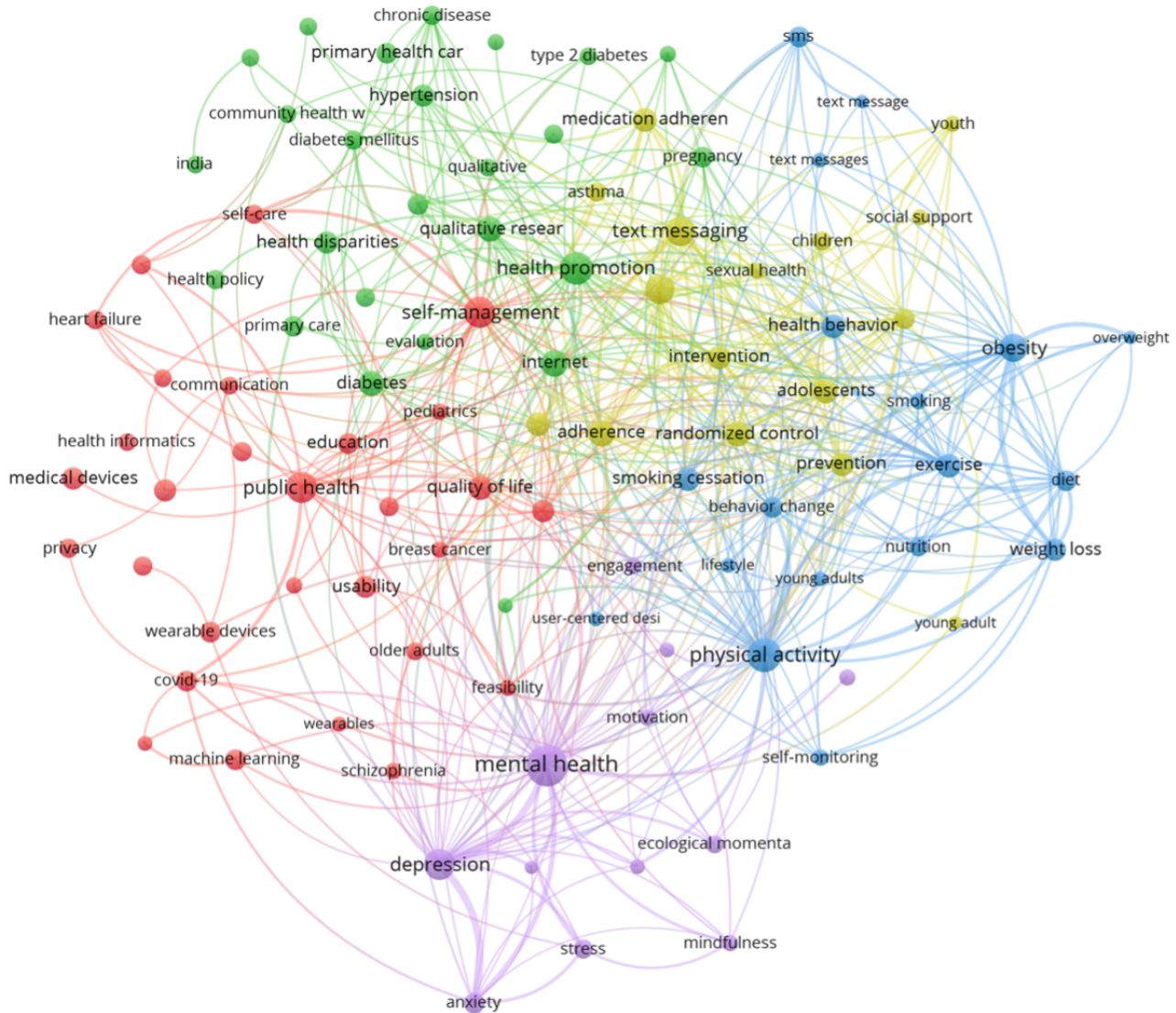


Table 4. Top 10 author-provided keywords of mHealth research between 2000 and 2020.

Rank	Keyword	Cluster	Occurrences, n	Average year of publication	Average number of citations
1	mental health	Purple	449	2017.30	12.48
2	physical activity	Blue	285	2017.46	14.00
3	health promotion	Green	243	2015.26	14.97
4	self-management	Red	234	2017.90	10.75
5	public health	Red	232	2016.29	13.41
6	depression	Purple	227	2017.51	17.98
7	HIV	Yellow	208	2017.57	11.37
8	text messaging	Yellow	207	2016.90	13.22
9	obesity	Blue	173	2016.65	13.81
10	adherence	Yellow	157	2017.48	13.85

