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Smartphones and health promotion: a review of the evidence.

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Abstract

Objectives

Communication via mobile phones has become an essential tool for health professionals. The latest generation of smartphones is comparable to computers, allowing the development of new applications in health field. This paper aims to describe the use of smartphones by health professionals and patients in the field of health promotion.

Methods

We conducted a bibliographic search through Pubmed. Then, research results were analyzed critically in order to select the best experiences available. All searches were carried out on November 2012 and were not limited by date. Each item from the initial search was reviewed independently by members of the project team.

Results

Initial search returned 472 items with PubMed. After the removal of duplicates, 406 items were reviewed by all the members of the project team and 21 articles were identified as specifically centered on health promotion. In the nutrition field there are applications that allow to count calories and keep a food diary or more specific platforms for people with food allergies, while about physical activity many applications suggest exercises with measurement of sports statistics. Some applications deal with lifestyles suggestions and tips. Finally, some positive experiences are reported in the prevention of falls in elderly and of sexually-transmitted diseases.

Conclusions

Smartphones are transforming the ways of communication but the lack of monitoring of contents, the digital divide, the confidentiality of data, the exclusion of the health professional from the management of patient, are the main risks related to their use.

Keywords:

Smartphones - Health promotion - Public health – m-Health – web applications

Manuscript

Background

Thanks to the development of new technologies and Web applications, medical doctors are able to practice medicine over long distances and patients have faster access to healthcare services. Indeed, telemedicine and m-health are fields in continuous growth that account for an increasing number of technologies that are practical applications with the considerable potentiality that offers to health care services in terms of accessibility of service, cost saving, efficiency, quality and continuity of care and in clinical practice [1-5]. M-Health is a component of eHealth. The Global Observatory for eHealth (GOe) defined m-Health 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 [6].

The Web-based applications use different kinds of devices that often are included into the group of Web 2.0 tools [7]. In this regard, in the field of m-health, smartphones are gaining ground [8]. The smart mobile technology has revolutionized how to communicate, to share and to consume contents, seeping into in many different sectors of society including healthcare. Indeed mobile communication has therefore become an increasingly essential tool for those who, like doctors and nurses, are responsible for the health of people, facilitating the interactions between health professionals and patients. Over the years, indeed the technologies in the medical field have been provided with technical equipment increasingly smaller, moving from the personal computer to the tablet to smartphones. Interestingly, these new technological customized tools, relatively inexpensive, give new possibilities for teaching and learning: u-learning (stands for ubiquitous learning) and m-learning (mobile learning) [7].

With the coming of smartphones the industry of mobile phone applications has experienced a boom. These specific applications (the so called apps) could be applied in the social, educational,

entertainment, including health field and are often free, very easy to download and to use [9]. Since medical apps are increasing, there are a growing number of clinicians and health professionals who use smartphones with success in different fields .

Recently, Kailas et al. claim that there are already more than 7000 documented cases of applications dedicated to health for smartphones [10]. There has been a large increase in the number of consumers of smartphones' applications downloaded in recent years. Estimates for 2009 reported 300 million apps downloaded, those of 2010 reported 5 billion [9,11].

This paper aims to explore the availability of smartphone applications in the field of health promotion and to point out advantages and disadvantages of their use.

Methods

According to Ozdalga et al., we defined the smartphone as any cellular device that has additional functions including a camera, global positioning system (GPS), and Wi-Fi capabilities and is running one of the following mobile devices: iPhone, Android, BlackBerry, or Windows Mobile [12]. We conducted a bibliographic search through Pubmed, Ovid and Scopus using the following keywords:

Smartphone – mHealth - iPhone - “Blackberry phone” - “Android phone” - “Windows Mobile phone”

