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A bibliometric analysis of research output, citation analysis, author productivity, collaborations, and institutions of repute in smartphone Health Applications (spHealth Apps).

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RESEARCH ARTICLE

A bibliometric analysis of research output, citation analysis, author productivity, collaborations, and institutions of repute in smartphone Health Applications (spHealth Apps).

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Authors' contributions:

DF & MC led the study design and data collection. DF conducted the statistical analysis and drafting of the finalized manuscript

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Abstract

Due to rapid smartphone health application growth and usage, we analyzed literature published in the field of spHealth Apps. SciVerse Scopus was used as the database of choice for this study. Research productivity, collaborations, citation analysis, authors and institutions were presented using well established bibliometric indicators.

During the study period (2000-20), 4546 documents were published in total. The average count of documents per year was 227. English was the language predominantly used in the retrieved documents (97%). The h- index of the retrieved documents was 137. Author submission of keywords used in documents pertaining to sp- Health Apps included human, randomized controlled trials, telemedicine, health care delivery, health promotion, physical activity among others. During the study period, Relative Growth Rate (RGR) and Doubling Time (DT) of retrieved literature fluctuated. An analysis of authorship and collaboration based on published data revealed 4244 multi-authored documents. The mean Collaboration Index (CI) was 5.8 authors per article. The country with the highest productivity was the United States of America with Harvard Medical School as the most prolific academic institution. Jmir Mhealth And Uhealth was the most productive journal in the field of spHealth Apps. Top cited articles in the field of spHealth Apps included the use of smartphone applications in phone sensing, point-of-care testing, health behavior promotion & modeling, mental health, contact tracing etc.

spHealth Apps is a growing field with increasing impact in people's day-to-day lifestyles. Our bibliometric indicators of research output in spHealth Apps mirror this increasing impact.

Keywords: Smartphone, Health Apps, Bibliometric Analysis, Vosviewer, Applications

Introduction:

Review of literature

The accessibility of high speed internet along with the drop of pricing of user friendly smartphones and internet services over the last few years has led to an explosion of smartphone demand. In particular, smartphone application usage across socio-demographic chasms has increased tremendously (UIT, 2020). The younger generation is hooked on to different types of social media applications such as face book, twitter, instagram, telegraph, signal etc. on Smartphones to the point of addiction. The older generation (people above 50) do not lag far behind in terms of smartphone application usage time (Anderson & Jiang, 2018; Anderson & Smith, 2018). The number of smartphone applications and their usage is growing in an exponential manner. According to a website in mobile usage analytics called 'App Annie', in the year 2018 alone, consumers downloaded 194 billion apps in 2018, spent $101 billion in app stores, and spent three hours per day using mobile apps (App Annie 2018). App screen time has increased by 50% from 2016 to 2018. There are approximately 2.8 million apps available on Google Play Store and 2.2 million apps on Apple's App Store, and these numbers are constantly increasing (Statista website 2021).

Among these apps, usage of health related smartphone apps is on the rise ((Pai & Alathur, 2018; Palmer, 2021; Sampat et al., 2020). Studies on spHealth Apps in areas such as mental health, psychological support for patients having chronic disease burden, adherence to medical regimes, physical fitness and weight loss, behaviors required to manage chronic diseases like diabetes, smoking cessation and addiction control etc. are numerous and many have shown promising result (Boels et al., 2018; Brindal et al., 2019; Chung et al., 2019; Colbert et al., 2020; Cui et al., 2016; Huberty et al., 2019; Juarascio et al., 2015; Krishna et al., 2009; Lüscher et al., 2019; Miralles et al., 2020; Santo et al., 2017; Schmuck, 2020; Vailati Riboni et al., 2020; Wu et al., 2020). Thus, spHealth App usage is on the rise and garnering steam as a separate technology driven medical sub-field of mobile Health (mHealth). The World Health Organization's(WHO) Global Observatory for eHealth defined mHealth as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices , personal digital assistants, and other wireless devices (OMS, 2012).

Healthcare based governmental organizations and local healthcare companies have tapped into this ever-growing rapidly changing field of spHealth Apps (Ben-Zeev, 2016).There are a number of advantages for such organizations in reaching out through smartphone applications: first, ease of accessibility of their intervention/ information/idea to a large number of people(both locally as well as globally) thereby benefiting a large audience; second, they can do this effectively with small amounts of cost; third, they can keep modifying their content on the go since it is relatively easy as no hard copies are involved; fourth, they can get advertisements onto their applications and thereby further lower cost; and finally, data can be easily updated and collected from end-users.

However, besides these advantages and ease of availability of spHealth Apps, there is a lot of research still needed in this area. A survey conducted by WHO Global Observatory for eHealth on the status of mHealth has shown that two thirds of mHealth programmes are in the planning stage, higher income countries show more mHeath activity than do lower-income countries, competing health system priorities are the major barrier to mhealth adoption, and evaluation of mHealth programmes to show effectiveness is lacking (Ryu, 2012). Thus, as a first step there is need for more studies which focus on app usability and effectiveness in the domain of healthcare & medicine (Alessa et al., 2021; Garnett et al., 2021; Malte et al., 2021; Rismawan et al., 2021; Romeo et al., 2019; Wisniewski et al., 2019; Workman et al., 2021).

Aim and objectives of research

The aim of this study was to analyze literature published in the field of smartphone health based applications to understand recent tends with well established indicators. Therefore, a bibliometric analysis was conducted in a bid to understand the growth rate, citations , keywords usage, authorship, co-authorship and collaborations, contributory institutions, journal usage, national and international contributions of literature in the field of spHealth Apps.

Methods:

Bibliographic database

In this study, data pertaining to Health applications on Smartphones were retrieved from Scopus. Scopus is the largest abstract and citation database of peer-reviewed literature (Elsevier B.V., 2020). Scopus is a source-neutral abstract and citation database curated by independent subject matter experts . Interestingly, this database is amenable to bibliometric studies due to the powerful discovery and analytics tools which are provided. Data obtained from Scopus' analysis tools are ideal for evaluating citations, authors, institutions and journal metrics but suffer from some limitations (Mongeon & Paul-Hus, 2016). We selected the source type as 'journal articles' in order to rule out false positives associated with conference proceedings and other non-published content. Once we limited our literature to journal publications, we further selected the document types to not include errata documents and corrections of an already published article, as these documents are not true publications. Conferences papers under document types refer to papers that were first presented at conferences and then were finally published as full journal articles. This ensures that they would not be counted twice in our analysis. Thus, filtering out documents based on journal articles and further filters in document types reduces false positives in our study (Supplementary Fig. 1).

Search strategy and validity

Our initial search strategy included (("Healthcare" OR "Health") and ("Application" OR "App")) that appeared in the title or abstract or author keywords. Since our study wanted to investigate applications on smartphones only, we included in the search terms ("Smartphone" or " Phone"). (("Healthcare" OR "Health") and ("Application" OR "App") and ("Smartphone" or " Phone")) was used as the finalized search term in Scopus (Supplementary Fig. 1).

For seeking the validity of the listed search strategy, the top 10 cited articles in each of the years between years 2010-2020(100 publications) was reviewed. The titles of these articles and the journals that they are from validated the search strategy. This analysis and validation of search strategy ensured that the Scopus retrieved articles were in the appropriate field of study.

Data Analysis

The data obtained from Scopus were analyzed for annual growth rate, document type, citation analysis, authorship and co-authorship analysis, keyword occurrence analysis, country productivity, top productive institutions, articles with the highest number of citations, and top areas of research.

Analysis of citations, Annual Growth Rate (AGR), Relative Growth Rate (RGR), Doubling time (DT) were conducted as established in previous literature(Kumar & Kaliyaperumal, 2015; Santhakumar & Kaliyaperumal, 2014; Sweileh et al., 2017; Zafrunnisha & Pullareddy, 2009).

Collaboration and authorship analysis

Excel was used to analyze the number of single-authored publications and the number of multi-authored (joint) publications (38). Parameters such as Degree of collaboration(C) and Collaborative Index (CI) were calculated by referring to published studies (Sweileh et al., 2017; Zafrunnisha & Pullareddy, 2009) .

Visualization and mapping

In order to visualize bibliometric networks, we used the VOSviewer progra (van Eck & Waltman, 2010, 2014). For displaying the geographical distribution of publications we used the iBuilder Maps software. Using iBuilder Maps software's heat map tool, a heat map was created to represent the percentage of publications of contributing countries.

Statistical analysis and ethics

Descriptive statistics such as measures of central tendency (i.e. mean, median) as well as variability measures (i.e. Standard deviation , Q1-Q3) were analyzed from the data along with frequency and percentages. In this study, statistical testing for significance was not carried out. Microsoft Excel was used for data analysis and presentation. Since this study included no human subjects or data associated with human subjects, this study was exempted from ethical scrutiny.

Results

Description of retrieved literature:

4546 documents were retrieved by using our finalized search string (("Healthcare" OR "Health") AND (“Application" OR "App") AND ("Smartphone" OR "PHONE")) in the Elsevier Scopus database (Supplementary fig. 1). Of these documents, the majority of them consisted of research articles (3634 articles; 80.16 %). Second in ranking was review articles which stood at 13.55 % (627 reviews) (Table 1). Table 1 shows details about the types, number and percentage of documents retrieved and the percentages of the different types of documents were represented as pie charts (Supplementary fig. 2).