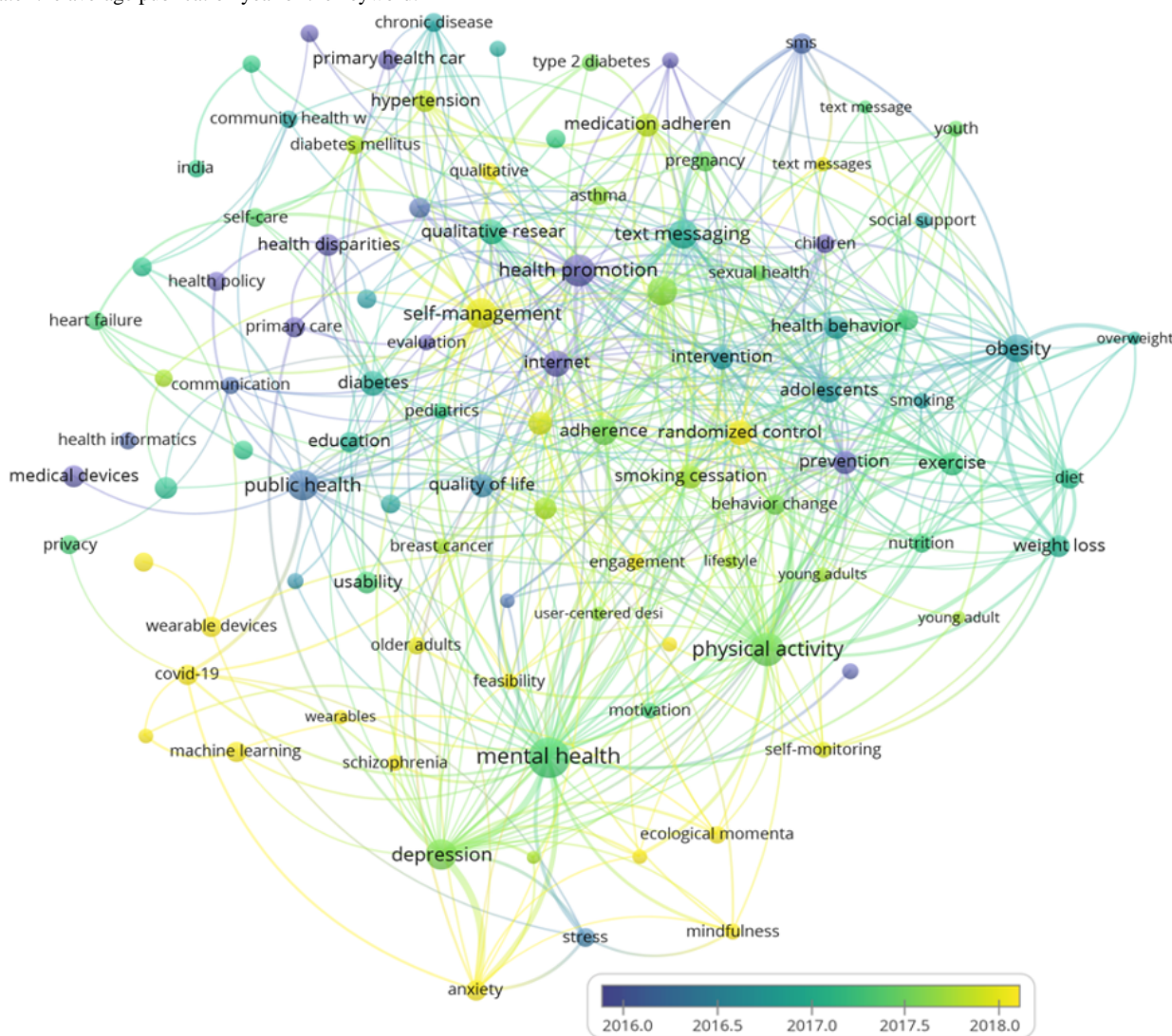
The average publication year range of the top 15 author-provided keywords was 2017.98 to 2020.05 (Table 5), and the occurrence range was 41 to 135 (Figure 7). Among the top 15 keywords, 8 belonged to cluster *red*, 5 belonged to cluster *purple*, 1 belonged to cluster *yellow*, and 1 belonged to cluster *green*. The

average publication year range of the bottom 15 author-provided keywords was 2015.26 to 2016.19, and the occurrence range was 46 to 243. Among the bottom 15 keywords, 10 belonged to cluster *green*, 2 belonged to cluster *red*, 2 belonged to cluster *yellow*, and 1 belonged to cluster *purple*.

Table 5. Comparison of the top 15 and bottom 15 author-provided keywords.

Cluster	Occurrences, n	Average publication year	Keyword
Top 15			
Red	86	2020.05	covid-19
Red	41	2019.05	artificial intelligence
Red	43	2018.79	wearables
Red	85	2018.55	machine learning
Purple	42	2018.54	gamification
Red	47	2018.48	feasibility
Red	87	2018.31	wearable devices
Purple	67	2018.26	ecological momentary assessment
Yellow	135	2018.24	randomized controlled trial
Red	69	2018.22	internet of things
Purple	54	2018.16	mindfulness
Purple	45	2018.09	sleep
Purple	93	2018.05	anxiety
Green	59	2018.04	qualitative
Red	55	2017.98	schizophrenia
Bottom 15			
Green	243	2015.26	health promotion
Green	95	2015.35	primary health care
Green	81	2015.40	health policy
Green	55	2015.45	evaluation
Yellow	80	2015.53	children
Red	103	2015.58	medical devices
Yellow	117	2015.79	prevention
Green	97	2015.82	health disparities
Green	152	2015.84	internet
Green	50	2015.94	focus groups
Green	87	2015.97	primary care
Green	67	2016.00	developing countries
Purple	46	2016.07	well-being
Red	59	2016.15	health informatics
Green	84	2016.19	health education

Figure 7. Overlay visualization maps of the average publication year of the top 100 author keywords. The more the node displays a yellow gradient, the later the average publication year of the keyword.



Discussion

Principal Results

Publishing Trends of mHealth Literature

The emergence of mHealth is a great innovation in the rapid development of information technology. It has circumvented the obstacles of location and medical resources of traditional health care, making health care more accessible to a wider range of people. The growth trend for mHealth literature published between 2000 and 2020 was exponential, which suggests that, when mHealth first started, acceptance was low, the number of users was small, and research on mHealth progressed relatively slowly. As the number of users of mHealth gradually increased, more and more researchers focused on this area, and the number of mHealth publications showed an increasing trend. Based on the theory of diffusion of innovation [35], the growth curve (Figure 3) coincides with the early part of the diffusion model of innovations; we can surmise that the development of mHealth technology is currently in the early stages of rapid growth.

International Trends

A comparison with the bibliometric analysis [25] of mHealth research up to 2016 shows that the United States remains the most productive country in this field. The number of annual publications in the United States continues to show a steady growth trend. This is followed by the United Kingdom, China, Australia, and Canada, which are also experiencing rapid growth in their publication trends.

