MEDIKUNTZA ETA ERIZAINTZA FAKULTATEA
FACULTAD DE MEDICINA Y ENFERMERÍA
UPV EHU
50 URTE AÑOS

Gradu Amaierako Lana / Trabajo Fin de Grado
Medikuntza Gradua / Grado en Medicina

New technologies towards international health cooperation

Review

Egilea /Autor:
Álvaro Paz Martín
Zuzendaria / Director/a:
Dr. Fco. Javier Benito Fernández

Leioa, 2019ko apirilaren 15a / Leioa, 15 de abril de 2019

ABSTRACT

Introduction: According to the World Bank statistics, 83% of world's population lives in low- and middle-income countries (LMICs). These countries, often run by Governments that make an inadequate distribution of the national budgets, undergo issues in assessing the health and educational needs of their communities. Thus, from the last 80s the presence of non-governmental organizations (NGOs), which appeared as an option to fill the gaps in the system, has grown significantly.

However, NGOs are usually unevenly distributed and there is rarely coordination among them, which often results in duplication of services or waste of resources. Nevertheless, the unprecedented and ubiquitous proliferation of mobile phone-based technology and internet, among other factors, appear as a promising scenario to face the health needs of the LMICs.

Methods: A review of articles and reviews published throughout the last 10 years was conducted in the main electronic databases: Pubmed, Embase and Medline.

For the search, the following key words were used: 'Developing countries', 'low income countries', 'Telemedicine', 'mHealth' and 'Data collection'. After this, 90 publications were obtained.

Eventually, after setting an inclusion and exclusion criteria, 45 publications entered the present review.

Results: Publications were classified according to the following characteristics: type of study, geographical area of the study, year of publication and telemedicine type studied. First, in what respects to the type of study, the vast majority (n=24) were articles, being the reviews the second most popular type of publication (n=11). Second, according to the geographical area, n=24 showed an international perspective, whereas n=17 were single-country publications. Furthermore, the most popular country among these last was Ethiopia. Third, the year in which more works were published was 2017 (n=9), followed by 2012 (n=8). Finally, several difficulties were faced to classify the publications according to the type of telemedicine used. However, overall, the most popular telemedicine solution were mobile applications.

Discussion: With the publication of the agenda 2030 in 2015, United Nations expressed their hope to reach universal health coverage by this year. Even though this could initially sound like a utopia, the growing ubiquity of information and communication technologies (ICTs) is contributing to mitigate the problems that traditional health systems are facing in developing countries. Some of those problems are the misinterpretation of written data, lack of standardization and high loss rates that traditional paper-based data collecting tools caused. Therefore, data collection and/or report appears as one of the most profitable fields new technologies could be applied to. In this sense, throughout these last ten years several mobile applications have been implemented for collecting data. The review and analysis of the challenges and hurdles faced by these previous telemedicine initiatives is crucial for designing a useful mobile app.

Conclusions: Three main conclusions are reached. First of all, mHealth has been proved to be effective for assessing health problems or difficulties in developing countries. Secondly, mobile apps appear as the optimal mHealth solution; however, their design is crucial. Hence, several factors such as the need of being concerned about the local context, the need of developing an easy-to-use interface or the importance of assuring a close participation with the Government must be considered. Thirdly, there is need of developing a global platform for universalizing all the initiatives as well as for making the trials, challenges and opportunities found in the field of telemedicine easy to access and study.

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1. INTRODUCTION

Up to date, according to the World Bank statistics, approximately 83% of world's population live in Low- and Middle-Income Countries (LMICs) (1) **(Figure 1)**, this is, countries defined as those with a Gross National Income (GNI) per capita of $12,055 or less in 2017 (2), but with a mean of $4,455 (which is far from the upper limit) (3). This lack of economic resources often results in a significant lack of health among the society living in them.

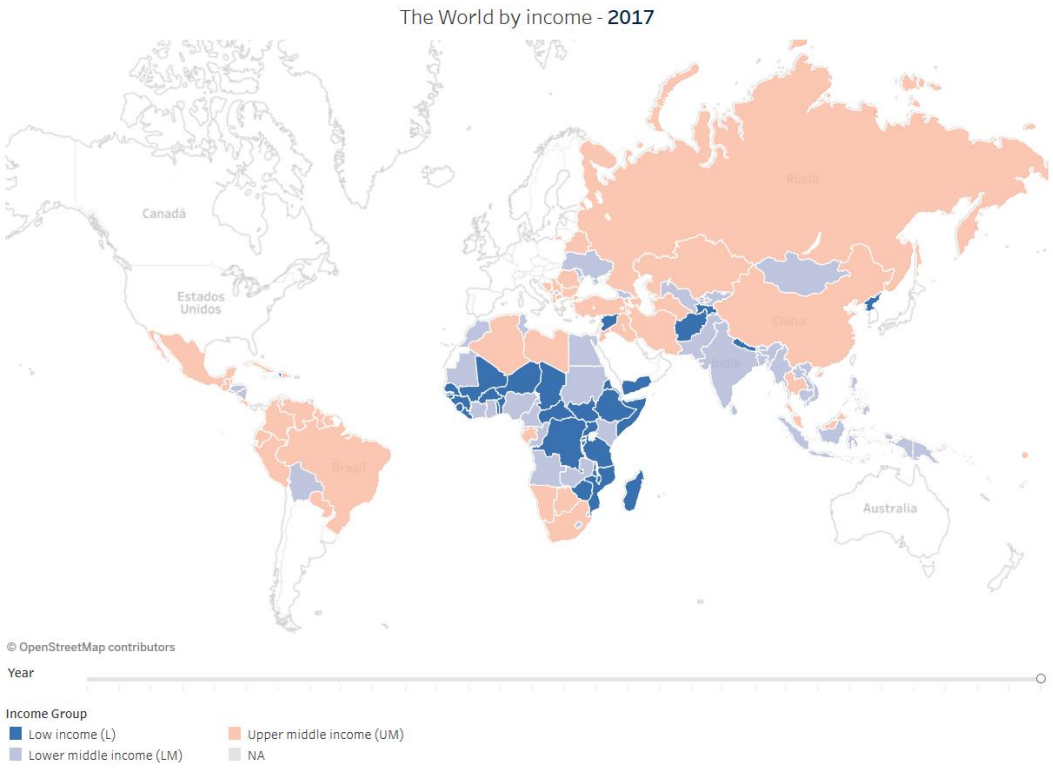

Figure 1: Low and Middle income countries by their income level [Source: WorldBank] (4) . The distribution of the low and middle income countries of the world is shown; this is, the countries with a GNI per capita of less than $12,055.

Heading to literature, it is easy to find out that a big number of these countries, which are often run by Governments that make an inadequate distribution of the national budget, undergo issues in assessing the health (4) and educational necessities of their communities. This all leads to the need of relying on the support of private organizations (5,6). Thus, from the late 80s, the presence of non-governmental organizations (NGOs) in these countries, which appeared as an option to fill the gaps in the system, has grown significantly (7).

However, NGOs are usually unevenly distributed and there is rarely coordination among them, which often results in duplication of services or waste of resources. As seen in Bolivia, the geography and related factors play a crucial role in understanding why NGO related resources go to certain areas and not others (7,8). In addition, the lack of coordination leads often to individual policies sustained with self-obtained funds, creating big differences in the budgets among organizations which are more commonly related to the size and prestige of the NGO rather than to the needs of the target population it aims to assess. Moreover, several studies have shown that the NGOs do not always target the poorest and neediest population within a nation (7,9-11).

The absence of cooperation policies between the Government and the local NGOs has also been defined as one of the crucial weaknesses for providing reliable healthcare (12).

Nevertheless, the unprecedented and ubiquitous proliferation of mobile phone-based technology and internet **(Figure 2)**, the decline in the price of devices (13,14), the increasing cell phones utilization rates and the increasing network coverage (15) appear as a promising scenario to face the health needs of the LMICs.

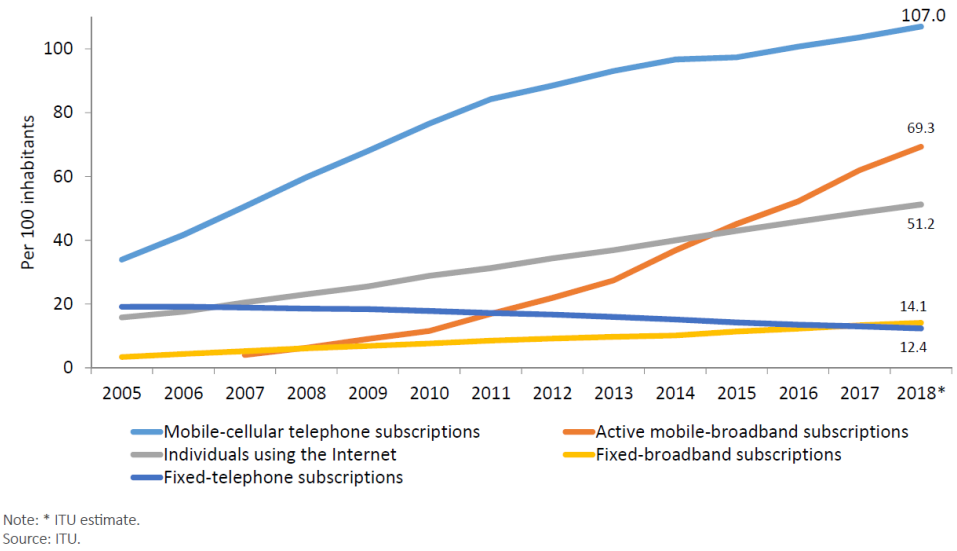

Figure 2: Global ICT developments, 2005-2018 [Source: ITU] (16). Mobile phone subscriptions, mobile broadband subscriptions and the internet usage show an ascendant tendency throughout the years.

