NEW AND EMERGING MOBILE HEALTH (MHEALTH) TECHNOLOGIES AND SOLUTIONS: A HORIZON SCANNING STUDY

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ABSTRACT

Introduction:

The popularity of mobile phone applications (Apps) and wearable devices for medical and health purposes is on the rise, but not all the mobile health (mHealth) innovative solutions that hit the news every day will sustain and have an impact on the health of people. The aim of this news-based horizon scanning study was to explore and identify new and emerging mobile technologies that are likely to impact the future of health and medical care.

Material and Methods:

We conducted a systematic search on top ranking technology websites, according to Alexa Ranking, to identify health-related mobile-based technologies. We followed the EuroScan guide for horizon scanning, which recommends four steps: identification, filtering, prioritization, evaluation and conclusion. Technologies of interest were mHealth technologies regardless of their maturity level. The impact of technologies was assessed and scored in four areas: user, technology, safety, and cost.

Results:

Five hundred news articles were identified through the electronic search. After screening, 106 mHealth innovative technologies were included in this study. We categorized the included technologies into three groups: mobile apps (n=37), smart-connected devices (n=19), and wearables (n=50). mHealth technologies were most frequently developed for preventive health services, mental health services and rehabilitation services. There was no remarkable difference between the technology groups in terms of safety and adverse effects, but the groups were significantly different in terms of the target population, technology, and cost.

Conclusion:

An increasing number of solutions based on mobile technology is being developed by both public and private sectors but a low proportion of them undergo proper scientific evaluations. Despite the commercial availability of many innovative mobile apps, wearables, and smart connected devices, few of them have been actually used in clinics, hospitals, and health centers. There is a clear need for changes in healthcare service models to unlock the full potential of these innovative technologies.

Keywords:

mHealth, Innovation, Horizon Scanning, Health, Technology.

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INTRODUCTION

Electronic health is the use of information technology and electronic communication resources

to change behavior and improve the quality and safety of healthcare [1, 2]. It is an emerging area of health informatics that uses data processing and software applications to provide health care on a computer network and allows organizations and health centers to provide services through the Internet and related technologies. It is not only a scientific field, but also a new vision for the use of information and communications technology and the link between the field of healthcare and information technology [1, 3]. With the development and emergence of new technologies, such as virtual reality, intelligent dimming technologies, nanotechnology, sensors and information processing, eHealth includes extensive interventions of modern technologies in patient groups, organizations and healthcare professionals and providers. Mobile health (mHealth), which is broadly defined as the use of mobile phones or portable digital devices in health care, represents a range of disruptive innovations in health care. mHealth is growing with the advent of smart digital devices to further enhance the health of the community. Over the past few years, mHealth has been used in many different groups of patients and communities. It also has been used by large-scale information technology organizations, such as Google, Apple and Microsoft, which have introduced applications, platforms, and new technologies [4-7]. Prioritization, planning, policy-making, and future research are influenced by the advancements and achievements of current and emerging technologies. A common approach for the identification of opportunities and challenges of new technologies is horizon scanning.

Horizon scanning is a systematic review of the threats and potential opportunities in a field [8]. This kind of review helps to improve decision-making processes and provides timely and useful information on relevant technologies for deciding whether or not to adopt in health care [9]. Horizon scanning also helps researchers to choose research material and method and introduce new and emerging technologies. Emerging technologies in eHealth include a wide range of devices, tools, and applications in the medical, pharmaceutical, surgical and other scopes of health, which requires the use of a complex and various process [9]. However, horizon scanning studies could identify new and emerging mHealth technologies and make clarify possible options for the policy-makers, researchers, investors, physicians, and patient groups.

Horizon scanning agencies professionally use protocols and predefined guidelines for horizon scanning of emerging technologies. The International Information Network on New and Emerging Health Technology (EuroScan International Network) has officially begun its work since the late 1990s [10]. The EuroScan is a collaborative network of agencies and associations

that have been established to share information and develop health technology identification methods, and to be aware of key, new and emerging or obsolete health-related technologies. The members of the network have developed a toolkit of applied methods to select technologies, comparative analysis and applied methods [9]. The EuroScan toolkit, derived from advisory processes [11], contains a guideline for all stages of horizon scanning. It is the first toolkit for the identification of new and emerging health technologies and assessment of these technologies [11]. Although, the methods used in this tool are not being used by all member agencies or there are different methods at some stages, however, it is a complete guideline that presents all stages of horizon scanning activities in a toolkit [9] and this instrument is agreed upon by all member agencies. The toolkit is a reliable protocol, which was used in previous horizon scanning studies [12-14].