The 4 most productive countries—the United States, the United Kingdom, Canada, and Australia—had close cooperative relationships with each other. In contrast, the rest of the countries and regions showed a clear geographic pattern. Cluster *red* contains mainly of Asian countries such as Japan, South Korea, Russia, Malaysia, Thailand, and Singapore (Figure 5), and cluster *green* is composed mainly of European countries such as France, Netherlands, Germany, Spain, and Italy. It is not difficult to speculate that the specificity of the EU has led to closer research cooperation among EU countries. Cluster blue comprises African countries such as Kenya, South Africa, Ghana, Nigeria, Tanzania and 3 of the most productive countries—the United States, Canada, and United Kingdom. It

can be presumed that African countries establish cooperation based on geography and have a major cooperation relationship with these 3 countries. In addition, China and Taiwan may be grouped in cluster *purple* because of the same language. Australia and New Zealand belong to cluster *yellow*, due to their close geographic locations. Therefore, we conjecture that international partnerships may be influenced by geography, regional characteristics, language, international relations, political, and economic alliances.

Research Hotspots

Cluster *red* contains the most author-provided keywords, comprising 29 keywords such as *artificial intelligence*, *electronic health records*, *global health*, *health informatics*, *health information technology*, *machine learning*, *medical devices*, *self-care*, and *wearable devices*. The keywords *breast cancer*, *cancer*, *covid-19*, *heart failure*, and other diseases also appeared in the list. This cluster focuses on the development of mHealth technologies and their application to various diseases. Globally, health issues such as aging populations and cancer pose a serious challenge to health care providers [36-38]. Researchers are increasingly trying to address many health issues with the use of mHealth technologies. *COVID-19* also appears among the high-frequency keywords. Importantly, the *COVID-19* pandemic exposed the shortage of health care resources in several countries. The demand for telemedicine, including mHealth, has also been indirectly increased by countries promoting policies to prevent their population from going outside under social isolation measures adopted to tackle *COVID-19* [39]. It is also worth noting that the keyword *privacy* appears in this cluster. Patient privacy, security in data transmission, and privacy-related health policy issues remain major barriers to the development of mHealth in both high-income and low- to middle-income countries [40].

Cluster *green* focuses on the use of mHealth technologies to improve basic public health and health policies. Some of the 25 keywords under this cluster include *health promotion*, *primary health care*, *health education*, *health policy*, *health communication*, and *community health workers*. Health care is one of the largest industries in the world. According to the World Health Organization, global health expenditure in 2017 was US \$7.8 trillion, or approximately 10% of the total gross domestic product [41]. Compared to traditional health services, mHealth, which relies upon mobile devices such as smartphones, provides timely health information and fast, inexpensive access to primary care. As of 2017, mobile phone apps related to mHealth exceeded 325,000 [42]. Therefore, it is necessary to formulate corresponding health policies to ensure that mHealth technology can serve society more effectively and to provide direction for future health initiatives. The author-provided keyword *developing countries* appeared in this cluster. The development of mHealth in low- and middle-income countries faces more serious challenges than those faced in high-income countries. Although smartphones have become commonplace globally, challenges exist in terms of the cost of owning and using smartphones in low- and middle-income countries. For example, resource scarcity and other issues have forced low- and middle-income countries to reduce the budget for building mHealth and related infrastructure to allocate resources to other

necessities such as potable water and food. The shortage of trained medical professionals and technical skills in low- and middle-income countries has also made the development of mHealth difficult [38]. Therefore, research focused on low- and middle-income countries remains a key research priority for the future of the field.

Cluster *blue* focuses on self-health testing and management in daily life. This cluster comprises 18 keywords such as *behavior change*, *diet*, *exercise*, *health behavior*, *lifestyle*, and *self-monitoring*. An increasing number of people are using emerging mHealth apps to improve their lifestyles and manage their health; these apps have a variety of functions. For example, people can control their daily calorie intake by recording their diet [43] or detect changes in their health by recording their weight, heart rate, and breathing rate [44,45]. In fact, the emergence of such apps has played a positive role in the popularization of mHealth. For example, mobile phone apps related to physical exercise have been combined with users' social networks. People are more willing to use the tracking function of such apps to record their physical changes and share their exercise status with others, thereby increasing their social contacts' motivation to exercise [46,47].

Cluster *yellow* focuses on the use of mHealth among adolescents. This cluster contains 16 keywords such as *adolescent*, *adherence*, *children*, *HIV*, *intervention*, *sexual health*, *social media*, *social support*, and *youth*. Research shows that the youth are the most prone to smartphone addiction [48,49]. There has been considerable research on the negative effects of smartphone addiction on health [50-52]. Excessive smartphone use affects sleep quality, and thus, other daily activities [48,53]. Adolescents are also a priority group for HIV prevention. mHealth apps that use social media technology make it easier for health workers to spread sexual health information more effectively, and thus, reduce the risk of HIV infection among adolescents [54]. Therefore, mHealth research focusing on adolescents is essential.

Cluster *purple* focuses on the use of mHealth in the context of mental health. It contains 12 keywords, including *mental health*, *anxiety*, *mindfulness*, *stress*, and *well-being*. The keyword *mental health* has the most frequent co-occurrence. Therefore, it can be assumed that this topic is the primary focus of researchers. Various factors influence mental health, such as past experiences [55], social stress [56], and interpersonal relationships [57]. People with mental health problems often resist talking to others [58], and even those who have undergone psychotherapy and have recovered are at high risk of reoccurrence [59]. Mental illness is a severe social problem, especially in high-income countries. For example, in Japan, the suicide rate due to depression has been high, and it has been increasing among youth in recent years [60,61]. For a country with a serious aging problem, an increase in the suicide rate among young people can incur a huge cost to the national economy. Moreover, people with depression can have poor physical health compared with that of individuals in the general population [62]. Timely intelligence technology that captures body information provided by mHealth can provide psychologists with more reference data to detect physical changes in patients through ecological

momentary assessment, thus providing more guidance to patients.

