Mobile Clinical Decision Support Systems and Applications: A Literature and Commercial Review

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Abstract

Background: The latest advances in eHealth and mHealth have propitiated the rapidly creation and expansion of mobile applications for health care. One of these types of applications are the clinical decision support systems, which nowadays are being implemented in mobile apps to facilitate the access to health care professionals in their daily clinical decisions.

Objective: The aim of this paper is twofold. Firstly, to make a review of the current systems available in the literature and in commercial stores. Secondly, to analyze a sample of applications in order to obtain some conclusions and recommendations.

Methods: Two reviews have been done: a literature review on Scopus, IEEE Xplore, Web of Knowledge and PubMed and a commercial review on Google play and the App Store. Five applications from each review have been selected to develop an in-depth analysis and to obtain more information about the mobile clinical decision support systems.

Results: 92 relevant papers and 192 commercial apps were found. 44 papers were focused only on mobile clinical decision support systems. 171 apps were available on Google play and 21 on the App Store. The apps are designed for general medicine and 37 different specialties, with some features common in all of them despite of the different medical fields objective.

Conclusions: The number of mobile clinical decision support applications and their inclusion in clinical practices has risen in the last years. However, developers must be careful with their interface or the easiness of use, which can impoverish the experience of the users.

Keywords

Mobile applications; apps; clinical decision support; mHealth.

Introduction

The creation of Internet, its extended use and the latest advances in telecommunications and mobile technologies have originated new forms of technology in every aspect of life [1]. One of these aspects is health care, being telemedicine or telehealth the technology most researched, specially the so-called eHealth, defined by the International Telecommunication Union as the paradigm that encompasses all of the information and communication technologies necessary to make the health system work [2]. In this context and thanks to these advances in communications, a new term arises: mHealth, a component of eHealth. The Global Observatory for eHealth (GOe) of the World Health Organization (WHO) defines mHealth or mobile health 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*" [3].

This mHealth has been supported by the incredibly expansion of the market of smartphones and tablets, thanks to those mentioned advances in mobile and communications technologies such as 3G, 4G, Bluetooth, Zigbee, Radio-frequency Identification (RFID), etc [4-9]. In numbers, there were in 2011 alone a total of 6 billion mobile subscriptions and more than 1.7 billion mobile phones sold in 2012, being 712.6 million smartphones [10]. Regarding tablets, there are estimated 117.1 and 165.9 million shipments in 2012 and 2013 respectively [11].

This fast spreading of mobile devices has propitiated the creation and growth of the mobile apps market. Focusing only on the most important app stores, in terms of the market share of smartphone operating systems [12-13], the App Store [14] for Apple iOS has close to 20,000 apps in the category of Health & Fitness and more than 14,000 in Medicine whereas Android's Google play [15] has more than 11,000 apps in the Health & Fitness section and roughly 5,000 in the Medical apps section [16].

The potential for mHealth applications is well-documented [17-20], e.g.: continuous surveillance of vital or physiological signs, move away from face-to-face visits at the doctor's office, access information relative to medications, view your own electronic medical record and access to a wide array of educational resources including information on disease-specific topics and general self-management tools.

Recently, there are proliferating several apps destined for medical professionals and dedicated to support these professionals in the clinical decisions they should make. Although there are many informatics systems usually used in health care facilities and organizations [21-24], the implementation of these systems in mobile devices is relatively new and the advantages it can provide are many: portability, possibility of customization, always at hand, low cost, etc. Hence, these new types of apps for medical decision support can enhance the existing systems in this field, being inseparable tools for physicians, nurses and specialists of health care.

Clinical Decision Support Systems (CDSS) link health observations with health knowledge to influence health choices by clinicians for improved health care. These systems are aligned with the P4 Medicine objectives to personalized diagnoses and treatments, predict the patient status and follow-up based on multi-level observations, generate preventive polices in risk patients and empower patients to actively participate in their health.

High performance CDSS (Clinical Decision Support Systems) are usually based in two technologies: Rule-Based Systems and Machine Learning models. Rule-Based Systems (RBSs) are computer-based systems that represent knowledge by IF…THEN rules. In CDSS, RBSs implement medical evidence linked to the patient conditions observed in the clinical data. Machine Learning models are mathematical functions to estimate the risk of patients given the observations. They are usually trained from retrospective data from real patients to solve diagnoses, treatments, or prognosis.

The aim of this paper is to study the existing applications for mobile devices dedicated to the medical decision support in order to find the different types of apps in this field, common features, and compare and analyse a representative sample of these apps. To achieve this, a review of the literature about existing mobile systems and applications, as well as mobile apps currently available on the most used app stores has been done.

The remainder of this paper is organized as follows. Next section elaborates about the methods conducted in this study and then there are shown the results obtained. Both sections are separated into three subsections: the first subsection is the literature review of applications and systems, the second is the review of commercial apps and, the third subsection is the analysis of the sample of apps selected. Finally, the last section presents the discussion of the results.

