Artículo original

The use of mobile applications to improve health outcomes in Latin America: a bibliometric analysis

El uso de aplicaciones móviles para mejorar los resultados de salud en América Latina: un análisis bibliométrico

Pedro Segura-Saldaña[1] https://orcid.org/0000-0002-7859-8466
Feeder J. Rojas-Vilar[2] https://orcid.org/0000-0003-3112-3815
Franko O. Garcia-Solorzano[3] https://orcid.org/0000-0002-0146-3571
Christoper A. Alarcon-Ruiz[4*] https://orcid.org/0000-0003-3907-2784

[1]Universidad peruana "Cayetano Heredia". Lima, Perú.
[2]Universidad "Ricardo Palma", Facultad de Medicina Humana. Lima, Perú.
[3]Universidad Científica del Sur. Lima, Perú.
[4]Universidad "San Ignacio de Loyola", Unidad de Investigación para la Generación y Síntesis de Evidencias en Salud. Lima, Perú.

[*]Autor para la correspondencia: christoper.alarconr20@gmail.com

ABSTRACT

Objective: To describe the existing scientific evidence on mobile health applications in Latin America.

Methods: Bibliometric study which analyzed scientific articles about mobile applications for health outcomes, published in peer-reviewed journals which were indexed in Scopus and LILACS until December 2019. All articles included had a minimum of one author with a Latin American affiliation. We analyzed the data with Stata and VOSviewer.

Results: There were 271 articles in this analysis. The scientific production per year increased from 1 article in 2012 to 18 articles in 2019. Most mobile health applications were designed for the general population or for patient use. Almost half of the studies explained

the design process of mobile health applications, 19.6 % were quasi-experimental studies, and 4.4% were randomized clinical trials. Primary care and public health were the most common medical specialty among mobile health applications (*n* = 42; 15.5%), while elderly care was the most frequent health issue (*n* = 13; 4.8%).

Conclusion: There has been a progressive increase in scientific publications on mobile health applications in Latin America since 2012. However, only a few of these mobile health applications have been tested as an intervention in clinical randomized trials and covers the health burdens of the region.

Keywords: bibliometric; mobile applications; health; Latin America.

RESUMEN

Objetivo: Describir la evidencia científica sobre las aplicaciones móviles en salud en América Latina.

Métodos: Se realizó un estudio bibliométrico que incluyó artículos científicos sobre las aplicaciones móviles para actividades en salud publicados en revistas científicas indexadas en Scopus y LILACS hasta diciembre de 2019. Todos los artículos incluidos tenían como mínimo un autor con filiación institucional de un país de América Latina. Se analizaron los datos con *Stata* y *VOSviewer*.

Resultados: Se incluyeron 271 artículos en el análisis. La producción científica por año aumentó de un artículo, en 2012, a 18 artículos en 2019. La mayoría de las aplicaciones móviles en salud fueron diseñadas para la población general o para el uso de los pacientes. Casi la mitad de los estudios explicaron el proceso de diseño de aplicaciones móviles en salud; el 19,6 % fueron estudios cuasiexperimentales y el 4,4 % fueron ensayos clínicos aleatorizados. La atención primaria y la salud pública fueron la especialidad médica más común entre las aplicaciones móviles en salud (*n* = 42; 15,5 %); mientras que la atención a las personas mayores fue el problema de salud más frecuente abordado por las aplicaciones móviles evaluadas (*n* = 13; 4,8 %).

Conclusión: Ha habido un aumento progresivo de las publicaciones científicas sobre aplicaciones móviles en salud en América Latina desde 2012. Sin embargo, solo unas pocas de estas aplicaciones móviles en salud han sido probadas como una intervención en ensayos clínicos aleatorios y cubren las cargas de salud de la región.

Palabras clave: bibliometría; aplicaciones móviles; salud; América Latina.