Table 1 Types of retrieved documents

Type of document	Frequency	% (N=4546)
Article	3634	80
Review	611	13.5
Conference paper	75	1.7
Note	73	1.6
Letter	65	1.4
Editorial	56	1.2
Short Survey	25	0.56

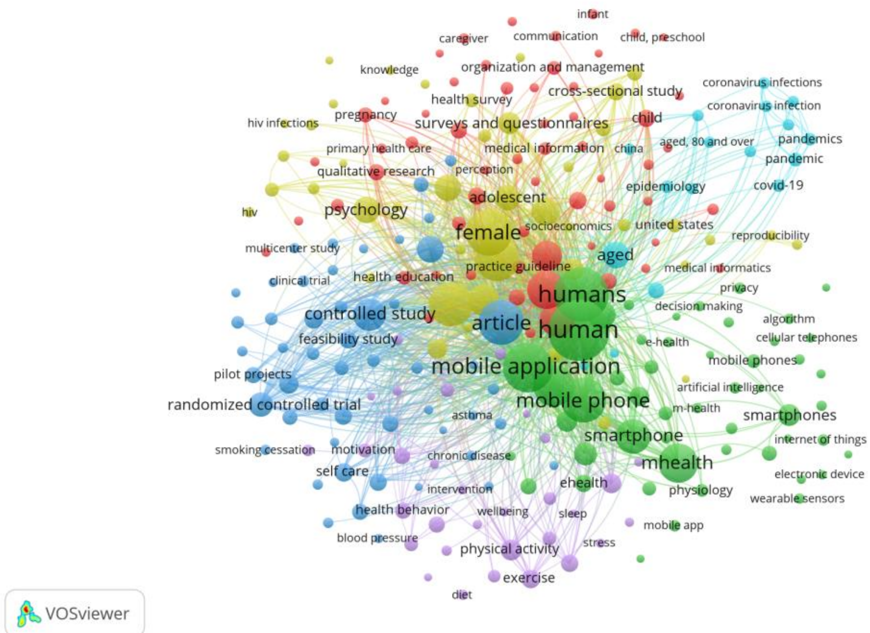
English was the most frequently encountered publication language at 4432 documents (97.6 %) (Table 2). Other commonly encountered languages were Spanish (34 documents, 0.7%), Chinese (28 documents, 0.6%), French (21 documents, 0.4%) and German (20 documents, 0.4%) (Table 2; Supplementary fig. 2).

Table 2 Proportion of documents using a particular language in the field of spHealth Apps

Language	Frequency	% (N=4546)
English	4432	97.6
Spanish	34	0.7
Chinese	28	0.6
French	21	0.4
German	20	0.4

There was a steady increase in the annual number of publications and number of citations between years 2000 - 20 (Table 3; Supplementary fig. 3). The total number of citations for the retrieved documents was 99448 with a mean of 21.9 ± 11.22 citations per document, median (Q1-Q3) of 3(1-7) and a range of (0-334) (Table 3).

Using VOSviewer to map author keywords with a frequency filter set at 25 for minimum keyword occurrence, we obtained a total of 252 keywords. Examples of frequently occurring keywords are: randomized controlled trials, telemedicine, adolescent, questionnaire, health care delivery, health promotion, physical activity, feasibility studies, patient compliance, self-care, psychology, MHealth, health behaviors and coronavirus which are distinct from the search terms used to retrieve these documents. These author keywords were clustered into 6 categories showing close relatedness among keyword in a cluster (Fig. 1). A VOSviewer map of title keywords used in the field of spHealth pulled out title keywords in 5 categories (Additional file 1-Fig. 4)



(Fig. 1 Network visualization map of author keywords occurrences (i.e., keywords listed by the author). Keywords with minimum occurrences of 25 times were shown in the map (252 keywords- 6 clusters). Keywords with the same color were commonly listed together. So, for example, aged ,80 and over, china, complication, coronavirus disease 2019, coronavirus infection, Covid 19, epidemic, pandemic, pneumonia, viral, public health, united kingdom, have similar color suggestive that these keywords have close relation and usually co-occur together)

Growth of publications:

The highest productivity was observed in the year 2020 with a total publication count of 755 (16.1%) whereas the lowest productivity was in the year 2000 with 11 documents (0.2%). The mean number of publications was at 226 documents per year over the entire study period. There was a jump in publication count between the year 2010 (66; double digit count) and 2011(124; triple digit count) (Table 3). This is interesting considering that there is a sharp rise in the number of publications between the last decade (2000-10) and this decade (2010-20) ((Supplementary fig. 3). The total citation count per year is shown in Table 3. The total citation count for these documents was highest in the year 2015 (15571 citations) (Table 3).The highest citation count in a given year for a single document was 334. During the study period, 11 documents received citations of more than 100 in a given year. With regard to citations per document, the count was highest for documents published in 2010 (67.9 citations per document) while the count was lowest for those published in 2020 (1.7 citations per document). This is expected as documents in 2020 have had the least intervening time to get cited.

Table 3 Annual numbers of publications and citation analysis per year

Year	Frequency	% N = 4546	TC	Mean +/- SD of Citations	Median (Q1-Q3)
2000	11	0.2	89	8.1 ± 4.0	2 (1-4)
2001	11	0.2	249	22.6 ± 11.3	2(1-4)
2002	11	0.2	266	24.2 ± 7.9	2(1-5)
2003	09	0.19	488	54.2 ± 20.2	2(1-4)
2004	15	0.33	486	32.4 ± 12.4	2(1-5)
2005	26	0.57	628	24.2 ± 9.7	2(1-5)
2006	23	0.50	407	17.7 ± 8.6	2(1-4)
2007	31	0.68	1317	42.4 ± 16.3	3(1-8)
2008	46	1.01	1839	40 ± 15.8	4(2-8)
2009	44	0.97	2035	46.2 ± 24.1	3(1-7)
2010	66	1.43	4481	67.9 ± 50.5	3(1-7)
2011	124	2.57	6976	56.2 ± 32	3(2-9)
2012	175	3.78	8457	48.3 ± 24.5	3(2-8)
2013	278	6.18	15278	54.9 ± 28.5	4(2-10)
2014	365	8.21	13469	36.9 ± 16.6	4(2-9)
2015	484	10.5	15571	32.2 ± 15.6	4(2-8)
2016	470	10.18	10754	22.9 ± 10.8	3(2-7)
2017	484	10.35	7575	15.6 ± 7.2	3(1-7)
2018	537	12.29	5071	9.6 ± 4.7	3(1-6)
2019	581	12.68	2758	4.7 ± 2.9	2(1-5)
2020	755	16.12	1254	1.7 ± 4.3	2(1-3)

(TC: Total Citations; SD: standard deviation; Q1: first quartile; Q3: third quartile)

Analysis of the Average Growth Rate (AGR) of documents showed a fluctuating trend with negative values in the year 2003, 2006, 2009 and 2016 which is shown by hyphen in Table 4(Supplementary fig. 5). The highest AGR Value was seen in 2011

(87.9%), which is in keeping with the rapid rise in publications between 2010 -11 (Table 4). Like the AGR values, the Relative Growth Rate (RGR) also kept fluctuating between relatively steady periods during the study. The highest Relative Growth Rate (RGR) value was 0.7 in 2001, fluctuated between 0.2 and 0.4 till 2010, then was steady at 0.4 during the period of 2011-14, and finally settled at a value of 0.2 between 2016-20 (Table 4; Supplementary fig. 5). The Doubling Time (DT) was highest in the year 2019 at 4.2 and the least in the year 2001 at 1.0. DT showed no stability throughout the course of study indicating that publications did not follow exponential growth during the study period (Supplementary fig. 5).

Table 4 Annual number of publications, AGR, RGR, and DT

Year	Frequency	AGR	Cumulative TP	loge W	RGR	DT
2000	11	-	11	2.4	-	-
2001	11	0	22	3.1	0.7	1.0
2002	11	0	33	3.5	0.4	1.7
2003	09	-	42	3.7	0.2	2.9
2004	15	66.7	57	4.0	0.30	2.3
2005	26	73.3	83	4.4	0.4	1.8
2006	23	-	106	4.7	0.2	2.8
2007	31	34.8	137	4.9	0.3	2.7
2008	46	48.4	183	5.2	0.3	2.4
2009	44	-	227	5.4	0.2	3.2
2010	66	50	293	5.7	0.3	2.7
2011	124	87.9	417	6.0	0.4	2.0
2012	175	41.1	592	6.4	0.4	2.0
2013	278	58.9	870	6.8	0.4	1.8
2014	365	31.2	1235	7.1	0.4	2.0
2015	484	32.6	1719	7.4	0.3	2.0
2016	470	-	2189	7.7	0.2	2.9
2017	484	3.0	2673	7.9	0.2	3.5
2018	537	9.5	3203	8.1	0.2	3.8
2019	581	9.6	3784	8.2	0.2	4.2
2020	755	30	4539	8.4	0.2	3.8

(TP: Total Publications; AGR: Annual Growth Rate; RGR: Relative Growth Rate; DT: Doubling Time)

Authorship pattern, collaboration, and prolific authors

The retrieved documents had a total of 25083 authors resulting in a mean of 5.4 authors per document. The highest numbers of total authors in this field in 2020 were 4348 while the lowest numbers of authors were 37 in 2000 (Table 5; Supplementary fig. 6). An increasing trend was seen in the mean number of authors per document (i.e. from 3.3 in 2000 to 6.4 in 2020) with fluctuations in the initial years of the study (2000-10) (Table 5; Supplementary fig. 6).