Research Trends

Based on the clusters to which these keywords belong, we can speculate that mHealth research hotspots have gradually shifted from research on mHealth policy and the improvement of public health care to the development of mHealth technology and social apps (cluster *green* to cluster *red* and cluster *purple*). Thus, we find that the development of mHealth requires appropriate health policy as a cornerstone. However, individual governments usually develop health policies, leading to national and regional limitations in the scope of policy application. In contrast, the scope of web-based mHealth services can be global. This may also make it more difficult to regulate mHealth services; therefore, it is still necessary to continue to explore how to establish regulations for cross-border telehealth in the future. Furthermore, we note that in high-income countries, especially in the health care field, government regulatory formation is critical to the growth of the mHealth market [63]. Governmental oversight measures often limit the development of mHealth technologies and services [64]. Although the United States is absolutely central to mHealth research, health care regulations in the country may be more conservative and less susceptible to change due to the huge health care infrastructure. Conversely, mHealth policy reforms are likely to be smoother in low- and middle-income countries because they are met with less opposition and fewer infrastructural barriers [65]. Therefore, effective strategies are needed to advance regulatory reforms related to mHealth.

Limitations

To the best of our knowledge, the results obtained in this study are the most recent available for mHealth bibliometric analysis;

however, this study has some limitations. First, we developed a search strategy that included as many mHealth-related studies as possible, but we still could not guarantee the inclusion of all mHealth-related studies. Second, our search strategy collected only English-language literature, which narrowed the scope. Hence, the data results are not representative of papers and conference papers published in other languages. Finally, the data used in this study were extracted only from the Web of Science and did not include other search engines such as Scopus and PubMed. Although the Web of Science has a large enough database to ensure the accuracy of the data to a certain extent, there are still many papers that are included only in the other databases, which may have impacted the study results. For example, our finding suggest that only 175 mHealth papers were in Japan ([Multimedia Appendix 1](#)); however, many mHealth papers published in Japanese are included in the CiNii database maintained by the National Institute of Informatics in Japan. The Chinese Science Citation Database in China also contains many papers published in Chinese; therefore, future studies can include more databases and languages to make the research results more accurate and rigorous.

Conclusions

This study reveals the latest research trends and hotspots and the current state of international collaboration in mHealth research. As previously suggested, mHealth has shown great potential in recent years for use in all aspects of our lives; however, the development of mHealth faces challenges from regulatory policies, national economies, and personal privacy. Therefore, we advise researchers in this field to work on these issues to further develop the mHealth field. We also hope that the results of this study provide valuable guidance for future mHealth research.

Acknowledgments

We would like to express our gratitude to Ritsumeikan University for providing access to the Web of Science database. We would also like to thank all study participants for their constructive advice and guidance for this research. This work was supported by the *Foundation France-Japon*/Air Liquide Fellowship. The authors gratefully acknowledge the generous support and assistance of the *Fondation France-Japon de École des Hautes Études en Sciences Sociales* and Air Liquide.

Conflicts of Interest

None declared.

Multimedia Appendix 1

List of countries and regions that have contributed to publications on mHealth.
[\[XLS File \(Microsoft Excel File\), 41 KB-Multimedia Appendix 1\]](#)

Multimedia Appendix 2

Details of the top 100 author keywords in mHealth research between 2000 and 2020.
[\[XLS File \(Microsoft Excel File\), 42 KB-Multimedia Appendix 2\]](#)

References

1. Penetration rate of smartphones in selected countries 2020. Statista. URL: <https://www.statista.com/statistics/539395/smartphone-penetration-worldwide-by-country/> [accessed 2021-03-02]

