Potential for the use of mHealth in the management of cardiovascular disease in Kerala: a qualitative study

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ABSTRACT

Objectives: To assess the potential for using mHealth in cardiovascular disease (CVD) management in Kerala by exploring: (1) experiences and challenges of current CVD management; (2) current mobile phone use; (3) expectations of and barriers to mobile phone use in CVD management.

Design: Qualitative, semistructured, individual interviews.

Setting: 5 primary health centres in Ernakulam district, Kerala, India.

Participants: 15 participants in total from 3 stakeholder groups: 5 patients with CVD and/or its risk factors, 5 physicians treating CVD and 5 Accredited Social Health Activists (ASHAs). Patients were sampled for maximum variation on the basis of age, sex, CVD diagnoses and risk factors. All participants had access to a mobile phone.

Results: The main themes identified relating to the current challenges of CVD were poor patient disease knowledge, difficulties in implementing primary prevention and poor patient lifestyles. Participants noted phone calls as the main function of current mobile phone use. The expectations of mHealth use are to: improve accessibility to healthcare knowledge; provide reminders of appointments, medication and lifestyle changes; save time, money and travel; and improve ASHA job efficacy. All perceived barriers to mHealth were noted within physician interviews. These included fears of mobile phones negatively affecting physicians’ roles, the usability of mobile phones, radiation and the need for physical consultations.

Conclusions: There are three main potential uses of mHealth in this population: (1) as an educational tool, to improve health education and lifestyle behaviours; (2) to optimise the use of limited resources, by overcoming geographical barriers and financial constraints; (3) to improve use of healthcare, by providing appointment and treatment reminders in order to improve disease prevention and management. Successful mHealth design, which takes barriers into account, may complement current practice and optimise use of limited resources.

BACKGROUND

mHealth, or mobile health, is the use of mobile devices to support medical and public health. Through the use of existing mobile phone infrastructure, mHealth offers innovative solutions to health problems in high-income economies, where the mHealth industry continues to grow, and also increasingly in low-middle income economies. An evaluation of mHealth technologies in developing countries identified a number of key drivers for its implementation, including the empowerment of patients with disease knowledge, overcoming geographical barriers, improved efficiency in data collection and transmission and multilevel cost saving opportunities. As the second largest subscriber of mobile phones with one of the lowest call tariffs worldwide, India is an attractive candidate for the mHealth industry. Additionally, India is the fastest growing smartphone market in Asia/Pacific, facilitating future adoption and development of novel mHealth services.

One of India’s most pressing public health concerns is its mounting cardiovascular disease (CVD) burden. By 2020, CVD is projected to become the largest cause of death and disability in India as mortality rates increase to 4.77 million deaths a year. However, the majority of CVD mortality and morbidity is avoidable through a decrease in key modifiable risk factors such as smoking, physical inactivity and dietary intake. The southern Indian state of Kerala portrays one
of the poorest CVD risk factor profiles in the nation: 21.9% are tobacco users, 39.7% have poor dietary habits, 33.9% show abdominal obesity, 28.8% have hypertension, 14.8% have diabetes mellitus and 54.1% have hyperlipidaemia. The consequence of such highly prevalent risk factors is reflected in the results of two separate studies in 2011, both showing CVD as the primary cause of death of adults during the study periods. Paradoxically, Kerala’s health indicators are favourable compared to the rest of India, including literacy rate (Kerala: 94%, India: 74%) and infant mortality rate (Kerala: 12, India: 40/1000 live births), and are similar to those of developed nations. The causes of Kerala’s unexpectedly high CVD prevalence are widely debated, but the urgent need for improved CVD prevention and control is undisputed.

Despite the majority of mHealth in low-middle income economies focusing on sexual health and communicable diseases, there is great potential for mHealth to improve CVD management. Existing non-communicable disease (NCD) mHealth trials have reported improved health outcomes related to NCD management, in particular regarding text message interventions to support exercise, diet and smoking cessation. Other potential benefits of mHealth in a low-resource setting include treatment reminders, disease monitoring and support for patients and health workers. In Kerala, a combination of the increasing popularity and economic feasibility of mobile phones, a growing CVD epidemic and a high risk factor prevalence provides a suitable context in which to implement CVD-related mHealth interventions.

Although there is a lack of CVD-related mHealth research in India, quantitative studies have highlighted the likely acceptability and feasibility of mHealth in a rural Indian setting. However, owing to the presence of inter-state health disparities, it is important to obtain region-specific data in India; thus, there is still a recognised need for in-depth qualitative research concerning the need and acceptability of mHealth to suit specific populations and develop optimal health interventions. Therefore, this study was designed to investigate the perceptions of three different stakeholder populations in order to assess the potential for using mHealth for CVD management in Kerala. The study objectives are to explore: (1) the experiences and challenges of current CVD management; (2) the current use of mobile phones; (3) the expectations of and barriers to mobile phone use in CVD management.

METHODS

Context

The government sector of healthcare in Kerala is structured on primary, secondary and tertiary levels between Ayurveda, Homoeopathy and modern medical systems, the last being the preferred system for specific conditions such as CVD. Primary health centres (PHCs), serving a population of around 10,000, offer health promotion services and activities. This includes the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke, which was implemented in Kerala during 2010–2012 to promote healthy lifestyles, early diagnosis and management of NCDs. The physicians’ roles at PHCs resemble that of a general practitioner and they are responsible for helping patients navigate and utilise higher levels of services or alternative medicines if required.

The National Rural Health Mission employs female community health workers, or Accredited Social Health Activists (ASHAs), to link rural communities with primary healthcare services. Deployed within a village, ASHAs act as the first point of access to healthcare for rural communities. Approximately one ASHA is deployed per thousand population. Their roles include promoting good health practices and providing information on basic determinants of health and existing health services. The role of ASHAs in communicable disease and maternal health is well established, but there is little evidence concerning their role in NCDs in Kerala. One study assessing ASHA performance motivation highlighted the need for healthcare delivery system improvements, supportive supervision, knowledge enhancement and enabling working modalities, providing justification for mHealth exploration in this group.

Setting, sample and recruitment

Following guidance on the qualitative sample size from Guest et al., a minimum sample size of fifteen participants was recruited from five different PHCs across five adjacent village districts in Kerala. The sample consisted of three different stakeholder groups: (1) ASHAs; (2) physicians treating CVD; (3) patients with CVD and/or its risk factors. Maximum variation sampling of patients, based on age, sex, CVD diagnoses and risk factors, aimed to capture a range of experiences and demographics. Convenience sampling was suitable for the rest of the sample.

Potential participants meeting the eligibility criteria, which included access to a mobile phone and language fluency in either English or Malayalam, were recruited either by telephone (patients directly) or in person at the PHC (via ASHAs and physicians). Participants non-fluent in English were recruited by a translator fluent in Malayalam and with healthcare experience (doctors or ASHAs); all other participants were recruited by the researcher. One participant from each stakeholder group was recruited from each of the five PHCs, resulting in five ASHAs, five physicians and five patients. All 15 participants initially contacted gave consent to participate.

Data collection

Individual semistructured interviews took place over a period of 6 weeks. Interview guides covered three topics: (1) the experiences and challenges of current CVD management; (2) the experiences of and barriers to mobile phone use in CVD management; (3) the role of the ASHA in CVD management. One participant from each stakeholder group was recruited from each of the five PHCs, resulting in five ASHAs, five physicians and five patients. All 15 participants initially contacted gave consent to participate.
management; (2) the current use of mobile phones; (3) expectations of and barriers to mobile phone use in CVD management. Questions were generated using previous qualitative literature examining mHealth applications and were designed to answer the three main research objectives through comprehensive exploration of experiences and views on the topic. Interviews were piloted for relevance, acceptability and understanding for each stakeholder group prior to data collection and adjusted accordingly (see online supplementary appendix 3). Field notes were made immediately after interviews to provide context. All interviews were: (1) with a translator present if necessary; (2) conducted in a private room at the PHC; (3) audio-recorded using a Dictaphone; (4) between 20 and 45 min in length.

Analysis
Interviews were transcribed verbatim as soon as possible after each interview and uploaded onto NVivo (qualitative data software manager) (RS and JR). Anonymised transcripts were analysed by the researcher (RS) using thematic analysis. Open coding, which involved thorough familiarisation and annotation of transcript data, occurred over a 2-month period in two phases: (1) familiarisation and annotation of transcript data, occurred over a 2-month period in two phases: (1) immediately after interview transcription; (2) 4 weeks after the last interview transcription. In the first phase, provisional codes were inductively derived from individual data and linked to form themes. Generated codes were recorded in a digital codebook and are displayed in online supplementary appendix 4. Analysis occurred concurrently with data collection to facilitate constant comparison of data—emerging themes were compared to previous individual interview data and between stakeholder group data to identify, develop and confirm overarching themes. Analysis was repeated and checked during the second phase of coding; codes and themes generated on both occasions were compared for agreement and discrepancies were reviewed with respect to the original transcripts in order to ensure rigour and consistency in analysis. In further acknowledgement of the need for transparency and the potential biases introduced by a sole researcher (RS) in data interpretation, reflexivity was practised throughout the entire process. Contradictory evidence was sought to minimise any researcher bias that might interfere with unusual insights. No new codes were added to the codebook after the ninth interview; by definition, data saturation was achieved.