Table 5 Average author per document and author productivity per year

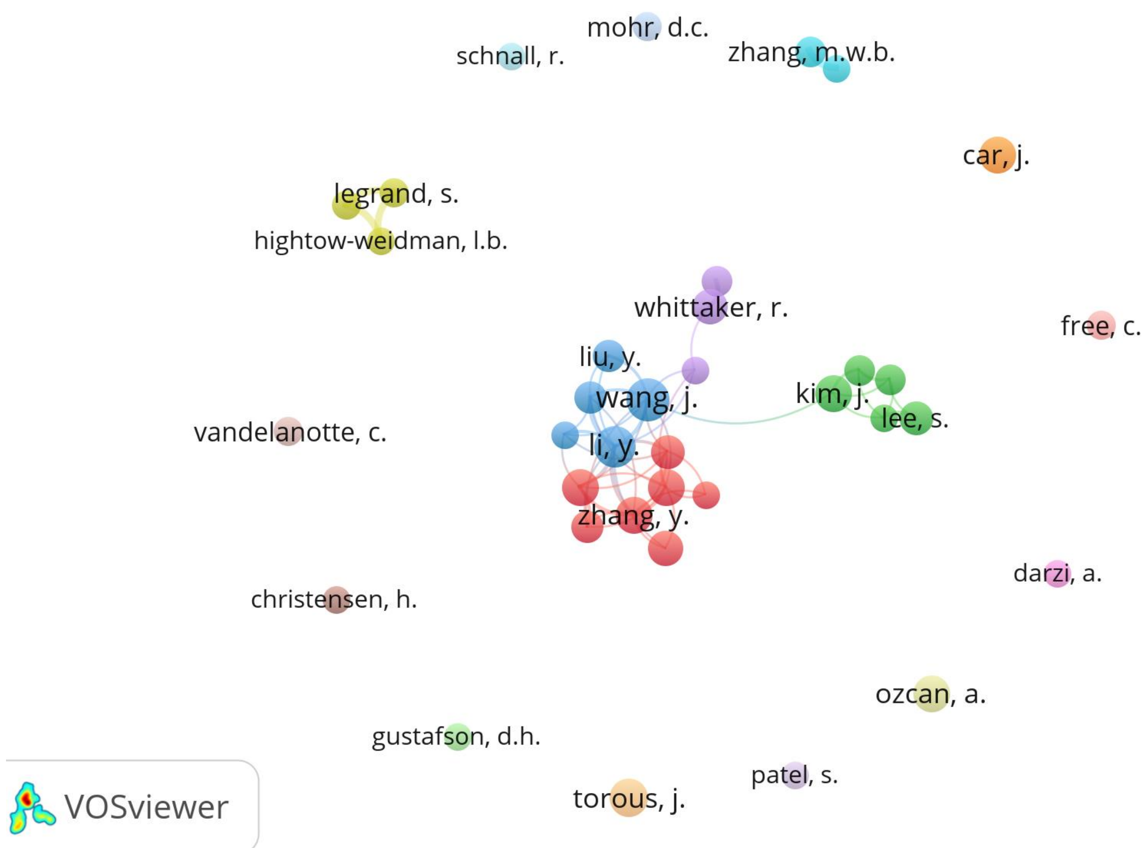
Year	Frequency	% (N= 4546)	Total number of authors	Authors per document
2000	11	0.24	37	3.3
2001	11	0.24	47	4.3
2002	11	0.24	44	4.0
2003	9	0.19	35	3.9
2004	15	0.33	66	4.4
2005	26	0.57	126	4.8
2006	23	0.51	73	3.2
2007	31	0.68	132	4.3
2008	46	1.01	164	3.6
2009	44	0.97	150	3.4
2010	66	1.45	261	4.0
2011	124	2.73	442	3.6
2012	175	3.85	709	4.0
2013	278	6.12	1200	4.3
2014	365	8.03	1752	4.8
2015	484	10.7	2420	5.0
2016	470	10.3	2589	5.5
2017	484	10.7	2611	5.4
2018	537	11.8	3510	6.5
2019	581	12.7	3872	6.7
2020	755	16.1	4843	6.4
Total	4546	100	25083	4.5

The count of single authored publications was 347(7.6%) while the remaining were multi-authored publications 4244(92.4%). The percentage of single authored publications reduced over time as whereas the percentage of multi-authored publications increased over time as a fraction of total publications (Table 6). The Collaborative Index (CI) fluctuated between the year 2000- 08, however post 2008 there was a steady increase from 3.9 in 2008 to 6.8 in 2019. In multi-authored joint publications, the mean CI was 5.8 authors per document (Table 6), indicating that more active collaboration between authors was taking place over the years in the field of spHealth Apps. The degree of collaboration also had a similar increasing trend with a mean degree of collaboration of 0.86 (Table 6).

Table 6 Collaboration index (CI) among authors in sp-Health Apps field

Year	Frequency	% N = 4546	Total number of authors	Single authored publications	%	Multi-Authored publications	%	Authors in multi-authored publications	Degree of Collaboration	CI
2000	11	0.24	37	3	27.3	8	72.7	34	0.73	4.3
2001	11	0.24	47	1	9.1	10	90.9	46	0.90	4.6
2002	11	0.24	44	2	18.1	9	81.8	42	0.82	4.7
2003	9	0.19	35	2	22.2	7	77.8	33	0.78	4.9
2004	15	0.33	66	2	13.3	13	86.7	64	0.87	5.5
2005	26	0.57	126	4	15.4	22	84.6	122	0.85	3.9
2006	23	0.51	73	6	26.1	17	73.9	67	0.74	5.0
2007	31	0.68	132	6	19.4	25	80.6	126	0.81	4.1
2008	46	1.01	164	8	17.4	38	82.6	156	0.83	3.9
2009	44	0.97	150	7	15.9	37	84.1	143	0.84	4.2
2010	66	1.45	261	5	7.6	61	92.4	256	0.92	4.3
2011	124	2.73	442	22	18.5	97	81.5	420	0.81	4.4
2012	175	3.85	709	17	9.7	158	90.3	692	0.90	4.7
2013	278	6.12	1200	36	12.6	250	87.4	1164	0.87	5.1
2014	365	8.03	1752	43	11.3	337	88.7	1709	0.89	5.5
2015	484	10.7	2420	56	11.5	430	88.5	2364	0.88	5.8
2016	470	10.3	2589	31	6.6	440	93.4	2558	0.93	5.8
2017	484	10.7	2611	40	8.3	439	91.6	2571	0.92	5.9
2018	537	11.8	3510	16	2.8	553	97.2	3494	0.97	6.3
2019	581	12.7	3872	21	3.6	566	96.4	3851	0.96	6.8
2020	755	16.6	4843	19	2.5	727	97.5	4824	0.97	6.6
Total	4546	100	25083	347	7.6	4244	93.4	24736	0.87	5.8

Authors with a minimum output of 10 documents and 100 citations were visualized using VOSviewer (Fig. 2). The map includes 36 authors which met the criteria of being active authors in spHealth Apps. Each circle represents one author. In the map, circles that are clustered close together represent close research collaboration. A different color represents a different cluster. In total, there are 17 such close research clusters. However, there were six prominent clusters in the center and authors in these clusters are interconnected [Cluster 1(7 items): Li, j.; Li, x.; Liu, x.; Wang,y.; Yang, j.; Zhang, j.; Zhang, y.;); Cluster 2 (5 items): Kim, j.; Kim, s.; Lee, h.; Lee, j.; Lee, s.); Cluster 3 (5 items) Li, y.; Liu, y.; Wang, j.; Wang, l.; Wang, s.); Cluster 4 (3 items) Hightow-weidman, l.b.; Legrand, s.; Muessig, k.e.; Cluster 5 (3 items) Chen, j.; Maddison, v.;Whittaker, v.; Cluster 6 (2 items) Ho, r.c.m.; Zhang, m.w.b.].The size of the circles indicate the total number of documents by the author (the larger the circle the more the number of documents) while the strength of the link between the authors is represented by the thickness of the connecting line. In terms of total link strength Li, y. had a total link strength of 22; followed by Hightow-weidman, Legrand, s., and Muessig, k.e. having a link strength of 18; followed by Wang, j., and Zhang, y. having a link strength of 14 (Supplementary Table 1).



(Fig. 2 Authors with a minimum of 10 publications and 100 citations were visualized. The map included 36 authors in 17 clusters who met the criteria of being active authors. Some names are not seen due to overlap of names. Clusters indicate active authors of close research collaboration.)

The top 12 authors in the field of spHealth Apps are listed in Table 7. Torous, John Blake stood at 18 publications, followed by Ozcan, Adyogan (17); Car, Jossip(16);Maddison, Ralph(12); Free, Caroline Jane(11); Mohr, David C. (11); Muessig, K.E.(11); Vandelanotte, Cornee(11); Gustafson, David H. (10);Hightow-Weidman, L.B. (10);Ho, Chun Man Roger(10) and Schnall, Rebecca(10). The affiliation of these authors is listed in Table 7.

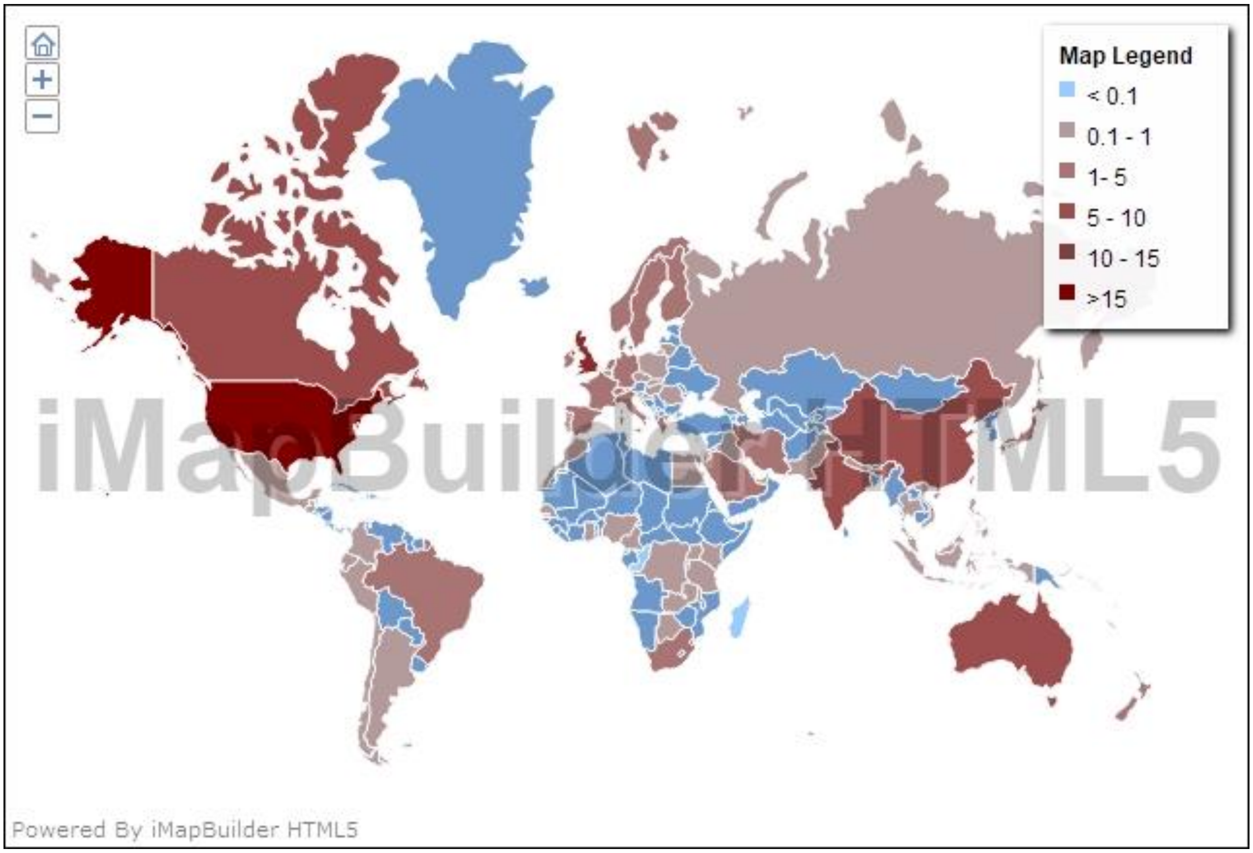
Table 7 Top ranking authors, current affiliation and country of origin in the field of sp- Health Apps