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Introduction

A mobile application is a computer tool or software developed to be used in mobile phones, smartphones, tablets, or any mobile electronic device depending on its operating system.[1] Mobile health applications (MHA) are design to improve health outcomes, health controls, and health care services.[2] According to the latest report of the Institute for Human Data Sciences, more than 318,000 MHA were publicly available in 2017.[3] As a result, MHA could empower patients and influence behaviors related to their health.

In 2019, there were 326 million mobile internet users in the Latin-American region.[4] Relevant tools such as MHA are essential in order to strengthen the effectiveness and efficiency of health services and mitigate the burden of disease in resources-limited areas like Latin America.[5,6] Health care professionals could also use them to ameliorate the management of their patient cases, monitor patients, access health information or medical history, and more.[7] However, in recent years, the total investment in research and development in Latin America has been lower compared to other regions throughout the world.[6]

Bibliometric studies are useful in measuring research productivity related to different topics.[8] Previous worldwide bibliometric studies about mobile health and medical informatics did not included any Latin American country because of their low research output.[9,10,11] On the other hand, the use of MHA based on low to none scientific evidence could be difficult in solving health problems[12] since health professionals and the general population would not take advantage or know their true benefits.[13] To date, there are no reports about MHA research in Latin America, which could help identify health topics involved in MHA, and if these tools help acknowledges the main problems in the region. The objective of the study was to describe the scientific evidence regarding MHA in Latin America.

Methodology

Source of information

We performed a bibliometric analysis using research articles published until 2019 in journals indexed Scopus (https://www.scopus.com/) and LILACS (https://lilacs.bvsalud.org/es/) databases. Scopus (Elsevier BV, Amsterdam, Netherlands) is one of the largest databases for scientific peer-reviewed articles, which include more than 24,000 indexed journals about different science areas and characteristics such as the institutional affiliation name and affiliation country of all authors, journal, and type of article.[14] LILACS (Pan-American Health Organization, Sao Paulo, Brazil) is one of largest databases in Latin America, which include 894 indexed journals and more than 505,000 registries.[15]

Search strategy

In order to find MHA articles in Latin America, we designed a research strategy for Scopus and LILACS databases. We used the terms "mobile applications", "mobile app", "portable electronic app*", "smartphone* app*", "app-based intervention*", "mhealth app*", "Health app", "phone* app*" or similar ones in the title, the abstract of research articles, or as keywords in both databases. Additionally, in Scopus research, we excluded the conference papers and included the Latin American countries according to the Scimago Country Ranking as the affiliation country[16] (Suuplementary file 1). The search was carried out on December 27th, 2019 in both databases. The validity of the search strategy was assessed by a manual review.

Selection criteria

A research article was included if it was an original paper (introduction, methods, results, and discussion) which assessed the effectiveness, described the development, or described the characteristics of at least one mobile application with a purpose related to health. MHA articles were also included if they had at least one author with institutional affiliation from any Latin American country according to the Scimago Country Ranking.[16] Exclusion criteria were articles published in 2020, articles not available in full-text, research papers published as an editorial, conference abstracts, proceeding papers, letters, narrative reviews, thesis, or technical documents.

Selection and data extraction

After downloading all data in a comma-separated values format, it was imported into Microsoft Excel 2016 (Microsoft, Washington). Duplicate articles were excluded manually, and then, two independent researchers (FJRV and CAAR) screened the remaining articles by reading titles and abstracts, considering the inclusion and exclusion criteria. In case of discrepancies, it was resolved in a consensus between both researchers. Once all eligible articles were selected, both researchers (FJRV and CAAR) used ten randomly selected articles for developing an Excel spreadsheet for data extraction and for standardized the extraction process.

