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REVIEW

m-Health in Coronary Disease Preventive Care

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ABSTRACT

Coronary heart disease (CHD) is the leading cause of death worldwide. Despite the overwhelming evidence of the benefits of preventive care, many patients with CHD fail to receive and adhere to the guideline recommendations, inclufding lifestyle advice and evidence-based cardiovascular medication. Prevention programmes such as cardiac rehabilitation can improve adherence to these recommendations and therefore, reduce hospitalisation and mortality, and improve quality of life. However, such programmes are underutilised due to a number of barriers. These barriers can be overcome with the use of mobile technologies to deliver healthcare, called mHealth. In this review, we discuss the potential use of mHealth in a variety of medical conditions and we highlight some promising applications in CHD prevention.

Key words: Coronary heart disease; Prevention; m-Health

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BURDEN OF DISEASE AND THE UNDERUSE OF EFFECTIVE STRATEGIES

Coronary heart disease (CHD) is the leading cause of death worldwide with 7.4 million deaths in 2012[1]. From those surviving a first acute coronary event, approximately 50% have a recurrent event[2]. Recurrent coronary events can be reduced with appropriate use of cardiovascular (CV) medications, including aspirin, beta-blockers, angiotensin-converting enzyme (ACE) inhibitors and statins[3,4]. Moreover, lifestyle changes, such as smoking cessation, exercise and healthy diet, have an additive effect in reducing CV events and all-cause mortality soon after an acute coronary event[5]. European and American guidelines emphasize the importance of preventive pharmacotherapy and lifestyle advice[6-8]. However, an audit in Australia and New Zealand found that only a quarter of the patients admitted to hospital with an acute coronary syndrome received optimal preventive care[9]. Similarly, despite the overwhelming evidence of the benefits of CV medication and lifestyle changes, the recent EUROASPIRE IV survey, in which preventive care data was collected in 24 European countries, continues to show that the majority of patients fail to achieve and adhere to these guideline recommendations[10].

Adherence to evidence-based recommendations can be significantly improved with prevention programmes such as cardiac rehabilitation (CR) programmes[6]. While in the early years of CR programmes, there was a focus on exercise-based rehabilitation, in recent years, these programmes were expanded to include information and motivation to maintain a healthy lifestyle. Studies have shown that patients who attend CR programmes have reduction in their hospitalisation and mortality, as well as, an improvement in quality of life, when compared to patients who did not attend CR[11,12]. However, Attendance of CR programmes is sub-optimal with only 14 to 43% of eligible patients participating in such programmes[13]. Furthermore, only half of these patients complete the total length of the program[13].

Barriers to CR uptake and adherence have been studied and the majority of patients report a lack of time or work commitments, as well as, lack of transport and financial costs to attend hospital-based

CR programs[14]. These barriers and sub-optimal use of CR highlight that there is a need for innovative approaches in coronary disease preventive care[15]. Innovative strategies to deliver CV preventive programmes such as home-based CR programmes were developed and were proven to have same effectiveness and higher adherence than hospital-based programmes[12]. Another alternative way to deliver CR programmes is the use of telecommunications technology (tele-Health), including telephone, video-conferencing and computer-based internet. Interventions delivered by such technologies were found to be effective in reducing risk factors for coronary disease and, potentially, also reduce mortality[16]. More recently, mobile communication technology has been increasingly used to deliver healthcare. Mobile communication technology has the potential to transform healthcare in a variety of medical conditions, and is particularly promising in long-term care of chronic diseases, including CHD. The aim of this review is to discuss how mobile communication technology can be used to improve healthcare delivery with a focus on CHD prevention by highlighting some of the promising evidence already available that can guide future mHealth research.

MOBILE TECHNOLOGY TO DELIVER HEALTHCARE - MHEALTH

Mobile communication technology has the potential to transform healthcare delivery across the globe[17]. In 2014, there were about as many mobile phone subscriptions globally, as there are people on Earth, around 7 billion[18]. In addition, mobile broadband subscriptions were expected to reach 2.3 billion with 55% in developing countries and Africa is leading the subscriptions' growth[18]. This increasing access to mobile technologies will allow people in remote areas and resource-poor environment to be reached even when unpaved roads don't reach them.