Rank	Author name	Document Count	Current affiliation	Country
1	Torous, John Blake	18	Harvard University, Cambridge	United States
2	Ozcan, Aydogan	17	University of California, Los Angeles	United States
3	Car, Josip	16	Nanyang Technological University, Singapore City	Singapore
4	Maddison, Ralph	12	Deakin University, Geelong	Australia
5	Free, Caroline Jane	11	London School of Hygiene & Tropical Medicine	London
6	Mohr, David C.	11	Northwestern University Feinberg School of Medicine, Chicago	United States
7	Muessig, K.E.	11	The University of North Carolina at Chapel Hill, Chapel Hill	United States
8	Vandelanotte, Corneel	11	CQ University Australia, Rockhampton,	Australia
9	Gustafson, David H.	10	University of Wisconsin-Madison, Madison	United States
10	Hightow-Weidman, L.B.	10	UNC School of Medicine, Chapel Hill,	United States
11	Ho, Chun Man Roger	10	National University of Singapore, Singapore City	Singapore
12	Schnall, Rebecca	10	Columbia University School of Nursing, New York	United States

The authors' Scopus IDs, year of first publication, total publications, h-index and total citations are listed in Additional file 1- Table 2 . The first publication for these prolific authors was between the years 1990 to 2014 with the top three authors having their first publications in the year 2014, 2002 and 2001 respectively. Ozcan, Adyogan has the highest number of total publications, followed by Car Jossip and Ho, Chun Man Roger- their publications standing at 461,369 and 363 publications respectively. Mohr, David C had the highest h-Index among the top 10 authors with an h-index of 68, with a total citation count of 11255 (Supplementary Table 2)

Geographical distribution of publications

Researchers from 130 countries contributed to the publications retrieved from scopus. IMap Builder Interactive HTML5 Map Builder was used to showcase the distribution of publications around the world by using a heath map (Fig. 3).



(Fig. 3 iMap Builder Heath Map based on the number of publications country wise: The dark maroon colour indicates the United States which is the major contributor of published Literature on spHealth Apps(>15% of total published documents). The lighter the shade the less the contribution from that country with the countries in blue colour showing relatively minor or no contribution at all to published Literature in spHealth Apps(< 0.1%).)

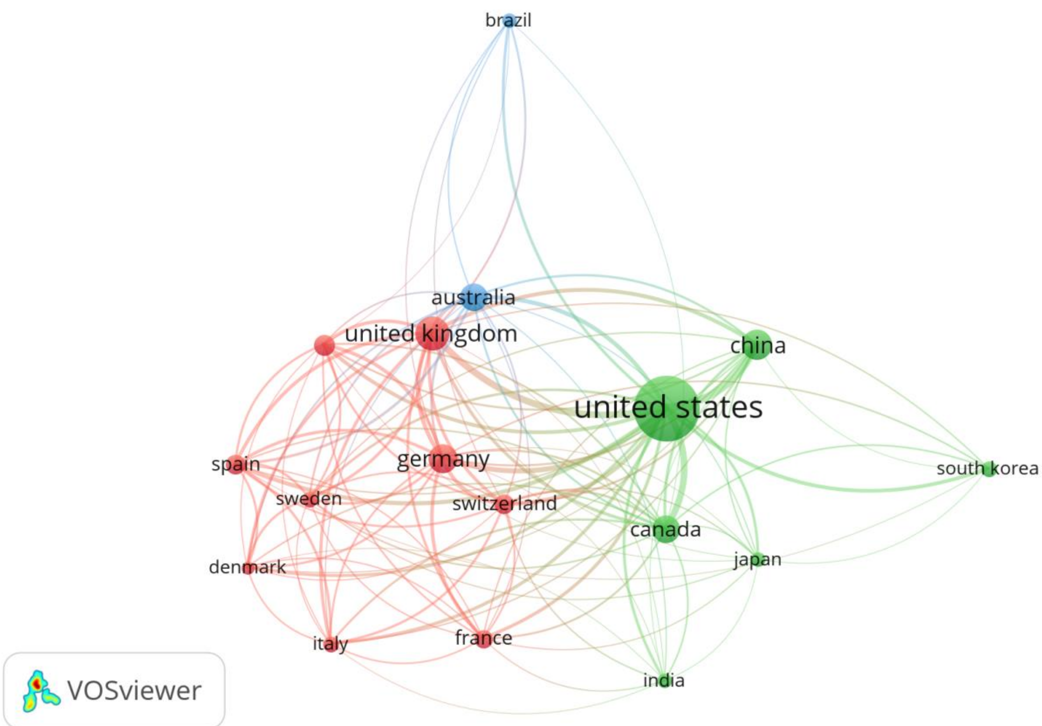
The United States had the highest contribution to the global publication list with 1775 publications (39.1%). This was followed by the United Kingdom with 582 publications (12.8%) and Australia with 387 publications (8.5%). India, Canada, and China contributed to an equal extent and were around the 255 mark with publications

(5.6%). Out of the participating 130 countries, 13 countries (10%) had a publication count above 100 publications and are listed in Table 8.

Table 8 Institution-wise retrieved documents

Affiliation	Number of Publications	% (N=4539)	Country
Harvard Medical School	96	2.1	USA
The University of Sydney	75	1.7	Australia
University of California, Los Angeles	68	1.5	USA
University of Toronto	67	1.5	Canada
Karolinska Institutet	64	1.4	Sweden
Imperial College London	64	1.4	UK
University of Washington, Seattle	62	1.4	USA
University of Melbourne	59	1.3	Australia
University of California, San Francisco	57	1.3	USA
Duke University	47	1.0	USA
University College London	47	1.0	UK
University of Pennsylvania	46	1.0	USA
Brigham and Women's Hospital	44	0.9	USA
Monarch University	44	0.9	USA
University of Michigan, Ann Arbor	44	0.9	USA

A visualization of collaboration between countries with a minimum productivity of 50 documents was performed using VOSviewer (Fig. 4). 3 distinct clusters containing a total of 17 countries are shown in the map. Each cluster was of a different color. The link strength which depicts collaboration strength between pairs of countries was as follows in descending order: USA-China (Link strength = 84), USA-UK (Link strength = 65), USA-Canada (Link strength = 63), USA-Germany (Link strength = 36), USA-Australia (Link strength = 26), USA-Spain (Link strength = 25) (Fig. 4).



(Fig. 4 Network visualization map of international collaboration among countries with a minimum productivity of 50 documents. The thickness of connecting line between any two countries indicates strength of collaboration. For example, the link strength (collaboration) between USA and China was 84 and it represents a thick line. On the other hand, the line between USA and India had a link strength of 12. Countries with similar color form one cluster. For example, countries with red color such as United Kingdom and Germany existed in one cluster and had the highest percentage of collaboration within this cluster. India, Canada, Japan, China and South Korea were clustered in green since the bulk of their collaboration is with the USA, so they are grouped with USA.)

The institutions around the globe that were actively involved in spHealth Apps research are shown in Table 9. Most of the top15 active institutes were based in the United States in keeping with higher productive output in this country. Harvard medical school was the most productive institution with 96 publications. This was followed by many institutions recognized for their cutting edge research: University of Sydney (75), University of California-Los Angeles (68), University of Toronto (67), Karolinska Institutet (64), Imperial college London (64), University of Washington Seattle (62), University of Melbourne (59), University of California at San Francisco (57) and Duke University (47).The countries to which each of these institutions belong to are shown in Table 9.

Table 9 Journal names with minimum productivity of 20 publications in sp-Health Apps

Rank	Journal	Frequency	% (N=4546)
1	Jmir Mhealth And Uhealth	352	7.6
2	Journal Of Medical Internet Research	240	5.3
3	Telemedicine And E Health	87	1.9
4	Jmir Research Protocols	66	1.5
5	Plos One	66	1.5
6	International Journal Of ER & PH	64	1.5
7	Journal Of Medical Systems	48	1.4
8	International Journal Of Medical Informatics	47	1.0
9	Journal Of Diabetes Science And Technology	42	1.0
10	Trials	40	1.0
11	BMJ Open	33	0.9
12	Sensors Switzerland	33	0.9
13	BMC Public Health	32	0.7
14	BMC Medical Informatics And Decision Making	31	0.7
15	Journal of Telemedicine And Telecare	28	0.7
16	IEEE Access	23	0.6
17	Journal Of The AMIA	23	0.5

(ER & PH: Environmental Research And Public Health; AMIA: American Medical Informatics Association)

Preferred journals:

17 journals in Scopus had a minimum productivity of 20 documents in spHealth Apps (Table 10). The journal '*Jmir Mhealth and Uhealth*' ranked first with 352 documents (7.6%). This was followed in second place by '*Journal of Medical Internet Research*' with 240(5.3%) documents and in third place by the journal '*Telemedicine and E-Health*' with 87 documents (1.9%) (Table 10). We next determined the most cited article in the year 2020 in the top 10 journals in spHealth Apps. Without any doubt, published documents related to the Covid-19 pandemic received the highest number of citation counts in these reputed journals. The most cited article was titled *"Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China"* from the journal of '*International Journal Of Environmental Research And Public Health*'. This article was cited 1272 times. This was followed by two other articles, one from the journal '*Plos One*' titled *"Mental health problems and social media exposure during COVID-19 outbreak"* (cited 249 times) and the other from the journal *'Telemedicine and e-Health'* titled *"The Role of Telehealth in Reducing the Mental Health Burden from COVID-19*" (cited 159 times) (Table 10).