In recent years, many researchers have turned to the use of new health technologies. There is a global potential in the field of eHealth and mHealth. It seems that given the fact that many corporations, and organizations around the world have been activated in the field of eHealth for many years, they have a high demand for consumer markets.

Also, papers in scientific journals are usually published after considerable time and what they are reporting are significantly different from the technologies that are in the commercialization stage. Therefore, news-based horizon scanning on the published news of new and emerging technologies that are in an early stage of development, or in the clinical trial stage or commercialization phase, can introduce technologies faster than scientific journals. In addition, professionals, researchers and students often refer to the published articles to select the tools they need in their studies; it seems that familiarity with new and emerging technologies can be useful in selecting the study tool.

Identifying new and emerging technologies is one of the basic requirements for choosing research tools and methods. The healthcare technologies, along with advances in the field of information and communication technology, have been challenging the choice of the method used in health research, and in particular eHealth. Although eHealth research is on the rise, selecting and identifying technologies that can have a greater impact on health and have a larger contribution to innovation in this area are not simple to undertake. Although horizon scanning agencies use large databases and programmed systems to explore a wide range of emerging health technologies, the present study is an attempt to follow the protocol of the EuroScan toolkit in a limited time and specialized in the domain of mHealth technologies.

The aim of this study was to identify new and emerging mHealth technologies that have the potential to impact healthcare. Also, we aimed to detect the scope and understand services that mHealth tools can provide to inform healthcare policymakers, researchers, research funders, clinicians and patients about new technologies 'on the horizon' for health management, prevention, and care.

MATERIALS AND METHODS

The present study is a news-based horizon scanning research. We used the EuroScan tool as a complete toolkit for early awareness and alert assessment activities. We followed the protocol with some changes to identify the new and emerging mHealth technologies and draw conclusions about promising solutions in the coming years. The protocol includes these steps: identification, filtration, prioritization, evaluation and conclusion (Fig 1).

Fig 1: Methodology

Identification and filtration

In this step, several available news websites considered as our search resources. The main criterion for selecting news websites was their Alexa Traffic Rank. Alexa tool is one of the Amazon (www.amazon.com) affiliate services, which is available at <https://www.alexa.com> and has been previously used in similar studies [15, 16]. Alexa ranks websites by estimating the number of websites visitors and other site statistics based on internet traffic data [17]. It can introduce popular websites globally or in a region. We considered the global rank of websites to identify more popular websites from all over the world. Due to the high percentage of news on various websites, the referrals of news websites to one another, we selected seven news websites with higher global Alexa rank (Table 1). A combination of key terms pertaining to mHealth, telemedicine, and health technology with Boolean operators was used for constructing a search query for Google search engine. Potential news articles related to mHealth technologies were identified by searching the contents of each of the seven news websites using site function in Google (e.g. 'mHealth OR "mobile Health" OR "wearable" site:techcrunch.com').

Table 1: The included news sources and their Alexa ranking

References name	Websites	Alexa's rank *
msn	http://www.msn.com/	31
techcrunch	https://techcrunch.com	156
cnet	https://www.cnet.com/	161
telegraph	http://www.telegraph.co.uk/	347
theguardian	https://www.theguardian.com	152
mashable	http://mashable.com	707
theverge	http://www.theverge.com/	767

* The order of these websites was based on the Global Alexa rank (December 2016).

The eligibility criteria were: 1) the text of the news should contain at least one of the technologies related to the search keywords 2); the technology should be mobile-based or highly portable, and 3) news should have mentioned a health-related technology. Search results were filtered to select technologies that were new (lunched and was available within the timeframe of interest) or emerging (in development, clinical trial, pre-lunch or pre-marketing processes or expected to be licensed and lunched early). The news articles that were about ideas and suggestions that are still at the stage of the idea and the team had not started any practical development were excluded. To filter technologies, search modifiers and limiters were used for more searches. While we had not enough details about a new technology that was mentioned

in the news, we visited the company website to get more information or studied the other relevant news on the internet. Amazon, iTunes and Google Play websites were used to check if the technology was available to the public. At the end of the filtration stage, technologies that met eligibility criteria entered the next stage.