Methods

In this research work, two different reviews were developed. The first was a literature review and the second a commercial applications review. Both were current as of September 2013. Finally, five applications for each review were chosen for an in-depth analysis. The methods used in these reviews and in the analysis mentioned are shown in this section.

Literature review of mobile clinical decision support applications

To perform the literature review, the following systems and databases were used: Scopus, IEEE Xplore, Web of Knowledge, and PubMed. The search was finished in September 2013.

The combination of words used for searching the publications were the following: mobile AND clinical AND decision AND support. The results were limited to the last 7 years, from 2007 forward.

Figure 1 shows a flowchart with the steps followed in both literature and commercial reviews. All the systems and databases returned a total of 405 results, of which 283 were repeated or with an irrelevant title for this study. Out of these papers, 30 were dismissed after reading their abstract or the whole paper when necessary. Finally, a total of 92 papers were selected as relevant.

To include a paper in this study it had to fulfil some criteria: it had to be in English and about one or several mobile clinical decision support applications, although it could include other types of systems or issues. Hence, reviews about the general status of medical systems or applications including decision support systems were included, the same as evaluations about these types of applications.

This process was done by reading the titles and the abstracts of the results obtained in the different databases from one of the authors. When there were doubts about the inclusion of a paper, the whole article was read by all the authors in order to reach an agreement to make a decision.

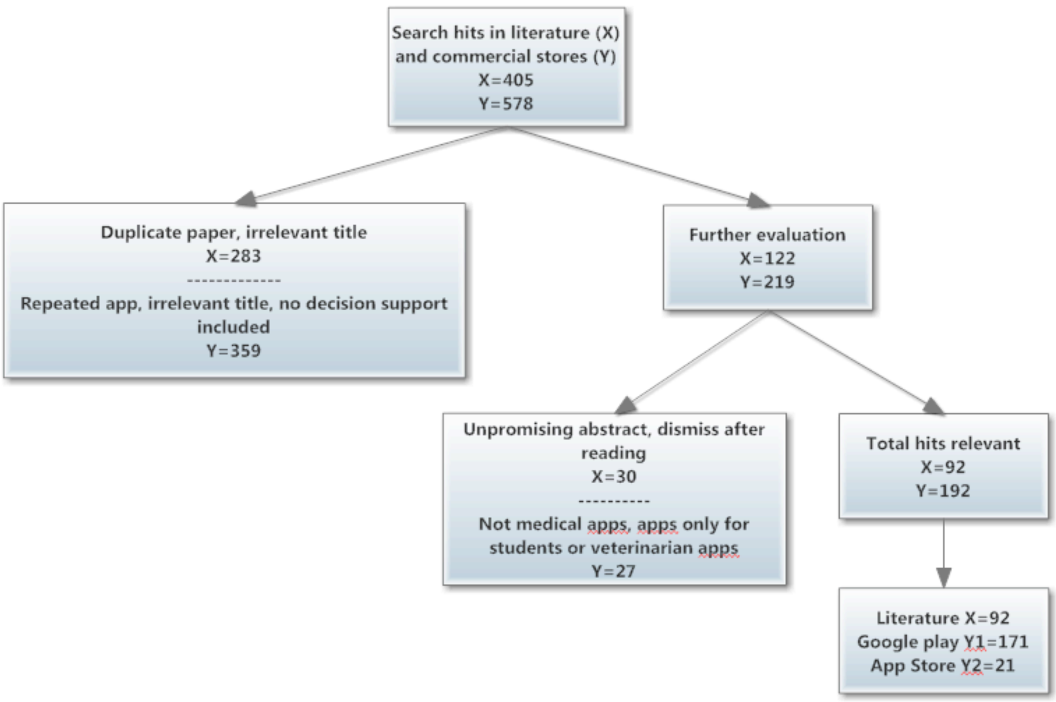


Fig. 1 Flow chart of the steps followed in the reviews

Review of commercial clinical decision support applications

The review of the commercial applications for supporting clinical decisions was developed in the two applications stores of the most extended smartphone operative systems [12-13]: Google play for Android [15] and App Store (iTunes) for iOS [14].

The search strings used in both stores were the following: "clinical decision", and "medical decision". The flow chart of Figure 2 also shows the steps followed in the commercial review. A total of 578 apps were initially found. 359 of these apps were repeated, had an irrelevant title or did not have any decision support included, so only 219 were evaluated, of which 27 did not fulfil the rest of the requisites and, therefore, only 192 were included in the study.