Mobile health or mHealth is defined as the provision of health-related services via mobile and wireless communication technologies, such as mobile phones, smartphones, tablets and personal digital assistants (PDAs), to support the achievement of health objectives[17,19]. mHealth can be delivered in different ways, including text-messages and smartphone apps, depending on the type of mobile device available and its internet capabilities. Furthermore, there is a diverse range of practical applications and uses of mHealth to address a number of health needs in different medical conditions, including education to patients and healthcare providers, data collection, diagnostics and screening, patient monitoring, treatment support, behavioural change support, and communication between patients, health professionals and health services.

Modes of mHealth delivery

The two main modes of mHealth delivery are mobile phone text-messages and smartphone applications. Mobile phone text-messaging is a relatively old technology that all digital mobile phones can deliver. Text-messages, also known as SMS (Short Message Service), are by definition short messages up to 160 characters that can be sent from the internet or from one mobile phone to one or more mobile phones[20]. Text-messages have become a convenient, important and inexpensive medium for communication. Hence, text-messages are being used in the healthcare setting as tool to support healthy behaviours and deliver preventive care. Text-messages have the advantages of an instant transmission and low cost, being less intrusive compared to phone calls[20], as well as, being a push technology, where the text-message will be received independent of the mobile phone being in use at the time. In addition, automated computer systems can be used to deliver text-messages on a large scale, being easy and saving the costs of hiring dedicated personnel for this task.

Smartphones are mobile devices that combine features of a traditional mobile phone with computer capabilities[21]. One of the major advantages of a smartphone is that it can run computer programs that can be downloaded to the smartphone, called applications or apps[21]. Smartphone apps have been increasingly studied for their potential use in delivery of healthcare. The easy to learn and user-friendly designs can greatly impact in the day-to-day management of chronic diseases[22]. Apps are a convenient way to deliver relevant information about medical conditions. Besides that, smartphone apps can have additional useful functions in management of diseases such as in-built diaries and messages, medication reminders and data-sharing capabilities[21]. Some disadvantages of smartphones and apps include the need for internet access to download the apps and the fact that the use of some of the app features such as data-sharing, in-built messages and reminders requires the user to access the app to be received (called pull technology). Smartphones also require some training for users who are not familiar with smartphone technology.

Potential uses and practical applications of mHeath

mHealth can be applied to a wide variety of health objectives, including but not limited to education, data collection, diagnostics, monitoring and communication. In this section, we will discuss the evidence available for some of these practical applications in a number of medical conditions. First, mobile technologies have the powerful ability to deliver education to patients and health professionals anywhere at any time. Patients can access information about a disease, its diagnosis and treatment, as well as, health services availability via their mobile devices. This is especially important in areas where there is a lack of health professionals to provide health education to the population. An example of the use of mHealth in health education is a program in Uganda and other countries in Africa, in which participants' general knowledge about HIV transmission was tested in an interactive quiz delivered via text-messages[23]. In this quiz, when participants gave a wrong answer, they were educated about HIV by receiving a text-message with the correct answer; and they were also encouraged to undertake voluntary HIV testing at a local healthcare centre. Moreover, an increasing number of health professionals now use their mobile devices as a tool to access information on the internet as well as clinical calculator apps to determine patients´ risks, for example[22]. One project in Canada, provided nurses with PDAs to easily access tools and detailed health information while working in remote Aboriginal communities[17].

mHealth can also be used for remote data collection, as well as, diagnostics and screening. In Poland, PDAs were used to collect data for a national survey on current tobacco use among adults[17]. In diagnostics, a quick and easy diagnosis of atrial fibrillation with an iPhone application, which records a high quality single lead of ECG, is a promising novel technology[24,25]. Electronic decision support tools are very useful in screening and identifying individuals at a high risk of developing a disease to appropriately manage this risk. In India, a multi-faceted mobile clinical decision support system for cardiovascular disease screening and management is being tested[26,27].