RESULTS
All ASHA and physician participants (collectively referred to as ‘health workers’) were female and aged <50 years. As a prerequisite, ASHAs are all literate and of a similar age. Homogeneity was also observed for physicians working at the PHCs, reasons for which are beyond the scope of this study, but are perhaps explained by Indian cultural norms regarding gender roles. The patient participant characteristics were varied: age range 51–83 years, three males and two females, CVD diagnoses ranging from only one CVD risk factor to more than one acute CVD event. The finalised key themes are categorised under the three interview topic areas and summarised in table 1.

Current experiences and challenges of CVD management
Although presented separately, the main themes overlap: poor patient disease knowledge, poor implementation of CVD prevention and poor lifestyle. These themes are displayed according to stakeholder group in table 2.

Poor patient disease knowledge
Twelve of fifteen participants showed low levels of disease awareness and knowledge. Despite existing strategies to increase awareness, the need to further improve patient education was recognised by all stakeholder groups.

“Actually what I think is that there has to be more and more of health education. Education is the main thing. Even though we have health education for the people it’s...
not in effect, they’re not actually very much informed.” (Physician 3)

“Sometimes I am unsure if I am doing the right thing, like with food, and so I would like advice on that.” (Patient 3)

Difficulties implementing primary prevention
Health workers believed that patients are “not bothered about primary prevention” and are unlikely to implement lifestyle changes and adhere to medication regimes until an acute CVD event occurs. For this reason, they stated that secondary preventative measures are more effective for patients. Participants implied that poor patient disease knowledge is the primary cause for this.

“But most patients, they address the doctor in the last stages … after they have had an operation, or angiogram, in the hospital, when they feel frightened. This time, when they are scared, they will start controlling the food and exercise. But patients need to be doing this before they have the problem!” (ASHA 2)

Poor lifestyle
Poor health behaviours were acknowledged to be highly prevalent in this population and a key contributor to CVD development. Moreover, ASHA and physician participants revealed that patients are often slow to practise lifestyle advice and make positive health behaviour changes: they are “busy or working or unavailable” or “tend to forget” lifestyle changes. Participants reported the difficulties of trying to change patient lifestyles, in particular smoking and alcohol use. Health workers thought that patients prefer medication because it is “easier for them” than lifestyle changes.

Diet is a particularly salient point; 8 of 10 health workers discussed the need for better food control in their populations. Participants blamed the increasing availability of fast food, combined with a traditional diet rich in coconut oil and carbohydrates, for causing deteriorating dietary habits. Additionally, urbanisation of formerly rural areas has preceded a rapid shift from daily physical exertion to an increasingly sedentary lifestyle. The detrimental effect of poor diet and lack of exercise is an important influence on CVD development.

“… people did not used to take so much of junk food and such things … and there’s no physical labour, physical exertion. People are mostly doing paperwork. In Kerala, mostly that is the problem.” (Physician 1)

Other
Other notable themes were identified concerning current CVD management:
1. Family influence. Family may be an invaluable support to those patients who are less willing or able to make healthier lifestyle choices.
2. Health worker knowledge support. Health workers would like support in keeping up to date with new guidelines and treatment protocols, especially when working in more remote areas.
3. Healthcare expenses. Patients may avoid having tests and investigations if they cost time, money or travel. Medications not supplied by the government are expensive.
4. Physicians are busy. PHCs are often overcrowded, leaving physicians very little time to spend with each patient.

2. Current mobile phone use
Phone calls
Making phone calls was reported as the primary function of mobile phones. Communication between stakeholders is informal and unregulated. In most cases, only those patients requiring more specialised care, such as antenatal and palliative patients, will have their physician’s contact number. The main reasons given for mobile phone communication between health workers and patients were for arranging immunisation appointments and home visits and to clarify patient doubts. Communication between health workers can involve calling superiors for advice and patient referrals.

Text messages were used infrequently. One ASHA was concerned that patients literate only in Malayalam would struggle to send and understand text messages on mobile phones, which only accommodate the English alphabet. Text messages can also be an insufficient

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**Table 2** Current experiences and challenges of CVD management

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<th>ASHAs</th>
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<th>Patients</th>
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CVD, cardiovascular disease.
source of information and fail to clarify the recipient’s questions. Furthermore, patients reported not being able to understand how to send text messages. The use of internet and email were scarcely mentioned.

Ubiquity of mobile phones
Participants stated that the vast majority of the population owns, or has access to, a mobile phone, and they have become a necessity in daily life.

“Because most of the patients, everybody, young or old they have the mobile, or at least a basic set.” (ASHA 3)

3. Expectations of and barriers to mobile phone use in CVD management
The main expectations of and barriers to mobile phone use according to the stakeholder group are summarised in figures 1 and 2.

Improve accessibility to health information
The communication networks offered by mobile phones could potentially benefit all stakeholders involved by improving accessibility to health information. First, in response to the high risk factor prevalence in this population, mobile phones can be used to disseminate healthy lifestyle advice to support and motivate patients making challenging lifestyle changes.

“I would like advice] about the food. I think it is good but sometimes I cannot be sure and maybe advice about the food would be helpful.” (Patient 2)

Health workers could improve their own clinical knowledge, as well as access decision-making information whenever and wherever they may require it. This removes the geographical and time restraints that are often encountered in busy, remote health centres.

“[I would like advice] about the food. I think it is good but sometimes I cannot be sure and maybe advice about the food would be helpful.” (Patient 2)

Data can be shared quickly and efficiently through mobile phones. For example, patients could send in measurements, such as blood glucose readings, without having to travel to the health centre. This enables remote monitoring of disease and treatment adjustment.

“We could send results through mobile phones, like the sugar levels, and the doctor can easily understand what is going on.” (ASHA 5)

Provide reminders
Thirteen of fifteen participants reported the potential benefit of receiving reminders about important aspects of disease management, such as appointments, medication and healthy lifestyle changes, in order to improve disease management.

“Actually about fixing appointments, like if they are taking drugs for one month, then if they can get a reminder about getting an appointment ... Actually it can be good if they can get a reminder of drug adherence. If they can get it, that would be good.” (Physician 3)

Save time, money and travel
Although two ASHA participants noted that cumulative use of mobile phones is costly, patients focused on the potential cost-saving opportunities mobile phones could offer.

“Actually about fixing appointments, like if they are taking drugs for one month, then if they can get a reminder about getting an appointment ... Actually it can be good if they can get a reminder of drug adherence. If they can get it, that would be good.” (Physician 3)
Improve job efficacy
ASHAs recognised the potential for mobile phone use to improve their work efficacy. The broad reason given was increased communication with patients and colleagues facilitating the planning and conduct of home visits.

“Our work efficiency can be improved. There are more patients who are contacting us, and for us contacting more people on the phone. It would be more useful in many ways.” (ASHA 3)

Usability of mobile phones
Participants acknowledged that you must know how to use the different functions of mobile phones in order to reap any potential benefits. Age was considered to play an important role in this. The younger members of the population are deemed more accepting of mobile phones and more knowledgeable about its various capabilities.

“The patients are not aware of the function of the mobile phones, especially those above fifty or sixty, those who are elderly, so they do not use it.” (Physician 4)

Radiation fears
Four health workers mentioned that the effects of radiation act as a barrier to mobile phone use. They were concerned about mobile phone overuse and the unintentional harm it may cause to the body.

“Mobile by the ear it is near the head, in the pocket it is near the heart, in the pants it is near the man parts! We worry about this bad radiation. It is not good.” (ASHA 2)

Potential negative effect for physicians
Physicians were the main advocates against the use of mobile phones. With busy work schedules, they were concerned that increased use of mobile phones will become a disturbance to their work and personal lives. Unregulated phone use may appear unprofessional and pose a threat to patient care.

“...but for the doctors I think that maybe their job will be affected. Sometimes the call may be coming when they are with another patient.” (Physician 5)

Need for physical consultation
Physicians still need patients to attend physical consultations at the health centre, rather than virtual consultations using a mobile phone. Increased mobile phone use may result in fewer patients attending appointments and hinder the need for physical patient examination.