2. Guo X, Chen S, Zhang X, Ju X, Wang X. Exploring patients' intentions for continuous usage of mhealth services: elaboration-likelihood perspective study. *JMIR Mhealth Uhealth* 2020 Apr 06;8(4):e17258 [FREE Full text] [doi: [10.2196/17258](https://doi.org/10.2196/17258)] [Medline: [32250277](https://pubmed.ncbi.nlm.nih.gov/32250277/)]
3. Fu Y, Guo J. Blood cholesterol monitoring with smartphone as miniaturized electrochemical analyzer for cardiovascular disease prevention. *IEEE Trans Biomed Circuits Syst* 2018 Aug;12(4):784-790. [doi: [10.1109/tbcas.2018.2845856](https://doi.org/10.1109/tbcas.2018.2845856)]
4. Nerminathan A, Harrison A, Phelps M, Alexander S, Scott KM. Doctors' use of mobile devices in the clinical setting: a mixed methods study. *Intern Med J* 2017 Dec;47(3):291-298. [doi: [10.1111/imj.13349](https://doi.org/10.1111/imj.13349)] [Medline: [27925381](https://pubmed.ncbi.nlm.nih.gov/27925381/)]
5. Rowan NJ, Laffey JG. Challenges and solutions for addressing critical shortage of supply chain for personal and protective equipment (PPE) arising from Coronavirus disease (COVID19) pandemic - Case study from the Republic of Ireland. *Sci Total Environ* 2020 Jul 10;725:138532 [FREE Full text] [doi: [10.1016/j.scitotenv.2020.138532](https://doi.org/10.1016/j.scitotenv.2020.138532)] [Medline: [32304970](https://pubmed.ncbi.nlm.nih.gov/32304970/)]
6. Sun S, Xie Z, Yu K, Jiang B, Zheng S, Pan X. COVID-19 and healthcare system in China: challenges and progression for a sustainable future. *Global Health* 2021 Jan 21;17(1):14 [FREE Full text] [doi: [10.1186/s12992-021-00665-9](https://doi.org/10.1186/s12992-021-00665-9)] [Medline: [33478558](https://pubmed.ncbi.nlm.nih.gov/33478558/)]
7. Sen-Crowe B, Sutherland M, McKenney M, Elkbuli A. A closer look into global hospital beds capacity and resource shortages during the COVID-19 pandemic. *J Surg Res* 2021 Apr;260:56-63 [FREE Full text] [doi: [10.1016/j.jss.2020.11.062](https://doi.org/10.1016/j.jss.2020.11.062)] [Medline: [33321393](https://pubmed.ncbi.nlm.nih.gov/33321393/)]
8. Tarricone R, Petracca F, Ciani O, Cucciniello M. Distinguishing features in the assessment of mHealth apps. *Expert Rev Pharmacoecon Outcomes Res* 2021 Aug 04;21(4):521-526. [doi: [10.1080/14737167.2021.1891883](https://doi.org/10.1080/14737167.2021.1891883)] [Medline: [33663324](https://pubmed.ncbi.nlm.nih.gov/33663324/)]
9. Byambasuren O, Sanders S, Beller E, Glasziou P. Prescribable mHealth apps identified from an overview of systematic reviews. *NPJ Digit Med* 2018 May 9;1(1):12 [FREE Full text] [doi: [10.1038/s41746-018-0021-9](https://doi.org/10.1038/s41746-018-0021-9)] [Medline: [31304297](https://pubmed.ncbi.nlm.nih.gov/31304297/)]
10. Wu X, Guo X, Zhang Z. The efficacy of mobile phone apps for lifestyle modification in diabetes: systematic review and meta-analysis. *JMIR Mhealth Uhealth* 2019 Jan 15;7(1):e12297 [FREE Full text] [doi: [10.2196/12297](https://doi.org/10.2196/12297)] [Medline: [30664494](https://pubmed.ncbi.nlm.nih.gov/30664494/)]
11. Xu H, Huang S, Qiu C, Liu S, Deng J, Jiao B, et al. Monitoring and management of home-quarantined patients with COVID-19 using a WChat-based telemedicine system: retrospective cohort study. *J Med Internet Res* 2020 Jul 02;22(7):e19514 [FREE Full text] [doi: [10.2196/19514](https://doi.org/10.2196/19514)] [Medline: [32568727](https://pubmed.ncbi.nlm.nih.gov/32568727/)]
12. Baumgart DC. Digital advantage in the COVID-19 response: perspective from Canada's largest integrated digitalized healthcare system. *NPJ Digit Med* 2020 Aug 31;3(1):114 [FREE Full text] [doi: [10.1038/s41746-020-00326-y](https://doi.org/10.1038/s41746-020-00326-y)] [Medline: [32923691](https://pubmed.ncbi.nlm.nih.gov/32923691/)]