The previous requisites were the following: the title and the description of the app had to be in English or in the language of the country where the search was done (Spanish in this case), it had to be included in the categories of Medical or Health & Fitness and be developed for medical professionals of any specialization. Apps developed only for students were dismissed, but those developed for students and medical staff were included in the study. Apps that are guidelines for diagnosis and/or treatment and include some calculators or decisions-tree in order to help the user with the decision making were included in this study. Apps for veterinarians were dismissed.

During the search an issue was faced: on iTunes, apps for iPod and iPhone were separate from the ones for iPad, hence only apps for the first ones were searched since it had more results, excluding the apps exclusively designed for the tablet of Apple.

This methodology followed was performed by reading the description provided on the corresponding store and, when necessary, the application was downloaded in order to decide its inclusion in the study or not. In these cases, the smartphones used were an iPhone 4 if the app was designed for iOS and a Sony Xperia Z in the case of an Android app. One author classified the apps by their public objective and the field of health care they are destined to. The other two authors checked the classification to be sure there were no mistakes.

Eligibility criteria of the applications for the analysis and procedure

Five papers and five commercial apps were selected for an in-depth analysis of features. The eligibility criteria are similar to the used in a previous work [25].

For the mobile clinical decision support systems found in the literature, only the studies published in 2013 were selected. The next requisite for the selection was the highest impact factor of the journal where the paper was published and, if the articles were published in the same journal, the number of citations was taking into account. Articles about reviews of several apps or with insufficient information about the app were dismissed.

To evaluate the papers, each author read them individually and convened to discuss the different opinions they could have until achieve a common agreement about the system or application.

To select the 5 commercial apps to analyze, it was decided to use the same commercial store and it was chosen Google play, since Android is the most extended smartphones operative system [13]. It was decided to select the 5 first relevant free apps shown by the store with a rating by users of 4 or more stars when searching for "clinical decision support". The apps were tested on a Sony Xperia Z.

For the analysis of the applications the procedure followed was similar to the one mentioned with the papers. One author downloaded them on the mentioned mobile phone before meeting with the rest of the authors to study the apps together and complete a table of features.

Results

Mobile clinical decision support applications in literature

A total of 92 relevant papers were found in the systems mentioned previously. Figure 2 shows the distribution of these publications by their year of publication, indicating the number of documents per year. It can be observed an increasing progression in this number of papers with the years.

Regarding to the type of papers found, several were obtained. There are papers about the development of complete and specific mobile decision support systems such as the system developed by Savel et al. (2013), where an iOS-based mobile application called PTT (Partial Thromboplastin Time) Advisor is developed to offer clinicians a resource to quickly select the appropriate follow-up tests to evaluate patients with a prolonged PTT [26]. There are also many papers about the evaluation and analysis of a mobile decision support system; e.g. the evaluation of the application for iOS iDoc [27], carried out by Hardyman et al. (2013) through surveys for trainee doctors [28].

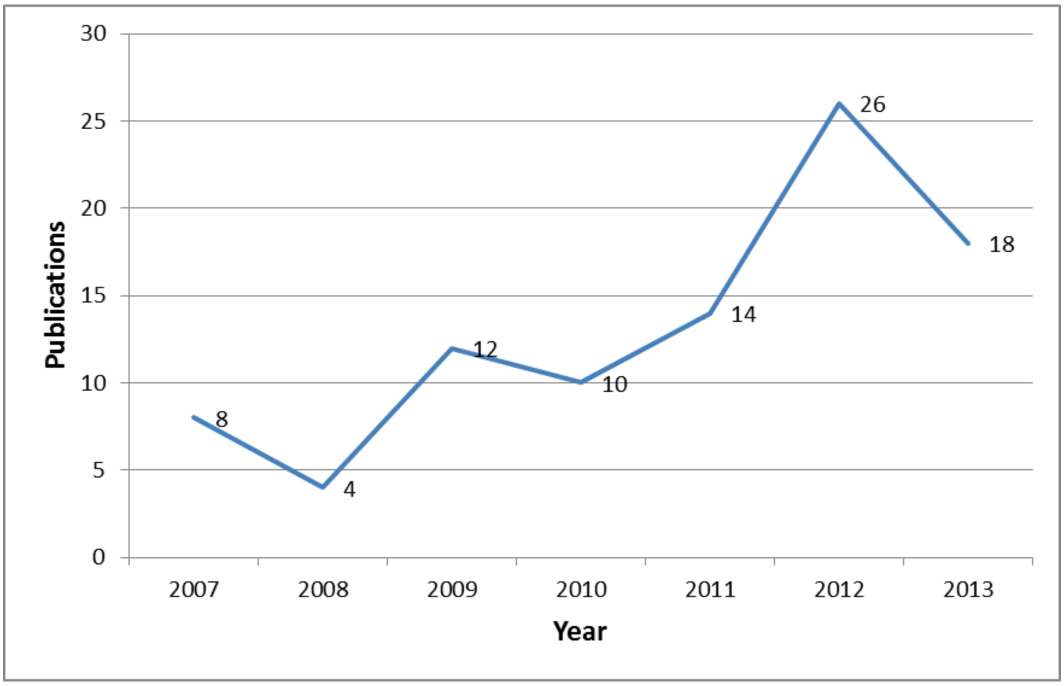


Fig. 2 Number of papers found per year of publication

The results and effectiveness of these systems were also studied in papers such as the one written by Lee et al. (2009), where a trial is developed in order to compare the proportion of obesity-related diagnoses in clinical encounters, documented by nurses using a personal digital assistant-based log with and without obesity decision support features [29]. Only 44 papers out of 92 were focused only on mobile CDSS.