Other potential uses that might overlap are patient monitoring and treatment support including behavioural change support. Smartphone applications provide a possible medium for monitoring asthma patients to help them manage their condition, but their effectiveness still needs further investigation[28]. In Kenya, a study found that treatment support with text-messages can improve medication adherence to anti-retroviral therapy with concurrent reduction in viral loads in

patients with HIV[29]. Text-messages were also found to be effective in behaviour change in a study where sending motivational text-messages improved smoking cessation[30].

Lastly, mobile technologies are an ideal way of communication between patients, health professionals and health services, as well as, between health professionals. Studies have shown that the use of text-messages as appointment reminders is associated with increased attendance to the medical consultations[31]. Mobile devices can also be used to improve communication between health professionals, which in turn can improve management of complex medical cases through discussions with specialists as well as facilitate exchange of information about bed availability and referral of patients to higher levels of care. Communication among physicians using a mobile phone is increasingly been used worldwide and it has been tested in Ghana with improved communication about patient management[17].

mHEALTH IN CHD PREVENTION

As with other medical conditions, CHD healthcare can also be improved by the use of mobile technologies. In the last few years, mHealth interventions aimed to improve CHD prevention and treatment were developed and such interventions are being studied to assess their effectiveness. mHealth studies in CHD prevention have been evaluating the use of mobile phone text-messages and smartphone apps to deliver care. A few completed studies have exciting results, however as mHealth is still in its early stages of research, ongoing trials will provide more substantial evidence in the use of mobile technologies in CHD prevention during the next few years.

Text-messaging in CHD prevention

Text-messaging in CHD prevention has been increasingly studied. Potential uses of text-messages include improvement of medication adherence, behavioural change and patient monitoring. These potential uses have been investigated in a few randomised controlled trials (RCTs) (Table1). All studies evaluated secondary prevention interventions in patients with a diagnosis of CHD, except for one study which evaluated primary prevention of CHD in patients taking blood pressure and/or lipid-lowering medications[32]. Four completed RCTs showed positive results in improving medication adherence using a text-messaging intervention[32-35]. Three of these studies reported automated computer programs to deliver the text-messages and two required the participant to respond back to the messages. One study that evaluated behaviour change achieved improvements in cholesterol, blood pressure, body mass index and smoking cessation[36]. Another trial evaluated patient monitoring and communication with a health professional and showed improvements in CV risk profile[37]. Most of these studies were small, but had overall good quality. In addition, one ongoing trial is also investigating the effects of text-messaging in behavioural change[38].

Table 1 Text- messaging trials in CHD prevention.

Study Author/ Year/ Country	Population/ Sample size	Category	Text-messages characteristics	Outcomes
Completed Studies				
Blasco, 2012[37] / Spain	ACS /203 patients	Patient monitoring	- Patients measured their weight, HR and BP weekly, capillary plasma lipid profile and glucose monthly - Patients sent their information through their mobile phones - Cardiologist reviewed the information and sent TM with recommendations	Improvement in cardiovascular risk factors profile at 12 months. A higher number of patients achieving goals for BP and HbA1c, but no differences in smoking cessation and LDL cholesterol at 12 months.
Chow, 2015 [36,39,40] / Australia	CHD/720 patients	Behaviour change	- 4 semi-personalised TM per week providing advice, motivation and information on healthy lifestyle - TM categories: General heart health, nutrition, physical activity and smoking cessation	- Significant reductions in LDL-cholesterol, systolic BP and BMI. Significant improvements in physical activity and smoking cessation.
Pandey, 2014 [34] /USA	MI /34 patients	Medication adherence	- Daily TM reminders at the prescribed times to take aspirin, beta-blocker, ACEi or ARB and statin	Smaller decline in overall medication adherence at 12 months. Greater improvements in age ≥ 65 years old and lower education group.
Park, 2014 [33] /USA	MI or PCI/ 90 patients	Medication adherence	Two intervention groups: - Education only: 14 TM in 30 days or - Education + medication reminders: 14 education TM + daily TM reminders correlated with the time to take aspirin and statin - Need to reply to TM	Improvement in number of doses taken, correct doses taken and doses taken on scheduled time for anti-platelets at 30 days. No statistically significant improvement for statins.
Quilici, 2013 [35] /France	ACS with PCI/ 521 patients	Medication adherence	- Daily TM personalized motivational reminders to take aspirin	Improvement in self-reported adherence to aspirin and lower rate of non-adherence assessed by a platelet functioning testing at 30 days.
Wald, 2014 [32] /UK	Primary prevention of CHD/ 303 patients	Medication adherence	- Daily TM for 2 weeks, then alternate days for 2 weeks then weekly up to 6 months - Need to reply to TM	Reduction in the proportion of patients who stopped or took <80% of their prescribed BP and lipid-lowering medications at 6 months.
Ongoing Studies				
Dale, 2014 [38] /New Zealand	CHD / 120 patients	Behaviour change	- Evidence and theory-based personalised TM providing education, support to a healthy diet and physical activity, stress management, alcohol consumption and smoking cessation	- Primary outcome is proportion of patients adherent to lifestyle behaviours, measured by a composite health behavior score. - Secondary outcomes are overall CV risk, body composition, illness perceptions, self-efficacy, anxiety/depression and medication adherence.