According to the International Communication Union (ITU), in 2018 there were 8 thousand million mobile subscriptions (76,4% of world's population) **(Figure 3)**; 96% of people lived in an area covered by a mobile-cellular network and 90% of the world's population had access to mobile broadband networks (3G or above) (17). Moreover, three quarters of the world population owned a mobile phone by 2017, standing at the 56% for the least developed countries (LDCs). In fact, in many places people are more likely to have access to a mobile phone than to have such basic things as clean water or a source of electricity (18).

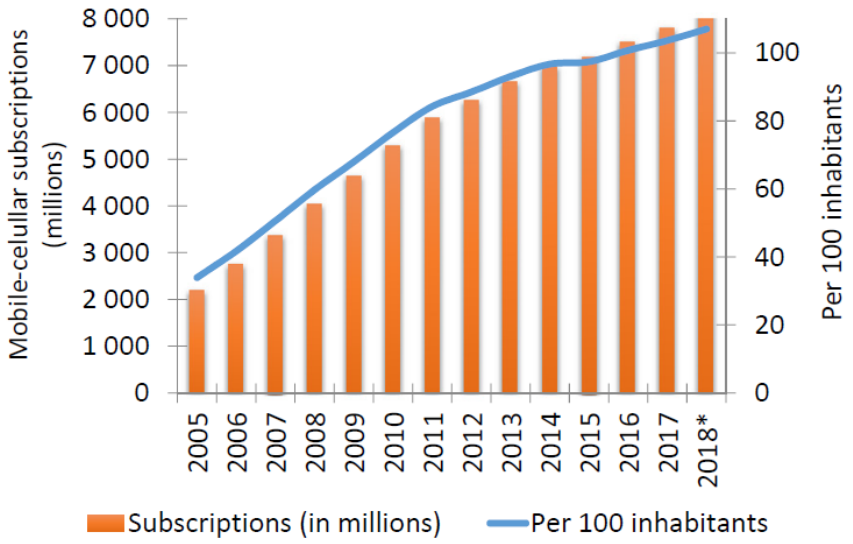

Figure 3: Global mobile cellular subscriptions, total and per 100 inhabitants, 2005-2018 [Source: ITU] (16). Mobile phones' subscriptions both per millions and per 100 inhabitants show a growing tendency.

Although the poorest countries still remain far from the mean statistics, mobile phone subscriptions keep growing unstoppably and, according to the agenda 2030, they should reach a 70% penetration rate for 2023 and a 75% for 2025 (19). Due to the fast and big impact these devices are supposing for development by reaching socially and geographically isolated people, health appears as one of the major fields benefited by all this (16).

Known by the terms 'telemedicine' or 'mHealth', new technologies appear, therefore, as an opportunity for developing better health policies in these limited-resource countries. However, the two terms, which will be widely used throughout the present review, do not mean the same. Whereas 'telemedicine' or 'e-Health' englobes all the initiatives focused on information and communication technologies (ICTs), 'mHealth' refers to the part of it which seeks to explore more into mobile phones or wireless communication. mHealth is, thus, a component of eHealth (13). However, it is important to clarify that this term encompasses all the technologies that can be used through a mobile phone, including Short Messaging Service (SMS), General Packet Radio Service (GPRS), Unstructured Supplementary Service Data

(USSD), Bluetooth, Wi-Fi, central processing unit (CPU), data storage, and operating systems for running apps that leverage the previously mentioned technologies in different ways (20). Although less frequently mentioned, video, voice services or Internet connection are also considered as part of mobile technology (13,21).

Even though a standardized definition has not been stablished yet, the World Health Organization (WHO) defines mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" (13). Combi et al. (22), for their part, define it as "the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advance in the health of individuals and their communities".

Throughout this last decade, with the development of daily increasing telemedicine and mHealth initiatives, the field of mHealth has gone widening. This new expansion arose the need to classify this growing trend into smaller categories, specifying the areas or steps of healthcare to which they attended. In this sense, whereas a report published by the WHO and the mHealth Alliance (23) divided it into the 10 categories shown in **Table 1**; Labrique et al. (24) described the 12 main areas to which telemedicine is trying to contribute **(Figure 4)**.

Table 1: World Health Organization & mHealth Alliance classification of mHealth initiatives [Source: Earth Institute] (23). The 10 categories in which these two organizations agree to classify mHealth initiatives.

WHO & mHealth Alliance classification for mHealth (23)
Treatment compliance
Health promotion and disease prevention
Awareness raising over health issues
Health monitoring
Disease surveillance
Communication
Data collection
Mobile telemedicine
Point of care and decision support
Emergency medical response

Figure 4: Twelve Common mHealth and ICT Applications [Source: Labrique et al.] (24). The 12 main applications of mHealth and ICT applications are shown.

The potential of this new field has already been confirmed by several global organizations, such as the WHO, that said that new technologies could make a positive impact on global health systems (13,25), or the GSM Association (GSMA), which sustains that the growth in connectivity is spurring the adoption of new mobile-based tools for improving the lives of the people residing in low and middle income countries through agriculture, education or healthcare (26).

Nevertheless, the application of this promising kind of programs face several difficulties both in a big and a smaller scale. In a big scale, mHealth effective implementation depends on certain conditions such as the economic capacity, the ICT availability and the health status in the country (17). In a smaller scale, in what respects to its practical implementation, technical, economical, infrastructural and other type of difficulties compromise their usability (27-29).

The poor quality of health information systems in developing countries due to data incompleteness, untimeliness, existent information systems and inadequate analysis (30), fosters the realization of this study, which aims to review the main implementations carried out in the last 10 years in these countries towards the areas 4 and 5 of Labrique's classification: 'data collection and reporting' and 'electronic health records'.

1.1. JUSTIFICATION

Currently, there is a lack of knowledge involving health necessities and their distribution in LMICs. The growing accessibility to smartphones and similar portable gadgets in these countries appears as an opportunity to develop new tools towards international cooperation. Review of the trials, ideas and problems found in the application of new technologies in this field could be profitable for developing new useful mobile apps.

1.2. OBJECTIVE

To review the existing knowledge and development of new technologies in the field of international health cooperation.

2. METHODS

2.1. DESIGN:

A review of scientific articles and reviews was made.

2.2. SEARCH STRATEGY

Several searches were performed from February 2018 to February 2019 into the following electronic databases: Pubmed, Medline and Embase (the last two using Ovid).

In order to avoid missing key words and, therefore, ensuring the collection of all the data available, the following main key words were chosen: ‘Developing countries’, ‘low income countries’, ‘Telemedicine’, ‘mHealth’ and ‘Data collection’. In order not to lose interesting content, two different strategies were followed depending on the search platform.

Firstly, in what respects to Pubmed, the terms ‘data collection’, ‘developing countries’ and ‘mHealth’ were first searched into the MeSH terms library, so that they would englobe all similar expressions which could not be regarded at first. Once the MeSH terms were obtained, the first two terms and ‘telemedicine [MeSH]’ (which was proposed by the website itself) were combined with an ‘AND’ for the search into the Pubmed platform. The strategy used is shown next:

"Developing Countries"[Mesh] AND "Telemedicine"[Mesh]) AND "Data Collection"[Mesh]

We first looked for the last 5 years’ publications, but as only 32 results were found, we extended the search to ‘last 10 years’ publications’:

("Developing Countries"[Mesh] AND "Telemedicine"[Mesh]) AND "Data Collection"[Mesh] AND ("2008/10/12"[PDat] : "2018/10/09"[PDat])

After this last search, 55 articles were found.

Secondly, in the Ovid search, based on the lections learned by the search in Pubmed, instead of limiting the search to the three terms initially proposed, the conjunction ‘OR’ was used twice to amplify the field of some of the concepts: ‘telemedicine OR mHealth’ and ‘developing countries OR low-income countries’. Both searches,

conducted independently, were combined with another separate search of 'data collection' by an 'AND', obtaining the search strategy shown in **Table 2**.

Table 2: First search strategy conducted in Ovid. N=51 articles proceeded to the next phase of the search.

#	Búsquedas	Resultados
1	data collection.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	244593
2	mHealth.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	5653
3	telemedicine.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	48022
4	developing countries.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	180483
5	low income countries.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	11412
6	4 or 5	189546
7	2 or 3	51801
8	1 and 6 and 7	51

After this, the duplicates were removed and, in order to be coherent with the previous step, the search was limited to '2009-Current', so that only the articles published in the last ten years were shown (**Table 3**).

Table 3: Second and definitive search conducted in Ovid. N=35 articles are finally obtained.