Finally, there are two types of papers that include these clinical support systems in a more global way. On one hand there are reviews of these systems, such as the one developed by Divall et al. (2013), where the authors carried out a systematic review of the use of PDAs in clinical environment, including the decision support [30]. On the other hand, other papers simply expose the possibilities and possible contributions that mobile clinical support systems can provide [31].

Commercial mobile clinical decision support apps

A total of 192 commercial apps for supporting the clinical decision were found. 171 from Google play and 21 from the App Store. 138 results were found using the search keywords “clinical decision” and 172 using “medical decision”. 111 apps were obtained using both search strings. Table 1 shows the number of apps sorted by the type of medical field they are intended for. In Figure 3 the percentage of apps classified by the objective public to whom they are developed is shown.

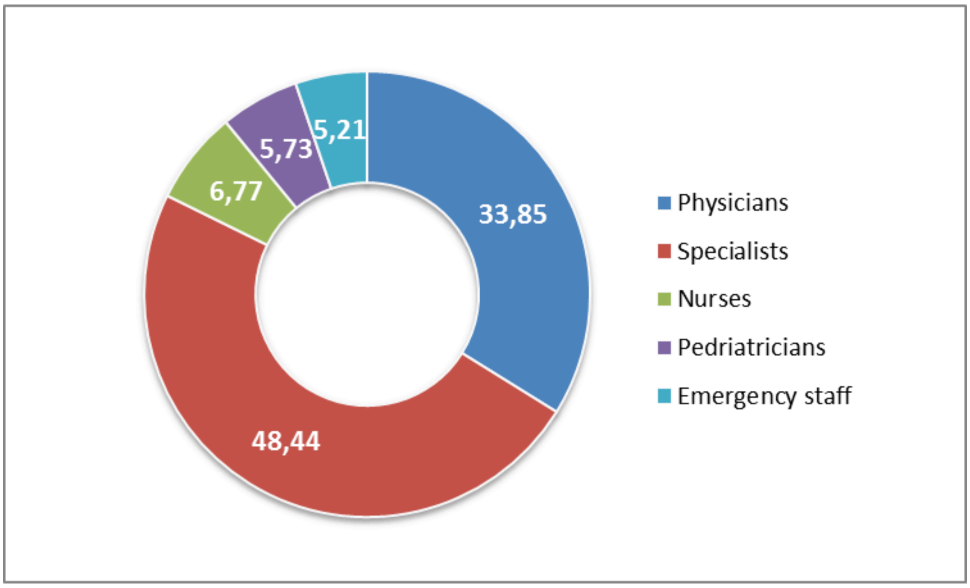


Fig. 3 Percentages of apps by objective users

Table 1 Classification of apps in the commercial review by medical field

Medical field	**Number**
General medicine	47
Drugs information	16
Emergencies	12
Pediatrics	11
Cardiology	7
Oncology	7
Psychiatry/mental health	7
HIV	6
Infectious diseases	6
Lab values	6
Neurology	6
Cardiovascular	4
Dermatology/wounds	4
Gynecology	4
Hematology	5
Radiation therapy/Radiology	4
Gastroenterology	3
Anesthesia	3
Hepatitis	3
Nutrition	3
Orthopedics	3
Respiratory system	3
Surgery	3
Urology	3

Diabetes	2
Geriatrics	2
Imaging	2
Albuminuria	1
Day time somnolence	1
Dysanatremia	1
Endocrinology	1
Hospital	1
Insomnia	1
Nephrology	1
News/research	1
Ophthalmology	1
Sclerosis	1

Analysis of a sample of systems and applications

First we analyze the systems selected from the literature review. These papers are the following: An analysis of the development and implementation of a smartphone application for the delivery of antimicrobial prescribing policy: lessons learnt [32]; Unbiased and Mobile Gait Analysis Detects Motor Impairment in Parkinson's Disease [33]; Mobile Monitoring and Reasoning Methods to Prevent Cardiovascular Diseases [34]; An end stage kidney disease predictor based on an artificial neural networks ensemble [35]; Exploiting causal functional relationships in Bayesian network modelling for personalised healthcare [36].