13. Sweileh WM, Al-Jabi SW, AbuTaha AS, Zyoud SH, Anayah FMA, Sawalha AF. Bibliometric analysis of worldwide scientific literature in mobile-health: 2006-2016. *BMC Med Inform Decis Mak* 2017 May 30;17(1):72 [FREE Full text] [doi: [10.1186/s12911-017-0476-7](https://doi.org/10.1186/s12911-017-0476-7)] [Medline: [28558687](https://pubmed.ncbi.nlm.nih.gov/28558687/)]
14. Daim TU, Rueda G, Martin H, Gerdri P. Forecasting emerging technologies: use of bibliometrics and patent analysis. *Technol Forecast Soc Change* 2006 Oct;73(8):981-1012. [doi: [10.1016/j.techfore.2006.04.004](https://doi.org/10.1016/j.techfore.2006.04.004)]
15. Morris S, DeYong C, Wu Z, Salman S, Yemenu D. Diva: a visualization system for exploring document databases for technology forecasting. *Comput Ind Eng* 2002 Sep;43(4):841-862. [doi: [10.1016/s0360-8352\(02\)00143-2](https://doi.org/10.1016/s0360-8352(02)00143-2)]
16. Fahimnia B, Sarkis J, Davarzani H. Green supply chain management: a review and bibliometric analysis. *Int J Prod Econ* 2015 Apr;162:101-114. [doi: [10.1016/j.ijpe.2015.01.003](https://doi.org/10.1016/j.ijpe.2015.01.003)]
17. Zupic I, Čater T. Bibliometric methods in management and organization. *Organ Res Methods* 2014 Dec 22;18(3):429-472. [doi: [10.1177/1094428114562629](https://doi.org/10.1177/1094428114562629)]
18. Kato M, Ando A. The relationship between research performance and international collaboration in chemistry. *Scientometrics* 2013 Apr 10;97(3):535-553. [doi: [10.1007/s11192-013-1011-y](https://doi.org/10.1007/s11192-013-1011-y)]
19. Chen K, Zhang Y, Fu X. International research collaboration: an emerging domain of innovation studies? *Research Policy* 2019 Feb;48(1):149-168. [doi: [10.1016/j.respol.2018.08.005](https://doi.org/10.1016/j.respol.2018.08.005)]
20. Li X, Du J, Long H. Dynamic analysis of international green behavior from the perspective of the mapping knowledge domain. *Environ Sci Pollut Res Int* 2019 Mar 7;26(6):6087-6098. [doi: [10.1007/s11356-018-04090-1](https://doi.org/10.1007/s11356-018-04090-1)] [Medline: [30617886](https://pubmed.ncbi.nlm.nih.gov/30617886/)]
21. Liu Z, Yin Y, Liu W, Dunford M. Visualizing the intellectual structure and evolution of innovation systems research: a bibliometric analysis. *Scientometrics* 2015 Jan 22;103(1):135-158. [doi: [10.1007/s11192-014-1517-y](https://doi.org/10.1007/s11192-014-1517-y)]
22. Liao H, Tang M, Luo L, Li C, Chiclana F, Zeng X. A bibliometric analysis and visualization of medical big data research. *Sustainability* 2018 Jan 11;10(2):166. [doi: [10.3390/su10010166](https://doi.org/10.3390/su10010166)]
23. Servantie V, Cabrol M, Guieu G, Boissin J. Is international entrepreneurship a field? a bibliometric analysis of the literature (1989–2015). *J Int Entrep* 2016 Mar 8;14(2):168-212. [doi: [10.1007/s10843-015-0162-8](https://doi.org/10.1007/s10843-015-0162-8)]
24. Donthu N, Kumar S, Pattnaik D. Forty-five years of journal of business research: a bibliometric analysis. *J Bus Res* 2020 Mar;109:1-14. [doi: [10.1016/j.jbusres.2019.10.039](https://doi.org/10.1016/j.jbusres.2019.10.039)]
25. Shen L, Xiong B, Li W, Lan F, Evans R, Zhang W. Visualizing collaboration characteristics and topic burst on international mobile health research: bibliometric analysis. *JMIR Mhealth Uhealth* 2018 Jul 05;6(6):e135 [FREE Full text] [doi: [10.2196/mhealth.9581](https://doi.org/10.2196/mhealth.9581)] [Medline: [29871851](https://pubmed.ncbi.nlm.nih.gov/29871851/)]
26. Peng C, He M, Cutrona SL, Kiefe CI, Liu F, Wang Z. Theme trends and knowledge structure on mobile health apps: Bibliometric analysis. *JMIR Mhealth Uhealth* 2020 Jul 27;8(7):e18212 [FREE Full text] [doi: [10.2196/18212](https://doi.org/10.2196/18212)] [Medline: [32716312](https://pubmed.ncbi.nlm.nih.gov/32716312/)]