“If you keep asking them about medicines and all on the phone, then I think they will not turn up to the primary care. You can’t believe whatever they say. It depends on your examination of the patient.” (Physician 2)

DISCUSSION
Principal findings and implications for practice
To the best of our knowledge, this is the first qualitative study of the potential of mHealth in India, and emphasises three main uses of mHealth: (1) as an educational tool; (2) to optimise the use of limited healthcare and patient resources; (3) to improve use of healthcare services for disease prevention and management. All stakeholders agreed on the potential of mobile phones as an educational tool for healthcare consumers and providers by improving patient disease knowledge and supporting health worker clinical knowledge. Utilisation of existing mobile phone functions, such as phone calls, text messages and internet, or the introduction of novel methods, such as health apps, could increase the
accessibility and quality of information available (interestingly, apps were not mentioned in any of the interviews, despite their increasing acclaim in the developed world\textsuperscript{40,41}). Consequently, disease prevention would be enhanced by improved compliance with a healthy lifestyle and other primary preventative measures. mHealth also offers opportunities to save time, money and travel, facilitating the optimisation of limited resources. The unique possibility of providing remote care at minimal cost has been echoed in a literature review of mHealth applications along the cancer continuum.\textsuperscript{42} The use of mHealth to provide reminders to patients about appointments, medication and lifestyle has shown improved health outcomes in previous studies;\textsuperscript{22,43} with evidence from participants of forgetfulness, non-attendance and non-adherence, this may play a valuable role in CVD prevention and management.

Physicians are the leading opposition to mHealth implementation, with all four themes regarding barriers arising during physician interviews (figure 2). A lack of physician support hindering widespread mHealth use is mirrored in a 2012 report by the Economist Intelligence Unit.\textsuperscript{14} Concerns over radiation are also of note, but current evidence is inconclusive; a review of the available epidemiological evidence states that mobile phone radiation is ‘probably’ carcinogenic.\textsuperscript{45} Until definitive evidence on the effects of mobile phone radiation emerges, it is likely to remain a barrier to its use. The usability of mobile phones in relation to age must be acknowledged. Participants show concern over the usefulness of mHealth for chronic diseases, which are typically prevalent in elderly, more technologically challenged patients. Although a valid concern for the current CVD population, only a few years separates the technologically literate generation from becoming the generation at risk of CVD. Thus, usability as a barrier is likely to lose its pertinence over future years.

There are several reasons why the success of potential mHealth use may lie in its ability to complement, rather than replace, existing methods of healthcare delivery. Evidence from the developed world has shown that mobile phones can be an effective complement to usual chronic disease management.\textsuperscript{22} Complementary methods would help to facilitate the acceptability of mHealth in a setting where mobile phone technology is a relatively recent innovation—outright replacement of conventional healthcare methods may deter instead of encourage apprehensive users, as is evident from the interviews. For moral and ethical reasons, mHealth should avoid perpetuating socioeconomic health inequalities: those who cannot afford a mobile phone should not be subjected to a lower standard of care than usual; thus, mHealth should not replace usual care. Finally, as reflected in the physician and patient interviews and supported by the results of a similar study for HIV/AIDS in Uganda,\textsuperscript{46} the importance of face-to-face patient-physician contact in disease management must not be forgotten. Without this, certain signs and the underlying context which might be crucial to diagnosis and management may be difficult to ascertain.

What may be most suitable for this population is an intervention similar to several trials worldwide using a bank of text messages to provide lifestyle advice and health awareness to high-risk individuals.\textsuperscript{47–49} This would target the current challenges of CVD management in Kerala in a manner suiting the limited resources and technological capability, as well as complement current methods of care without being intrusive to health workers.

**Strengths and limitations**

The results do not aim to be generalisable, but instead transferable to similar settings within Kerala as a valuable first step towards developing future mHealth interventions. However, our findings are likely to be relevant and generalisable to other rural settings in India, where access to health professionals and healthcare infrastructure is limited, despite the rapidly growing private healthcare sector. The timing of this research is also important, considering the growing interest and feasibility of mHealth applications in India across diverse disease areas.\textsuperscript{50–53}

Triangulation, through the use of mixed methodology and multiple data analysers, would strengthen this study by improving validity and producing robust and comprehensive findings. Respondent validation of results may establish the credibility of this research; however, participants are yet to comment on this report at the time of production. The researcher also acknowledges that data saturation is a disputable concept and novel themes may have emerged from further interviews.\textsuperscript{54}

**Areas for future research**

mHealth may have a role to play in improving CVD management in rural India in several ways, including improving access to healthcare professionals where resources are limited and task-shifting to non-physician health workers. Lifestyle change and patient education could be influenced by enabling easier access to information and by increasing patient networks. A survey in PHCs quantifying the extent and depth of physicians' perceived barriers to mHealth would be useful in prioritising where the need for adaptation and development of mHealth design is the greatest. Although text messages are feasible in a population with a high literacy rate, it is evident that calling is preferred; future research may investigate the acceptability and feasibility of text message versus call-based interventions.

**CONCLUSION**

mHealth may be a feasible way to target the current challenges of poor lifestyle and patient education in rural India. Complementary mHealth services may reduce high risk factor prevalence in this setting through health promotion and improved measures of...
primary prevention. Possible uses of mHealth include improving attendance at follow-up appointments and improving adherence to medications in primary and secondary prevention of CVD. Development of future uses of mHealth must address the barriers put forward by physicians in order to gain further support for its implementation.

Contributors The research and analysis was conceived by AB. RS, LF and JGR conducted the interviews under the supervision of RKK and JM. AL provided qualitative methodological support. RS and AB conducted the analyses. RS produced the initial draft of the manuscript and all authors contributed to the final manuscript.

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Competing interests None declared.

Ethics approval This study received ethical approval from the BMedSc.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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APPENDICES

Appendix 1: Research protocol

Appendix 2: Participation information sheets and consent forms

Appendix 3: Interview topic guides

Appendix 4: Codebook
Appendix 1: Research protocol

Potential for the use of mobile health applications in the management of cardiovascular disease in Kerala: a qualitative study

*Keywords:* mobile health, m-health, mobile phones, cardiovascular disease, Kerala, qualitative

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Local Supervisor: Dr. Jaideep Menon (Cardiologist, Amrita Institute of Medical Sciences, Cochin, India)

Introduction
Cardiovascular diseases (CVDs) alone are responsible for a third of all deaths worldwide, thus posing a major threat to global health (1-3). Moreover, the disproportionate global burden of CVDs is projected to rise over the next fifteen years, in contrast to the declining burden of communicable, maternal, perinatal and nutritional diseases (4-6). India is no exception as its CVD epidemic continues to thrive. CVD is projected to become the largest cause of death and disability in India by 2020, with mortality rates increasing to a staggering 4.77 million deaths per year (7,8).

India’s deteriorating outcomes are magnified in the Indian state of Kerala. In 2011, CVD was responsible for nearly 40% of all deaths in a survey of 161,942 rural adults (9). Such a high mortality rate may be explained by the state’s CVD risk factor profile: 21.9% are tobacco users, 39.7% have poor dietary habits, 33.9% show abdominal obesity, 28.8% have hypertension, 14.8% have diabetes mellitus, and 54.1% have hyperlipidaemia (10). Not only do these risk factors predispose to CVD, but they also place populations at risk of other important non-communicable diseases (NCDs) such as cancers and respiratory disease; thus, it is of great interest to public health initiatives to develop methods of managing these risk factors in order to confront the rising threat of NCDs.

With 900 million subscriptions in 2013, India is the second largest user of mobile phones worldwide (11). A combination of the overwhelming popularity, economic feasibility and widespread network coverage of mobile phones in both urban and rural contexts offers plenty of opportunities for health care delivery. The concept of using mobile devices to support medical and public health has been dubbed ‘mobile health’ or ‘m-health’ by the World Health Organisation and has already been integrated into disease control worldwide (12). The majority of m-health applications currently focus on sexual health and communicable diseases such as HIV/AIDS, tuberculosis and malaria, with evidence showing that SMS interventions are both acceptable and appropriate in many populations (13).

Despite ongoing research concerning other important diseases, the need for CVD prevention and surveillance in developing countries is unparalleled yet overlooked (6,8,14-16), and the potential for the uses of m-health in both primary and secondary CVD prevention is vast: it can identify high risk individuals; it can aid drug adherence; it can provide reminders about lifestyle and behavioural change; it can monitor CVD risk factors; more generally, it can improve doctor-patient communication and improve health care accessibility. There are already several CVD m-health interventions being trialled around the world, albeit in high income countries rather than low-middle income countries (LMICs) like India. An ongoing randomised controlled trial in Australia using SMS interventions for secondary prevention of CVD has received positive feedback regarding acceptability, comprehensibility and usefulness of the intervention (17,18). A systematic review of trials using similar interventions for primary
prevention of CVD found insufficient evidence to determine the effectiveness of interventions in reducing overall CVD risk, but lacked generalisability to LMICs (19). It is evident that CVD is no longer a disease of wealthier populations, and so further research is needed concerning m-health in LMICs where the NCD burden is rapidly escalating.