Then, the researchers (FJRV and CAAR), after the full-text reading, independently extracted the following data from each selected article in the screening process: publication year, journal, Scimago journal index quartile (if applicable), language (English, Spanish, English and Spanish, and Portuguese), type of study (observational, quasi-experimental, randomized clinical trial, application design, etc.), institutional and country affiliation of authors, health areas (promotional and preventative care, therapeutic or follow-up, rehabilitation, public health or administration in health, and healthcare education), medical specialty, specific subject, objective population (patient or general population, health students, physicians, and non-physician health personnel), and study funding (not reported, self-funded, public, private, and research or education center). In case of discrepancies, it was resolved in a consensus between both researchers. Data associated with this article are available in the FigShare repository at https://doi.org/10.6084/m9.figshare.13543100.v1.

Scopus Journal Metrics were used to extract the metrics of the top ten journals, including CiteScore 2019, Scimago Journal Ranking 2019, and Source-Normalized Impact per Paper 2019. Total scientific production from Latin American countries were evaluated according to their number of articles. The research output of each country was adjusted according to the population size by million in 2019 (available at: https://population.un.org/wpp/DataQuey/) and the number of researchers by million inhabitants during 2012 to 2017 (available at: https://datos.bancomundial.org/indicador/SP.POP.SCIE.RD.P6).

Statistical analysis

For the descriptive analysis, variables were summarized according to their relative frequency and absolute frequency. Data analysis was performed using the statistical package

STATA MP v16 (Statacorp, Texas, U.S.) and the visualization software VosViewer v1.6.519 (Leiden University, Leiden, Netherlands).[17] Graphs were obtained with the collaboration clusters between countries, where the size of the circles represent the number of articles and the thickness of the lines indicate the number of articles in collaboration.

Results

From the 844 citations obtained from the initial search in Scopus and LILACS, 811 were screened. Then, 540 articles were excluded mainly because they were not original articles or were not related to MHA. Ultimately, 271 articles were included in the present analysis (fig. 1). MHA articles in Latin America increased progressively from 1 article to 84 articles per year between 2012 and 2019 (fig. 2).