Prioritization

Technologies were categorized, based on characteristics into three groups: mobile applications, wearable and smart connected technologies. At this stage, PriTec technology prioritization tool (URL: <http://pritectools.es/index.php>) was used, which is created by the Galician Health Assessment Agency (avalia-t) based in northwest Spain. The PriTec prioritization tool was introduced as an effective tool for prioritizing health technologies that has a standard structure compared with other horizon scanning prioritization tools [18]. Each extracted technology from the previous stage was studied by population/users, technology, safety/adverse effects, cost and other implications of the technology. The core question at this stage was “can the technology have any potential impact (user and population; safety or adverse effects; technology; cost) on healthcare systems?” Table 2 shows the criteria considered in each area. This tool is a checklist by means of which we answered a question for each item by 10-point Likert scale (1 to 10, 1 for lowest and 10 for highest degree). Technologies were scored to include only mHealth tools that claimed to demonstrate some degree of population benefits, technology innovation and usefulness, safety, lower costs and other implications. To prioritize mHealth technologies, we needed more details about the technology. That’s why, we studied the company website, and relevant information on the web about the technology, the events and exhibitions in which companies or research teams present their products, as well as app stores reviews and user comments. Two authors carried out this step independently, and a third author checked the technologies.

Evaluation and Conclusion

After prioritizing the technologies, in order to rank the technologies within a group, they were compared against each other based on their potential impact on healthcare. There is no practical way to evaluate technologies in the real world to find out if they really had an impact on the healthcare system, because it needs a post-marketing evaluation (after a real user used the device), so it was impossible for us to evaluate all technologies in the real world. However, we were able to predict the potential for impact of technologies and examine if the groups exhibit any

difference based on their expected impact on healthcare systems, One-way ANOVA, Kruskal-Wallis, Tukey Honestly Significant Difference and Dunn’s Kruskal-Wallis multiple comparison tests were performed to compare three groups as mobile apps, wearable and smart connected technologies in four aspects of population, technology, safety and costs and detect statistical differences between technology groups. All tests were performed in R statistical software version 3.5.3. The statistical significance was assessed at $P\text{-value} \leq 0.05$. For more investigation about the new and emerging technologies, we identified the health service to which each technology contributed using the classification of the US National Medical Library.

Table 2: Prioritization criteria

Area	Criteria
Populations/users	Frequency of use
	Burden of disease
	Population/user impact
	Vulnerable populations
Technology	Innovative Technology
	Invasive Technology
	Different expectations of Use
Safety/adverse effect	Safety
	Potential adverse effects not detected
	Risks
Costs and other	learning requirements
	Economic Impact
	Organizational or structural impact
	Other implications

RESULTS

In this study, 500 pieces of news were identified. Each article contained one or more technologies. Some technologies were redundant. 106 technologies were extracted from the filtration stage. Of these technologies, 50 technologies were wearable technologies, 19 technologies were in the smart connected device group, and 37 technologies were mobile applications. Sixty-six technologies were commercialized, and 40 were not commercially available. Of these 40 non-commercial technologies, 8 technologies were being studied in clinical trials and testing phase, and the rest were in the early stages or pre-testing phase. 10 technologies were developed by associations, hospitals or research centers, and 96 technologies were produced by startups, private teams and companies. Fig 2, 3, and 4 show the cumulative scores in four impact areas for mobile apps, wearables and smart-connected devices, respectively.

Fig 2: Cumulative score for mobile applications

Fig 3: Cumulative score of wearable technologies

Fig 4: The cumulative score of smart-connected technologies

Fig 5: Technologies services

Prioritized technologies were categorized based on the services that they provide (Fig 5). mHealth technologies were most frequently developed for preventive health services, mental health services and rehabilitation services. Other mHealth technologies that were investigated in this study are mainly used for reproductive health, childcare, community health, dietary, nursing care, patient care and pharmaceutical services.

Table 3 shows the results of the statistical analyses. There was no statistically significant difference between the technology groups in terms of safety and adverse aspect, but the groups were significantly different in terms of population, technology, cost and other aspects. In total, there was no significant between the technology groups.

Table 3: Statistical analyses of the difference between the three groups of mHealth technologies in terms of population, safety, and cost.