Despite the lack of CVD-specific m-health research in India, recent literature has proved that health care delivery via mobile phones is acceptable and feasible in a rural Indian context (20,21). However, due to the presence of inter-state health disparities, it is important to obtain region-specific data in India; thus there is still a recognised need for in-depth qualitative research regarding the acceptability of m-health interventions in a particular context (20-23). Throughout the literature, it is undisputed that m-health has enormous potential for revolutionising health care delivery in all settings; it is now the duty of researchers to explore and refine m-health services to suit specific populations to produce effective health interventions. This qualitative study will explore the perceptions of three different stakeholder populations concerning the potential uses of m-health and its acceptability in a Keralan context. It aims to look at management of CVD as a whole to explore where stakeholders think the greatest need for intervention is; whether in targeting CVD risk factors to prevent the development of acute CVD (primary prevention) or in managing established CVD (secondary prevention). This research will be carried out in conjunction with a quantitative survey addressing the acceptability and potential for use of mobile phones in CVD health care, and both studies will act as pilots for a large randomised trial using SMS intervention to improve primary prevention of acute CVD in high risk individuals.

**Aims & Objectives**

The aim of this research is to explore the potential for using m-health applications to manage cardiovascular disease in Kerala, India. This will be achieved by exploring: the experiences and perceived challenges in the current management of CVD; the current use of mobile phones; and the expectations, perceptions and barriers of using mobile phones for CVD management.

**Design**

This research will use both interviews and focus groups. Qualitative methodology is appropriate for rigorous exploration of personal experiences and expectations, generating rich, in-depth information relating to the topic (24).

**Setting**

The setting for this research is in the Ernakulam district of Kerala. Within Ernakulam district, this study will look at individuals from five adjacent panchayats (village districts) – Mookkannur, Karukutty, Manjapra, Thuravoor and Kalady. The Epidemiology of Noncommunicable Diseases in Rural Areas (ENDIRA) study, currently in press (25), conducted a survey of over 100,000 individuals from this area and identified those with CVD risk factors.

**Sample**

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<td>• employed in one of the five panchayats</td>
<td>• no specific exclusion criteria</td>
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<td>• involved in care of patients with CVD risk factors</td>
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A total of fifteen participants will be sampled from three key stakeholder populations in Ernakulam, resulting in the recruitment of five participants from each stakeholder population: (i) accredited social health activists (ASHAs) (ii) physicians treating CVD (iii) CVD patients with CVD and/or risk factors.

(i) **ASHAs.** Kerala state employs ASHAs as community health care workers to link the community with primary health care services. Firstly, five ASHAs will be recruited from the network of 75 ASHAs identified by the ENDIRA study (25), one ASHA from each of five panchayats. ASHAs are all female, literate and of a similar age (26); thus, due to limited variation of ASHAs, convenience sampling will be used.

(ii) **Physicians.** One physician involved in the care of a patient with CVD will be conveniently sampled from each of the five panchayats.

(iii) **Patients.** One patient will be sampled from each of the five different panchayats. Maximum variation sampling will aim to recruit five patients with varying demographics, CVD risk factors, and whether or not they have established CVD.

Malayalam is the official language of Kerala, although English is widely used in both education and social situations in both urban and rural contexts (27). Kerala has an impressive literacy rate of around 96% (27) and participant information sheets and consent forms will be provided in both languages to account for the participant’s literacy preferences. Doctors speak English fluently, whereas patients and ASHAs are more comfortable conversing in Malayalam. Thus, a bilingual research assistant, who is not a participant in the study, will translate the interviews/focus groups for patients and ASHAs and assist the researcher with any linguistic issues that arise during participant contact. The research assistant will be trained for several different roles, which will be described in further sections of this protocol, and sign a confidentiality agreement [appendix 1].

**Recruitment**

The research assistant will make the initial contact with all eligible participants by telephone. Participants will be informed on the nature and intent of the research and invited to participate. If participants express an interest in the study, the researcher and research assistant will meet them as soon as possible at their place of employment (ASHAs and physicians) or at home (patients) in order to start to build a rapport with participants, provide further information on the study (including withdrawal procedures and local contact details) and obtain written consent [appendix 2]. Consent will be gained by the researcher before enrolment into the study. If the participant is literate only in Malayalam, the research assistant will take consent. Fifteen participants will be recruited in total. Ideally, more participants would be recruited in order to ensure data saturation, which is the point at which no new ideas...
emerge from subsequent data collection (24). However, the time constraints of the research limit the number of participants recruited to fifteen.

**Data Collection and Storage**

Convenient dates for interviews/focus groups will be arranged after consent is given and participants will be reminded of their upcoming interviews/focus groups by telephone three days prior. All interviews/focus groups will: (i) be led by the researcher (ii) be conducted in English (iii) have a research assistant present for linguistic issues (iv) be audio-recorded using a Dictaphone (v) last around thirty minutes each (vi) take place in a private room in the local community health centre. All participants will be financially reimbursed for travel expenses. Field notes from interviews and focus groups will be recorded immediately in order to aid analysis and provide context.

Each participant will be interviewed separately by the researcher in one face-to-face, semi-structured interview. Semi-structured interviews allow the collection of rich, in-depth data relating to the research questions, while still maintaining flexibility to probe and expand on ideas (24). Topic guides are developed from previous qualitative literature concerning m-health applications (28-30) and will vary depending on the stakeholder group of the participant [appendix 3]. Broadly, the interview will explore three main areas: (i) the experiences and challenges of current CVD management (ii) how mobile phones are currently used on a daily basis (iii) ideas, perceptions and expectations of a potential CVD management mobile phone application.

Three to five weeks post-interview, participants will form a focus group consisting of the other four recruited members of their stakeholder population. Thus there will be three focus groups: one for ASHAs, one for physicians, and one for patients. Focus group discussion will facilitate interplay between the different stakeholders and may lead to both the emergence of novel themes and the recurrence of old themes (24). The topic guide for focus groups will again cover the three areas discussed during interviews [appendix 4] but may be adapted in the field to allow further discussion of themes generated from all interviews. Any themes from interview data will be discussed broadly, anonymised and exclude direct quotations in order to protect participant confidentiality.

Audio-recordings will be transcribed and stored on an encrypted hard-drive and a secure University of Birmingham server before deleting the original recording from the Dictaphone as soon as possible. Consent forms will be photographed and uploaded onto the same encrypted hard-drive before hard copies are destroyed and photographs deleted from the camera. A file of participants’ contact details will also be stored on an encrypted hard-drive. Transcribed data will be anonymised to maintain identity confidentiality. Upon return to the United Kingdom, research data will be stored on a University server. University regulations advise that research data be preserved and accessible for up to ten years after research completion (31).

**Analysis**

Interviews will be transcribed verbatim and anonymised before being uploaded onto Nvivo (a qualitative software data programme) and analysed by the author using thematic analysis, as described by Braun and Clarke (32). Firstly, transcripts will be read thoroughly and annotated. Data will then be broken down and derived into codes, before codes are linked and structured into themes (33). In order to allow emerging themes to be developed and tested, constant comparison will be employed throughout analysis: between interview data; between focus group data; and between focus group and interview data. The latter, as a method of triangulation, aims to increase the validity of the research if the themes developed from different methods of data extraction are consistent (24). Furthermore, respondent validation will be used to allow participants to corroborate any findings, encouraging the
researcher to practice reflexivity during analysis (34). Reflexivity will aim to minimise potential biases in data interpretation by continuous evaluation of the researcher’s influence on the analytical process.

Ethical Approval

Ethical approval will be sought from BMEdSc Population Sciences and Humanities Internal Ethics Review Committee at the University of Birmingham and the ethics committee at the Amrita Institute of Medical Sciences in Cochin, India. Ethics approval has already been applied for in India and this ethics review meeting will take place in Cochin on the 24th January 2015. Ethical approval is required from both committees because the proposed methodology of data collection involves human participants outside the United Kingdom.

Feasibility

Prior to the research, a pilot study will allow for the reviewing of the interview schedule to improve cultural appropriateness and understanding of questions following a trial on a patient, ASHA and physician. Recruiting patients and ASHAs should be feasible on account of the high prevalence of CVD and its risk factors in this population, in addition to the ENDIRA study authors stating that their network of 75 ASHAs were co-operative during their research (25). Physicians may be more difficult to recruit as they are fewer in number and may not have the time nor the desire to participate. The proposed timetable and relatively low costs of the research over an eight week period mean that the study is both practically and financially feasible [appendix 5]. Participant information sheets and consent forms will be translated and produced at the Amrita Institute of Medical Sciences and checked for understanding during the pilot study.

Acknowledgements

I would like to acknowledge Drs. Amitava Banerjee and Jaideep Menon for their continuing support and advice in constructing this research project, as well as Dr. Antje Lindenmeyer for all her help regarding qualitative methodology.