Table 10 Top 10 journal rankings along with Most Cited Articles, Times Cited, and Publisher in sp- Health Apps

Rank	Journal	Most Cited Article	Times Cited
1	Jmir Mhealth And Uhealth	Peer-to-peer contact tracing: Development of a privacy-preserving smartphone app	40
2	Journal Of Medical Internet Research	Top concerns of tweeters during the COVID-19 pandemic: A surveillance study	69
3	Telemedicine And e-Health	The Role of Telehealth in Reducing the Mental Health Burden from COVID-19 (note)	159
4	International Journal Of ER & PH	Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China	1272
5	Plos One	Mental health problems and social media exposure during COVID-19 outbreak	249
6	Jmir Research Protocols	A mobile-based app (Mychoices) to increase uptake of HIV testing and pre-exposure prophylaxis by young men who have sex with men: Protocol for a pilot randomized controlled trial	17
7	International Journal Of Medical Informatics	Blockchain in healthcare and health sciences—A scoping review	19
8	Journal Of Medical Systems	AI-Driven Tools for Coronavirus Outbreak: Need of Active Learning and Cross-Population Train/Test Models on Multitudinal/Multimodal Data	73
9	Journal Of Diabetes Science And Technology	Glycemic Characteristics and Clinical Outcomes of COVID-19 Patients Hospitalized in the United States	107
10	Trials	Treatment of Middle East respiratory syndrome with a combination of lopinavir/ritonavir and interferon-β1b (MIRACLE trial): Statistical analysis plan for a recursive two-stage group sequential randomized controlled trial(Article)	64

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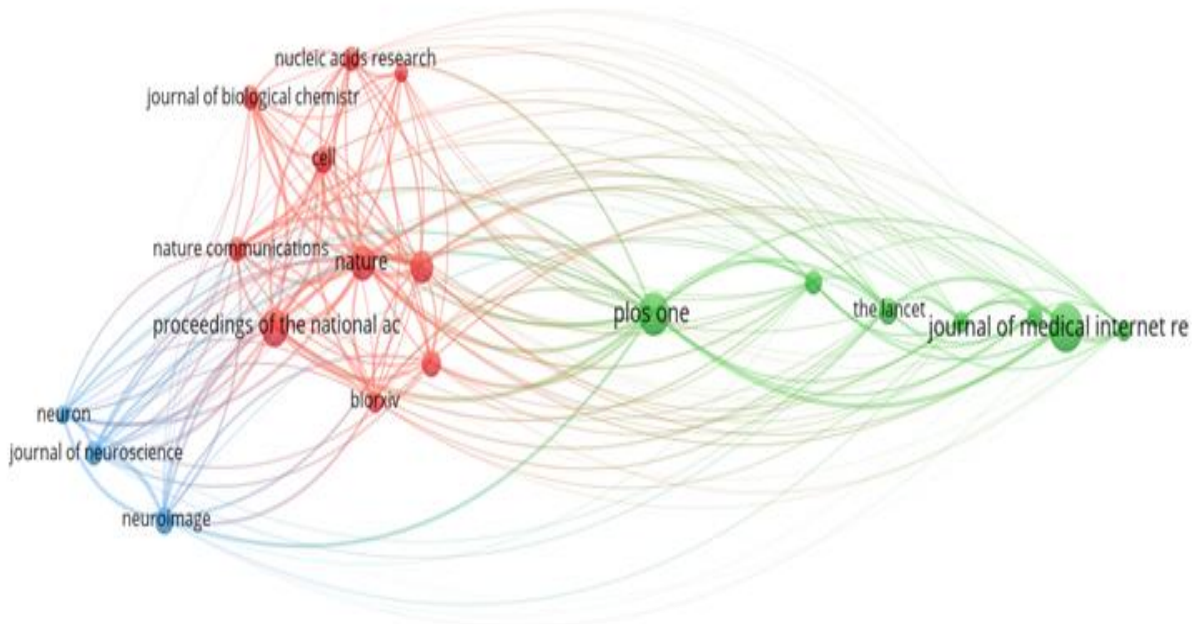
q et al., 2020; Arabi et al., 2020; Biello et al., 2019; Bode et al., 2020; Gao et al., 2020; Hasselgren et al., 2020; Santosh, 2020; C. Wang et al., 2020; Yasaka et al., 2020; Zhou et al., 2020)

The Total Publications (TP) in 2020, Total Citations (TC) between 2016-2020, Cite Score in 2019, the h- index for the journal, most recent Impact Factor (IF) and publishing house for the 10 most productive journals in spHealth Apps is shown in Supplementary file 1 (Supplementary Table 3).

Using VOSviewer, a visualization of co-citation among journals with minimum co-citations of 500 documents was shown in Fig. 5. The map showed 20 journals distributed in 3 different clusters. Each cluster was of a different color. Journals that co-cited articles to a larger extent were close to each other. ‘*Plos One’*, ‘*The Journal of Medical Internet Research’,’ The Lancet’, ‘New England Journal of Medicine’,’ jmir mhealth and uhealth’, ‘JAMA’, the BMJ* are in one cluster; ‘*Neuron’, ‘The Journal of Neuroscience’,and ’ Neuroimage’* in another cluster and finally ‘*Bioinformatics’, ‘Biorxiv’, ‘Cell’, ‘Journal of Biological Chemistry’,’ Nature’,’ Nature communications’, ‘Nucleic acid Research’, ‘Proceedings of the National Academy of Sciences’,’ Science, Scientific reports’* formed the third cluster (Fig. 5).



(Fig. 5 Network visualization map of journal co-citation analysis for journals which published documents in m-Health with a minimum total of 500 citations. The journal PLOS one had many connecting lines with various journals indicating that this journal is being co-cited with various journals. Journals in the same cluster with the same color are being commonly co-cited together (20 journals; 3 clusters))

Top cited documents in spHealth Apps:

The top-20 most cited articles in the field of spHealth Apps are shown in table 11. The top cited documents include 13 reviews, 6 articles and 1 editorial. The article with the highest citation count was titled, "*A survey of mobile phone sensing*". This article received 1563 citations and was published in 2010 in the IEEE communications magazine. The other documents were in the field of mobile health interventions, health apps, behavioral models and apps associated with mental health, apps for doctors, apps for Covid-19 contact tracing, weight-loss and next generation point-of-care testing(Table11).

Table 11 Top 20 cited articles in the field of spHealth App

Rank	Title	Year	Journal name	Cited by	Type of document
1	A survey of mobile phone sensing	2010	IEEE Communications Magazine	1563	Review
2	Paper-based microfluidic point-of-care diagnostic devices	2013	Lab on a Chip	1214	Review
3	Consort-ehealth: Improving and standardizing evaluation reports of web-based and mobile health interventions	2011	Journal of Medical Internet Research	715	Editorial
4	How smartphones are changing the face of mobile and participatory healthcare: An overview, with example from eCAALYX	2011	BioMedical Engineering Online	645	Review
5	A systematic review of healthcare applications for smartphones	2012	BMC Medical Informatics and Decision Making	599	Review
6	Health behavior models in the age of mobile interventions: Are our theories up to the task?	2011	Translational Behavioral Medicine	581	Review
7	Smartphones for smarter delivery of mental health programs: A systematic review	2013	Journal of Medical Internet Research	570	Review
8	Healthcare in the pocket: Mapping the space of mobile-phone health interventions	2012	Journal of Biomedical Informatics	554	Review
9	Mobile devices and apps for health care professionals: Uses and benefits	2014	P and T	505	Review
10	Health app use among US mobile phone owners: A national survey	2015	JMIR mHealth and uHealth	485	Article
11	Mobile phone based clinical microscopy for global health applications	2009	PLoS ONE	485	Article
12	MHealth for mental health: Integrating smartphone technology in behavioral healthcare	2011	Professional Psychology: Research and Practice	466	Article
13	"Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing"	2020	Science	450	Article
14	"Mobile-health: A review of current state in 2015 "Open Access"	2015	Journal of Biomedical Informatics	418	Review
15	"The smartphone in medicine: A review of current and potential use among physicians and students "Open Access"	2012	Journal of Medical Internet Research	402	Review
16	Opportunities and challenges for smartphone applications in supporting health behavior change: Qualitative study	2013	Journal of Medical Internet Research	394	Article
17	Lensfree microscopy on a cellphone	2010	Lab on a Chip	384	Article
18	Mobile phone sensing systems: A survey	2013	IEEE Communications Surveys and Tutorials	382	Review
19	Adherence to a smartphone application for weight loss compared to website and paper diary: Pilot randomized controlled trial	2013	Journal of Medical Internet Research	373	Review
20	Emerging Technologies for Next-Generation Point-of-Care Testing	2015	Trends in Biotechnology	361	Review

Ref: (Boulos et al., 2011; Breslauer et al., 2009; Carter et al., 2013; Dennison et al., 2013; Donker et al., 2013; Eysenbach, 2011; Ferretti et al., 2020; Khan et al., 2013; Klasnja & Pratt, 2012; Krebs & Duncan, 2015; Lane et al., 2010; Lee Ventola, 2014; Luxton et al., 2011; Mosa et al., 2012; Ozdalga et al., 2012; Riley et al., 2011; Silva et al., 2015; Tseng et al., 2010; Vashist et al., 2015; Yetisen et al., 2013)

Discussion

In this study, bibliography indicators in mHealth Apps publications were sought using the Scopus database as a retrieval source. English remained the language of choice for most authors in the field of mHealth Apps. More than 97 % of the retrieved articles were in English, However, it is important to point out that Scopus, as a database is biased towards publications in the English language(Mongeon & Paul-Hus, 2016) . Most of the contributing sources to Scopus majorly accept only publications in the English language, thus the percentage of the retrieved articles in English might be an overestimation when considering the literature in its totality.

The number of publications in spHealth-Apps showed a rapid growth in the second half of the study, i.e., between years 2010-2020. Along with the increase in total number of publications, there was an accompanying increasing trend of total citation count. This indicates a steady growth in literature related to spHealth Apps. This is in keeping with a recent bibliometric study in mobile applications related to mHealth using the Web of Science database (WOS) (Peng et al., 2020).