In [32] the authors talk about the development, adoption and implementation process of a smartphone application for antimicrobial prescribing policy called 'IAPP' (Imperial Antibiotic Prescribing Policy). They designed the app in iterative stages focusing on junior doctors and pharmacists. The app was implemented in five teaching hospitals of West London among junior medical staff. After a period of 12 months some surveys were sent to the participants of the study to obtain feedback. The app has clinical calculators and decision support, is native, initially username and password protected and comprised a mobile evolved version of the policy with additional functionality, including therapeutic drug monitoring and clinical calculators. The most appealing features of the IAPP reported by clinical users were its usability, accessibility at point of care, some clinical decision support features and transportability. 81% of the participants stated that using the app helped them adhere to the policy.

In [33] the authors developed a mobile gait detector, useful for diagnosing motor impairment in Parkinson's disease (PD) patients. This system is called Embedded Gait Analysis using Intelligent Technology (eGaIT) and consists of accelerometers and gyroscopes attached to shoes, data capture, wireless data transfer, feature extraction, and pattern recognition algorithms that record motion signals during standardized gait and leg function. Since clinical scores such as the Unified Parkinson Disease Rating Scale (UPDRS) or Hoehn&Yahr (H&Y) staging are time-of-assessment dependent, it was necessary to made the system mobile. To measure the efficacy of the system, 42 patients and 39 controls were used, who underwent 3 specific exercises. eGaIT was able to successfully distinguish PD patients from controls with an overall classification rate of 81% and was able to classify different H&Y stages, or different levels of motor impairment. eGaIT was proved to be able to complete and confirm the global assessment by a clinician.

[34] is about a system that uses a mobile phone to monitor the blood pressure of a patient and a reasoning engine to calculate the Cardiovascular Disease (CVD) risk applying the SCORE (Systematic Coronary Risk Evaluation) method over the blood pressure values and other clinical factors. The system uses a Bluetooth sensor for obtaining the blood pressure data, which will be used taking into account the clinical data of the patient/user to enable the estimation of CVD risk, supporting clinical decisions. As the system depends on the user actions (i.e., the patient must take the blood pressure himself), the system includes notifications and reminders to facilitate this fact. It is focused on adults over 45 years and it is only valid for

European regions. The authors evaluated the system through interviews and user feedback after tested it with 23 users, who reported a high satisfaction level but they gave lower ratings to issues related to the way to input information. In general, the usability of the mobile application obtained a rate of acceptance of 69%.

The authors of [35] developed a mobile tool for predicting Endstage Kidney Disease (ESKD) in patients with IgA Nephropathy (IgAN) disease, which is the most common primary glomerulonephritis worldwide and a leading cause of ESKD thus requiring renal replacement therapy with dialysis or kidney transplantation. The system uses a large and complete dataset of IgAN patients (587) to provide a valuable predictive tool for clinicians. It uses artificial neural networks since they have been proven to be an excellent tool in terms of predictive power as they have the ability to learn. It is embedded in a decision support system called m-IgAN, composed by a server application and two clients: a mobile application and a Web application. Users have to insert the clinical data of the patient, which are sent to the server which checks their validity and, in case they are valid, it predicts the risk degree and sends a set of information to the client containing the prediction and a summary of the patient's data. The system has proved to be efficient as shows the fact that it is being used at Polyclinic of Bari, Italy.

In [36], the authors argued that Bayesian networks offer appropriate technology for the successful modeling of medical problems, including the personalization of healthcare and proposed ways to represent physiological knowledge as part of engineering principles employed in building clinically practical probabilistic models. These principles have been used in implementing a Bayesian network model for preeclampsia being a part of a mobile home-monitoring system. The system is called eMomCare, implemented for Android, and uses smartphones for predicting possible problems. It collects data from the patient and a blood pressure meter connected, which are sent to a smartphone where the Bayesian model is stored, and returns the results obtained from the data. The results of the evaluation of the system were encouraging and show the potential of exploiting physiological knowledge for personalized decision-support systems.

Referring to the commercial review, the 5 apps selected for the analysis are the following:

- Pediatric Clinical Pathways [37]. This app accesses to the Clinical Standard Work (CSW) Pathways of the Seattle Children's Hospital, which are a documented standard approach that guides practitioners when providing care to specific patient populations, in this case children. These pathways were developed by committees of experts from different disciplines and are presented in an easy-to-read algorithm format.

- Calculate by QxMD [38]. A medical calculator and decision support tool, with algorithms in several medical specialties to impact diagnosis, treatment or determining prognosis. These tools are developed by a collaboration of clinician experts from diverse backgrounds.

- ACC Pocket Guides [39]. A support tool set from the American College of Cardiology Foundation with material adapted and enhanced for Android devices from the full text version of ACC/AHA Practice Guidelines. It contains several tools and calculators, but they have to be downloaded by the user "manually". Actually, the app solicited to download another app called Skyscape [40], which is the one to be used for the user, with the resources obtained from ACC Pocket Guides.