Lay Statement

Cardiovascular disease (heart attack and stroke) is a growing epidemic in India. In the state of Kerala, 40% of all deaths in 2011 were caused by cardiovascular disease alone. Reasons for such a high death toll may be due to the high rates of smoking, obesity, high blood pressure, high cholesterol and diabetes – all predisposing to cardiovascular disease. Also evident in India is the overwhelming popularity and widespread accessibility of mobile phones. Mobile phones have the potential to be a revolutionary source of health care delivery, and disease management schemes now need to harness the ubiquity of mobile phones towards improving health. This could involve the dissemination of health information, reminders to take medication or sending in blood pressure readings. This research will recruit patients, doctors and healthcare workers, exploring their views and expectations of the current management of cardiovascular disease, how they currently use mobile phones, and how mobile phones could be used in future disease management. This data will be extracted using interviews and focus groups before being analysed for common themes. With these findings, we can start to grasp where mobile phones have the most potential in improving cardiovascular disease in Kerala and combat these escalating trends.
References


Appendix 2: Participation information sheets and consent forms

Potential for the use of mobile health applications in the management of cardiovascular disease in Kerala: a qualitative study

[informed Consent Form for ASHAs]

Part I: Information Sheet

Dear Participant,

I am a medical student from the University Of Birmingham, England. As part of my degree, I am conducting research relating to international health.

I would like to invite you to take part in my research study. Before you decide, I would like you to understand why the research is being done and what it would involve for you. Either myself or the research assistant (who made the initial contact with you by telephone) will go through this information sheet with you and answer any questions you have. We suggest this will take about 20 minutes.

Purpose and Intent of Research

This research will explore how mobile phones can be used to support public health, a concept known as mobile health. I am specifically interested in cardiovascular disease (CVD) and its risk factors. Risk factors for CVD include high blood pressure, high cholesterol, obesity, diabetes, smoking and physical inactivity. I would like to find out what you think the current challenges are of managing CVD and its risk factors and what potential role mobile phones may have in managing the disease in the future.

Participant Selection

I believe your experience as an Accredited Social Health Activist (ASHA) looking after patients in your panchayat with CVD and/or CVD risk factors means that your thoughts are extremely valuable to my research. You have also been chosen because you can speak English and have access to a mobile phone.

Procedures

If you choose to participate, you will be asked to take part in both:

1. An interview, on your own
2. A focus group, with four other ASHAs

I will ask you to discuss your views on current CVD management, how you use your mobile phone in your daily life, and how you think mobile phones could be used to improve CVD care. The interview will take place first, followed by the focus group about 3-5 weeks later, with each session lasting about thirty minutes. You shall be reminded of your upcoming sessions three days before via telephone. Both sessions will be led by me and questions will be asked through a translator. Both will be conducted in a
private room in your local community health centre. You will be reimbursed on the day of your interview/focus group in cash for any travel expenses incurred – please provide your receipts used for travel to the health centre.

Confidentiality

Discussions will be audio-recorded and no-one else apart from myself will have access to the recorded information. Recordings will be uploaded and transcribed onto a password-protected computer and deleted off the recording device as soon as possible. All of your data will remain anonymous and I will not be sharing information about you to anyone outside the research team.

It is difficult to ensure confidentiality in focus groups due to the presence of other participants. Please respect the confidentiality of other members of the focus group by not sharing the information discussed in the focus group with others.

Voluntary Participation and Right to Refuse or Withdraw

Your participation in this research is entirely voluntary and you do not have to share any information or answer any questions that make you feel uncomfortable. It is your choice whether to participate or not and the choice that you make will have no effect on your job or job-related evaluations. If you choose to participate and later change your mind, you are free to withdraw from the research without giving any reason up to a week after the focus group. You may do so by contacting me using the contact details given below. If you choose to withdraw during/after focus group, your interview data will be excluded and destroyed. However, we cannot withdraw the data you provide in the focus group and this may still be analysed and included in the research.

Sharing the Results

After the research has been conducted, you will receive a summary of the results and have the opportunity to make sure your views have been accurately interpreted. There is a chance that the results of the research will be published so that others may learn from the research. You will not be identified in the published data.

Who to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, or you wish to withdraw from the research, you may contact the following:

Name: Rebecca Smith
Local telephone number: [local phone number not yet known]
E-mail: rxs189@bham.ac.uk

If you have a concern about any aspect of this study, you should ask to speak to the research supervisors:

Jaideep Menon (Amrita Institute of Medical Sciences, Cochin, Kerala): menon7jc@gmail.com
Amitava Banerjee (University of Birmingham, United Kingdom): a.banerjee.1@bham.ac.uk
Potential for the use of mobile health applications in the management of cardiovascular disease in Kerala: a qualitative study

[Informed Consent Form for Patients]

Part I: Information Sheet

Dear Participant,

I am a medical student from the University Of Birmingham, England. As part of my degree, I am conducting research relating to international health.

I would like to invite you to take part in my research study. Before you decide, I would like you to understand why the research is being done and what it would involve for you. Either myself or the research assistant (who made the initial contact with you by telephone) will go through this information sheet with you and answer any questions you have. We suggest this will take about 20 minutes.

Purpose and Intent of Research

This research will explore how mobile phones can be used to support public health, a concept known as mobile health. I am specifically interested in cardiovascular disease (CVD) and its risk factors. Risk factors for CVD include high blood pressure, high cholesterol, obesity, diabetes, smoking and physical inactivity. I would like to find out what you think the current challenges are of managing CVD and its risk factors and what potential role mobile phones may have in managing the disease in the future.

Participant Selection

I believe your experience as a patient with established CVD and/or CVD risk factors (as listed above) means that your views are extremely valuable to my research. You have also been chosen because you are being prescribed at least one drug to prevent CVD, you can speak English and you have access to a mobile phone.

Procedures

If you choose to participate, you will be asked to take part in both:

1. An interview, on your own
2. A focus group, with four other patients

I will ask you to discuss your views on current CVD management, how you use your mobile phone in your daily life, and how you think mobile phones could be used to improve CVD care. The interview will take place first, followed by the focus group about 3-5 weeks later, with each session lasting about thirty minutes. You shall be reminded of your upcoming sessions three days before via telephone. Both
sessions will be led by me and questions will be asked through a translator. Both will be conducted in a private room in your local community health centre. You will be reimbursed on the day of your interview/focus group in cash for any travel expenses incurred – please provide your receipts used for travel to the health centre.

Confidentiality

Discussions will be audio-recorded and no-one else apart from myself will have access to the recorded information. Recordings will be uploaded and transcribed onto a password-protected computer and deleted off the recording device as soon as possible. All of your data will remain anonymous and I will not be sharing information about you to anyone outside the research team.

It is difficult to ensure confidentiality in focus groups due to the presence of other participants. Please respect the confidentiality of other members of the focus group by not sharing the information discussed in the focus group with others.

Voluntary Participation and Right to Refuse or Withdraw

Your participation in this research is entirely voluntary and you do not have to share any information or answer any questions that make you feel uncomfortable. It is your choice whether to participate or not and the choice that you make will have no effect on the medical care you receive. If you choose to participate and later change your mind, you are free to withdraw from the research without giving any reason up to a week after the focus group. You may do so by contacting me using the contact details given below. If you choose to withdraw during/after focus group, your interview data will be excluded and destroyed. However, we cannot withdraw the data you provide in the focus group and this may still be analysed and included in the research.

Sharing the Results

After the research has been conducted, you will receive a summary of the results and have the opportunity to make sure your views have been accurately interpreted. There is a chance that the results of the research will be published so that others may learn from the research. You will not be identified in the published data.

Who to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, or you wish to withdraw from the research, you may contact the following:

Name: Rebecca Smith

Local telephone number: [local phone number not yet known]

E-mail: rxs189@bham.ac.uk

If you have a concern about any aspect of this study, you should ask to speak to the research supervisors:

Jaideep Menon (Amrita Institute of Medical Sciences, Cochin, Kerala): menon7jc@gmail.com

Amitava Banerjee (University of Birmingham, United Kingdom): a.banerjee.1@bham.ac.uk
Potential for the use of mobile health applications in the management of cardiovascular disease in Kerala: a qualitative study

[Informed Consent Form for Physicians]

Part I: Information Sheet

Dear Participant,

I am a medical student from the University Of Birmingham, England. As part of my degree, I am conducting research relating to international health.

I would like to invite you to take part in my research study. Before you decide, I would like you to understand why the research is being done and what it would involve for you. Either myself or the research assistant (who made the initial contact with you by telephone) will go through this information sheet with you and answer any questions you have. We suggest this will take about 20 minutes.