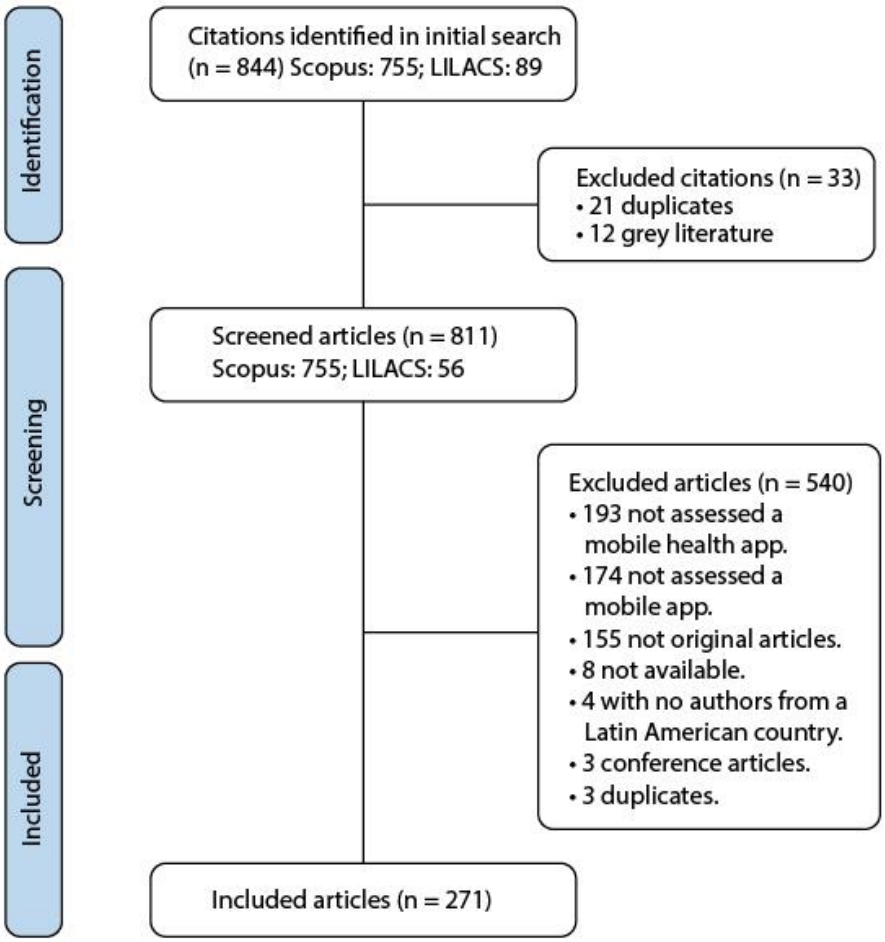


Fig. 1 – Flow chart of article selection process.

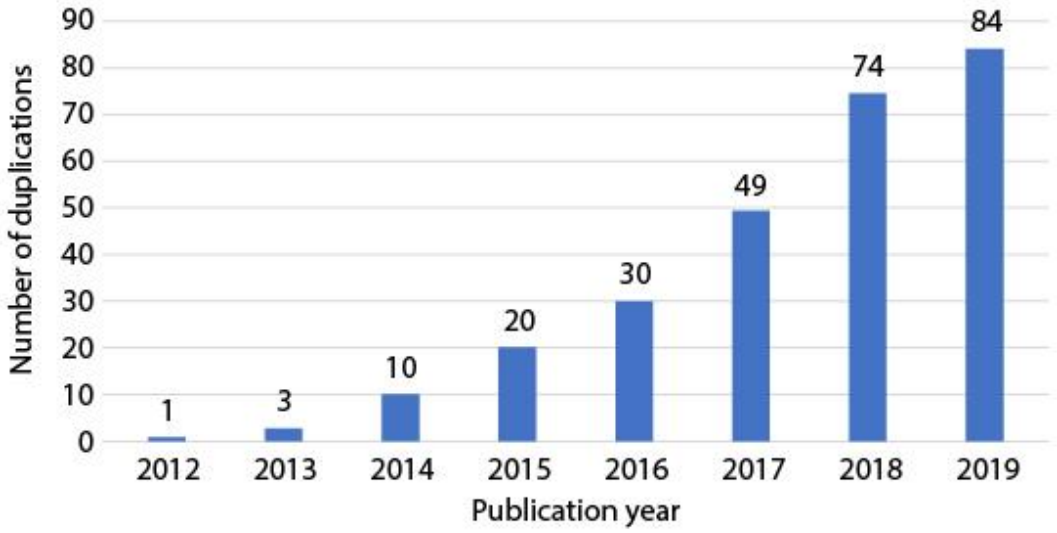


Fig. 2 – Trend of MHA articles published in Latin America from 2012 to 2019.

The main characteristics of the included articles are shown in table 1. Regarding the study design, 46.5% of the studies explained the design process of the MHA, while other study designs included randomized clinical trials and quasi-experimental studies, which were 4.4% and 19.6% respectively. Most of the articles were published in English (82.3%). Less than half of the articles did not declare their funding (42.1%), followed by public funded studies (31.4%), articles funded by research or education centers (15.9%), and self-funded studies (7.7%). Most of the assessed MHA articles focused on the general population or patients (54.3%), followed by medical personnel (26.7%). The most frequent levels of health care included promotional and preventative (23.1%), treatment (23.5%), and rehabilitation (26.7%).