Research results were analyzed critically in order to select the best experiences available. The aim was to access the literature and the data available about the smartphones' use in health promotion field. Health promotion is the process of enabling people to increase control over, and to improve, their health. It moves beyond a focus on individual behaviour towards a wide range of social and environmental interventions [13]. We focused our research on the main topics in health promotion field (nutrition, lifestyles, physical activity, health in elderly, prevention of sexually transmitted

diseases). All searches were carried out on November 2012 and were not limited by date. The bibliographic details for each item from the initial search were reviewed independently by members of the project team. Articles were retrieved for further analysis according to the following criteria:

- The full text of the article is readily and freely available online, *i.e.* open access or available via the host institution's e-library of online journals.
- The article is published in English or German.
- The article includes an explicit reference of use of smartphones for health promotion topics.
- All the three reviewers agree that the article should be included (disagreements over which items to include being resolved through negotiation at a face-to-face meeting).

According to these criteria, the articles were selected by title, abstracts and then full-text. The flow diagram of the bibliographic search is shown in Figure 1.

Our search has also some limitations, described in the discussion section, that must be considered when interpreting the results.

Results

Globally, the initial search using the above mentioned keywords returned 4669 items. After the removal of duplicates and titles and abstracts revision, the reviewers agreed that 63 articles were deserving of a closer examination, as strictly related to the topic of interest. Among these, 32 were identified as meeting the inclusion criteria and specifically centered on health promotion – these were subjected to further analysis [12, 14-45].

We categorized the possible smartphones' use in health promotion in 4 categories, according to the objects of selected papers in our research:

- *Nutrition*

Among the fastest growing areas, we certainly find the set of applications that concern nutrition and diet. There are, indeed, countless applications for smartphones that allow us to count calories and keep a food diary. Among all we can mention iFood and Calorie Counter, two apps that act as a daily calendar of weight control, lost or absorbed calories and assimilated food [12]. Handel described health-related apps covering a variety of areas designed to help people take a proactive approach to their health, including nutrition. Among these apps there are: “Mindful Eating”, designed as a daily food experience journal that helps build mindful eating habits over time; “Tap and Track” that keeps track of calories by calculating basal metabolic rate (BMR) and finding daily calorie count based on gender, age, weight, height, and the type of the job; “Is that Gluten Free?” for those with gluten sensitivity or celiac disease; “NutriSleuth” that translates everyday foods bought in the grocery store into “allowed or not allowed” based on an individual’s medical, allergy, and lifestyle needs [14]. Albrecht et al. described an innovative project aimed to develop an iPhone/iPad application to inform families with young children on safe food handling of leftovers and other food, and the risk of foodborne illness for a wide range of food products (4 Day Throw Away educational program) [15]. 'My Meal Mate' (MMM) is a smartphone application designed to support weight loss. The present study aimed to validate the diet measures recorded on MMM against a reference measure of 24 h dietary recalls. wide; however, at the group level, MMM appears to have potential as a dietary assessment tool [16]. The Luxembourgian MENSSANA project, instead, is a new telemedicine tool developed for allergy patients and allergists. Thanks to a Smartphone Personal Allergy Assistant (PAA), patients are able to fill an electronic diary by scanning the barcode of the consumed food products. The information derived from the diary is then regularly transmitted to the allergist's electronic patient record. Furthermore, the PAA support the individual diet management warning the patient before consumption of allergenic food. In order to collect data about allergenic foods and their description, a dedicated web-based platform of food

consumers and producers www.wikifood.eu) has been established [17]. A recent randomized controlled trial (RCT) conducted by Hebden et al. aimed to measure the effect of a 12-week mobile health (mHealth) intervention on body weight, showed as the participants after the application use decreased their body weight, increased their light intensity activity and reported an increased vegetable and decreased sugar-sweetened beverage intake [36,38]. Moreover Hebden described other four apps aimed at modifying key lifestyle behaviors associated with weight gain during young adulthood, reporting positive feedback about nutrition and dietetics tips from ten subjects enrolled [39]. Finally, Carter et al. in 2013 investigated acceptability and feasibility of the self-monitoring weight management intervention delivered by a smartphone app. He found very positive effects of smartphone app intervention compared with a control group using a paper diary [37].