Literature in spHealth Apps showed a steady increase in the average number of authors per document during the study period. In keeping with this, the fraction of single authored publications steadily went down while the fraction of multi-authored publications increased over the analysis period. This increasing trend in the number of authors per document in authorship analysis lends to the fact that mHealth Apps is a multidisciplinary field that requires authors specialized in areas of healthcare as well as in areas of technology. Due to easy accessibility/sharing of large data sets with existing data networks as well as no wet lab work, multi-authorship and collaborations across the globe is seen to be a trend in this area. As compared to other specific and specialized disciplines, the area of mHealth-Apps showed higher Collaborative Index (CI) and multi-authored publications(Elango & Rajendran, 2012; Navaneethakrishnan, 2014; Rajgoli & Laxminarsaiah, 2015; Thavamani, 2015; Zafrunnisha & Pullareddy, 2009).

As expected, the USA ranked first in this area with the highest number of publications, however, Europe -in particular the United Kingdom- and the East were also significant contributors. Of particular interest is the rise of Low-and-Middle Income Countries (LMIC) in the number of publications. China and India were pretty much in the same league with regards to the number of publications in spHealth Apps. This area of research is beginning to have a huge impact and has enormous potential in these LMIC countries due to their vast sizes, large populations, and people with different languages, ethnicities and culture (Jain et al., 2019; Littman-Quinn et al., 2013; Mutebi et al., 2020; Umali et al., 2016). However, there is need to customize spHealth Apps for a specific region keeping culture differences like language in mind (Grau-Corral et al., 2020; Hsu et al., 2016; Jain et al., 2019; Martin Payo et al., 2019; Rodriguez & Singh, 2018).

Along with collaboration with the United States, there is more need for collaborations with European countries and South Asian countries like Australia in order for this area to rapidly grow in developing countries. There is also need for further collaboration between the top authors in spHealth Apps. Authors from LMIC may need to enter collaborative clusters with high quality researchers seasoned in this field in order to advance the quality, effectiveness, and impact of their designs and study outcomes.

The Harvard Medical School in Boston, USA was the most productive institution. This is not surprising considering that the research departments of Harvard Medical School are known for their cutting edge high quality research. Out of the top 15 institutions for spHealth Apps, eight of them were from the USA, three institutions were from Europe while the rest were from Australia and Canada signifying that the US is still a dominant force with regards to research in this area. In keeping with this data, the majority of the top ten authors were based in the United States.

Visualization of author keyword analysis shows that keywords based on the types of studies (i.e. randomized controlled trials, controlled study, feasibility studies, pilot studies) occurred frequently, were clustered together and were highly connected (i.e. high link strength). However, some keywords in certain clusters like infants, newborns, preschool child, caregiver, health personnel, and emergency health services occurred less frequently and were less connected to other keywords indicating areas that can be studied further. Similarly, occurrence of keywords like wearable sensors and wearable devices suggest future scope in these areas.

The Journal of '*Jmir Mhealth And Uhealth*' ranked number one with regards to the most preferred journal for publishing documents in spHealth Apps, followed by '*Journal Of Medical Internet Research*', and by '*Telemedicine and E Health*'. This preference is in corroboration with other bibliometric studies in this field of mobile health applications (Peng et al., 2020; Sweileh et al., 2017). The drastic drop from 240 to 87 publications between the second and third ranked journal clearly indicates that the Journal of '*Jmir Mhealth And Uhealth*' and the '*Journal Of Medical Internet Research*' are the preferred journals to publish in by most authors in this field. Regarding co-citations between journals, '*PLOS ONE'* has publications in spHealth Apps which are co-cited with journals in the field of Neuroscience, Biological Sciences, and journals related to the Medical Technology field. *'PLOS ONE'* has the highest count of total citations and Journal publications among the journals in spHealth Apps. Thus, it is not surprising that "PLOS ONE" is a central hub in co-citation analysis given the wide coverage of research in diverse fields which are published in *'PLOS ONE'* .

Among the top cited articles in spHealth Apps, apps making an impact can be grouped into three broad categories: advancing health services, improving lifestyles and reversing the burden/spread of diseases. For e.g. apps like Calm, Fit bit among other top fitness apps are very popular with the highest number of downloads in US, India and Brazil. These apps have shown to be useful and effective as interventions encouraging more physical activity in patients as well as in non-patients(Broers et al., 2020; Petersen et al., 2020). Interestingly apps incorporating fitness related video content along with integrating information from wearable sensors are more popular, particularly during the COVID-19 pandemic when gyms are closed. Besides improving physical health, certain studies have shown that phone apps also have great potential for reduction of mental health burden in the community (Collins et al., 2020). Further studies on effectiveness of phone apps in this regard are in the pipeline(K. Wang et al., 2018). This aspect is of particular interest to the government and other health regulatory agencies due to the ever increasing mental health problem especially in the developing world (Wainberg et al., 2017). With regard to point-of-care diagnostic health services, the use of phones as portable microscopes with resolutions capable of detecting disease causing microorganisms are beneficial on field (Koydemir & Ozcan, 2017). In keeping with point-of-contact care diagnostics, many Lab On Chip (LOC) devices and Paper Based Assays(PBAs) are being developed and integrated with current smartphone applications for quantitative and quantitative analysis(Chen et al., 2014; Hu et al., 2016; Yang et al., 2016). In terms of controlling infectious diseases spread, the use of contact tracing apps in COVID-19 (SARS-CoV-2), along with manual contact tracking is underway. However, the actual effectiveness of such contact tracing applications along with data privacy and other ethical aspects is still under investigation (Almagor & Picascia, 2020; Braithwaite et al., 2020; Klar & Lanzerath, 2020; Morley et al., 2020; Yasaka et al., 2020).

Our study had a few limitations: First, the use of databases for searches and retrieval of publications comes with its own limitations- the reader should understand that Scopus has inherent biases towards published literature versus grey literature, unindexed journals, and language used in publications. Thus, there is a possibility of important articles being missed in the process of data retrieval from Scopus. Second, the search query is never 100% perfect and can lead to false positives and false negatives like any other study in bibliometrics. Thus, the count is to be expected with a certain margin of error; however, this should be small enough not to remain a significant factor. Third, it is important to keep in mind that some journals have been reviewed and removed from Scopus during this study. Equally important to note is the ranking of institutions and authors as reported by Scopus might be inaccurate as it could be possible that a single author or institution can be represented by more than one name. In these instances the score count detected by Scopus could be lower than the actual count, thereby creating a discrepancy in the productivity of the authors and institutions. Finally Scopus is updated frequently so it could be that numbers and values could change over time.

In terms of merits of our study, to our knowledge this is the first study to bibliometrically analyze publications on smartphone health applications using Scopus as a database within this study period.

Conclusion

spHealth Apps used in healthcare is a rapidly growing field that holds much promise for the future. Earlier spHealth Apps were predominant in certain health related fields particularly as interventions for certain disease conditions. However, in more recent times, a slew of applications focusing on general fitness and well-being (e.g. physical and mental health) are being widely used. Last year, the Covid-19 pandemic highlighted the immense potential Apps have in informing the public and combating the spread of the virus. Careful thought in planning and designing of health related applications as well as educating the public with regards to their benefits and advantages of usage should be a top priority of health-care companies, agencies and governments going forward. These steps if taken at the right time could keep the population ready and prepared for future major public health crisis and Challenges. The data given here serves as a guide for policymakers in government and institutes as well as researchers in the field to locate active authors and their clusters understand active publication areas and quality of publications using the indicators discussed in this study.

Additional File:

Additional file 1:

Supplementary fig. 1 Flowchart of the search strategy- search strategy using the search string [("Healthcare" or "Health") and ("Application or "App") and ("Smartphone"or "App")] in title-abstract-keyword fields - used on the Scopus database to retrieve documents

Supplementary fig. 2 Pie charts depicting the type of contributing documents and the number of documents in terms of language

Supplementary fig. 3 Line graphs depicting the number of retrieved document & the number of citations received by the retrieved documents per year (2000-20)

Supplementary fig. 4 Network visualization map of author title keywords occurrences (i.e., keywords in the title listed by the author)

Supplementary fig. 5 Line graphs depicting the % AGR, RGR & DT of the retrieved documents

Supplementary fig. 6 Bar graphs depicting the total number of authors and average number of authors per document of retrieved documents

Supplementary Table 1 The top 10 Authors in spHealth Apps having highest total link strength and strong linkage (Linkage Score) with other authors in a particular cluster

Supplementary Table 2 Top ranking authors in the field of sp-Health Apps along with their publication details and indices

Supplementary Table 3 Top journal rankings with details of Total Publications (TP), Total Citations (TC) and Cite Score (CS) in sp-Health Apps (2000-20)

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Availability of data and materials

The data can be retrieved from the Scopus database by using the search query presented in the methods section.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

As this study was solely based on bibliometric analysis, no patients or patient data were involved in this type of analysis. Therefore, there was no need for ethics approval by the Institutional Review Board and it was exempted based upon the design of this study.