27. Agarwal A, Durairajanayagam D, Tatagari S, Esteves S, Harlev A, Henkel R, et al. Bibliometrics: tracking research impact by selecting the appropriate metrics. *Asian J Androl* 2016;18(2):296. [doi: [10.4103/1008-682x.171582](https://doi.org/10.4103/1008-682x.171582)]
28. He Y, Cheung Hui S. Mining a web citation database for author co-citation analysis. *Inf Process Manag* 2002 Jul;38(4):491-508. [doi: [10.1016/s0306-4573\(01\)00046-2](https://doi.org/10.1016/s0306-4573(01)00046-2)]
29. Uribe-Toril J, Ruiz-Real JL, Nievas-Soriano BJ. A study of eHealth from the perspective of social sciences. *Healthcare* 2021 Jan 21;9(2):108. [doi: [10.3390/healthcare9020108](https://doi.org/10.3390/healthcare9020108)]
30. Waltman L, van Eck NJ, Noyons EC. A unified approach to mapping and clustering of bibliometric networks. *J Informetr* 2010 Oct;4(4):629-635. [doi: [10.1016/j.joi.2010.07.002](https://doi.org/10.1016/j.joi.2010.07.002)]
31. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 2009 Dec 31;84(2):523-538. [doi: [10.1007/s11192-009-0146-3](https://doi.org/10.1007/s11192-009-0146-3)]
32. Merediz-Solà I, Bariviera AF. A bibliometric analysis of bitcoin scientific production. *Res Int Bus Finance* 2019 Dec;50:294-305. [doi: [10.1016/j.ribaf.2019.06.008](https://doi.org/10.1016/j.ribaf.2019.06.008)]
33. Zyoud SH, Sweileh WM, Awang R, Al-Jabi SW. Global trends in research related to social media in psychology: mapping and bibliometric analysis. *Int J Ment Health Syst* 2018;12:4 [FREE Full text] [doi: [10.1186/s13033-018-0182-6](https://doi.org/10.1186/s13033-018-0182-6)] [Medline: [29387147](https://pubmed.ncbi.nlm.nih.gov/29387147/)]
34. Kumar R, Kaliyaperumal K. Scientometric analysis of global publication output in mobile technology. *DESIDOC J Library Inf Technol* 2015 Jul 30;35(4):287-292. [doi: [10.14429/djlit.35.4.7884](https://doi.org/10.14429/djlit.35.4.7884)]
35. Rogers E. *Diffusion of Innovations: Fifth Edition*. New York, NY: Free Press; 2003.
36. Köppen J, Maier CB, Busse R, MUNROS team. What are the motivating and hindering factors for health professionals to undertake new roles in hospitals? A study among physicians, nurses and managers looking at breast cancer and acute myocardial infarction care in nine countries. *Health Policy* 2018 Oct 25;122(10):1118-1125. [doi: [10.1016/j.healthpol.2018.07.018](https://doi.org/10.1016/j.healthpol.2018.07.018)] [Medline: [30097353](https://pubmed.ncbi.nlm.nih.gov/30097353/)]
37. Kurpas D, Gwyther H, Szwamel K, Shaw RL, D'Avanzo B, Holland CA, et al. Patient-centred access to health care: a framework analysis of the care interface for frail older adults. *BMC Geriatr* 2018 Nov 12;18(1):273 [FREE Full text] [doi: [10.1186/s12877-018-0960-7](https://doi.org/10.1186/s12877-018-0960-7)] [Medline: [30419817](https://pubmed.ncbi.nlm.nih.gov/30419817/)]
38. Kanchanachitra C, Lindelow M, Johnston T, Hanvoravongchai P, Lorenzo FM, Huong NL, et al. Human resources for health in southeast Asia: shortages, distributional challenges, and international trade in health services. *Lancet* 2011 Mar 26;377(9767):769-781. [doi: [10.1016/S0140-6736\(10\)62035-1](https://doi.org/10.1016/S0140-6736(10)62035-1)] [Medline: [21269674](https://pubmed.ncbi.nlm.nih.gov/21269674/)]
39. Rauschenberg C, Schick A, Hirjak D, Seidler A, Paetzold I, Apfelbacher C, et al. Evidence synthesis of digital interventions to mitigate the negative impact of the COVID-19 pandemic on public mental health: rapid meta-review. *J Med Internet Res* 2021 Mar 10;23(3):e23365 [FREE Full text] [doi: [10.2196/23365](https://doi.org/10.2196/23365)] [Medline: [33606657](https://pubmed.ncbi.nlm.nih.gov/33606657/)]
40. Sunyaev A, Dehling T, Taylor PL, Mandl KD. Availability and quality of mobile health app privacy policies. *J Am Med Inform Assoc* 2015 Apr;22(e1):e28-e33 [FREE Full text] [doi: [10.1136/amiainl-2013-002605](https://doi.org/10.1136/amiainl-2013-002605)] [Medline: [25147247](https://pubmed.ncbi.nlm.nih.gov/25147247/)]
41. Global spending on health: a world in transition. World Health Organization. 2019. URL: https://www.who.int/health_financing/documents/health-expenditure-report-2019/en/ [accessed 2021-03-02]
42. Larson RS. A path to better-quality mHealth apps. *JMIR Mhealth Uhealth* 2018 Jul 30;6(7):e10414 [FREE Full text] [doi: [10.2196/10414](https://doi.org/10.2196/10414)] [Medline: [30061091](https://pubmed.ncbi.nlm.nih.gov/30061091/)]
43. Franco RZ, Fallaize R, Lovegrove JA, Hwang F. Popular nutrition-related mobile apps: a feature assessment. *JMIR Mhealth Uhealth* 2016 Aug 01;4(3):e85 [FREE Full text] [doi: [10.2196/mhealth.5846](https://doi.org/10.2196/mhealth.5846)] [Medline: [27480144](https://pubmed.ncbi.nlm.nih.gov/27480144/)]
44. Coorey GM, Neubeck L, Mulley J, Redfern J. Effectiveness, acceptability and usefulness of mobile applications for cardiovascular disease self-management: Systematic review with meta-synthesis of quantitative and qualitative data. *Eur J Prev Cardiol* 2018 Dec;25(5):505-521. [doi: [10.1177/2047487317750913](https://doi.org/10.1177/2047487317750913)] [Medline: [29313363](https://pubmed.ncbi.nlm.nih.gov/29313363/)]
45. Coppetti T, Brauchlin A, Müggler S, Attinger-Toller A, Templin C, Schönraht F, et al. Accuracy of smartphone apps for heart rate measurement. *Eur J Prev Cardiol* 2017 Aug 02;24(12):1287-1293. [doi: [10.1177/2047487317702044](https://doi.org/10.1177/2047487317702044)] [Medline: [28464700](https://pubmed.ncbi.nlm.nih.gov/28464700/)]
46. Yu N, Huang Y. Important factors affecting user experience design and satisfaction of a mobile health app: A case study of daily yoga app. *Int J Environ Res Public Health* 2020 Sep 23;17(19):6967 [FREE Full text] [doi: [10.3390/ijerph17196967](https://doi.org/10.3390/ijerph17196967)] [Medline: [32977635](https://pubmed.ncbi.nlm.nih.gov/32977635/)]
47. Hamari J, Koivisto J. "Working out for likes": an empirical study on social influence in exercise gamification. *Comput Human Behav* 2015 Sep;50:333-347. [doi: [10.1016/j.chb.2015.04.018](https://doi.org/10.1016/j.chb.2015.04.018)]
48. CAO J, Lim Y, Kodama K. Smartphone addiction and life satisfaction: mediating effects of sleep quality and self-health. *Glob J Health Sci* 2021 Jan 13;13(3):8. [doi: [10.5539/gjhs.v13n3p8](https://doi.org/10.5539/gjhs.v13n3p8)]
49. Duan L, Shao X, Wang Y, Huang Y, Miao J, Yang X, et al. An investigation of mental health status of children and adolescents in China during the outbreak of COVID-19. *J Affect Disord* 2020 Oct 01;275:112-118 [FREE Full text] [doi: [10.1016/j.jad.2020.06.029](https://doi.org/10.1016/j.jad.2020.06.029)] [Medline: [32658812](https://pubmed.ncbi.nlm.nih.gov/32658812/)]
50. Elhai JD, Dvorak RD, Levine JC, Hall BJ. Problematic smartphone use: a conceptual overview and systematic review of relations with anxiety and depression psychopathology. *J Affect Disord* 2017 Jan 01;207:251-259. [doi: [10.1016/j.jad.2016.08.030](https://doi.org/10.1016/j.jad.2016.08.030)] [Medline: [27736736](https://pubmed.ncbi.nlm.nih.gov/27736736/)]