Table 1 - Characteristics of articles about mobile health applications in Latin America, 2012-2019

Characteristics	n	%
Study design		
Application design	126	46.50 %
Quasi-experimental	53	19.60 %
Observational	41	15.10 %
Systematic review	29	10.70 %
Randomized clinical trial	12	4.40 %
Others	10	3.70 %

Languages		
English	223	82.30 %
Spanish	23	8.50 %
Portuguese	22	8.10 %
English and Spanish	3	1.10 %
Target population of MHA (n = 258)		
General population or patients	140	54.30 %
Medical personnel	69	26.70 %
Non-medical personnel	39	15.10 %
Healthcare students	10	3.90 %
Health area of MHA (n = 255)		
Promotional and preventative care	59	23.1 %
Therapeutic or follow-up	60	23.5 %
Rehabilitation	68	26.7 %
Public health or administration in health	17	6.7 %
Healthcare education	35	13.7 %

The most common specialty in the articles were primary care and public health (42; 15.5%), followed by health education (16; 5.9%), and psychiatry (16; 5.9%). On the other hand, the most common MHA field was elderly care (13; 4.8%), followed by allergic rhinitis (11; 4.1%), and diabetes (9; 3.3%) (table 2).

Table 2 - Specialty and field of articles on mobile health applications in Latin America

Specialty	**n**	**%**
Primary care and public health	42	15.5 %
Health education	16	5.9 %
Psychiatry	16	5.9 %
Geriatrics	13	4.8 %
Allergology	12	4.4 %
Endocrinology	12	4.4 %
Physical medicine and rehabilitation	12	4.4 %
Cardiology	11	4.1 %
Gynecology and obstetrics	10	3.7 %
Sports medicine	10	3.7 %

Neurology	10	3.7 %
Nutrition	10	3.7 %
Health field		
Elderly healthcare	13	4.8 %
Allergic rhinitis	11	4.1 %
Diabetes mellitus	9	3.3 %
Exercise	8	3.0 %
Nutrition	8	3.0 %
Physical activity	6	2.2 %
Visual disability	6	2.2 %
Nursing	6	2.2 %
Cardiovascular risk	6	2.2 %
Oral health	6	2.2 %
Lifestyle	5	1.8 %

The articles included in this study were published in 177 scientific journals. The majority of MHA articles were published in journals with high quartiles: *Q*1 (99; 36.5%) and *Q*2 (69; 25.5%), *Q*3 (60; 22.1%), and *Q*4 (18; 6.6%). The top ten journals with the largest number of articles published are presented in table 3. The "Journal of Medical Internet Research" collected the largest number of MHA articles (12; 4.4%). From the top ten journals, the "Journal of Health Informatics" and "Revista Eletrônica de Comunicação, Informação e Inovação em Saúde" were non-indexed in Scopus. The total number of MHA articles published in journals not indexed in Scopus was 9.2% (*n* = 25).

Table 3 - Top ten journals with the highest number of articles published on mobile health applications in Latin America

Order	Journal	Country	Published articles (n, %)	CiteScore 2018	SJR 2018	SNIP 2018
1	Journal of Medical Internet Research	Canada	12 (4.4)	5.82	1.744	2.106
2	Journal of Medical Systems	USA	10 (3.7)	3.31	0.565	1.392
3	Journal of Health Informatics	Brazil	7 (2.6)	NA	NA	NA
4	ACTA Paulista de Enfermagem	Brazil	7 (2.6)	0.62	0.262	0.55
5	IEEE Latin America Transactions	USA	7 (2,6)	1.05	0.337	0.606

6	Revista Eletrônica de Comunicação, Informação e Inovação em Saúde	Brazil	6 (2.2)	NA	NA	NA
7	Allergy: European Journal of Allergy and Clinical Immunology	United Kingdom	5 (1.8)	5.86	2.459	1.931
8	International Journal of Medical Informatics	Netherlands	5 (1.8)	3.76	0.96	1.633
9	Sensors (Switzerland)	Switzerland	5 (1.8)	3.72	0.592	1.576
10	Revista Cubana de Información en Ciencias de la Salud	Cuba	4 (1.5)	0.18	0.131	0.122

Legend: NA = Not available information.