ACEi: Angiotensin converting enzyme inhibitor; ACS: Acute coronary syndrome; ARB: Angiotensin receptor blocker; BMI: Body mass index; BP: Blood pressure; CHD: Coronary heart disease; CV: Cardiovascular; HbA1c: Glycated haemoglobin; HR: Heart rate; LDL: Low density lipoprotein; MI: Myocardial infarction; PCI: Percutaneous coronary intervention; TM: text-messages

Smartphone apps in CHD prevention

In addition to text-messaging, smartphone apps can also be used as a tool to deliver CHD prevention. A recent review discussed the availability of an increasing number of health-related apps, including apps for CV diseases, in the smartphones app stores, despite a lack of regulation and evidence-based development of such apps[41]. The review pointed out the need for evidence-based apps development and discussed the core components and ideal features that should be present in a CHD prevention app for a higher success rate, including simplicity, credible information, rewards, personalisation and social components. However, there is still a small number of studies investigating if smartphone apps can improve CHD prevention. In our review, we discuss three studies that might help address this research question.

The first study in the United States, a Mayo Clinic research group developed a smartphone app to deliver CR[42]. In a RCT, the Mayo Clinic group compared the CR smartphone app intervention to a control group who received a standard CR program. Thirty-seven patients in the smartphone app group were required to perform daily tasks and enter risk factor information, such as weight, blood pressure, glucose, lipids, physical activity and diet throughout the 90-day program. Patients in the intervention group had significant reductions in weight and blood pressure, as well as, 40% reduction in rehospitalisation and emergency department visits.

In another study, a research group from Australia developed a Care Assessment Platform to deliver a CR programme, called the CAP-CR[43]. The patients in the CAP-CR programme were provided with a smartphone with pre-installed health diary and activity monitoring apps, a blood pressure monitor and a weight scale. These devices were used to monitor the patients, as well as, deliver motivational and educational materials via text-messages, audio and video files. Physical activity monitoring was automatic through the smartphone's in-built accelerometer. Participants were advised to make daily entries in the health diary app reporting their weight, blood pressure, sleep duration and quality, stress, meals, and, if relevant, alcohol consumption and smoking. These data were synchronised to a web portal, where mentors would have access to this information to guide discussions in weekly consultations with the participants via the web portal. The CAP-CR programme was investigated in a RCT in which 120 patients were randomised to traditional CR or CAP-CR for 6 weeks. The primary outcome measures were uptake, adherence and completion of a CR programme. Secondary outcomes included lifestyle factors (physical activity, nutrition, psychosocial functioning), biomedical risk factors (blood pressure, heart rate, weight, body mass index, waist circumference, lipid profile) and health-related quality of life. The uptake, adherence and completion of CR programme were significantly higher in CAP-CR compared to traditional CR. Secondary outcomes were not significantly different between groups, except for diastolic blood pressure and quality of life, which were better in the CAP-CR group, and triglycerides which was better in the traditional CR group.