- *Fitness and physical activity*

There are many applications that suggest a range of physical exercises, specific for women and men, complete of demo videos and able to measure all sports statistics (such as distance, speed and calories consumed) [18]. There are also specific applications that allow to use the smartphone as a pedometer and therefore to measure the number of steps carried out daily by the subject. West et al. provide an overview of the developers' written descriptions of health and fitness apps and appraises each app's potential for influencing behavior change [19]. Stephens and Allen conducted a systematic review of studies of smartphone applications and text messaging interventions related to the cardiovascular risk factors of physical inactivity and overweight/obesity. More than half of the seven studies included (71%) reported statistically significant results in at least 1 outcome of weight loss, physical activity, dietary intake, decreased body mass index, decreased waist circumference, sugar-sweetened beverage intake, screen time, and satisfaction or acceptability outcomes [20]. Rabin in his paper states that smartphone technology presents an exciting opportunity for delivering

physical activity interventions remotely. Although a number of physical activity applications are currently available for smartphones, these "apps" are not based on established theories of health behavior change and most do not include evidence-based features (e.g., reinforcement and goal setting). So he tried to collect formative data to develop in the future a smartphone physical activity app that is empirically and theoretically-based and incorporates user preferences [21]. Fukuoka et al. described the study design and protocol of the mPED (mobile phone based physical activity education) randomized controlled clinical trial that examines the efficacy of a 3-month mobile phone and pedometer based physical activity intervention and compares two different 6-month maintenance interventions. The mobile phone, using the smart phone technology, serves as a means of delivering the physical activity intervention, setting individualized weekly physical activity goals, and providing self-monitoring (activity diary), immediate feedback and social support [22]. Gay and Leijdekkers have developed a mobile health and fitness app called myFitnessCompanion®, available via Android market. Thanks to this application users are able to keep track of their weight, manage and Control their fitness, track their exercises using real-time vital signs monitoring, collect details about exercises performance and schedule their workout sessions using the reminder functionality [23]. Gregoski et al. developed an Android application to detect and capture Heart Rate measurements and provide preliminary results at varying levels of movement free mental/perceptual motor exertion. Further validation will be conducted in order to determine its applicability while engaging in physical movement-related activities [24]. Kirwan et al. in 2012 conducted a matched case-control trial to measure the potential of a newly developed smartphone application to improve health behaviors in existing members of a website-delivered physical activity program ("10,000 Steps", Australia). Over the study period (90 days), the intervention group logged steps on an average of 62 days, compared with 41 days in the matched group. Intervention participants used the application 71.22% of the time to log their steps [41]. Finally, two RCT study protocols were developed in 2013 by Glynn et al. and by Pellegrini et al.

The first one aimed to promote physical activity in primary care, while the second one examined the feasibility and efficacy of an abbreviated smartphone-supported weight loss program [40,42].

- *Lifestyles*

Boyer et al. described the preliminary development of "iHeal", a set of technologies incorporating artificial intelligence, continuous biophysical monitoring, wireless connectivity, and smartphone computation. In its fully realized form, iHeal can detect developing drug cravings; as a multimedia device, it can also intervene as the cravings develop to prevent drug use [25]. Abrams et al. examined the content of 47 iPhone applications for smoking cessation that were distributed through the online iTunes store. Each app in the study was evaluated basing on the adherence to the U.S. Public Health Service's 2008 Clinical Practice Guidelines for Treating Tobacco Use and Dependence. It arose that iPhone apps for smoking cessation rarely adhere to established guidelines for smoking cessation [26]. Paradoxically, in another study, Bindhim et al. identified and classified into six categories based on functionality 107 pro-smoking apps. 42 of these apps were from the Android Market and downloaded by over 6 million users [27]. Popularity of the smartphone and use of the Internet for multimedia offer a new channel to address health disparities in traditionally underserved populations. One of the applications focused on the prevention of sexual-transmitted diseases, such as HIV [28]. In terms of HIV infection prevention, for instance, it is interesting the experience implemented by Jones that, in his paper, describes the development and the realization of a 12-episode soap opera video series created as an intervention to reduce HIV sex risk [29]. The effects on women's HIV risk behavior was evaluated in a randomized controlled trial in 238 high risk, predominately Afro-American, young adult women in the urban Northeast. To facilitate on-demand access and privacy, the episodes were streamed by a smartphone provided during the study. A mobile platform to deliver the 12-weekly video episodes or weekly HIV risk reduction written messages to smartphone was developed. Gabarron et al. described a Virtual Clinic for Sexually