51. David P, Kim J, Brickman JS, Ran W, Curtis CM. Mobile phone distraction while studying. *New Media Soc* 2014 Apr 22;17(10):1661-1679. [doi: [10.1177/1461444814531692](https://doi.org/10.1177/1461444814531692)]
52. Lepp A, Barkley JE, Sanders GJ, Rebold M, Gates P. The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of U.S. college students. *Int J Behav Nutr Phys Act* 2013 Jul 21;10(1):79 [FREE Full text] [doi: [10.1186/1479-5868-10-79](https://doi.org/10.1186/1479-5868-10-79)] [Medline: [23800133](https://pubmed.ncbi.nlm.nih.gov/23800133/)]
53. Demirci K, Akgönül M, Akpınar A. Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. *J Behav Addict* 2015 Jun;4(2):85-92 [FREE Full text] [doi: [10.1556/2006.4.2015.010](https://doi.org/10.1556/2006.4.2015.010)] [Medline: [26132913](https://pubmed.ncbi.nlm.nih.gov/26132913/)]
54. Hightow-Weidman LB, Muessig KE, Bauermeister J, Zhang C, LeGrand S. Youth, technology, and HIV: recent advances and future directions. *Curr HIV/AIDS Rep* 2015 Dec;12(4):500-515. [doi: [10.1007/s11904-015-0280-x](https://doi.org/10.1007/s11904-015-0280-x)] [Medline: [26385582](https://pubmed.ncbi.nlm.nih.gov/26385582/)]
55. Crandall AA, Miller JR, Cheung A, Novilla LK, Glade R, Novilla MLB, et al. ACEs and counter-ACEs: how positive and negative childhood experiences influence adult health. *Child Abuse Negl* 2019 Oct;96:104089. [doi: [10.1016/j.chiabu.2019.104089](https://doi.org/10.1016/j.chiabu.2019.104089)] [Medline: [31362100](https://pubmed.ncbi.nlm.nih.gov/31362100/)]
56. Wolniewicz CA, Tiamiyu MF, Weeks JW, Elhai JD. Problematic smartphone use and relations with negative affect, fear of missing out, and fear of negative and positive evaluation. *Psychiatry Res* 2018 Apr;262:618-623. [doi: [10.1016/j.psychres.2017.09.058](https://doi.org/10.1016/j.psychres.2017.09.058)] [Medline: [28982630](https://pubmed.ncbi.nlm.nih.gov/28982630/)]
57. Shin YC, Lee D, Seol J, Lim SW. What kind of stress is associated with depression, anxiety and suicidal ideation in Korean employees? *J Korean Med Sci* 2017 May;32(5):843-849 [FREE Full text] [doi: [10.3346/jkms.2017.32.5.843](https://doi.org/10.3346/jkms.2017.32.5.843)] [Medline: [28378560](https://pubmed.ncbi.nlm.nih.gov/28378560/)]
58. Capone V. Patient communication self-efficacy, self-reported illness symptoms, physician communication style and mental health and illness in hospital outpatients. *J Health Psychol* 2016 Jul 01;21(7):1271-1282. [doi: [10.1177/1359105314551622](https://doi.org/10.1177/1359105314551622)] [Medline: [25274717](https://pubmed.ncbi.nlm.nih.gov/25274717/)]
59. Solomon D, Keller M, Leon A, Mueller T, Lavori P, Shea M, et al. Multiple recurrences of major depressive disorder. *Am J Psychiatry* 2000 Mar;157(2):229-233. [doi: [10.1176/appi.ajp.157.2.229](https://doi.org/10.1176/appi.ajp.157.2.229)] [Medline: [10671391](https://pubmed.ncbi.nlm.nih.gov/10671391/)]
60. Tanaka T, Okamoto S. Increase in suicide following an initial decline during the COVID-19 pandemic in Japan. *Nat Hum Behav* 2021 Feb;5(2):229-238. [doi: [10.1038/s41562-020-01042-z](https://doi.org/10.1038/s41562-020-01042-z)] [Medline: [33452498](https://pubmed.ncbi.nlm.nih.gov/33452498/)]
61. Mizuta A, Suzuki K, Yamagata Z, Ojima T. Teachers' support and depression among Japanese adolescents: a multilevel analysis. *Soc Psychiatry Psychiatr Epidemiol* 2017 Feb;52(2):211-219. [doi: [10.1007/s00127-016-1320-6](https://doi.org/10.1007/s00127-016-1320-6)] [Medline: [28032137](https://pubmed.ncbi.nlm.nih.gov/28032137/)]
62. Aiba M, Matsui Y, Kikkawa T, Matsumoto T, Tachimori H. Factors influencing suicidal ideation among Japanese adults: from the national survey by the Cabinet Office. *Psychiatry Clin Neurosci* 2011 Aug;65(5):468-475 [FREE Full text] [doi: [10.1111/j.1440-1819.2011.02228.x](https://doi.org/10.1111/j.1440-1819.2011.02228.x)] [Medline: [21679277](https://pubmed.ncbi.nlm.nih.gov/21679277/)]
63. Onodera R, Sengoku S. Innovation process of mHealth: an overview of FDA-approved mobile medical applications. *Int J Med Inform* 2018 Oct;118:65-71. [doi: [10.1016/j.ijmedinf.2018.07.004](https://doi.org/10.1016/j.ijmedinf.2018.07.004)] [Medline: [30153924](https://pubmed.ncbi.nlm.nih.gov/30153924/)]
64. Malvey D, Slovensky D. *mHealth: Transforming Healthcare*. New York, NY: Springer; 2014.
65. Malvey DM, Slovensky DJ. Global mHealth policy arena: status check and future directions. *Mhealth* 2017 Sep 22;3:41-41 [FREE Full text] [doi: [10.21037/mhealth.2017.09.03](https://doi.org/10.21037/mhealth.2017.09.03)] [Medline: [29184893](https://pubmed.ncbi.nlm.nih.gov/29184893/)]

Abbreviations

COVID-19: coronavirus disease 2019

HIV: human immunodeficiency virus

mHealth: mobile health

Edited by G Eysenbach; submitted 10.06.21; peer-reviewed by T Lefèvre; comments to author 02.07.21; revised version received 15.07.21; accepted 02.08.21; published 08.09.21

Please cite as:

Cao J, Lim Y, Sengoku S, Guo X, Kodama K

Exploring the Shift in International Trends in Mobile Health Research From 2000 to 2020: Bibliometric Analysis

JMIR Mhealth Uhealth 2021;9(9):e31097

URL: <https://mhealth.jmir.org/2021/9/e31097>

doi: [10.2196/31097](https://doi.org/10.2196/31097)

PMID:

©Jianfei Cao, Yeongjoo Lim, Shintaro Sengoku, Xitong Guo, Kota Kodama. Originally published in JMIR mHealth and uHealth (<https://mhealth.jmir.org>), 08.09.2021. This is an open-access article distributed under the terms of the Creative Commons

Attribution License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work, first published in JMIR mHealth and uHealth, is properly cited. The complete bibliographic information, a link to the original publication on <https://mhealth.jmir.org/>, as well as this copyright and license information must be included.