Purpose and Intent of Research

This research will explore how mobile phones can be used to support public health, a concept known as mobile health. I am specifically interested in cardiovascular disease (CVD) and its risk factors. Risk factors for CVD include high blood pressure, high cholesterol, obesity, diabetes, smoking and physical inactivity. I would like to find out what you think the current challenges are of managing CVD and its risk factors and what potential role mobile phones may have in managing the disease in the future.

Participant Selection

I believe your experience as a physician caring for patients with CVD and/or CVD risk factors means that your views are extremely valuable to my research. You have also been chosen because you can speak English and have access to a mobile phone.

Procedures

If you choose to participate, you will be asked to take part in both:

1. An interview, on your own
2. A focus group, with four other doctors

I will ask you to discuss your views on current CVD management, how you use your mobile phone in your daily life, and how you think mobile phones could be used to improve CVD care. The interview will take place first, followed by the focus group about 3-5 weeks later, with each session lasting about thirty minutes. You shall be reminded of your upcoming sessions three days before via telephone. Both sessions will be led by me, in English, with the research assistant present for any language issues. Both
will be conducted in a private room in your local community health centre. You will be reimbursed on the day of your interview/focus group in cash for any travel expenses incurred – please provide your receipts used for travel to the health centre.

Confidentiality
Discussions will be audio-recorded and no-one else apart from myself will have access to the recorded information. Recordings will be uploaded and transcribed onto a password-protected computer and deleted off the recording device as soon as possible. All of your data will remain anonymous and I will not be sharing information about you to anyone outside the research team.

It is difficult to ensure confidentiality in focus groups due to the presence of other participants. Please respect the confidentiality of other members of the focus group by not sharing the information discussed in the focus group with others.

Voluntary Participation and Right to Refuse or Withdraw
Your participation in this research is entirely voluntary and you do not have to share any information or answer any questions that make you feel uncomfortable. It is your choice whether to participate or not and the choice that you make will have no effect on your job or job-related evaluations. If you choose to participate and later change your mind, you are free to withdraw from the research without giving any reason up to a week after the focus group. You may do so by contacting me using the contact details given below. If you choose to withdraw during/after focus group, your interview data will be excluded and destroyed. However, we cannot withdraw the data you provide in the focus group and this may still be analysed and included in the research.

Sharing the Results
After the research has been conducted, you will receive a summary of the results and have the opportunity to make sure your views have been accurately interpreted. There is a chance that the results of the research will be published so that others may learn from the research. You will not be identified in the published data.

Who to Contact
If you have any questions, you can ask them now or later. If you wish to ask questions later, or you wish to withdraw from the research, you may contact the following:
Name: Rebecca Smith
Local telephone number: [local phone number not yet known]
E-mail: rxs189@bham.ac.uk
If you have a concern about any aspect of this study, you should ask to speak to the research supervisors:
Jaideep Menon (Amrita Institute of Medical Sciences, Cochin, Kerala): menon7jc@gmail.com
Amitava Banerjee (University of Birmingham, United Kingdom): a.banerjee.1@bham.ac.uk
Potential for the use of mobile health applications in the management of cardiovascular disease in Kerala: a qualitative study

Part II: Consent Form for Participants

- I confirm that I have read and understand the information sheet version 3.1 for the above study.

- I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

- I understand that my participation is voluntary and that I am free to withdraw up until a week after the focus group without giving any reason.

- I agree to take part in the above study.

Print Name of Participant: __________________________________________

Signature of Participant: __________________________________________

Date (DD/MM/YY): ______________________

Print Name of Person Gaining Consent: ________________________________

Signature of Person Gaining Consent: _________________________________

Date (DD/MM/YY): ______________________
Appendix 3: Interview topic guides

Interview topic guide for ASHAs

Introduction:

As you know, we are currently looking into ways in which mobile phones can be used to help support those living with cardiovascular disease (CVD) and/or its risk factors in order to better manage their condition. We would like to explore your views on the current management of CVD and the potential for the use of mobile phones in this aspect. If at any point you do not wish to answer any of the questions, you may say so and I will move on to the next question. You are free to terminate the interview at any point, in which case the data you provide will be erased. Do you have any questions before we begin?

Current CVD management:

- What is your current role in managing patients with CVD and/or CVD risk factors?
- How do you feel about the amount of contact you have with patients?
- Do you think patients feel well supported in managing their condition?
- What challenges do you face in managing patients with CVD and/or its risk factors?
- Is there anything you can think of that might facilitate the management of CVD in your population?
- How might management of CVD be improved in your population?

Mobile phone use:

- What experiences have you had using mobile phones in a health care setting? (Probe: contacting patients or other health care professionals, looking up clinical information, reminders, calendar, alarm)
- Have you ever given/received health care information on your mobile phone? If so, in what way? (Probe: given advice to patients; received information as advertising e.g. prescribing certain drugs)

Potential role of mobile phones in CVD management:

- What particular benefits are there of using mobile phones in managing CVD? (Probe: effects on drug adherence, improving accessibility to health care information, better appointment attendance, communication)
- What particular concerns do you have of using mobile phones to manage CVD? (Probe: usability, understanding, cost)
- Do you think patients would like to use mobile phones in managing their condition?
- More specifically, what do you think the advantages/disadvantages are of using mobile phones in:
  - primary prevention of CVD, i.e. managing CVD risk factors?
  - secondary prevention of CVD, i.e. preventing further acute CVD episodes? (Probe: sending in clinical data measured at home, e.g. blood pressure or blood glucose; providing healthy lifestyle reminders, contact with patients, inability to measure outcomes yourself, etc.)
- How do you think such a system would affect your job as an ASHA?
- Any further comments/ideas regarding mobile phone use in CVD management
Thank you so much for your time, your participation in this research is greatly appreciated.
Interview topic guide for **Physicians**

**Introduction:**
As you know, we are currently looking into ways in which mobile phones can be used to help support those living with cardiovascular disease (CVD) and/or its risk factors in order to better manage their condition. We would like to explore your views on the current management of CVD and the potential for the use of mobile phones in this aspect. If at any point you do not wish to answer any of the questions, you may say so and I will move on to the next question. You are free to terminate the interview at any point, in which case the data you provide will be erased. Do you have any questions before we begin?

**Experience of current CVD management:**
- What is your current role in managing patients with CVD and/or CVD risk factors?
- What kind of things do you make appointments with patients for?
- How do you feel about the amount of contact you have with your patient?
- What challenges do you face in managing patients with CVD and/or its risk factors?
- Is there anything you can think of that might facilitate management of CVD in this population?
- In what ways can the management of CVD be improved in your population?

**Mobile phone use:**
- What experiences have you had using mobile phones in a health care setting? (Probe: contacting patients or other health care professionals, looking up clinical information, reminders, calendar, alarm)
- Have you ever given/received health care information on your mobile phone? If so, in what way? (Probe: given advice to patients; received information as advertising e.g. prescribing certain drugs)

**Potential role of mobile phones in CVD management:**
- What particular benefits are there of using mobile phones in managing CVD? (Probe: effects on drug adherence, improving accessibility to health care information, better appointment attendance, communication)
- What particular concerns do you have of using mobile phones to manage CVD? (Probe: usability, understanding, cost)
- Do you think patients would like to use mobile phones in managing their condition?
- More specifically, what do you think the advantages/disadvantages are of using mobile phones in:
  - primary prevention of CVD, i.e. managing CVD risk factors?
  - secondary prevention of CVD, i.e. preventing further acute CVD episodes? (Probe: sending in clinical data measured at home, e.g. blood pressure or blood glucose; providing healthy lifestyle reminders, contact with patients, inability to measure outcomes yourself, etc.)
- How do you think such a system would affect your job as a doctor?
- Any further comments/ideas regarding mobile phone use in CVD management

Thank you so much for your time, your participation in this research is greatly appreciated.
Interview topic guide for Patients

Introduction:
As you know, we are currently looking into ways in which mobile phones can be used to help support those living with cardiovascular disease (CVD) and/or its risk factors in order to better manage their condition. We would like to find out how you currently experience your condition and how you think mobile phones can be used in managing your condition in the future. If at any point you do not wish to answer any of the questions, you may say so and I will move on to the next question. You are free to terminate the interview at any point, in which case the data you provide will be erased. Do you have any questions before we begin?

Experience of current CVD management:

• How has this condition impacted on your life?
• How do you currently manage your condition? (Probe: do you remember to take medication, appointments, maintain healthy behaviours, do you know what symptoms you should be aware of)
• What challenges do you face in managing your condition?
• If you have questions relating to your condition, how do you usually go about answering them?
• What is your experience of the current care provided to you?
• When would you normally contact your doctor or ASHA?
• Is there anything you can think of that might facilitate the management of your condition?