#	Búsquedas	Resultados
1	data collection.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	244593
2	mHealth.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	5653
3	telemedicine.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	48022
4	developing countries.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	180483
5	low income countries.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, an, ui, sy]	11412
6	4 or 5	189546
7	2 or 3	51801
8	1 and 6 and 7	51
9	remove duplicates from 8	40
10	limit 9 to yr="2009 -Current"	35

Finally, n=90 articles were found (n=55 from Pubmed and n=35 from Ovid), which were analysed in the following way (summarized in **Figure 5**).

Of these, 5 articles appeared repeated in both search strategies, so they were removed from the review.

Of the 85 articles remaining, the inclusion and exclusion criteria (**Table 4**) was applied. For entering the review, a publication must cope with all the items from the inclusion criteria whereas a single item from the exclusion list was enough for getting it discarded. After this filter, n=23 were eliminated after title review for not meeting the designed criteria:

- n=2 not human
- n=2 sexual health and contraception
- n=7 chronic illnesses
- n=8 maternal and newborn health
- n=1 abortion
- n=1 prostate cancer diagnosis
- n=2 conference abstracts

Therefore, n=62 proceeded to abstract review, of which n=4 articles were taken out from the study for the following reasons:

- n=2 not scientific structure
- n=1 chronic illness
- n=1 maternal and newborn health

Moreover, 5 articles were inaccessible, so they were also taken out from the study.

53 articles proceeded to full text review. Of these, n=9 articles more were excluded from the study for not coping with the established criteria as follows:

- n=3 were incomplete
- n=5 did not conduct data collection
- n=1 designed for behavioural change

Table 4: Inclusion and Exclusion criteria. For entering the review, a publication must cope with all the items from the inclusion criteria, whereas a single item from the exclusion list is enough for getting it discarded.

Inclusion criteria
Only in Humans
Written in English
2009 or newer
Empower health in poor countries
Includes data collection and report
Mhealth or telemedicine
Exclusion criteria
Publications from other application areas of mHealth in which data collection and/or report was not the main purpose, such as the following: a) focused on following chronic diseases, b) focused on contraception or sexual health education, c) focused on maternal or newborn health management, d) focused on diagnosing cancer or e) designed for behavioural change.
Conference abstracts
Not scientific structured article

During the process, one extra article (n=1) was added by cross-reference links.

Eventually, n=45 articles and reviews were considered into the review.

Apart from this, two extra searches were conducted in order to understand the context in which these articles were taking place.

The first of them was conducted in websites of relevant international organizations such as the World Bank, The WHO, the International Telecommunication Union, the OECD, the GSMA or the mHealth Alliance.

The second one was conducted in Google academic in order to note the implication of NGOs within health issues in different countries.

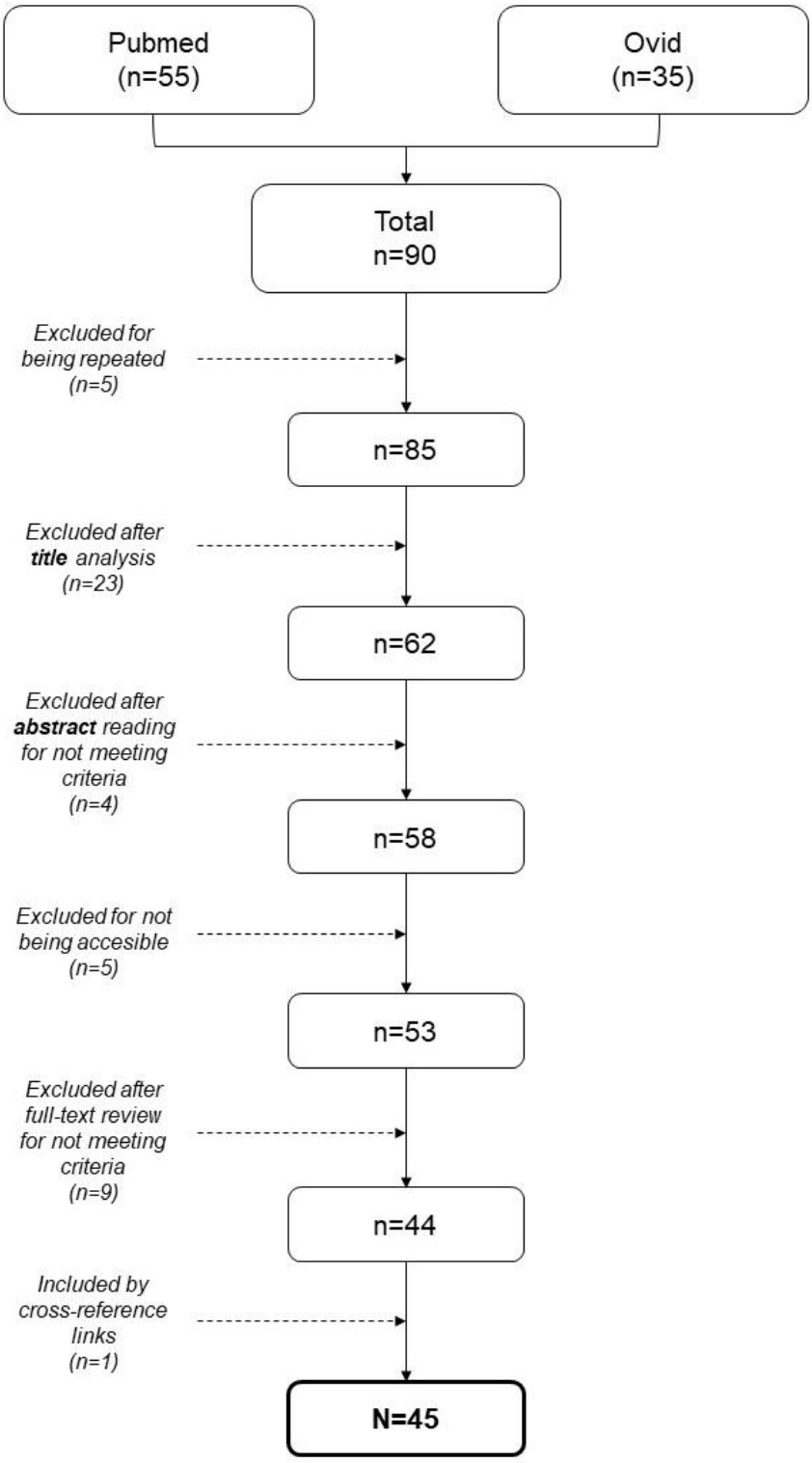

Figure 5: Flow chart used for the search strategy. Finally, 45 out of the 90 initial publications entered this review.

3. RESULTS

According to the 45 publications that entered the study, they were classified according to the following characteristics: type of study, geographical area of the study, year of publication and telemedicine type studied.

3.1. TYPE OF STUDY

In what respects to the type of study, the vast majority (n=24) were articles, whereas the reviews were the second most popular type of publication with n=11. Apart from this, five systematic reviews were included (27,30-33), as well as the following: a scoping review (15), a case control study (34), a meta-analysis (35), a pilot study (36) and a prospective study (37) **(Figure 6).**

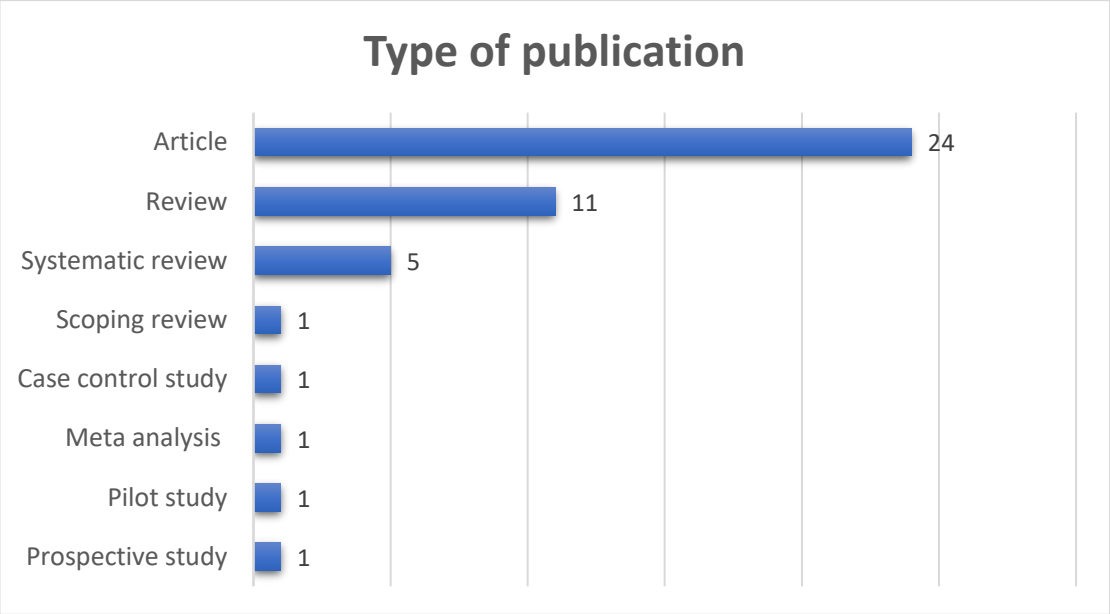

Figure 6: Type of publications. The vast majority of publications were articles (n=24) or reviews (n=11).