Transmitted Diseases (VCSTD), developed in order to provide early guidance and reliable information sources concerning reproductive health, delivered in a novel and innovative way to the younger population. The VCSTD consists of an “avatar” supported intervention in a serious gaming and e-learning environment, accessible through smartphones and tablets [30]. Finally, Dennison et al. organized a focus group in order to explore young adults’ perspectives on apps related to health behavior change, finding among young and healthy subjects a very high level of interest in apps supporting health-related behavior change [43].

- *Health in elderly*

A further example is represented by the European Farseeing project (FALL Repository for the design of Smart Environments and Self-adaptive Prolonging independent living) whose objective is to prevent falls in the elderly. The research will start from the analysis of behavioral and physiological data collected using Smartphone through wearable and environmental sensors, during activities of everyday life. Data will be used to create and complete the largest database in the world about falls in the elderly. Thanks to this study will be possible to detect any falls and to obtain useful information to prevent them, ensuring more autonomy for the elderly and providing to health personnel more chance to prescribe preventive behaviors and appropriate treatment [31]. In particular telemedicine models will be developed, using open platforms, which allow to detect falls and to exchange information among elderly, caregiver, family and health personnel. A review of Mosa et al. reported other three human fall detection smartphones’ applications available on the market [32]. For instance, iFall is an Android-based smartphone technology with an integrated tri-axial accelerometer. Data from the accelerometer is evaluated with several threshold based algorithms and position data to determine a fall. If a fall is suspected a notification is raised requiring the user's response. If the user does not respond, the system alerts pre-specified social contacts with an informational message via SMS [33]. Similarly, Majumder et al. developed i-

Prevention, a smartphone-based fall prevention system that can alert the user about their abnormal walking pattern [44]. Kerwin et al. described a mobile application, called “Dance! Don't Fall (DDF) game”, that enable users to monitor their risk of falls and consequently prevent falls from occurring through fun and easy exercise [34]. A similar study was developed in Japan in order to evaluate the use of a Smartphone-based application for assessing dual-tasking ability as a tool for predicting the risk of falls in elderly population [35]. The application teaches some simple manual tasks (i.e. maintaining a small circle in a central position on a large circle) that participants can easily understand and perform and provides the ability to measure performances in these tasks. The results of the study reveal that the Smartphone test promoted by Yamada et al. evaluates the risk of falls by using a different parameter from the ones used in previously validated physical performance tests. Finally, Brouillette and colleagues validated an application for the assessment of cognitive function in the elderly, finding how the application-based Color-Shape Test (CST) was able to measure cognitive processing speed and attention in the elderly [45].

Discussion

Results of our study shows that most of the web applications existing on health belongs to one of the following categories: Nutrition, Fitness and physical activity, Lifestyles and Health in the elderly. These results are consistent with the most common diseases and the inappropriate behaviours affecting the most industrialized countries' populations. Interestingly it arose that the smartphones apps developers have been able to understand precisely the needs of smartphones users, also in public health field.