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Supplementary Figures and Tables

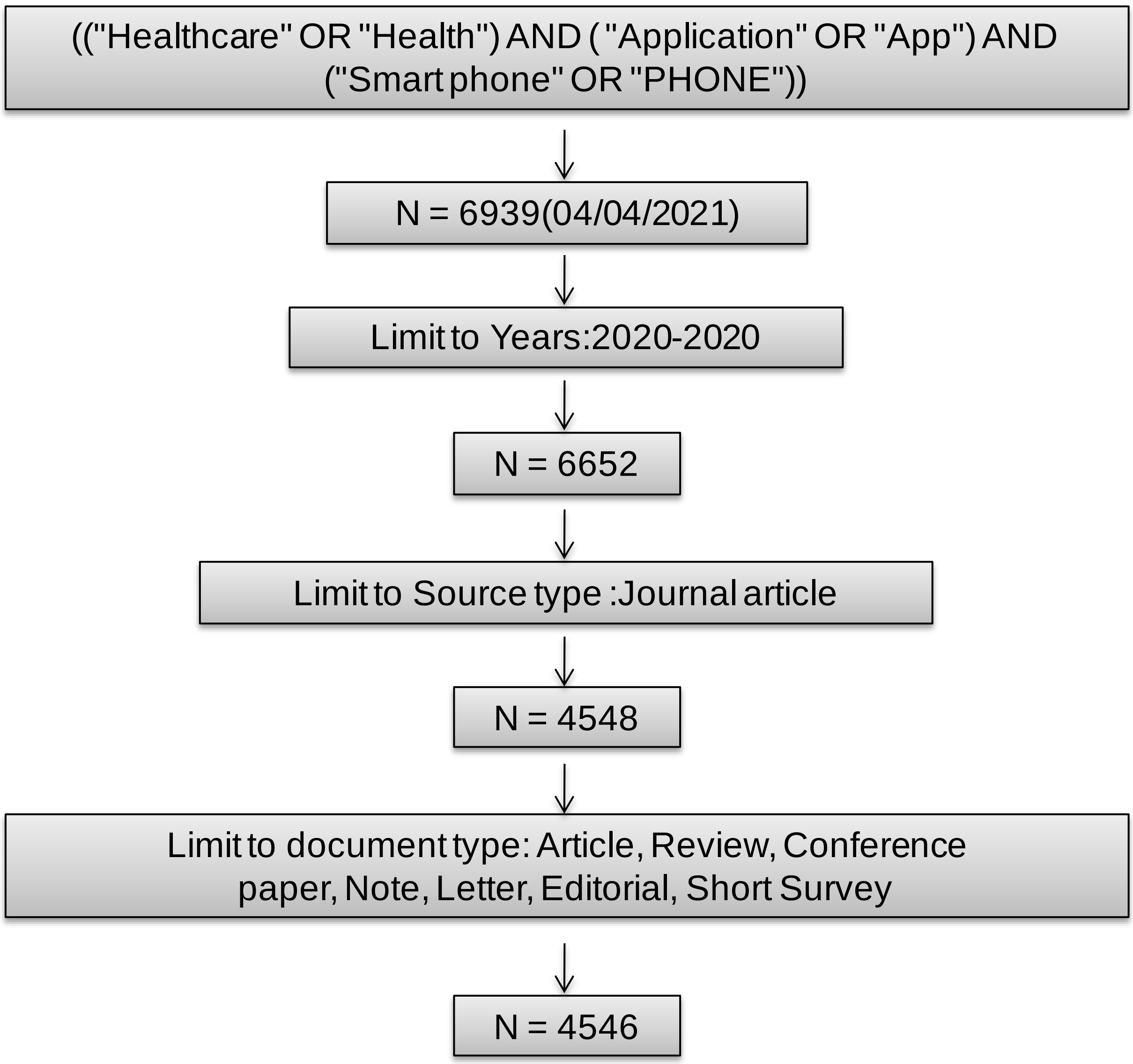

Fig. 1 The search strategy used on the Scopus database to retrieve documents

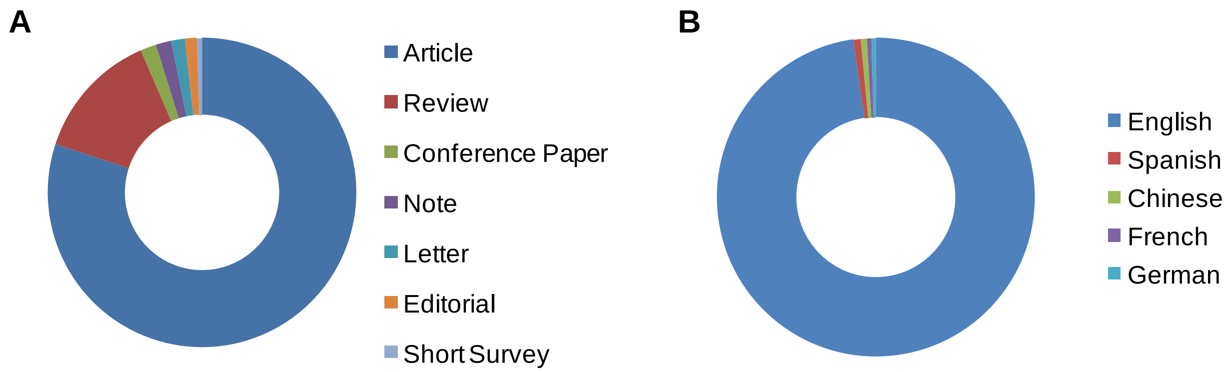

Fig. 2 A) Pie charts depicting the type of contributing documents and B) the number of documents in terms of language

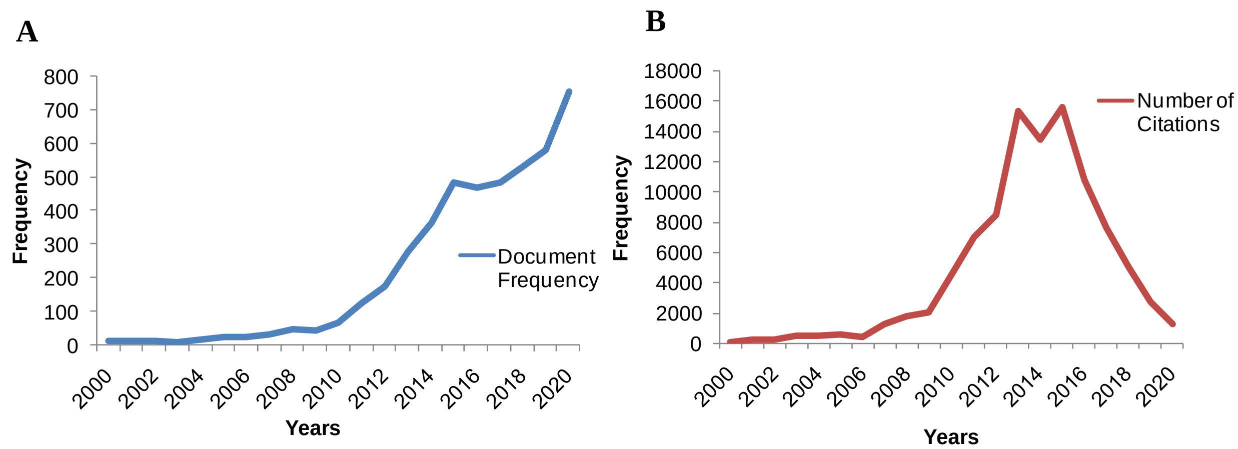

Fig. 3 A) Line Graphs depicting the number of retrieved document and B) the number of citations received by the retrieved documents per year (2000-2020)

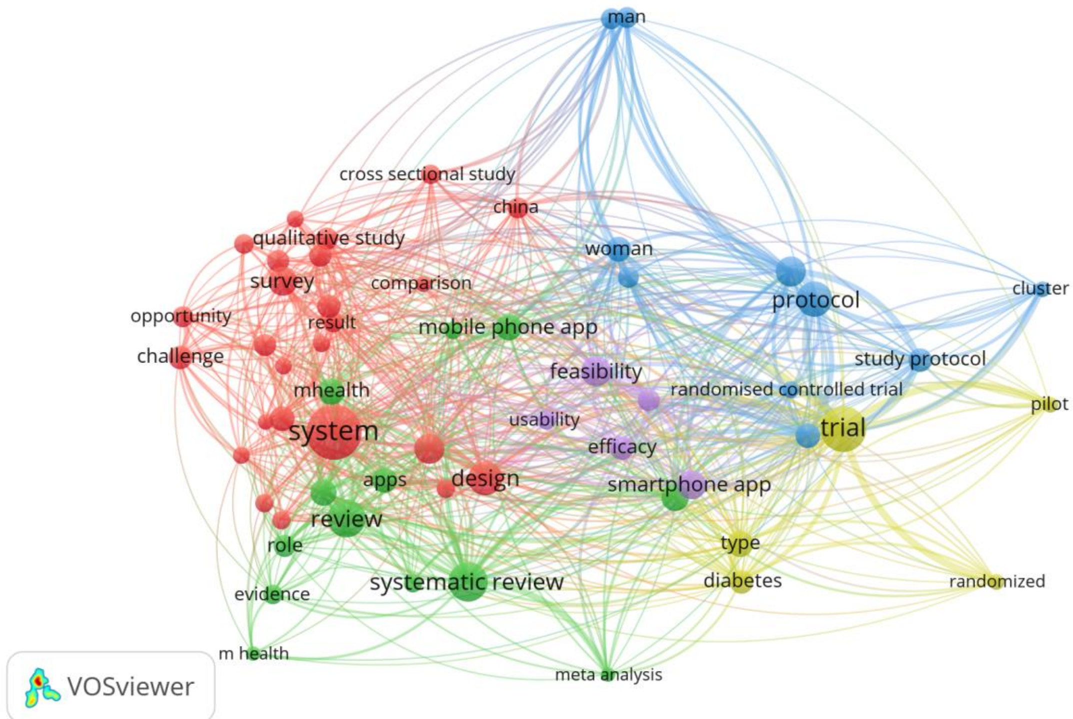

Fig. 4 Network visualization map of author title keywords occurrences (i.e. keywords in the title listed by the author). Keywords with minimum occurrences of 25 times were shown in the map. Title keywords with the same color were commonly listed together. So, for example, systematic review, meta -analysis, mobile phone app, evidence, content analysis, apps, m health, mhealth, mental health, mobile health, physical activity, review, and role (Cluster 2; 13 items) have similar color suggestive that these keywords have close relation and usually co-occur together.