Lastly, an ongoing RCT aims to test whether a consumer-focused e-health portal will improve CV risk factor control[44]. The CONNECT study plans to enrol 2000 participants with diagnosis of CVD or who are at high risk of CVD. The intervention focuses on CV risk assessment, medication adherence, lifestyle change and patient-provider communication. The intervention will be integrated with general practitioners software to capture data of each participant into the CONNECT app (Figure 1), such as medications in use, blood pressure measurements, and lipids and glucose laboratory results. The key features of the app include personal health record summary, use of interactive tools and resources such as a CV risk calculator that allows participants to explore "what if scenarios", access to lifestyle and medication reminders, and goal-setting. The primary outcome of the study is proportion of participants meeting blood pressure and lipid targets. The secondary outcomes include difference in body mass index, physical activity levels, smoking cessation, medication adherence, quality of life, hospital readmissions and all-cause mortality.

FUTURE DEVELOPMENT AND RESEARCH

mHealth in CHD prevention remains an emerging area of research. To try to estimate how much evidence can be built in the next few years, we conducted a search on Clinicaltrials.gov database using the search terms mHealth, mobile health, mobile phone, cell phone OR smartphone AND cardiovascular in June 2015. We found another five ongoing RCTs evaluating either text-messaging or smartphone apps for either primary or secondary prevention of CHD. The results of ongoing studies will add to the mHealth body of evidence.

It is important to highlight that there is a need for large, high-quality RCTs with hard outcomes to provide more robust evidence of effectiveness. Alongside evaluation of effectiveness, future studies should have a process evaluation to better understand why an intervention works or not and which components or features of the intervention are essential and contribute most to the success of the intervention. Furthermore, future research should also include cost-effectiveness analysis as the development of interventions using technology can be expensive and time-consuming, therefore increasing the costs of the intervention. Another important aspect to be considered when developing future mHealth interventions is having mechanisms to ensure privacy and security in the data transmission and storage. Finally, future research should also investigate mHealth effectiveness in different age groups, socio-economic status and cultural contexts.

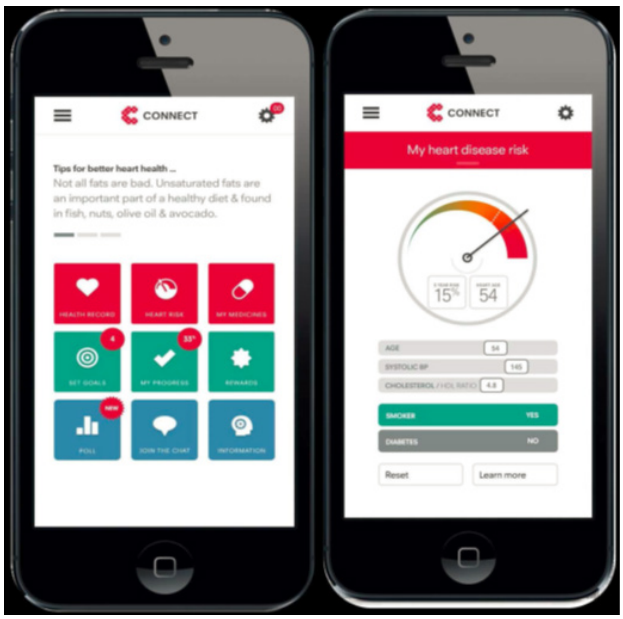

Figure 1 A smartphone app for prevention of CHD being tested in the CONNECT Study. Permission obtained from study investigators.

CONCLUSION

In this review, we have discussed the potential use of mHealth in a variety of medical conditions and we highlighted some promising applications in CHD. CHD prevention and management, amongst other chronic diseases, faces a challenge of sub-optimal patient's adherence to guideline-recommended medications and lifestyle changes. Some barriers to adherence can be overcome with the use of mobile technologies. Recent studies of the use of mHealth in CHD patients show exciting benefits in medication adherence, behavioural change and patient monitoring. Although there is still little evidence of these benefits, we believe that mHealth has the potential to transform healthcare delivery in CHD.

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CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

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