Moreover, we found that some papers we retrieved are focused on scientific validation of these apps and this data shows that the scientific world is being wondering about the real utility of these new tools and, in particular, about their real efficacy and safety. This suggestion is confirmed by the use of smartphones' apps in randomized controlled trials that represent the study design more suitable

to provide the strong evidence in medicine. As results of our search, some reviews are available on the use of apps in medicine field, even if they are not focused on prevention. Our study is the first overview investigating the world of smartphones application with a focus on the different branches of prevention. This study has, however, some limitations that must be considered when interpreting the results. First of all, our search was not exhaustive because of the language restriction and the criterion of full-text availability. Then, only the articles published in the scientific literature were included with a potential underestimation of the real number of works and researches related to this topic. Finally, it should be noted as the continuous evolution of the technology and apps development makes very difficult to provide a comprehensive and updated reporting of the evidence available.

Given our findings, we have to consider that, while the potentialities offered by these tools are huge and in many cases still to be discovered, on the other hand, it becomes increasingly clear the hazardous nature of lack of control in the contents and in the behaviors carried by the spread of these new technologies. The development of applications for prevention and health promotion on smartphones platforms are, to date, totally disconnected from the logic of monitoring and control of contents both in terms of scientific validity and of understandability by users. This leads to a variety of inappropriate and possibly dangerous behaviors for the health of patients and for the quality of the relationship between doctor and patient. The task of public health in this scenario of possible confusion of the relationship between patient and information and between patient and doctor is the implementation of specific training interventions for both the actors of the doctor-patient relationship. These training programs are indispensable especially when it becomes evident the presence of the phenomenon called "digital divide". The digital divide relates not only to Internet access but also to the existence of a gap between people who can effectively use new information and communication tools, such as the Internet, and those who cannot [46,47]. The digital divide,

known phenomenon associated with e-health becomes a priority feature on three fronts: age, socioeconomic status and geographic area [48-51].

The generational gap in digital literacy, evident transversally in all industrialized countries, is even more pronounced in the case of the latest generation technologies such as smart phones, commercially available in recent years [52-57]. The personal computer, indeed, has become a common tool for work and the ability to use it has increased significantly up to be widely popular in all segments of the population, with the exception of the older age group that, however, is more and more reducing this gap. The smartphones are affected to a greater extent of this digital divide related to age and it is expected that the time needed to overcome this gap is longer. Another front of interest for the digital divide is the socio-economic status, a source of disparities in access to health care services. The cost of a last generation mobile phone or of internet connection may be, indeed, a cause of occurrence of inequalities in accessing to these instruments and consequently the services that these tools offer from the perspective of health and medicine. Finally, the geographic area of domicile or the place of residence may be a source of digital divide when there is not a completely homogeneous coverage of the telephone network and/or even more of the internet connection (UMTS, 3G, WiFi) on the territory. In that case, the residents in mountainous or rural areas may be affected by the lack of access to computer services made available through the Internet connection or through the medical and health applications. That should be probably added up to the difficult physical access to these services for the geographical distance from themselves. A further aspect to be taken into account is the risk of a reduction in the humanization of this technology that, leading to a reduced interaction between the patient and caregivers (except through the electronic means), can lead to a remarkable laceration of the relationship between the two parties with the lack of direct communication and in-depth information. Finally, the problems related to privacy of the patients are even more pronounced with the use of mobile technology. As

we have seen, these tools allows to take pictures, record audio and video files, storing clinical and laboratory data, radiological images and diagnostic reports and access the electronic health records.

However, they can become very dangerous for the maintenance of confidentiality of data and for privacy when lost

or when control of accesses to the smartphone is not performed.