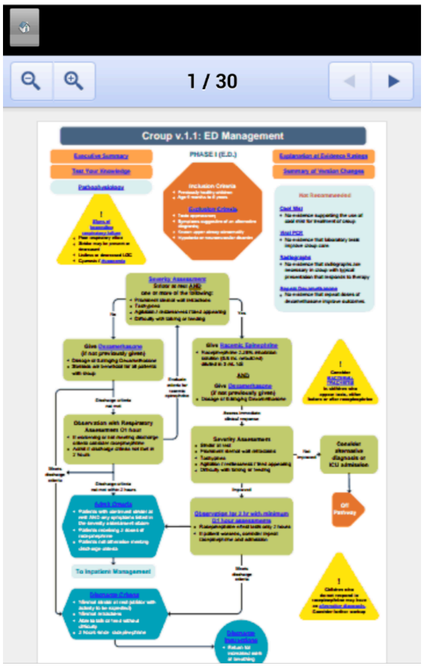
- NeuroMind [41]. Application for neurosurgery with 24 items of interactive clinical decision support and 113 scores that are relevant for neurosurgical practice. It has even anatomical images for explanation to patients and a safe surgery checklist developed by the WHO. The app is supported for several important associations in the field of neurosurgery.

- 2013 Medical Diagnosis TR [42]. An annual guide to all fields of internal medicine intended to accelerate the clinical decision making delivering at-a-glance summaries of the signs, symptoms, epidemiology, etiology, and treatment options for more than 1,000 diseases and disorders. Although the app is free, it offers to the user a free trial of one day, being forced to pay for its use after the trial.

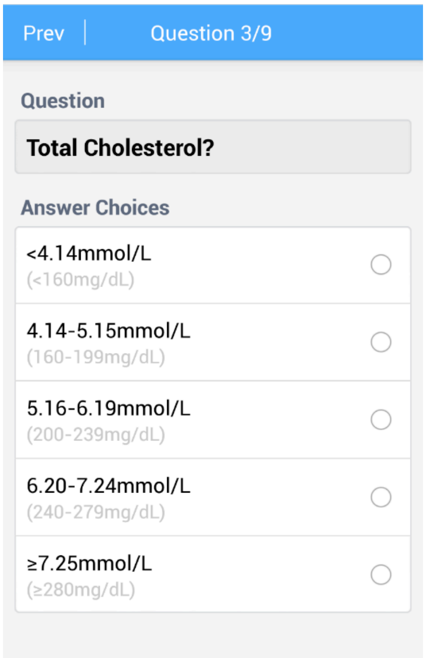
The analysis of features is shown in Table 2 whereas Figure 4 shows some snapshots of these applications.

Table 2 Analysis of features of the sample of commercial apps selected

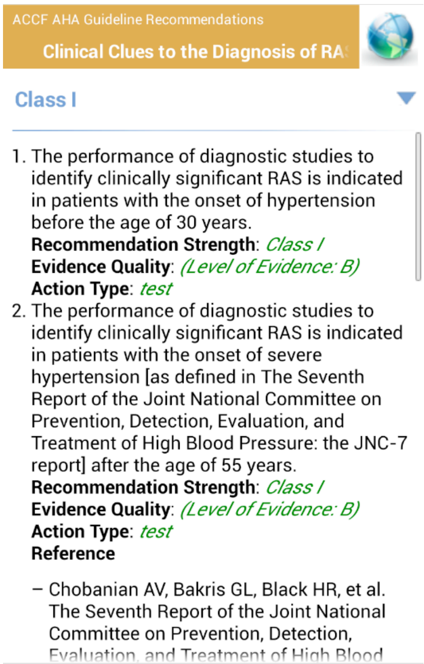
	Pediatric Clinical Pathways	**Calculate by QxMD**	**ACC Pocket Guides**	**NeuroMind**	**2013 Medical Diagnosis TR**
Rating	4.7	4.6	4.0	4.2	4.0
Class	Pediatrics	General medicine	Cardiology	Neurosurgery	Internal medicine
Internet requirement	Yes	No	Only login	No	Both possibilities
Form of decision support	Algorithms, tables	Calculators by steps	Tables, logical trees	Calculators	Text
Data visualization	Text, algorithms	Text, numbers	Text, tables	Text, images	Text, images
Context awareness	No	No	No	No	No
Login	No	Yes	Yes	No	No
Frequency of use	Occasional	Occasional	Occasional	Occasional	Occasional
Interface	Simple	Simple	Complex	Simple	Simple
Public	Pediatricians	Any professional	Cardiologists	Neurologists	Any professional