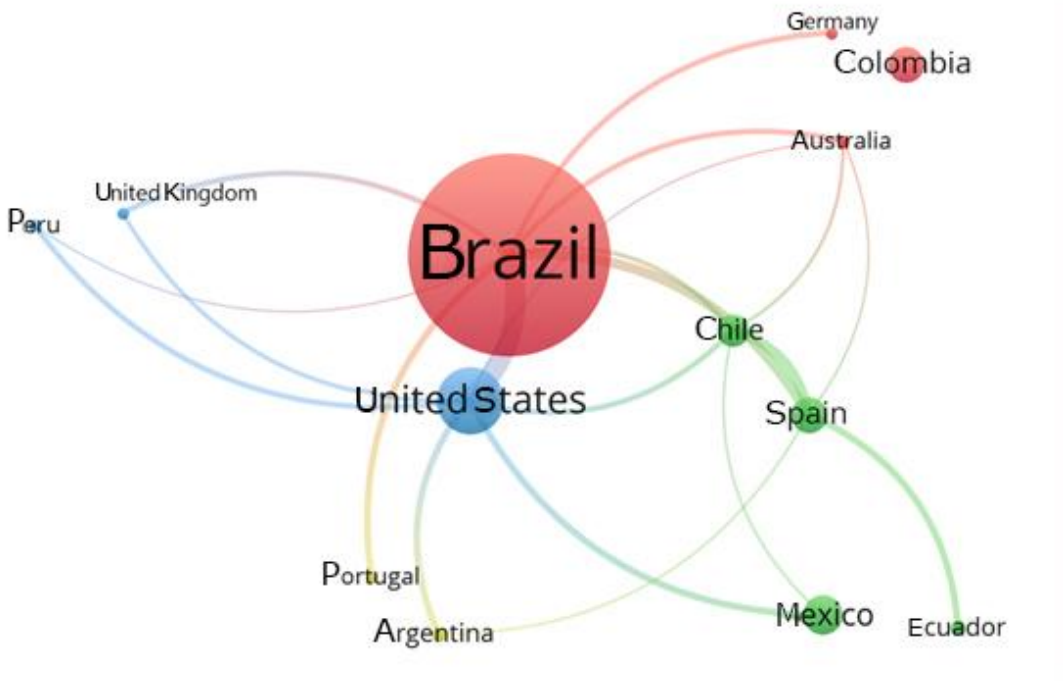
Regarding country of affiliation, more than half of MHA articles were from Brazil (160; 59.0%). The percentage of MHA articles that were from Mexico, Colombia, and Chile were 14%, 10%, and 9.2%, respectively. Nevertheless, Puerto Rico and Chile, had the highest number of MHA articles per million inhabitant index. Colombia had the highest MHA articles per researcher per 10 million inhabitants index (table 4). The United States (53; 19.6%), Spain (36; 13.3%), the United Kingdom, Portugal, and Australia (17; 6.3%, each) were the main countries represented in all assessed articles. Regarding country collaboration, the greatest interaction was Brazil with the United States (18 collaborations), followed by Brazil with Spain, and Chile with Spain (9 collaborations each) (fig. 3).

Table 4 - Country affiliation of MHA articles in Latin America

Country	n	%	MHA articles per million inhabitants	MHA articles per researcher per 10 million inhabitants
Brazil	160	59.0 %	0.76	1.91
Mexico	38	14.0 %	0.30	1.52
Colombia	27	10.0 %	0.54	3.72
Chile	25	9.2 %	1.32	0.59
Argentina	15	5.5 %	0.33	0.12
Ecuador	12	4.4 %	0.71	0.35
Peru	9	3.3 %	0.27	0.54
Guatemala	4	1.5 %	0.22	1.95
Puerto Rico*	4	1.5 %	1.33	0.13
Panama	3	1.1 %	0.75	0.78
Venezuela	3	1.1 %	0.10	0.10

Paraguay	2	0.7 %	0.29	0.13
Dominican Republic	2	0.7 %	0.18	NA
Costa Rica	1	0.4 %	0.20	0.02
El Salvador	1	0.4 %	0.17	0.16

Legend: NA = Not available information; *Puerto Rico is a U.S. territory.