Despite these potentially negative connotations, however, smartphones have been shown to have positive aspects worthy of further study and additional research. The relative cheapness, the widespread distribution, the small size, the homogeneity of commercially available products at international level are all factors that make these smart phones the easiest source of access to health information and the most common ways of communication between health care world and population. The adequate training of users and health professionals can lead to satisfactory results in health education, health promotion, primary and secondary prevention. The management of chronic degenerative diseases, the fight against obesity and voluptuary habits (such as smoking, alcohol and substance abuse), the promotion of healthy lifestyles, adequate nutrition and physical activity are all possible and desirable through the use of these tools. In conclusion, it is important to underline the crucial role of physicians in the management of the patient, and in this context the smartphones should play only a complementary role just to support the doctor in the health management of each individual patient. In addition, future studies, such as the recent randomized controlled trials developed, are strongly needed to analyze the usefulness, the quality and accuracy of smartphones applications in the field of preventive medicine.

Conflict of interest

The authors declare that they have no conflict of interest.

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Table 1 - Overview of the studies about Smartphones' applications regarding Health Promotion.

Category	Article	Study Design	Outcome	Results
<i>Nutrition</i>	Ozdalga E (2012) ⁹	Review	To provide a comprehensive and up-to-date summary of the role of the smartphone in medicine.	Sixty studies that were identified. They found many uses for the smartphone in medicine but very few high-quality studies about how best to use this technology.
	Handel MJ (2011) ¹¹	Applications overview	To review a number of quality Apps that provide information related to patient self-management health and wellness approaches.	Thirty-four applications were described. Nutrition, Fitness and Smoking Cessation were the main topics in the field of health promotion.
	Albrecht JA (2012) ¹²	Application implementation and description	To develop an iPhone/iPad application to inform families with young children on safe food handling of leftovers and other food, and the risk of foodborne illness for a wide range of food products.	Within 6 months of application launch, 1,924 actual users and 6,429 total sessions have been measured. The unsolicited online rating of 4/5 includes positive comments.
	Carter MC (2012) ¹³	Application validation and implementation	To validate 'My Meal Mate' (MMM), a smartphone application designed to support weight loss. In particular to validate the diet measures recorded on MMM against a reference measure of 24 h dietary recalls.	At the individual level, the limits of agreement between MMM and the 24 h recall were wide; however, at the group level, MMM appears to have potential as a dietary assessment tool.
	Rösch N (2009) ¹⁴	Application description	To describe a Smartphone based Personal Allergy Assistant (PAA) that allows patients to keep an electronic patient diary by scanning the barcode of the consumed food products.	Up to now, more than 13.000 food descriptions are public available within wikifood.eu.
	Hebden L (2013)	RCT	To measure the effect of a 12-week mobile health (mHealth) intervention on body weight, body mass index and specific lifestyle	Pre- to post-intervention, participants in the intervention group decreased their body weight, increased their light intensity activity and reported an increased vegetable and decreased sugar-

			behaviours.	sweetened beverage intake. Despite this, post-intervention changes in outcomes were not significantly different from controls.
	Carter MC (2013)	Application validation	To collect acceptability and feasibility outcomes of a self-monitoring weight management intervention delivered by a smartphone app, compared to a website and paper diary.	Adherence was statistically significantly higher in the smartphone group with a mean of 92 days of dietary recording compared with 35 days in the website group and 29 days in the diary group. Self-monitoring declined over time in all groups. Mean weight change at 6 months was -4.6 kg in the smartphone app group, -2.9 kg in the diary group, and -1.3 kg in the website group.
	Hebden L (2013b)	RCT study protocol	TXT2BFiT is a nine month two-arm parallel-group randomized controlled trial aimed at improving weight management and weight-related dietary and physical activity behaviors among young adults.	Since it is a study protocol, the results are not available.
	Hebden L (2012)	Application development	To describe the development of four apps aimed at modifying key lifestyle behaviors associated with weight gain during young adulthood.	The four apps took 18 months to develop, involving the fields of marketing, nutrition and dietetics, physical activity, and information technology. Ten subjects provided qualitative feedback about using the apps. The slow running speed of the apps (due to a reliance on an active Internet connection) was the primary issue identified by this group
<i>Fitness and Physical Activity</i>	Stevens CJ (2012) ¹⁵	Application description	To design a smartphones application to monitor daily improvements on quality of life constructs correlated with exercise participation.	This smartphones application could be useful to disseminate and reinforce switching the focus from the long-term benefits of exercise that improve health, to the immediate benefits of exercise that