3.2. GEOGRAPHICAL AREA

Several subclassifications according to the geographical area studied were made. Firstly, 29 articles with an international perspective where identified; of these, one of them was a systematic review focused only in Africa (30), another two were centred in the Sub-Saharan region (27,35) and, lastly, an article introduced a comparison of Asia and South America (38). The rest of publications were mainly reviews that analysed more than one country with a no clear geographical pattern.

Apart from this, 17 single-country studies were full-text reviewed. The global distribution of them is summarized in **Figure 7**. The most popular country among the publications reviewed was Ethiopia (n=3) (21,36,39), followed by Mali (n=2) (37,40).

Eventually, 1 article could not be classified (41).

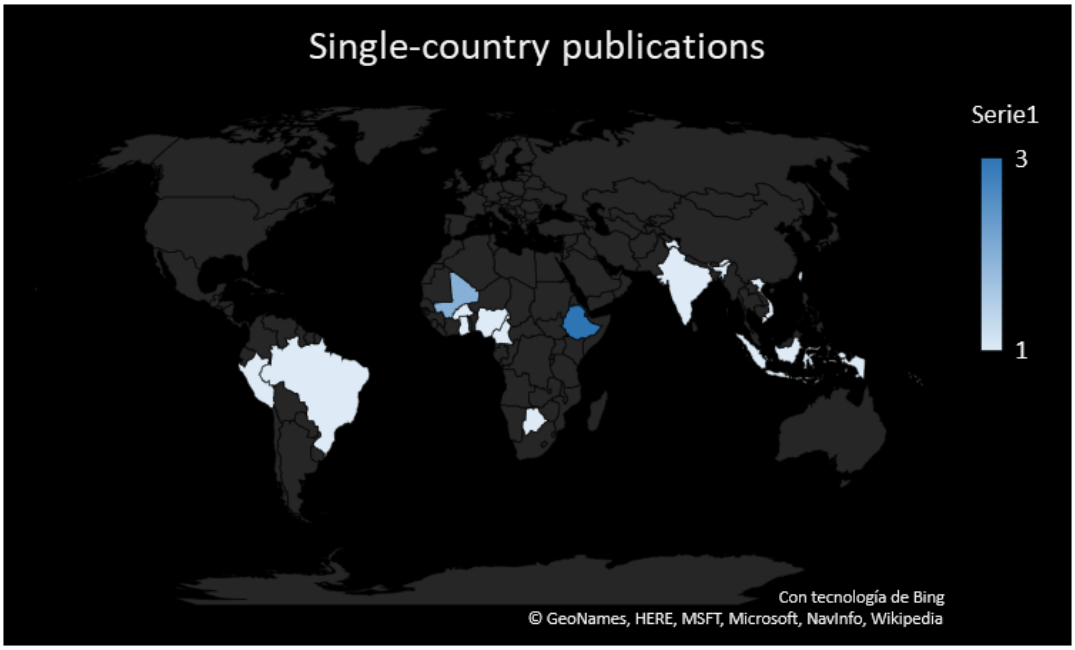

Figure 7: Single-country publications. The country with the greatest number of publications was Ethiopia (n=3), followed by Mali (n=2).

3.3. YEAR OF PUBLICATION

In **Figure 8** the publications considered into the study are represented. The year in which more works were published was 2017 (n=9), followed by 2012 (n=8).

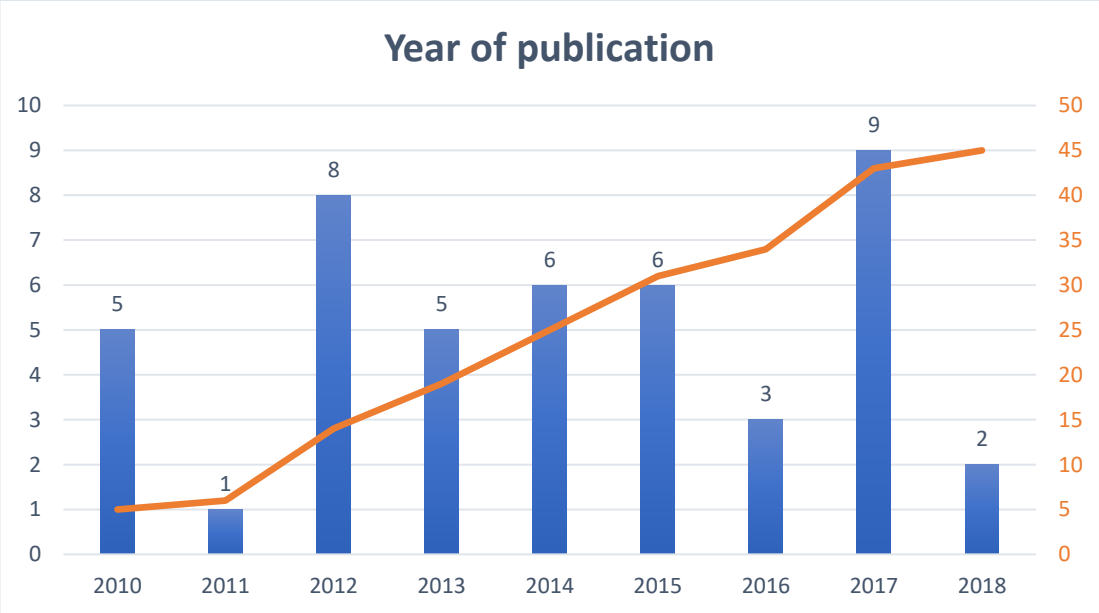

Figure 8: Year of publication. The year with the greatest number of publications was 2017 (n=9), followed by 2012 (n=8). The tendency line (orange) shows the growing amount of publications entering the actual review.

3.4. TELEMEDICINE TYPE STUDIED

The big variety of options and combinations of these, added to the little technical explanation of the mHealth initiatives in some of the publications, complicated the classification of these in relation to the type of technology used. However, 4 groups were defined based on the main technological options seen: mobile apps, SMS, web-based systems or unspecified.

The field of mobile apps was the most popular telemedicine solution studied. N=7 articles were focused on a mobile app, two of them mentioning a combination with another type of technology to support the app. One of them combined the application with a web-based system (42), whereas the other one used a USSD system in combination with the mobile app (20).

In what respects to web-based systems, 5 publications were identified. These projects were based on introducing data in a certain web via an Internet connection using either a mobile phone or a computer. Programs such as the 'iPath' (29) or the 'e-TB Manager' (43) are some examples of these.

In relation to SMS, mentioned in other publications as the main telemedicine option in developing countries (44), in this review, this field was the least popular. Only n=2 articles focused on pure SMS initiatives (45,46), adding n=1 article more that combined SMS with a web-based system and a mobile application (47), both used as support.

Nonetheless, overall, the most popular group was the one named 'unspecified'. Indeed, approximately the 58% of the publications entered it. N=21 articles did not work on a specific type of telemedicine (most of them were reviews that compared several types of telemedicine), whereas n=4 did not provide enough technical information for being classified in any of the previous groups. One article more (n=1) was focused on telemedicine networks (48); however, it did not provide information about the specific type of telemedicine delivered.

Eventually, 6 publications could not be classified. They worked on a specific type of solution providing enough technical details, but were neither a mobile app, a web-based system or an SMS-based program. One of them (n=1) worked on the development of biosensors to be used in combination with other telemedicine technologies (mostly mobile apps) (41), a second one (n=1) focused on a 'data integrity module' for reducing the time in reviewing the human errors done during the introduction of the data in any data collection program (35), a third one (n=1) analysed a computer program called 'Telemed-ETH' (36), a fourth one (n=1) studied an app for mobile devices such as laptops or radios (not mobile phones) (49) and a fifth one (n=1) worked on 'Mobile Phone Surveys (MPS)', a non-Internet dependent

mobile phone telemedicine option (50). Finally, one article (n=1) did not work on any telemedicine solution; it analysed the results of a survey conducted about the eHealth implementation in South America and Asia (38).

The difficulties found in this section could be due to several reasons; however, the approach of most of the publications, focusing more on the impact and results of these initiatives rather than in the technical aspects, could explain some of them. Nevertheless, a big difference was noticed in the number of mobile app solutions analysed in contrast with the ones focused on SMS. Apart from the number of publications itself (which is higher for the first group) the mobile apps were a lot more common in the reviews that had to be classified into the 'unspecified' group. This fact may be important to notice for future analysis.

4. DISCUSSION

Since the expansion of telemedicine started, several initiatives have been tried in very different settings. Based on the lessons and difficulties experienced during these trials, a summary of all these has been done under 3 different subtitles: 'Telemedicine and mHealth', 'data collection' and 'mHealth apps'.

4.1. TELEMEDICINE & mHEALTH

In 2014 the WHO launched the second Global Health Initiative by which they called for affordable and practical technology for low- and middle- income countries (51). Only a year later, United Nations published the agenda 2030, by which they hope to reach universal health coverage by this year, 2030 (19).

This objective, which appears to be nearly impossible without the help of eHealth (52), associated to the mentioned unstoppable growing of mobile devices' penetration among world population and the increasing accessibility to purchase them (53) has led to the popularization of this field of medicine.

At present, 83% of world's countries have reported to have at least one mHealth initiative, but very few have reported their evaluations (51). Therefore, it is really difficult to know whether they have been useful or not.