Footnote: Only countries with a minimum of 5 articles were included and articles with more than 10 countries authors were excluded.

Fig. 3 – Collaboration network of publications in mobile health applications between countries.

Discussion

The number of articles about MHA in Latin America have been constantly increasing since 2012. Although no date limitations were applied in this analysis, no articles were found before the year 2012. This is most likely due to the popularity of mobile applications, thus leading to its success in 2010 with the use of smartphones.[18] In concordance, a previous bibliometric analysis performed only in Web of Science database described an increasing trend in the number of MHA articles from 2000 to 2019.[10] This increase contributes to the need for scientific evidence on the design and usefulness of MHA.[19]

MHA articles were published mainly in English, although the main languages in Latin American countries are Spanish or Portuguese. English was also the main language in other

bibliometric studies on systematic production in Latin America.[20] More than half of the total number of articles (170, 62.9 %) included in this analysis were published in non-Latin American or Brazilian journals, which primarily publish in English. Additionally, more than 90 % of articles analyzed in this study have come from Scopus, which predominantly includes English-written journals.[21]

Almost half of the articles analyzed 46.5% focused on the technical design of MHA, while less than 5 % of the articles selected were randomized clinical trials. Randomized clinical trials are considered the ideal type of study to evaluate the effects of health interventions.[22] It is likely that most of the MHA developed in Latin America do not have reliable scientific evidence about their effectiveness or the damage they can potentially cause. These findings were also observed in other regions of the world, where the number of MHA have increased; however, many of them do not have scientific evidence to support their effectiveness.[19]

Most of the MHA articles in this study were focused on three levels of health care: primary (with a promotional and preventative objective), secondary (diagnosis and treatment), and tertiary (rehabilitation). However, Latin American countries are increasingly focusing on primary health care in response to their main health problems,[23] and as a result, these applications could be an important contribution in achieving this objective.

The assessed MHA articles focused on elderly care, allergic rhinitis, diabetes, exercise, and nutrition. However, this does not fully correlate with the burden of disease in the Latin American region. In Latin America, ischemic heart disease, diabetes mellitus type 2, violence by firearms, lower back pain, and respiratory tract infections are the pathologies that increase the disability-adjusted life year (DALY) within the population.[24] In consequence, it is possible for a relationship between mobile applications on elderly care, exercise, and nutrition with non-communicable chronic diseases to be considered. However, there is no evidence of a complete relationship between the topics addressed by MHA designed in Latin America with respect to the main pathologies that affect this region.

More than half of the scientific articles analyzed had at least one author with an institutional affiliation from Brazil, followed by Mexico and Colombia. This order was similar in previous Latin American bibliometric analyses performed in other health areas.[25,26,27] These countries are among the best with scientific production in the region and with whom the rest of the countries in the region collaborate the most with.[16] However, the scientific production of MHA articles for each country does not necessarily follow its total scientific production order, such as Argentina, where the production of mobile applications would respond to commercial and export interests.[28] On the other hand, the United States and

Spain are the non-Latin American countries with the most participants in MHA articles in Latin America, producing the greatest number of MHA articles during the last years.[10,11] This study had the following limitations:

1) Scientific articles were only obtained from journals indexed in Scopus or LILACS databases. Scopus is one of the most important databases worldwide that includes the largest number of relevant scientific journals in the area of study, while LILACS is one of the most important databases in Latin America. Additionally, there was also a bibliometric analysis of MHA articles, performed in Web of Science, that complement the findings presented in this study.[10]
2) Conference papers with important information about MHA were excluded in the present study. However, these types of documents are less cited, compared to articles in scientific journals, and do not follow a clear peer review or an editorial process that guarantees the quality of the published articles.[29]
3) Scientific articles that did not have access to full-text were not included, however, they did not represent a significant amount of the total of articles analyzed (less than 10).
4) Target population and MHA field were not collected in all the included articles because the systematic reviews did not necessarily include a single MHA.