Mobile phone use:

• Do you personally own a mobile phone, or do you share the use of a mobile phone with others?
• How confident are you in using a mobile phone?
• What things do you use a mobile phone for in daily life? (Probe: texts, calls, internet, alarms, calendars, pictures, social media; are they aware of all the functions of their phone)
• Have you had any experiences in the past in using your mobile phone for managing your health? (Probe: appointment reminders, calls from doctors, health apps, medication reminders)

Potential role of mobile phones in CVD management:

• How do you feel about using a mobile phone to manage your condition? (Probe: in terms of travel, cost, time saved; give examples of things that you could do using a mobile phone instead of in person)
• What kind of things would you like to receive information about concerning your condition? (Probe: health behaviours, appointments, medication)
• How would you like to receive such information using your mobile phone?
• How do you think a system, such as reminders about appointments, lifestyle change, and taking medications might benefit you in managing your condition?
• What would benefits would you expect from such a system? (Probe: in terms of care given, how they manage their condition, how they feel, outcomes)
• What difficulties might you anticipate in using such a system? (Probe: cost, understanding, confidentiality)

• Can you think of any other ways mobile phones can be used to help you manage your condition?

Thank you so much for your time, your participation in this research is greatly appreciated.
Appendix 4: Codebook
N.B. The codebook is a list of codes generated during data interpretation and was used to visualise the point at which no more codes were being generated in order to determine data saturation. It is not a representation of coding density as codes may have been represented more than once in a single interview. Coding density was analysed using NVivo.

1. Experiences and challenges of current CVD management

<table>
<thead>
<tr>
<th>Code</th>
<th>When to use</th>
<th>Example</th>
<th>Interviews where code is used (interview number)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Referral</td>
<td>When participant mentions referring patients to higher/alternative services</td>
<td>“If the patient is showing a sudden symptom, I will refer them to a cardiologist”</td>
<td>ASHA 1,2,3 Physician 2,4,5 (1,4,5,7,10,14)</td>
</tr>
<tr>
<td>Home visits</td>
<td>When participant mentions visiting patients’ homes</td>
<td>“I visit patients at home”</td>
<td>ASHA 1,2,3,4,5 (1,4,7,10,13)</td>
</tr>
<tr>
<td>Signs/Symptoms</td>
<td>When participant mentions looking for signs and asking about symptoms of disease</td>
<td>“And then I see if there are any signs which need to be seen by a doctor”</td>
<td>ASHA 1 Physician 4,5 (1,11,14)</td>
</tr>
<tr>
<td>Checking compliance</td>
<td>When participant discusses the need to make sure patient is taking medication properly</td>
<td>“Then I see whether they are taking their medications on time, taking regularly or not”</td>
<td>ASHA 1,3,4 Physician 3 (1,7,8,10)</td>
</tr>
<tr>
<td>Clinical measurements</td>
<td>When participant mentions their role in taking clinical measurements, e.g. blood pressure</td>
<td>“And to repeat the examination, to analyse their BP and see whether it is an acceptable level”</td>
<td>ASHA 1,3 Physician 2,3,4 (1,5,7,8,11)</td>
</tr>
<tr>
<td>Early diagnosis and screening</td>
<td>When participant mentions role of early diagnosis and disease screening</td>
<td>“We have detected many of people who have just started with disease”</td>
<td>ASHA 4 Physician 2,4,5 (5,10,11,14)</td>
</tr>
<tr>
<td>Follow-up</td>
<td>When participant talks patients visiting the health centre for a follow up</td>
<td>“So if you once get a patient with a high BP, we will start the medicine, and then ask them to come back for a follow-up”</td>
<td>ASHA 2,3,4 Physician 2,3,4,5 Patient 1,2,4,5 (3-8,10-12,14,15)</td>
</tr>
<tr>
<td>Medication</td>
<td>When participant discusses giving/receiving medication as part of practice</td>
<td>“And we treat them using both health advice and medication”</td>
<td>ASHA 1,2 Physician 1,2,3,4,5 Patient 1,2,3,4,5 (1-6,8,9,11,12,14,15)</td>
</tr>
<tr>
<td>Medication problems</td>
<td>When participant discusses problems with taking medication</td>
<td>“So that is one issue, having to take medicines regularly”</td>
<td>Patient 3,4,5 (9,12,15)</td>
</tr>
<tr>
<td>Patient support</td>
<td>When participant talks about generally supporting patients</td>
<td>“We are giving a lot of support to them , in taking their medications and coming for regular check-ups”</td>
<td>ASHA 1,2,3,4,5 Physician 1,2,5 Patient 5 (1,2,4,5,7,10,13-15)</td>
</tr>
<tr>
<td>Health advice</td>
<td>When participant mentions role of health workers in giving patient general health advice</td>
<td>“We give them advice from the doctor about medicine, exercise, food controlling, we explain to them why this is needed”</td>
<td>ASHA 1,2,3,4,5 Physician 1,2,3,4 Patient 3 (1,2,4,5,7-9,10,11,13)</td>
</tr>
<tr>
<td>Consulting to clarify doubts</td>
<td>When participants mention that patients consult the doctor when they would like to clarify doubts</td>
<td>“I go to the doctor with my doubts and I consult the doctor”</td>
<td>Patient 1,2,3,4,5 (3,6,9,12,15)</td>
</tr>
<tr>
<td>Family influence</td>
<td>When participants mention the influence of the family on healthcare</td>
<td>“Sometimes we give the patient advice, and the other family members are listening, so the family members help them to follow the advice”</td>
<td>ASHA 2.3 Patient 4,5 (4,7,12,15)</td>
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<tr>
<td>Fear influence</td>
<td>When participant mentions the influence of fear on healthcare</td>
<td>“The last stage is when patients see the doctor, after they have had an operation, or angiogram, in the hospital, when they feel frightened”</td>
<td>ASHA 2 Physician 2 Patient 3 (4,5,9)</td>
</tr>
<tr>
<td>Diet</td>
<td>When participant discusses the need to modify/control diet</td>
<td>“Beef, fish, chicken, food! They eat lots of this. And lots of coconut oil! Not enough vegetables and too much food...Snacks, lots of snacks”</td>
<td>ASHA 1,2,3,4,5 Physician 1,3,4 Patient 1,3,4,5 (1-4,7-12,13,15)</td>
</tr>
<tr>
<td>Exercise</td>
<td>When participant discusses need to improve exercise</td>
<td>“And less exercise, they don’t do enough exercise. Now they just sit and watch TV, eating food”</td>
<td>ASHA 1,2,5 Physician 1,3,4 Patient 1,2,3,4,5 (1-4,6,9,11-13,15)</td>
</tr>
<tr>
<td>Alcohol</td>
<td>When participant mentions alcohol problems in population</td>
<td>“Drinking, lots of the people of Kerala are drinking”</td>
<td>ASHA 2,3,4,5 Physician 1 (2,4,7,10,13)</td>
</tr>
<tr>
<td>Smoking</td>
<td>When participant mentions smoking problems in population</td>
<td>“The most risk factor in our community is lifestyle problems, lifestyle issues like smoking”</td>
<td>ASHA 3,4,5 Physician 1,4 Patient 2 (2,6,7,10,11,13)</td>
</tr>
<tr>
<td>Difficulties</td>
<td>When participant talks about the difficulties patients experience in making lifestyle changes</td>
<td>Some patients are alcoholic and they find it difficult to give up the alcohol...these are the hardest lifestyles to change”</td>
<td>ASHA 2,3,4,5 Physician 2,4 Patient 2 (4-7,10,11,13)</td>
</tr>
<tr>
<td>Adequate patient contact</td>
<td>When participant says there is enough patient contact</td>
<td>“I feel it's adequate time, I spend around half an hour with the patient”</td>
<td>ASHA 1,2,3,4,5 Physician 1,4,5 (1,2,4,7,10,11,13,14)</td>
</tr>
<tr>
<td>Inadequate patient contact</td>
<td>When participant says there is not enough patient contact</td>
<td>“We don’t get enough time to actually see a patient properly. We just rush through most of the patients”</td>
<td>Physician 2,5 (5,8)</td>
</tr>
<tr>
<td>Money</td>
<td>When participant mentions money/expenses affecting healthcare delivery</td>
<td>“Some people have a mind-set, like if we spend money we get better treatment”</td>
<td>ASHA 1,2,4,5 Physician 2,5 Patient 1 (1,3,4,5,10,13,14)</td>
</tr>
<tr>
<td>Investigations</td>
<td>When participants mentions any tests/investigations</td>
<td>“Maybe they need scanning, x-ray, ECG”</td>
<td>ASHA 2 Physician 2,4 (4,5,11)</td>
</tr>
<tr>
<td>Lack of resources</td>
<td>When participants mention a lack of resources affecting healthcare delivery</td>
<td>“We don’t have a lab. So even the basic things we have to order outside.”</td>
<td>Physician 2,4,5 (5,11,14)</td>
</tr>
<tr>
<td>Health inequalities</td>
<td>When participant mentions health inequalities in this population</td>
<td>“Not all the poor people of course can afford to buy”</td>
<td>ASHA 1 (1)</td>
</tr>
<tr>
<td>Government</td>
<td>When participant discusses the role of the government in health and Kerala’s health care system</td>
<td>“So they are having most of the medications prescribed by the government”</td>
<td>ASHA 1 Physician 2,3,5 (1,5,8,14)</td>
</tr>
<tr>
<td>Patient interference</td>
<td>When participant mentions patient interfering with</td>
<td>“But some of them, they’re buying medicines and causing a”</td>
<td>ASHA 1 Physician 2</td>
</tr>
<tr>
<td>Treatment/healthcare delivery</td>
<td>Problem with their treatment</td>
<td>Improving patient awareness/education</td>
<td>Reduce risk factors</td>
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<tr>
<td>When participant discusses the need to improve the awareness and education of patients</td>
<td>“People need to be more informed”</td>
<td>ASHA 1,2,3,4,5 Physician 1,3,4,5 Patient 3,4</td>
<td>“Management is mainly, first it is the risk factors...if the risk factors are reduced, patients with CVD will be less”</td>
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<tr>
<td>Improving patient awareness/education</td>
<td>When participant discusses the need to improve the awareness and education of patients</td>
<td>“People need to be more informed”</td>
<td>ASHA 1,2,3,4,5 Physician 1,3,4,5 Patient 3,4</td>
</tr>
<tr>
<td>Reduce risk factors</td>
<td>When participant mentions the need to reduce risk factor prevalence</td>
<td>“Management is mainly, first it is the risk factors...if the risk factors are reduced, patients with CVD will be less”</td>
<td>ASHA 1,3,4 Physician 1,2,3,4,5</td>
</tr>
<tr>
<td>Physicians are busy</td>
<td>When participant mentions that doctors are busy</td>
<td>“Doctors may be being so busy, so busy that we can't encourage all patients to have contact with them”</td>
<td>Physician 1,3,4,5</td>
</tr>
<tr>
<td>ASHA/physician power</td>
<td>When participant mentions the power that health workers have over patients</td>
<td>“But if an ASHA worker or whoever says it’s necessary to come in to hospital, then they come in”</td>
<td>ASHA 1 Physician 2</td>
</tr>
<tr>
<td>Waiting time</td>
<td>When participant mentions waiting time at health facilities</td>
<td>“There is always a long line here and at the hospital”</td>
<td>ASHA 1 Physician 5</td>
</tr>
<tr>
<td>Population demographics</td>
<td>When participant mentions demographics specific to Kerala</td>
<td>“All are literate here, there’s 100% literacy in Kerala”</td>
<td>ASHA 1,4 Physician 1,3,5</td>
</tr>
<tr>
<td>Implementing primary prevention</td>
<td>When participant mentions primary prevention measures or preventing disease development</td>
<td>“We actually give them advice to prevent...to advise them not to go to cardiovascular diseases”</td>
<td>ASHA 2,3,4,5 Physician 1,2,3</td>
</tr>
<tr>
<td>Patients prefer secondary prevention</td>
<td>When participant discusses patients preferring secondary prevention/not being bothered about primary prevention</td>
<td>“More for secondary prevention. Because people are not bothered about primary prevention”</td>
<td>ASHA 2,3,5 Physician 2,3,4,5</td>
</tr>
</tbody>
</table>