Although mHealth and telemedicine appear as a promising field, the truth is that the articles published often are weak and lack scientific evidence (31,37,39,40,48,53). However, even if not very consistent, generally doctors refer that clinical outcomes for the patients running in telemedicine initiatives were often improved (48). In fact, Burnit et al. (54) conducted a review in which they concluded that 92% of the articles published in the field of mHealth had resulted in a positive impact.

For example, in Bamako (Mali), the *Pesinet* telehealth initiative showed that being enrolled in it resulted in a greater utilization of primary healthcare among children (37).

Furthermore, in Vietnam a pilot study proved the effectiveness of collecting data via SMS using, therefore, no more than the readily available technology of basic mobile phones (45).

In what refers to tuberculosis, several initiatives have been raised too. For example, the PIH-EMR electronic data record system, or the OpenMRS, which is being deployed as part of the health system architecture plans in Rwanda and Kenya, have proved to be effective in data collection, leading to improvements in clinical care, reporting and surveillance. Moreover, in relation with these new systems, several programmers keep on developing new tools for facilitating data management, such as Imogene, which was created in France to enable data collection in different operating systems, both via mobile phones and web (55).

As telemedicine grows in importance for the international organizations, the innovation and creativity applied to them does not stop. The unstoppable growing offer of new specifications such as the application of biosensors (41) connected to the mobile devices compels a continuous update in the topic.

The growing ubiquity of ICT is contributing to mitigate the problems that traditional health systems were facing in developing countries, such as the shortage of professionals in rural areas or the fraud (14). Moreover, telehealth is allowing the rural population to reach the healthcare system for the first time, increasing attendance (37) and reducing costs (22,40,56). Nonetheless, it is important to stay cautious when referring to mHealth. Even though it has been already proved that mHealth could cause a positive impact in global health, it is important to know that

mHealth will not solve the challenges the projects are facing in many African countries (30).

4.2. DATA COLLECTION

Up to date, if existing, the data reporting or collecting traditional systems have been paper-based (57). This often has resulted in misinterpretation of written data, lack of standardization and higher loss rates (42). With the proliferation of new technologies, a faster and more structured way to collect this data has emerged, placing the field of data collection and/or report as one of the most profitable upgrades these technologies could carry. In fact, data collection has been proved to significatively reduce the time and errors, improve the data quality or even save costs with respect to previous methods (50,58).

But not only the global North thinks this tool could make a big and positive impact towards health coverage; in fact, the development of electronic health records to substitute the traditional paper has had a very good welcoming among the local communities. Actually, they have expressed their preferences for this new way of collecting health data in several articles (21,39).

Currently, according to the third global survey on eHealth conducted by the WHO, 47% of world's countries have electronic health records. However, these are a lot less frequent in lower-middle income countries (35%) and even less in low-income countries (15%) (13).

The potential of this field if applied from the lowest levels such as communities and health facilities has been widely described. Reporting data from these levels could enable it to be later introduced in the national trunk, leading to a much greater impact in national health (59).

Furthermore, a good architecture for a data collection eHealth initiative could transmit information to professionals located in remote areas (15), leading to connection between disparate health centres which could result in cooperation among them. This cooperation has ultimately the potential of changing health outcomes (21).

4.3. MHEALTH APPS

As previously mentioned, the application of mobile technology has a big potential in improving data collection and facing some of the most usual problems in LMICs (59). These countries do not only cope with a little ICT network, but the possibility of having other infrastructural and health problems which may only been addressed in them (20,27,29).

Although several apps have been developed, some mHealth initiatives such as DHIS or OpenMRS have emerged as the top data collecting tools. This apps use a local database with a limited and small number of variables per patient which allow to obtain interesting statistics. Apart from that, Fraser Hs et al., in their review, remarked the following aspects: importance of uploading information even if you were offline, importance of communication among clinics, data backups, confidentiality and privacy and support to local users (57).

In relation to that, another review conducted in 2016 reported the need to set clear goals, adopt user friendly interfaces, foster a continuing use and motivate the local users not abandoning them, define a suitable duration and measure cost-effectiveness and satisfaction from the users (22). Along these lines, they proposed two visual schemas of all the items a telemedicine project should tackle (**Figures 9 & 10**).

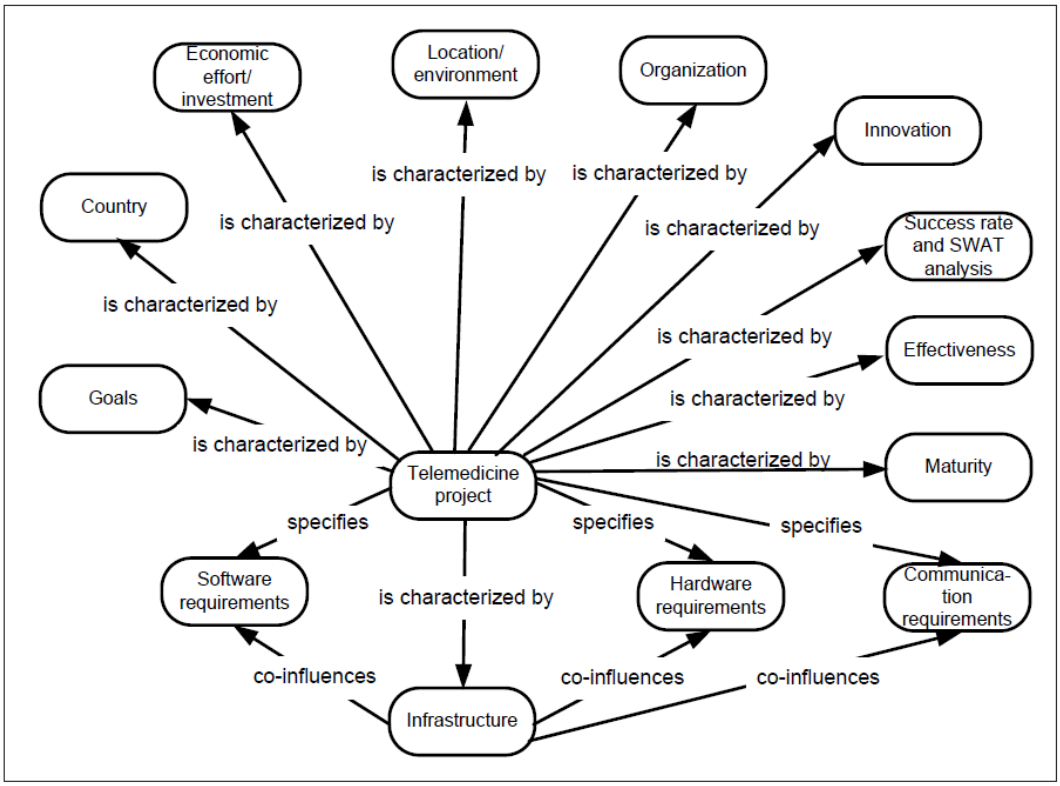

Figure 9: The concept map of the proposed taxonomy. Relation "co-influences" to requirements has been depicted only from the concept "Infrastructure", but it holds for all the concepts a Telemedicine project is characterized by [Source: Combi et al. (22)]

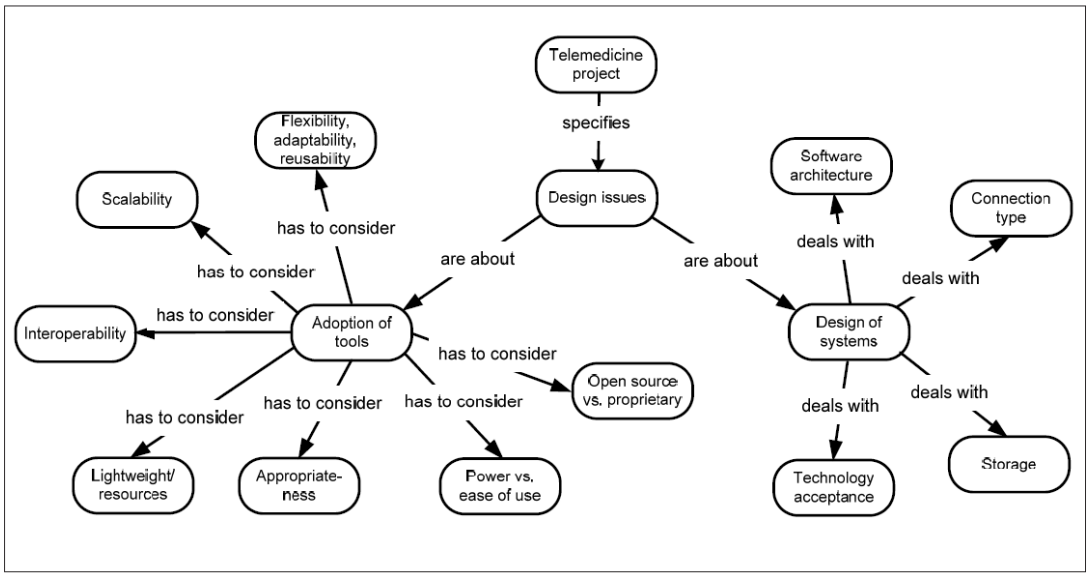

Figure 10: The concept map of the classification for design issues. Design issues every data collection mobile app entrepreneurship project should follow to be useful in developing countries [Source: Combi et al. (22)]

GeoHealth, original from Brazil and based in other mHealth initiatives such as eSteps or MoTECH (42), is another interesting example of an app launched in order to improve data collection. One of the most remarkable aspects of this app is the option of introducing data offline, which would later be uploaded. This characteristic has been also highlighted by several authors (20,56,60), such as Piette et al. (15), who reported that a "store and forward" system is needed in low- and middle-income countries, where the internet connection may not be stable.