				enhance quality of life.
	West JH (2012) ¹⁶	Applications overview	To provide an overview of the developers' written descriptions of health and fitness apps and appraises each app's potential for influencing behavior change.	More expensive apps were more likely to be scored as intending to promote health or prevent disease, to be credible or trustworthy and more likely to be used personally or recommended to a health care client.
	Stephens J (2013) ¹⁷	Systematic Review	To determine user satisfaction and effectiveness of smartphone applications and text messaging interventions to promote weight reduction and physical activity.	Seven articles were included. The most frequent outcome was weight loss (57%). Around 70% of the studies reported significant results in at least 1 outcome, such as weight loss, physical activity, dietary intake, decreased BMI or decreased waist circumference.
	Rabin C (2011) ¹⁸	Application building and description	To collect formative data to develop a smartphone Physical Activity app that is empirically and theoretically-based and incorporates user preferences.	Findings indicate that users have specific preferences including that apps provide automatic tracking of Physical activity, track progress toward exercise goals, well-documented features and user-friendly interfaces.
	Fukuoka Y (2011) ¹⁹	RCT	To describe the study design and protocol of the mPED (mobile phone based physical activity education) RCT that examines the efficacy of a 3-month mobile phone and pedometer based physical activity intervention and compares two different 6-month maintenance interventions.	To date, it is available only the study design. If efficacy of the intervention with a mobile phone is demonstrated, the results of this RCT will be able to provide new insights for current behavioral sciences and mHealth.
	Gay V (2012) ²⁰	Application description	The authors developed a mobile health and fitness app called myFitnessCompanion®. The aim was to share their experience with rolling out a mobile health and fitness app.	The authors discuss the acceptance of health apps by end-users and healthcare industry and how m-health apps will be distributed in the near future.

	Gregoski MJ (2012) ²¹	Application validation	To develop an Android application and compare HRs derived from a Motorola Droid to electrocardiograph (ECG) and Nonin 9560BT pulse oximeter readings during various movement-free tasks.	Across conditions, all device pairs showed high correlations. Bland-Altman plots further revealed the Droid as a valid measure for HR acquisition.
	Glynn LG (2013)	RCT study protocol	To evaluate the effectiveness of a smartphone application as an intervention to promote physical activity in primary care.	Since it is a study protocol, the results are not available.
	Kirwan M (2012)	Matched Case-Control trial	To measure the potential of a newly developed smartphone application to improve health behaviors in existing members of a website-delivered physical activity program (10,000 Steps, Australia).	Over the study period (90 days), the intervention group logged steps on an average of 62 days, compared with 41 days in the matched group. Intervention participants used the application 71.22% of the time to log their steps.
	Pellegrini CA (2012)	RCT study protocol	The ENGAGED study is a theory-guided, randomized controlled trial designed to examine the feasibility and efficacy of an abbreviated smartphone-supported weight loss program.	Since it is a study protocol, the results are not available.
<i>Lifestyles</i>	Boyer EW (2012) ²²	Application description	To develop "iHeal", an innovative constellation of technologies that incorporates artificial intelligence, continuous biophysical monitoring, wireless connectivity, and smartphone computation.	Preliminary data related to the iHeal Project and the experience with its use suggest that will be necessary further analysis to make this application a useful tool for general population.
	Abroms LC (2011) ²³	Review	To examine the content of the 47 iPhone apps for smoking cessation that were distributed through the online iTunes store, as of June 24, 2009	Apps identified for smoking cessation were found to have low levels of adherence to key guidelines in the index. Few, if any, apps recommended or linked the user to proven treatments such as pharmacotherapy, counseling, and/or a quit line.