1 / 30
Croup v.1.1: ED Management

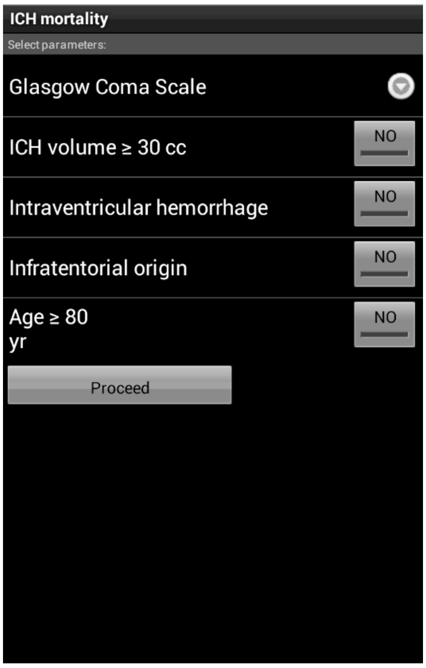
(a)


Prev
Question 3/9
Question
Total Cholesterol?
Answer Choices
<4.14mmol/L
(<160mg/dL)
4.14-5.15mmol/L
(160-199mg/dL)
5.16-6.19mmol/L
(200-239mg/dL)
6.20-7.24mmol/L
(240-279mg/dL)
≥7.25mmol/L
(≥280mg/dL)

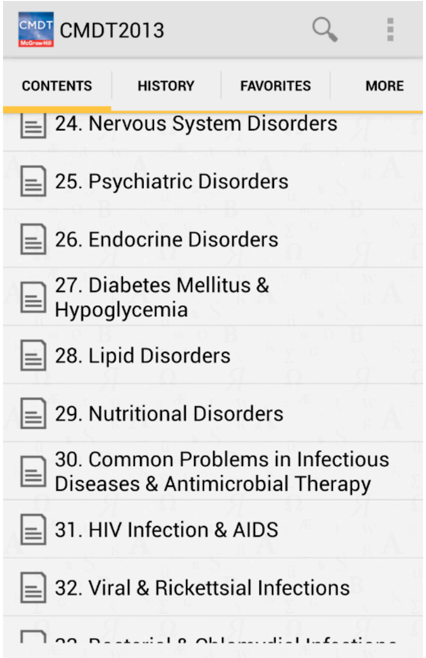
(b)


ACCF AHA Guideline Recommendations
Clinical Clues to the Diagnosis of RA
Class I
1. The performance of diagnostic studies to identify clinically significant RAS is indicated in patients with the onset of hypertension before the age of 30 years.
Recommendation Strength: Class I
Evidence Quality: (Level of Evidence: B)
Action Type: test
2. The performance of diagnostic studies to identify clinically significant RAS is indicated in patients with the onset of severe hypertension [as defined in The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC-7 report] after the age of 55 years.
Recommendation Strength: Class I
Evidence Quality: (Level of Evidence: B)
Action Type: test
Reference
– Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection,

(c)


ICH mortality
Select parameters:
Glasgow Coma Scale
ICH volume ≥ 30 cc
NO
Intraventricular hemorrhage
NO
Infratentorial origin
NO
Age ≥ 80 yr
NO
Proceed

(d)



(e)

Fig. 4 Snapshots of (a) Pediatric Clinical Pathways, (b) Calculate by QxMD, (c) ACC Pocket Guides, (d) NeuroMind and (e) 2013 Medical Diagnosis TR

Discussion

Findings

Several interesting findings can be extracted from the results presented previously, especially from the results obtained from the commercial review. Nevertheless, focusing on the literature review, it can be seen that there have been a significant growth in the number of the researches in mobile clinical decision support systems in the last two years, with almost half of the papers found (43/92) being published in these years.

The majority of the papers found are about the design, development and implementation of innovative and new mobile clinical decision support systems and their analysis. However, there are other types of papers less common, those about the effectiveness of these systems, systematic reviews of the ones being used currently and those talking about the possibilities, advantages and contributions the implementation and expansion of these tools can achieve.

In the analysis of the papers selected, we can obtain some findings about the systems that are developed. First of all, almost every mobile application found was intended for research purposes, not being available in commercial stores. All of them used a smartphone (as the only hardware used in some cases or as a part of a more complex system in others), which means that the smartphone is the tool the researches focus in their works. However, the purposes and the medicine fields these systems are intended for are very different, existing, as we could see, systems for predicting ESKD in patients with IgAN disease and others for monitoring the blood pressure of a patient to calculate the CVD risk applying the SCORE method, for example. This fact shows that mobile CDSS can be applied to a wide range of fields of the modern medicine. Furthermore, we have seen that their reliability and acceptance among the medicine professionals are very high.

Focusing now on the commercial applications, the first thing that attracts our attention is that it seem that there are many more apps for Android than for iOS, as there were found 171 apps for Android and only 21 for iOS. This difference is explained by the use of different search engines in the commercial stores of Google play and the App Store. In light of the results returned by the same search strings it is clear that the engine of Google play is less strict than the one from the App Store.