Other example is the Nacer app, which uses internet and mobile technology to allow health professionals to collect data from different populations in Peru with the aim of sharing it remotely with medical experts for data analysis (14).

The Anesthesiologist app appears also as a relevant case to study. In this case, the authors show the potential of any mHealth app in an LMIC in order to take demographic information and statistics out of it. Moreover, they remark the importance of designing brief questionnaires with relevant variables in order to avoid the 'respondent fatigue', what causes the users to leave the questionnaire before finishing it for being too long or complicate (also addressed by Sutiono et al. (49)). Finally, it is suggested that future apps prioritise an Android version prior to an Apple one, since this first operating system is far more used in developing countries (34).

It is in fact the design of a good questionnaire which could make the app turn from good to bad. For this reason, studying the case of e-TB could be profitable. This app, created for addressing tuberculosis in developing countries, developed a very efficient questionnaire that reached a completion rate superior to the 86% (43).

However, not all the initiatives have shown a positive result. This happens, for example, with the case of Unified Theory of Acceptance and Use of Technology (UTAUT) which according to Bawack et al. (61) proved to be inadequate when predicting the adoption of Health Information Systems (HIS) in Cameroon.

The impact this data collection method-change could have in the professionals themselves is another critical point to consider when designing a project. For example, the step towards mobile technology could result in communicating and behaving patterns (59,32). Moreover, although free access to internet has been

reported to be preferred by the users from a study in Ethiopia (21), the fact of giving the local professionals access to mobile phones in the poor economic context implies running other risks, such as the fact that people could lose or sell them (59). For this reason, securing free airtime for health professionals from telecommunication providers or limiting the workers' top-up voucher would be necessary in a long-term strategy (21).

To prevent those changes from turning wrong, the mHealth solutions proposed must be tailored for local settings and driven by local people (20,57,32). The eHealth systems must be based in community participatory researches, which implies that eHealth systems must be adaptable (21). The failure to implement the previous statement could result in discomfort for both the patient and the health worker, breaking down that good atmosphere which is crucial during the admit period (62).

A very good practical example of this is the *Allillanchu* project, which used a very interesting multidisciplinary approach to tackle mental problems among the peruvian population. This project, always focusing on the importance of the context-specific problems, developed a program based in the combination of an app, a web and SMS notifications to reach, in the most efficient way, the maximum amount of people possible (47).

Nevertheless, only by the fact of being humans, errors will always remain unavoidable (63). However, the development of tools (such as the data integrity module implemented within the AMRS electronic health record system (35)) to audit and try to fix them, sets an important step towards the applicability of these new technological advances in developing countries.

But not only that, in order to achieve the maximum benefits, mHealth initiatives must be integrated in the local health care system (33) and the participation of the Government, via de Ministry of Health (30), is crucial for success in mHealth projects (32,38,44,64). In fact, a program developed in Ethiopia, which consisted on collecting data in primary health, addressed the importance of incorporating the Government in order to standardize the paper forms used in primary care (39).

Finally, as most of the cases report individual practical initiatives, several articles have remarked the need of a bigger connection among networks (24,44,65) with the

aim of achieving an “integrated mobile supported health information infrastructure” (59). Standards for data storage and exchange (55), reporting experiences and national practice, guidelines and security protocols (66), always customized to local settings, are needed in order to develop reliable future ehealth initiatives (36,46,67,68). There is strong need of sharing the lessons learnt and the challenges faced (27).

4.4. LIMITATIONS

Several limitations, classified in the following three main topics, were found during the present review.

Firstly, the width, the novelty, the variability in the sense of the perspective it can be analysed from or even the big and heterogeneous amount of terms that can lead to the main topic (telemedicine or mHealth), made it very hard to stablish solid limits to the search field. Even if it was tried to include as many key words as possible by using the MeSH terms library or the combination of terms, publications may have stayed out of the review. Furthermore, even if the research was conducted using the most important search engines in the field of medicine, the possibility of analysing the same topics, problems or alternatives from other perspectives such as the social or humanitarian sciences undoubtedly results in a standpoint bias in the review.

Secondly, fixing the inclusion and exclusion criteria was neither easy. Even if the study was focused on data collection and report, some of the advances and issues found in other fields when applying a telemedicine initiative, just for being a telemedicine tool, could have enriched the present study. For example, the system used for monitoring chronic diseases in low resource countries could shed light on the future development of a data collection mobile app. The present review tried to delimit the search to the best balance between technical and practical outcomes.

Thirdly, in what respects to the type of telemedicine used, difficulties were also faced. The scarce technical details of the different telemedicine initiatives from most of the publications (often developed in different and more technical publications which did not cope with the inclusion criteria), made it difficult to stablish the categories in which the publications would later be classified. Although a significative predominance of mobile apps was found, there is need to be cautious

when analysing the results from this review in detail; some of the initiatives may have included combinations of other types of telemedicine or may have used a type of telemedicine which has not been as detailed as necessary resulting in misclassification errors.

5. CONCLUSIONS

After the review done, three main conclusions are reached.

First, mHealth has been proved to be effective for assessing health problems or difficulties in developing countries due to the fast and nearly global proliferation of mobile phones and mobile-network coverage. Indeed, the application of new technologies towards universal health coverage is not only highly recommended by the World Health Organization, but it is one of the global development goals in the agenda 2030. Therefore, the creation and utilization of mHealth initiatives for collecting data is undoubtedly backed up by the biggest and most relevant international organizations.

Secondly, looking at the growing smartphone penetration rates and internet coverage, mobile apps appear as the optimal telemedicine solution. Along these lines, when designing a mobile app, in order to cause a positive impact on health and the local population towards it, it has to cope with the following characteristics (**Table 5**). First of all, the **resources needed for the app to function correctly must be available** in the community. Second, it has to be **designed based on the community it will be used by and for**; this is, the culture, the working patterns, the language… of the local community have to be taken into consideration if the app is wanted to work. Third, in order not to generate the 'respondent fatigue' (31), a **short questionnaire with a few but relevant number of variables** appears as a good schema for reporting data. The short fill-in-time and the big range of statistics that can be obtained out of not many but correctly chosen variables can be highly profitable. Fourth, due to the inconstant mobile network or broadband in these countries, the app should include an **offline functionality** by which professionals could keep on uploading data even though it is not instantly transferred to the central server until the internet connection (via wifi or broadband) is recovered. Once the

connection is back, the data uploaded during the offline period will be transferred to the central server. Fifth, it is highly important to **keep the privacy and confidentiality of the health data collected**; for that, all data has to be previously encrypted before being transferred to the central server. Sixth, if the utilization of the app by healthcare professionals is wanted to last in time, it must be designed with an **easy-to-use interface**. Seventh, as the app will be used by **health professionals, they should be trained** in the use of both mobile phones and the app itself. Eighth, it should be launched in an **Android system**, as it is far more used in low- and middle-income countries. Ninth, in order to allow future analysis of the data entered by different professionals in different locations, a common language must be stablished through the **adoption of standards, common protocols and guidelines**. Finally, the **connection, communication and participation with the Government** is crucial towards its success.

Table 5: Important factors to note when creating a mobile app for data collection in developing countries. Ten main characteristics.

Important factors to note when creating an mHealth app for data collection.
Availability of resources required by the app functioning.
Based in a participatory-dynamic with each community to address context-specific needs.
Short questionnaire with 5-15 variables.
“Store and forward” system. Data uploadable offline.
Privacy and Confidentiality as a must.
Easy-to-use interface.
Training of professional health workers.
Android system.
Adopt standards, share protocols and guidelines.
Close participation with the Government.

Thirdly, the review of the articles for this study showed that most articles, projects and pilot studies ran in developing countries lack consistent evidence. The problem might remain in the little or absence of communication among the authors. The different cultures, academic formation and personal ideas from which they all analyse reality leads to a very heterogeneous data, often difficult to compare.

As suggested in several articles, there is need of developing a global platform for universalizing all the initiatives as well as for making the trials, challenges and opportunities found in the field of telemedicine easy to access and study. This platform would allow a greater connection among authors and projects, creating something like the 'integrated mobile supported health information infrastructure' that was proposed in one of the articles reviewed.

6. FUTURE DIRECTIONS

The origin of the study is based on personal experience after several years of working towards international health cooperation in Benin (Africa). The disorganization, the lack of a consistent patient data record system and the waste of the scarce resources (both material and time) added to the high -and growing- mobile phone penetration in the region, motivated the present study. The objective of this study was to identify the main factors towards the development of a useful mHealth app for data collection that could contribute to the improvement of the local and country's health system.

As several articles have mentioned, which appears to be clear in literature is that if a good telemedicine project is launched, a better distribution of resources and the consequent improvement of health systems could be achieved (5). This fact, added to the proved potential of mHealth, promotes future work towards the following two proposals.