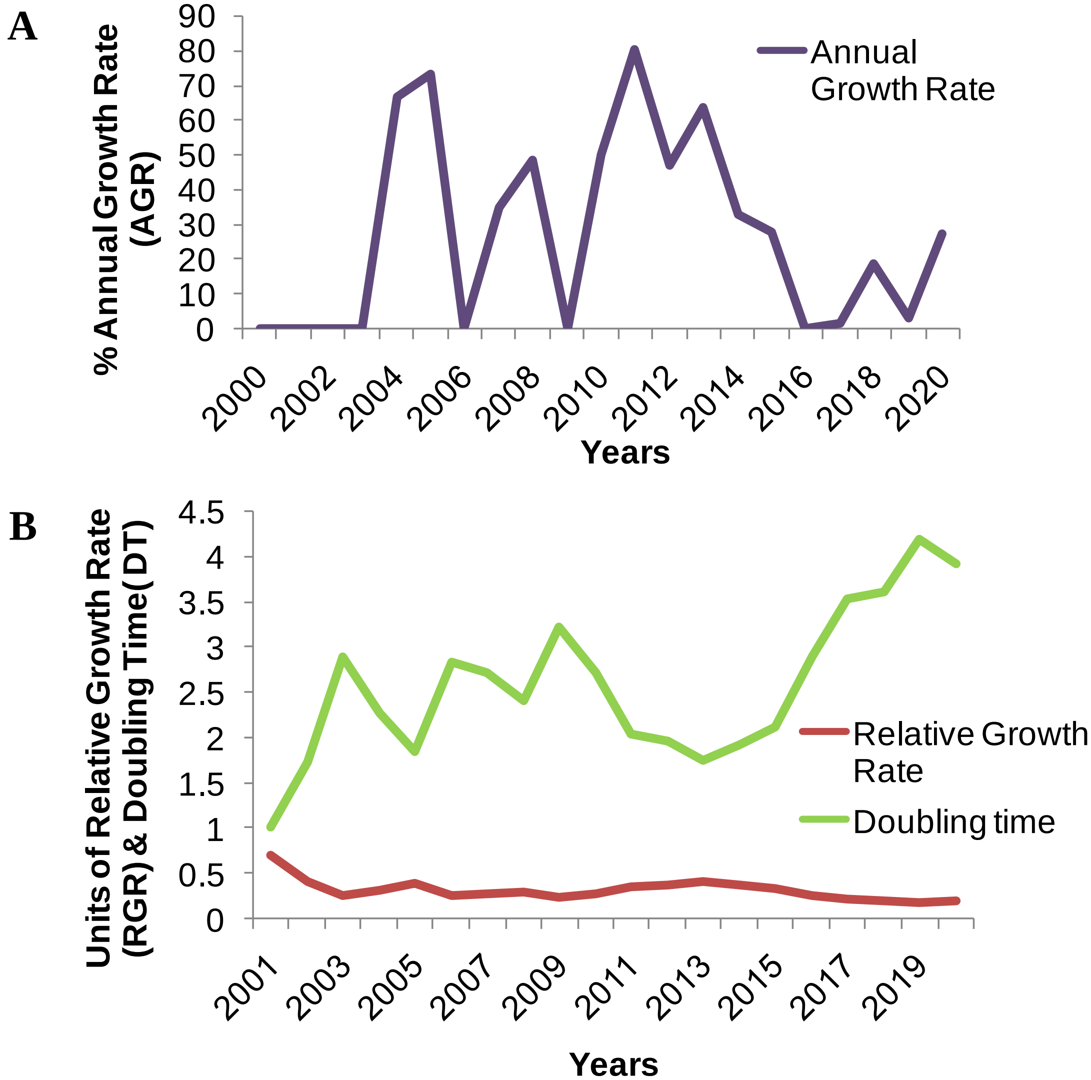

Fig. 5 A) Line graphs depicting the % AGR of retrieved document and B) Line graphs depicting the RGR & DT of retrieved document

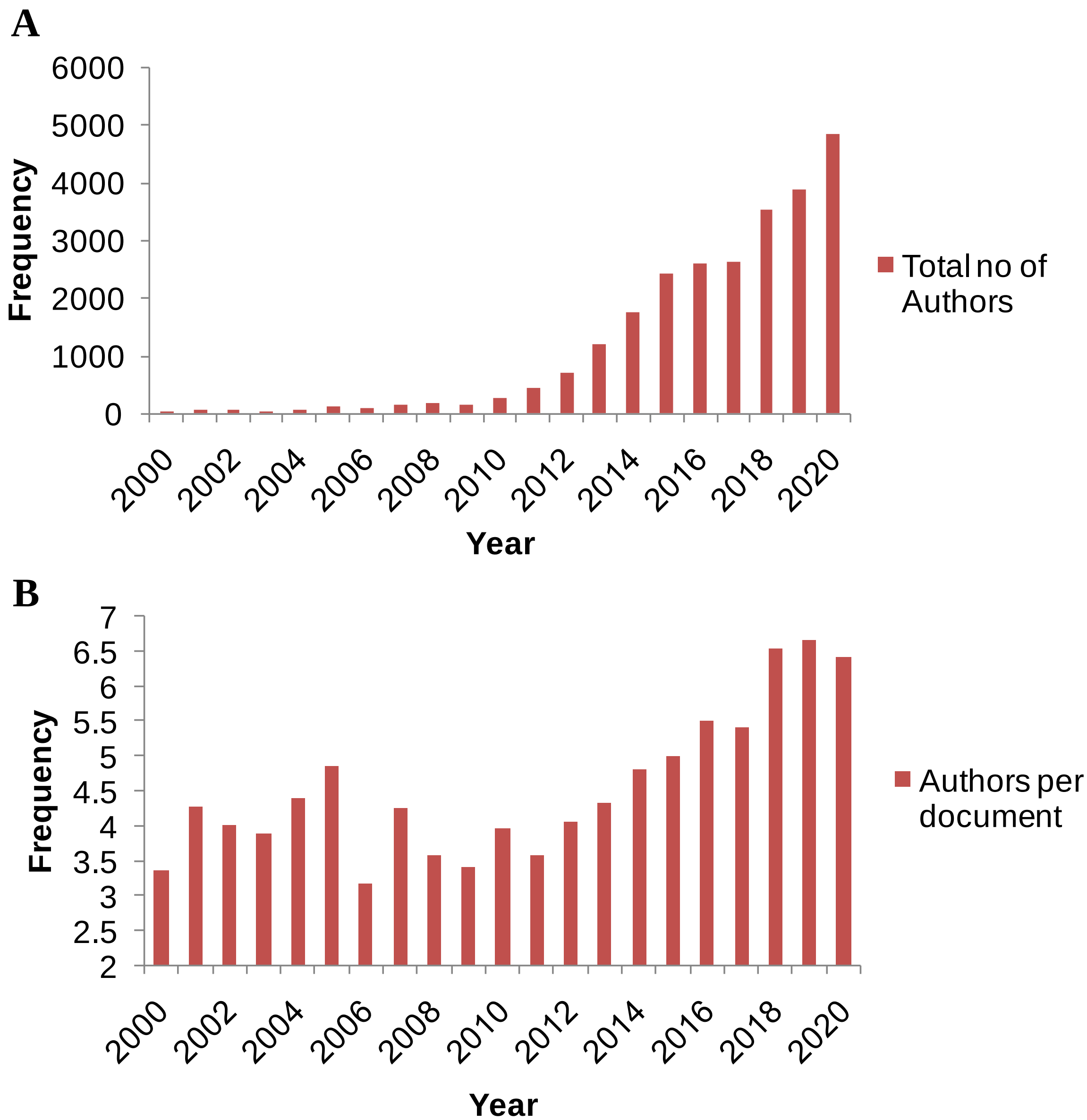

Fig. 6 A) Bar graph depicting the total number of authors of the retrieved document and B) Bar graph depicting the authors per document of retrieved document

Author (Cluster)	Document count	Citations	Total Link Strength	Number of Links	Top linked Authors (Linkage Score)
Li, y.(3)	21	170	22	10	Zhang, y.; Wang, l. (4)
Hightow-weidman, l.b.(4)	10	444	18	2	Legrand, s.; Muessig, k.e. (9)
Legrand, s.(4)	11	467	18	2	Hightow-weidman, l.b.; Muessig, k.e. (9)
Muessig, k.e.(4)	11	475	18	2	Legrand, s.; Hightow-weidman, l.b.(9)
Wang, j.(3)	22	431	14	10	Li, y.(3)
Zhang, y.(1)	17	200	14	8	Li, y.(4)
Li, x.(1)	16	189	12	7	Zhang, y.; Li, y.(3)
Zhang, j.(1)	17	128	11	9	Zhang, y.; Wang, y. (2)
Wang, l.(3)	13	189	10	6	Li, y.(4)
Ho, r.c.m.(6)	10	149	9	9	Zhang, m.w.b.(9)

Table1 The top 10 Authors in spHealth Apps having highest total link strength and strong linkage(Linkage Score) with other authors in close clusters

Rank	Author name	Scopus Author ID	Year of 1st Publication	Total Publications	h-index	Total Citations
1	Torous, John Blake	55816955800	2014	216	29	3243
2	Ozcan, Aydogan	7005667692	2002	461	63	6201
3	Car, Josip	6701783618	2001	369	57	11240
4	Maddison, Ralph	8552158500	1998	191	39	4974
5	Free, Caroline Jane	7006967593	1998	110	28	3963
6	Mohr, David C.	55614489700	1990	227	68	11255
7	Muessig, K.E.	16432537800	2007	87	24	2640
8	Vandelanotte, Corneel	15926457000	2002	221	40	4444
9	Gustafson, David H.	7101609444	1968	243	54	6802
10	Hightow-Weidman, L.B.	23094096600	1968	136	29	3042
11	Ho, Chun Man Roger	23004658600	2004	363	42	6301
12	Schnall, Rebecca	57214054625	2007	116	19	1172

Table 2 Top ranking authors in the field of sp-Health Apps along with their publication and citation details (2000-2020)

Rank	Journal	TP	TC	CS	h- index	IF	Publisher
1	Jmir Mhealth And Uhealth	576	1387	2.1	11	4.3	JMIR Publications Inc.
2	Journal Of Medical Internet Research	1430	15057	3.9	116	4.9	JMIR Publications Inc.
3	Telemedicine And E Health	217	2158	4.2	58	2.4	Mary Ann Liebert Inc.
4	Jmir Research Protocols	809	749	0.9	35	4.7	JMIR Publications Inc.
5	Plos One	16741	393347	5.2	21	2.7	Public Library of Science
6	International Journal Of ER & PH	9644	31708	3.0	78	2.8	MDPI
7	Journal Of Medical Systems	208	6129	5.8	63	3.0	Springer Nature
8	International Journal Of Medical Informatics	214	4086	5.8	6	3.2	Elsevier Ireland Ltd
9	Journal Of Diabetes Science And Technology	225	3196	5.4	61	3.3	SAGE Publications Inc.
10	Trials	1037	7875	3.0	64	1.9	SAGE Publications Inc.

TP: Total Publications(TP) 2020; Total Citations (TC) 2016-2019; Cite Score(CS) 2019; Impact Factor (IF)

Table 3 Top journal rankings with Total Publications (TP), Total Citations(TC) and Cite Score(CS) in sp-Health Apps(2000-2020)

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