The most common medical field of these commercial apps is general medicine, involving all the specific fields of health care. Other fields with many clinical decision support apps are drugs prescribing and contraindications, emergencies services tasks and pediatrics. Cardiology, oncology, psychiatry, neurology and infectious diseases (with special attention to HIV) are among the specialties with more apps. Developers focused their works on these medical specialties since some of the most important causes of death (ischemic heart disease, HIV/AIDS and trachea, bronchus and lung cancers), one of the most prevalent diseases (unipolar depressive disorders), and some of the most disabling diseases (Alzheimer, Parkinson) are included in these specialties [43].

As it can be seen in Figure 3, almost half of the applications for clinical decision support are developed for medical specialists, such as the mentioned previously. This is logical since, despite the fact that general medicine is the focus of many apps, the majority of them are focused on specialties, as it is shown in Table 1. Excluding specialists and physicians, the rest of the applications are similarly distributed in apps exclusively dedicated for nurses, pediatricians and emergencies staff.

From the analysis of the sample of commercial apps, several similarities and differences can be observed. Although the apps studied are designed for different fields and different types of users, all of them have similar interfaces, being quite simple and based on the use of text. Only one has a more complex interface and it is due to the fact that it is a part of another bigger application. Similarly, all of them do not offer any context awareness such as location, language or user, although some of them require a login. The frequency of use depends on the level of knowledge of the user and the difficuly of the medical issue to cover. Typically, these systems are used for very difficult questions, for training of novel doctors and to review routinary cases semi-automatically.

Among the differences, the Internet requirement is probably the most clear. Some apps need the use of the Internet for showing the information, others only need it for login or doing the first download of information and there are those which are stand-alone applications and do not use the Internet at all. Even there are apps that let the user choose the method to access the information. Referring to the form of showing the decision support tools there are also differences: some use algorithms in form of logical trees, some have calculators which uses the data introduced by the user and even only text is used in other apps. These tools also influence in the data visualization, which can vary from tables to images, always complementing text.

Recommendations

After checking the existing mobile applications for decision support and trying a sample of them, we have some recommendations to give to the developers of these types of applications. First of all, it is important to avoid using only text for the interface of the applications. The feeling of these sorts of applications is similar as reading a book. Developers must take advantage of the interactivity the smartphones offer in order to develop a decision support app with more involvement by users. It is useful to use images and logical trees of decision, but we found the best choice the one used in [38], which is using algorithms to assist the diagnosis in several steps. In each step the user has to input some data to finally reach the possible solution. It is also recommended to make clear the steps and the data introduced by the user

Another aspect to take into account is the time the user requires to interact with the CDSS. In order to reduce it, it is worth to integrated mobile CDSS with EHR or applied incremental forms, in order to reduce the manual input of values. This principle should be mandatory to applications focused in routinely medical problems, but optional for difficult problems.

Another recommendation to developers is to develop apps in the medicine fields with less apps of this type, such as endocrinology, nephrology or ophthalmology, or even focus on common diseases with a difficult diagnosis. This way, more specialists and physicians can take advantage of the use of these systems and developers can cover an unexplored field in this type of applications, resulting very profitable.

Conclusions and future work

The number of mHealth apps with CDSS functionalities has been speedily increased during the last two years. Several research lines for different medical specialties are opened and many commercial apps for mobile decision support systems are available. Besides, it seems that the research has been increasing in the last years, proving the good reception and acceptance that these systems have obtained from the medical world.

However, there are many applications released focused only on the information contained but not on the interface or the easiness of use and search by the users, which impoverish the experience and, therefore, the valuation from the users.

For future work several things can be done. A mobile app for clinical decision support can be developed, focusing on a medicine field with little research and following the recommendations exposed previously. Another line of work can be the evaluation of the Quality of Experience (QoE) from the users of some of these applications using the tools obtained in [44] to write a document with the main steps to be followed by the developers of these types of systems. The purpose of the document would be the design of high quality applications, meeting the users' expectations.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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Abbreviations

CDSS: Clinical Decision Support System; CSW: Clinical Standard Work; CVD: Cardiovascular Disease; eGaIT: Embedded Gait Analysis using Intelligent Technology; ESKD: Endstage Kidney Disease; GOe: Global Observatory for eHealth; H&Y: Hoehn&Yahr; IAAP: Imperial Antibiotic Prescribing Policy; IgAN: IgA Nephropathy; PD: Parkinson's disease; PDA: Personal Digital Assistant; PTT: Partial Thromboplastin Time; QoE: Quality of Experience; RFID: Radio-frequency Identification; SCORE: Systematic COronary Risk Evaluation; UPDRS: Unified Parkinson Disease Rating Scale; WHO: World Health Organization.