First, the development of an mHealth app for reporting data having into consideration the aspects reviewed in **Table 5** would show the strengths and weaknesses of each of these. Besides, this app could benefit not only the local

hospital, but also the local community. mHealth has been proved to be highly useful for taking medicine to the most marginalized communities, integrating them in a health system they had not been able to reach before. Moreover, a data collecting server could allow the interconnection between two or more hospitals from a region, which could accelerate and improve the health outcomes in patients. But not only that, if well developed, an mHealth app could collect health data from all the hospitals and health centres from a country, allowing any professional working in the nation to take care of a patient, regardless of the specific location. Even more, if all countries would have an Electronic Health Record (HER), statistics of the real health situation of a country could be obtained, resulting in the development of international health cooperation policies to assess the pointed needs. Bidirectional educational programs could be implemented, humanitarian aid efficiency could be improved, treatment of noncommunicable diseases could be more easily provided and even specific health cooperation programs could be arranged (in case of an epidemy, for example).

Secondly and probably more important, as pointed in the third conclusion, professionals must help each other in order to reach solid results when applying mHealth initiatives. We therefore suggest the development of a global initiative towards mHealth apps. Even if each of the apps should be adapted to the local community it was created for, a common central structure would facilitate the comparison of data and development of statistics which could be used for assessing the gaps in the health systems of these countries from an international perspective.

Moreover, the short studied, wide and little defined field of telemedicine needs a platform for collecting in a clear way all the initiatives done up to date in this. A clear analysis of which the results and difficulties faced by the different projects were will definitely help in the development of future mHealth applications or studies such as this one.

As O'Reilly Shah V et al. (69) mentioned: *"Apps downloaded by hundreds of thousands have the potential to affect the care of millions of patients"*.

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APPENDIX 1 – Publications included into the review.

Article No.	Title	Type of article	Year	Country	Type of mHealth used	Major findings	Magazine
14	E-health in low- and middle-income countries: findings from the Center for Health Market Innovations.	Review	2012	International	Not specific	TeleDoctor (Pakistan) // 38% of programs focus on data collection // Nacer (Peru) // M-DOK (Philipinnes) // Operation ASHA // RapidSMS (Malawi) // reliance on donor funding // ICT can extend access to care & improve data management // traditional problems can be mitigated through ICT: shortage of professionals in rural areas, quality of care, lack of patient compliance or fraud.	Bulletin of the World Health Organization
15	Impacts of e-health on the outcomes of care in low- and middle-income countries: where do we go from here?	Scoping Review	2012	International	Not specific	"Store and forward" system // asynchronous telemedicine // training of local staff // community-based participatory research // 92% of the e-health articles reach positive conclusions // how an e-health architecture can help connect disparate health information systems, how interoperability can support coordination between multiple points of care, and how this coordination can improve health outcomes.	Bulletin of the World Health Organization
17	E-Health: A Global Approach with Extensive Semantic Variation	Review	2012	International	Not specific (E-Health in general)	Regular ICT as key of the health systems around the world // challenges for eHealth // level of health status is highly influential // the appropriate distribution of resources could improve health systems.	Journal of medical systems
20	mHealth to Revolutionize Information Retrieval in Low and Middle Income Countries: Introduction and Proposed Solutions Using Botswana as Reference Point	Article	2013	Botswana	USSD + mobile app	Ultimately mHealth solutions must be tailored for local settings and driven by local stakeholders in order to be sustainable// USSD: free system dialling a code + algorithm that guides the professional + all phones can use it// Txt2Medline: SMS based technology for searching in Pubmed // smartphone apps have proved to be useful in remote areas of Botswana // NLM Gallery of Mobile Apps // DImagi // Store and forward medicine.	Studies in health technology and informatics

21	Health workers' experiences, barriers, preferences and motivating factors in using mHealth forms in Ethiopia.	Article	2015	Ethiopia	Mobile app	Vast majority prefers to use the electronic record systems // Dangers in using the smartphones and internet for extramedical purposes.	Human resources for health
22	Telemedicine for Developing Countries. A Survey and Some Design Issues.	Review	2016	International	Not specific	Major goals of Telemedicine // Need for future research // Need of a minimum of infrastructure // Requirements in software & hardware // Multiple case studies analysing the mHealth projects by geographical area // Major challenges & recommendations.	Applied clinical informatics
24	mHealth innovations as health system strengthening tools: 12 common applications and a visual framework	Review	2013	International	Not specific	The absence of a shared language + lack of a common framework complicates mHealth // "touch-points" // 12 common applications for mHealth.	Global health, science and practice
27	Mobile phone-based mHealth approaches for public health surveillance in sub-Saharan Africa: a systematic review.	Systematic review	2014	Sub-saharan Africa	Not specific (SMS-based, app-based, VRS-based, and telephony-based)	Mobile and wireless technologies have the potential to change the face of global health systems: 4 facts // IDSR // some studies reported errors in data collection due to diagnosis stocks-out // technical, financial, infrastructural, security and diagnosis tools issues // market of eHealth constantly increasing // surveillance systems needed to support global health // strong need of sharing what we have achieved so far.	International journal of environmental research and public health
28	Towards reinforcing telemedicine adoption amongst clinicians in Nigeria	Article	2017	Nigeria	Not specific	The obvious challenge of mHealth is whether the clinicians are willing to use this technological innovation // HIS adoption voluntarily has received little attention // challenges // TAM // UTAUT // Nigerians will implement telemedicine if they see benefits over conventional use, if it is easy to use and if it is somehow supported // IPMA: reinforcement is crucial // seen as an extra workload // the biggest challenge is in implementation.	International journal of medical informatics
29	Telemedicine in the Solomon Islands: 2006 to 2009	Article	2011	Solomon Islands	Web-based system (iPath)	iPath // infrastructural challenges as main problem // telemedicine has the potential to access to unevenly distributed resources.	Journal of telemedicine and telecare

30	Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa	Systematic review	2014	Africa	Not specific (mHealth projects in general)	In Kenya, mHealth is a cost-effective tool // Benefits of mHealth were described at every level (from governments to patients) // mHealth integration into the healthcare system is critical // The participation of the Government is crucial // security & privacy measures // The poor quality of health information systems in developing countries due to data incompleteness, untimeliness, existent information systems and inadequate analysis // mHealth projects are not a solution to the challenges that health systems face in many African countries.	BMC public health
31	Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: Systematic review.	Systematic Review	2015	International	Not specific (mHealth in general)	Training // cultural barriers // use of mobile phones by FHWs is feasible irrespective of their education or prior training // Data collection via mobile phones reduces time, errors and improves data completeness // number of mHealth projects has doubled over 2015.	Tropical medicine and international health
32	MHealth: An updated systematic review with a focus on HIV/AIDS and tuberculosis long term management using mobile phones.	Systematic Review	2015	International	Not specific	mHealth has proved to have multiple benefits // it is important to address the gaps of previous studies // mHealth must be integrated in national plans and budgets submitted by the Governments // make attention of the (negative) impact on behaviour patterns.	Computer methods and programs in biomedicine
33	Health Worker mHealth Utilization: A Systematic Review	Systematic review	2016	International	Not specific (mHealth)	mHealth has a lot of potential, although not very popular // benefits workers, patients and the system itself // need for integrating the mHealth solutions into the healthcare delivery.	Computers, informatics, nursing: CIN
34	Evidence for increased use of the Society of Pediatric Anesthesia Critical Events Checklist in resource-limited environments: A retrospective observational study of app data.	Case control study - Article	2017	International	Mobile app	It arguments the potential of using any mHealth app in a LMIC in order to take demographics and statistics out of it // mHealth apps as an invaluable solution // Android systems higher penetration rates // Respondent fatigue --> short questions.	Paediatric anaesthesia

35	Data integrity module for data quality assurance within an e-health system in sub-Saharan Africa	meta-analysis	2012	Sub-saharan Africa	Data Integrity Module	Module for correcting the human-errors when introducing data in any e-health system // AMPATH Kenya, part of OpenMRS // Audited data and quality problems in data collection // the module reduces the scale of manual reviews done to identify records with errors.	Telemedicine journal and e-health
36	The role of information communication technology (ICT) towards universal health coverage: the first steps of a telemedicine project in Ethiopia.	Pilot study	2012	Ethiopia	Computer program (Telemed-ETH)	Telemed-ETH // Health care systems of many african countries have been proved to lack e-readiness // "developing countries still have to organize themselves nationally and regionally in order to benefit from global partnerships between the North and the South" // Suggestions for the implementation of an mHealth initiative // telemedicine or e-health can address the voice of the poor and marginalized.	Global health action
37	Effects of a telehealth programme using mobile data transmission on primary healthcare utilisation among children in Bamako, Mali	Prospective Study	2013	Mali	Mobile app	*Pesinet* telehealth initiative // Most of the studies lacking scientific rigour // structured questionnaire // Use of the mobile app increased primary healthcare utilisation.	Journal of telemedicine and telecare
38	Challenges and Hurdles of eHealth Implementation in Developing Countries	Article	2015	South America + Asia	None (survey about the use of mHEalth)	Training of human resources in eHealth is critical // Hard to find coordination Estate-ehealth initiative // huge gap in cultural and educational issues regarding eHealth.	Studies in health technology and informatics
39	Quality of routine health data collected by health workers using smartphone at primary health care in Ethiopia	Article	2017	Ethiopia	Mobile app	There is no evidence on the use of electronic forms for data collection // Compares the use of paper-based vs electronic records for data collection // Good quality data = good health system // electronic forms on smartphones seen as a way to improve data collection in developing countries // Importance of setting phones correctly in order not to recruit incorrect data // Important to incorporate the Government in the design of health data reporting forms // language barrier // training.	International journal of medical informatics