Conclusion

There has been a progressive increase in scientific publications on mobile health applications in Latin America since 2012; however, a few of the MHA articles were assessed as an intervention in a randomized clinical trial, and most of them do not follow the main health problems in the region.

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Anexos

Research strategies

Search strategy for LILACS:

tw:(mobile app OR smartphone app OR health app OR cellphone app) AND (db:("LILACS"))

Search strategy for Scopus:

TITLE-ABS-KEY ("Mobile App*" OR "Portable Electronic App*" OR "Portable Software App*" OR "smartphone* app*" OR "app-based intervention*" OR "mhealth app*" OR "Mobile Health App*" OR "Health app" OR "Health apps" OR "phone* app*" OR "cellphone* app*" OR "Cellular phone* app*") AND (AFFILCOUNTRY (Argentina) OR AFFILCOUNTRY (Bolivia) OR AFFILCOUNTRY (Brazil) OR AFFILCOUNTRY (Colombia) OR AFFILCOUNTRY (Chile) OR AFFILCOUNTRY (Ecuador) OR AFFILCOUNTRY (Guyana) OR AFFILCOUNTRY (French Guiana) OR AFFILCOUNTRY (Paraguay) OR AFFILCOUNTRY (Perú) OR AFFILCOUNTRY (Suriname) OR AFFILCOUNTRY (Uruguay) OR AFFILCOUNTRY (Venezuela) OR AFFILCOUNTRY (Belize) OR AFFILCOUNTRY (Costa Rica) OR AFFILCOUNTRY (El Salvador) OR AFFILCOUNTRY (Guatemala) OR AFFILCOUNTRY (Honduras) OR AFFILCOUNTRY (Nicaragua) OR AFFILCOUNTRY (Panamá) OR AFFILCOUNTRY (México) OR AFFILCOUNTRY (Cuba) OR AFFILCOUNTRY (Dominican Republic) OR AFFILCOUNTRY (Haiti) OR AFFILCOUNTRY (Jamaica) OR AFFILCOUNTRY (Puerto Rico) OR AFFILCOUNTRY (Trinidad and Tobago) OR AFFILCOUNTRY (Barbados) OR AFFILCOUNTRY (Guadeloupe) OR AFFILCOUNTRY (Grenada) OR AFFILCOUNTRY (Martinique) OR AFFILCOUNTRY (Bermuda) OR AFFILCOUNTRY (Bahamas) OR AFFILCOUNTRY (Saint Kitts and Nevis) OR AFFILCOUNTRY (Netherlands Antilles) OR AFFILCOUNTRY (Falkland islands) OR AFFILCOUNTRY (Dominica) OR AFFILCOUNTRY (Cayman Islands) OR AFFILCOUNTRY (Virgin Islands) OR AFFILCOUNTRY (Antigua and Barbuda) OR AFFILCOUNTRY (Saint Lucia) OR AFFILCOUNTRY (Aruba) OR AFFILCOUNTRY (Montserrat OR Saint Vincent and the Grenadines OR Anguilla OR Turks and Caicos Islands OR Suth Georgia and the South

Sandwich Islands) AND (EXCLUDE (DOCTYPE, "cp")) AND (EXCLUDE (PUBYEAR, 2020))

Conflicto de intereses

Los autores declaran que no tienen conflicto de intereses.

Contribuciones de los autores

Conceptualización: Pedro Segura-Saldaña, Franko O. Garcia-Solorzano.

Curación de datos: Feeder J. Rojas-Vilar, Christoper A. Alarcon-Ruiz.

Análisis formal: Pedro Segura-Saldaña, Christoper A. Alarcon-Ruiz.

Metodología: Pedro Segura-Saldaña, Feeder J. Rojas-Vilar, Christoper A. Alarcon-Ruiz.

Visualización: Christoper A. Alarcon-Ruiz.

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