Group	P-value*				
	Population	Technology	Safety	Cost	Total
Wearables vs. Mobile apps	0.1340	0.0009	0.3656	0.0014	0.2861
Smart connected devices vs. Mobile apps	0.0002	0.0003	0.0607	0.3741	0.7648
Smart connected devices vs. Wearables	0.1429	0.4472	0.5359	0.3741	0.1290

DISCUSSION

In this news-based horizon scanning, guided by the EuroScan strategy [9], news articles related to mHealth were identified and retrieved from popular tech news websites. News websites with higher Alexa ranking were searched using predefined keywords. It, therefore, facilitated access to information on state-of-the-art technology utilized in products or services in their early stages. This validates Simpson et al. [11] opinion that introduces web-based horizon scanning as one of the primary sources for identifying new and emerging health technologies. At the end of the filtration phase, many new and emerging technologies were identified that have had an impact on people's health.

This study showed that inventors, startups, and organizations as a solution have introduced mHealth products, such as mobile apps, wearable tools or smart connected devices to support community members. Considering developing technologies, it seems that mobile application has expanded and interlocked with other technologies, including wearable and network technologies. Other studies have suggested that in the coming years, the need to use the potential capabilities of wearable devices and smart-connected devices as a promising solution for health problems should be considered [19].

Although there are significant differences between wearables, smart-connected devices and mobile apps in terms of population, technology and costs, there are no significant differences in terms of safety and adverse effects. The results of this study show that although these technologies are used in different populations with different infrastructures, it doesn't lead to different consumer safety. The result of the study may help researchers, clinicians,

patients and decision-makers to choose the right technologies based on cost, safety, innovation.

Most of the new and emerging healthcare technologies are related to wearables. Although consumers' decision to accept wearable tools for improving their health and self-care depends on many factors, including technology, privacy, and type of health care service [20-22], in the present study we found that wearable tools are going to play a big role in mHealth in near future. In previous studies, it was anticipated that in the upcoming years, the purchase of wearable devices would increase and lots of money would be spent on the purchase and use of these tools [23]. Among wearable tools, fitness and exercising tools are gaining more popularity than other product or services. In this regard, our study is in line with the findings of the study by Robson et al. [24].

Mobile apps are in second place in terms of frequency of mHealth development. They can be used in decision aid and help people to improve sleep and mental health, health tracking, diagnosis and treatment of diseases, rehabilitation, fulfil lab test at home, teleconsultation and other health services.

The results also highlighted the significance of developing health smart-connected devices in health monitoring and vital signs, drug monitoring and reminders, and food monitoring. The importance of using smart-connected devices will be more relevant to changing lifestyles for use in remote regions. Considering the age variations of different communities, it is likely that the use of these types of health technologies will be prioritized in monitoring the health of the elderly, and those who are vulnerable to a condition. Sending consumer data from an appliance to a caretaker's cellphone will increase over the next few years.

The results also indicated that mHealth technologies will be widely used for preventive health services. The most popular health services which benefit from mHealth are fitness tracking, health and sleep monitoring, vital signs and physical activities tracking, measuring, diagnostic and screening tests and pregnancy tracking. Tracking fitness is the most frequent use of preventive services. Supporting psychiatric patients and those who might have psychological problems, such as stress or anxiety or people with sleep problems, is one of the most useful services of mHealth. Mental health services, due to the growth of patients in this domain and changes in their lifestyle, requires more attention. According to the results, reproductive health services, rehabilitation, patient care, pharmaceuticals, community health, nursing, and childcare services will attract less attention in comparison to other services, using mHealth. Our results showed that the most common use of these applications is for fitness.

CONCLUSION

In this news-based horizon scanning, news articles related to mHealth were identified and the scope of services and the potential impact on healthcare that tools can put out detected. Then, intragroup and intergroup comparisons were done between technologies in three groups of new technologies (mobile apps, wearable tools or smart connected devices). There was no significant difference between technologies in all group in term of safety, cost, user and technology. The technologies identified in this horizon scanning showed the need for change in the type of service provided to the community and patients. In the near future, wearable and smart technologies will have a great impact on healthcare providers' decisions and services that will be provided to patients and consumers. These changes will be due to the availability of more wearable tools and portable smart devices. Since horizon scanning can be used to support health technology risk analysis (15), the results of this study can play a role in choosing a suitable device for providing services to consumers, as well as selecting appropriate tools for self-care and prevention.

The information provided in this study, and the conclusions which are drawn based on it, might be more relevant to industrialized countries and not generalizable to low-middle income countries.

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AUTHOR'S CONTRIBUTION

All the authors approved the final version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

FINANCIAL DISCLOSURE

No financial interests related to the material of this manuscript have been declared.

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