	Bindhim NF (2012) ²⁴	Review	In this study, the availability of 'pro-smoking' apps in two of the largest smartphone app stores (Apple App store and Android Market) was examined.	107 pro-smoking apps were identified and classified into six categories based on functionality. 42 of these apps were downloaded by over 6 million users. Some apps have explicit images of cigarette brands.
	Ramanathan N (2013) ²⁵	Focus group	To inform the design of an adaptable m-health application in order to identify the dimensions and range of user preferences for application features by different user groups.	Both groups considered customization of reminders and prompts as necessary, and goal setting, motivational messaging, problem solving, and feedback as attractive. Privacy protection and invasiveness were the primary concerns. Mothers' preferences focused on customization that supports mood, exercise and eating patterns.
	Jones R (2012) ²⁶	Application description and development	To develop and evaluate a mobile platform delivering the 12-weekly video episodes or weekly HIV risk reduction written messages to smartphones	Useful insights in assessing advantages and disadvantages of smartphones to implement a video-based intervention were provided.
	Gabarron E (2012) ²⁷	Study protocol of a virtual clinic implementation	To achieve that North Norwegian youngsters become more aware of Sexual Transmitted Disease through the use of popular technologies among young people.	A Virtual Clinic for Sexually Transmitted Diseases (VCSTD) will be developed. The VCSTD will provide early guidance and reliable information sources concerning reproductive health, delivered in a novel and innovative way to the younger population.
	Dennison L (2013)	Focus group	To explore young adults' perspectives on apps related to health behavior change	Study findings suggested that young, currently healthy adults have some interest in apps that attempt to support health-related behavior change. Accuracy and legitimacy, security, effort required, and immediate effects on mood emerged as important influences on app usage.

<i>Health in Elderly</i>	Mosa AS (2012) ²⁹	Review	Evaluation of smartphone-based software for healthcare professionals.	Fifty-five articles discussing 83 smartphone-based healthcare apps were retrieved. The apps were grouped by the potential users: healthcare professionals, medical or nursing students, and patients.
	Sposaro F (2009) ³⁰	Application description	To analyze an alert system for fall detection, developed using common commercially available electronic devices to both detect the fall and alert authorities.	The system provides a realizable, cost effective solution to fall detection using a simple graphical interface while not overwhelming the user with uncomfortable sensors.
	Kerwin M (2012) ³¹	Review and m-health application development	Through a literature review and two observation session the authors conducted an iterative design process with the aim to develop a mobile application.	The authors developed “Dance! Don't Fall (DDF)” game, a mobile application that enables users to both monitor their fall risk and actively reduce it through fun and easy exercise.
	Yamada M (2011) ³²	Application description	To evaluate the use of a Smartphone-based application for assessing dual-tasking ability as a tool for predicting the risk of falls in a community-dwelling elderly population.	The dual tasking is an effective tool in the clinical assessment of fall risk. Several characteristics of the Smartphone application developed are considered to contribute to increasing the demands on the attention elderly participants during walking.
	Majumder JA (2013)	Application description	To describe iPrevention, a smartphone-based fall prevention system that can alert the user about their abnormal walking pattern.	The authors validated their approach using a decision tree with 10-fold cross validation and found 99.8% accuracy in gait abnormality detection
	Brouillette RM (2013)	Application validation	To assess the feasibility, reliability, and validity of a smartphone-based application for the assessment of cognitive function in the elderly.	A total of 57 non-demented elderly individuals were administered a newly developed smartphone application-based Color-Shape Test (CST) in order to determine its utility in measuring cognitive processing speed in the elderly. Scores on the CST were significantly correlated with global cognition and multiple measures of processing speed and attention. The CST was not correlated with naming

				and verbal fluency tasks or memory tasks.

Figure 1 - Flow-chart describing results of Pubmed search