40	Medical and economic benefits of telehealth in low- and middle-income countries: results of a study in four district hospitals in Mali.	Article	2014	Mali	Not specified (EQUI-ResHus project)	Telehealth can improve attendance to health centres in remote areas // telehealth is very promising // ICTs can improve health in LMICs in many ways // quote from a patient.	BMC health services research
41	Personal Health Records: Mobile Biosensors and Smartphones for Developing Countries	Article	2012	------	Biosensors (mostly in combination with mobile apps)	Open Health (Spain) // Biosensors can be adapted to areas with no existing broadband networks // georeferenced information.	Studies in health technology and informatics
42	Georeferenced and secure mobile health system for large scale data collection in primary care	Article	2016	Brazil	Mobile app & Web	GeoHealth, a system for improving the collection and analysis of primary health data // lack of flexibility from traditional paper forms // structured data fields // mobile technology has the potential to distribute information efficiently // mobile health can improve health care programs.	International journal of medical informatics
43	User experience analysis of an eHealth system for tuberculosis in resource-constrained settings: A nine-country comparison.	Article	2017	International	Web-based system (e-TB Manager)	Example of a web-based system: e-TB - It was designed in order to improve the WHO's politics in what refers to TB // users to complete the electronic survey in 5-10 mins // 86.3% completion rate // collaborate with Governments.	International journal of medical informatics
44	mHealth Application Areas and Technology Combinations*	Review	2017	International	Not specific (mHealth in general)	The most popular mHealth solution is SMS, followed by apps // there is need to develop studies in the area of data collection // need to develop common guides and protocols // involve governments.	Methods of information in medicine
45	A New Paradigm for Disease Surveillance in Vietnam	Article	2014	Vietnam	SMS	Prove data collection to be profitable // SMS could initially complement and finally replace traditional paper-based forms // readily available, simple-to-use and low-cost technology.	Telemedicine journal and e-health

46	Technological solutions for an effective health surveillance system for road traffic crashes in Burkina Faso.	Article	2017	Burkina Faso	SMS	Georeferenced data collection in one of the least developed countries of the world proves to be effective // Offers an example of how difficult it is to deal with the local context // Supports the importance of EHRs // fulfilling has to be done without disrupting their routines and without compensation // Supports the development of an app to replace the geotracer // Implementing electronic surveillance systems will support public health.	Global health action
47	Design and content validation of a set of SMS to promote seeking of specialized mental health care within the Allillanchu Project	Article	2018	Peru	SMS & web & app	Few human resources unevenly distributed in LMICs // Multidisciplinary approach: Creation of a three component-based system: app, Web & SMS to get to the people which do not use the previous // SMS aimed to address some context-specific barriers.	Global health, epidemiology and genomics
48	Comparative performance of seven long-running telemedicine networks delivering humanitarian services	Article	2012	International	Telemedicine networks (not further details about the specific type of telemedicine delivered)	Little published evidence about the effectiveness of telemedicine networks // Clinical outcomes for patients were often improved with the use of telemedicine // Improved collaboration among networks will improve the situation.	Journal of telemedicine and telecare
49	Designing an Emergency Medical Information System for the Early Stages of Disasters in Developing Countries: The Human Interface Advantage, Simplicity and Efficiency	Article	2010	Indonesia	App for mobile devices (laptop, radio…)	Proves the efficacy of using an app for monitoring disasters // very useful in the early phases of a disaster // easy-to-use interfaces needed.	Journal of medical systems
50	Moving the Agenda on Noncommunicable Diseases: Policy Implications of Mobile Phone Surveys in Low and Middle-Income Countries	Article	2017	International	MPS (mobile phone surveys) (not internet-based mHealth)	MPS can be very useful in addressing NCDs // MPS include SMS, IVR (interactive voice-response) and CATI (computer assisted telephone interviews) // MPS can considerably shorten the time for gathering population-based data as well as for data analysis and data sharing // Need for private-public partnerships // importance of the environment and the culture for engaging communities --> need to adapt to local context // via MPS recruited data can help inform policies to address key public health challenges.	Journal of medical internet research

55	E-health systems for management of MDR-TB in resource-poor environments: a decade of experience and recommendations for future work.	Article	2013	International	Web-based system (PIH-EMR & OpenMRS-TB)	eChasqui // objectives of an mHealth app // better systems are required to manage inventory at national, district and local levels // Imogene // eTB manager // MOTECH // OpenMRS deploys as part of the national plans in Rwanda and Kenya // open standards for data storage and exchange // Systems must be developed collaboratively to foster local development, innovation and support worldwide.	Studies in health technology and informatics
56	Hearing health access in developing countries	Article	2017	International	Not specific	The most common causes of hearing loss are conductive and treatable // telehealth for training and assessing the locals by a 'store and forwarded' format // Project EAR // If we had data, we could improve the distribution of cochlear implants // telehealth contributes to reach rural population.	Current opinion in otolaryngology & head and neck surgery
57	Implementing medical information systems in developing countries, what works and what doesn't.	Review	2010	International	Not specific	Development of different apps for EMR (electronic medical record) systems // PIH // The importance of local leadership // individual records // records with a limited number of variables per patient // "even a simple local database can create valuable statistics" // data backups // support and train locals // GHDonline.	AMIA 2010 symposium proceedings
58	Bridging the Human Resource Gap in Primary Health Care Delivery Systems of Developing Countries With mHealth: Narrative Literature Review	Review	2013	International	Not specific	Data collection // Data collection reduces costs, errors, saves time and improves quality // Data accuracy & sustainability two important targets // Most mHealth projects are not self-sustaining // mHealth can bring a revolution in health care // the potential remains underutilized // well-designed research studies are needed // Several mHealth examples (CHITS, Cell-PREVEN system, text to change, Masiluleke…).	JMIR mHealth and uHealth
59	The Emergence of Mobile-Supported National Health Information Systems in Developing Countries	Article	2010	Nigeria + India	Mobile app	Robust national system // mhealth has huge potential // mHealth has the potential to change the way of working and communicating, which can have a great effect in health provisioning // risk of losing the mobile phones // low-end phones as a possible solution.	Studies in health technology and informatics

60	Telemedicine Utilization to Support the Management of the Burns Treatment Involving Patient Pathways in Both Developed and Developing Countries: A Case Study	Review	2012	Taiwan	Not specified (telemedicine)	Benefits from the use of the telemedicine // store and forward telemedicine.	Journal of burn care & research
61	Adequacy of UTAUT in clinician adoption of health information systems in developing countries: The case of Cameroon	Article	2018	Cameroon	Not specified (UTAUT)	developing countries still face duplication of data records and time waste // HIS adoption depends on the level of engagement // UTAUT not appropriate for predicting HIS (Health Information Systems) adoption.	International journal of medical informatics
62	A patient as a self-manager of their personal data on health and disease with new technology--challenges for nursing education.	Article	2015	International	Not specific	Importance of ensuring a good atmosphere for the patient, not reducing the attention of the nurse for fulfilling electronic records // strong emphasis in co-designing the healthcare system with the patient's needs as a key driver.	Nurse education today
63	E-health technologies show promise in developing countries	Review	2010	International	Not specific	Vista System (India): most complete system // effectiveness and cost-effectiveness of e-health systems in developing countries// poor data quality a constant problem // urgent need for solid evidence to justify and guide the investment.	Health affairs (Project Hope)
64	'Mobile' Health Needs And Opportunities In Developing Countries	Review	2010	International	Not specific	Different initiatives (Masiluleke) // privacy // large databases to be available online // 'Smile for you' program // potential of mhealth is huge, although there are risks that should be minimized // importance of strategic collaborations with governments.	Health affairs (Project Hope)
65	Redesigning primary care to tackle the global epidemic of noncommunicable disease.	Article	2015	International	Not specified	mobile telephones are a promising tool for supporting healthy lifestyles and management of chronic diseases // dearth of data on how to design and scale-up strategies // More information in order to empower primary care is needed. If we could collect data of all the patients viewed, future campaigns, trainings or resources could be arranged. // global primary care evidence database.	American journal of public health

66	Use of mHealth Systems and Tools for Non-Communicable Diseases in Low- and Middle-Income Countries: a Systematic Review	Review	2014	International	Not specific	WHO-PEN // mhealth for NCDs stay as a non-explored area --> insufficient evidence // none have looked at safety issues // 4 priority areas for improving research // greater engagement needed.	Journal of cardiovascular translational research
67	Building the Evidence Base for Remote Data Collection in Low- and Middle-Income Countries: Comparing Reliability and Accuracy Across Survey Modalities	Article	2017	International	Not specific (not internet based mobile phones)	Importance of addressing the local context.	Journal of medical Internet research
68	Electronic health in ghana: current status and future prospects	Article	2014	Ghana	Not specific	Locally set // several examples of initiatives from Ghana.	Online journal of public health informatics