2. Current mobile phone use
### Communication

When participant says they use their phone for general communication

"So you can keep regular contact with the patients"

ASHA 1,2,3,4,5
Physician 1,4,5
Patient 2,4

(1,2,4,6,7,10-14)

### Calls preferred

When participant states that phone calls are the preferred method of communication

"They call, no messages"

ASHA 1,2,3
Physician 1,2
Patient 1,2,3,4,5

(1-7,9,12,15)

### Texts not preferred

When participant explicitly states that texts are not the preferred method of communication

"Text message is limited information, nothing more nothing less"

ASHA 1
Physician 1,2
Patient 1,4,5

(1-3,5,12,15)

### Call/text no preference

When the participant states no preference between calling or texting

"Both, either message or phone. I do not mind"

ASHA 2
Physician 2

(4,5)

### Phones ubiquitous

When participant states everyone has/uses a mobile phone

"Because most of the patients, young or old, they have a mobile"

ASHA 1,2,3,5
Physician 1,4,5

(1,2,4,7,11,13,14)

### Internet use

When participant mentions using the internet on their phone

"Nowadays, internet are also available on phone, so we can easily access those information from the net too"

ASHA 4
Physician 1
Patient 3

(2,9,10)

### Advertising

When participant says they have received advertising through their mobile phone

"We have experienced also call from some private companies, to advertise drugs"

Physician 3

(8)

### Current use: appointments

When participant mentions using their phones to make appointments

"We use it to fix a time to see the doctor, to make appointment"

ASHA 2,3,4
Patient 5

(4,7,10,15)

### Current use: clarifying doubts

When participant uses phone to clarify doubts

"Patients can contact the ASHA workers for any doubts or problems"

ASHA 3,4,5
Physician 5
Patient 3

(7,9,10,13,14)

### Current use: referrals

When participant mentions use of phones to refer patients

"We use [phones] to refer patients diagnosed with CVD to cardiologists or physicians"

Physician 2,4,5

(5,11,14)

3. Expectations and barriers to mobile phone use in CVD management
| Phones improve health accessibility | When participant mentions that phones improve accessibility to healthcare services | “We can be using mobile phones to...give information about the different services available” | ASHA 1.2,4,5  
Physician 1.2,3,5  
Patient 2,4  
(1,2,4-6,8,10,12-14) |
| Phones improve health knowledge | When participant mentions that phones will improve their knowledge about health/disease | “We can be using mobile phones to help give information about the disease” | ASHA 1.4,5  
Physician 1,3,4  
Patient 2  
(2,6,8,10,11,13) |
| Phones improving communication | When participant states that phones will generally improve communication | “We can get good control of their symptoms, and better communication” | ASHA 1.2,3,4,5  
Physician 1,4,5  
Patient 4  
(1,2,4-7,10,14) |
| Phones for providing reminders | When participant discusses benefits of providing reminders of medication, appointments, lifestyle change | “We can give them messages for the advice and to remember” | ASHA 1.2,3,5  
Physician 1,2,3,4,5  
Patient 1,3,4,5  
(1,5-7,9-11-13) |
| Phones to make appointments | When participant says phones are useful for arranging appointments | “It would be useful to phone about appointments and medication” | ASHA 2,3,4  
Physician 2,3,5  
Patient 1,4,5  
(3,5,7,8,10,12,14,15) |
| Phones to help change lifestyle | When participant states that phones may help to change poor lifestyle | “If it was available, it would be beneficial to receive information about healthy lifestyle” | ASHA 2  
Physician 1,2,3,5  
Patient 1,2,3,4  
(2-6,8,9,12,14) |
| Phones to clarify doubts | When participant mentions that phones could help patients/health workers clarify doubts about disease | “So if there is any doubt, I can ask the doctor by telephone” | ASHA 3,4,5  
Physician 2,5  
Patient 2,3  
(5-7,9,10,13,14) |
| Phones to transmit data | When participant mentions that phones can be used to share clinical data, e.g. blood pressure readings, between patients and health workers | “We could send results through mobile phones, like the sugar levels, and the doctor can easily understand what is going on” | ASHA 3,5  
Physician 3,5  
(7,8,13,14) |
| Phones in emergencies | When participant states it would be useful to use phones in emergency situations | “In case of emergencies, if we are using phones, it would be more helpful to quickly contact the doctors” | ASHA 4,5  
Physician 2,4  
Patient 4  
(5,10-13) |
| Phones for symptom assessment | When participant mentions that phones might be useful for symptom assessment | “Patients could call and phone up with their symptoms” | ASHA 1  
Physician 4  
Patient 2  
(1,6,11) |
| Phones for reporting disease | When participant discusses the potential for phones in reporting disease | “Like, alert about some outbreak of any disease” | ASHA 3  
Physician 1  
(2,13) |
| Potential for text messaging | When participant discusses potential for using text messages | “Like if there was a text in mobiles in which you could send Malayalam messages, that would be better.” | ASHA 1,2  
Physician 2  
(1,4,5) |
| Phone usability | When participant mentions the usability of phones as a barrier | “First you need to know how to actually use the device before it can be useful. That’s one of the main drawbacks” | ASHA 3,4  
Physician 1,2,4  
Patient 3,4,5 |
<table>
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<tr>
<th>Topic</th>
<th>Participant Comments</th>
<th>References</th>
</tr>
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<td>Phone acceptability</td>
<td>When participant mentions the acceptability of phones as a barrier</td>
<td>(2,5,7,9,10)</td>
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<tr>
<td>Consider age</td>
<td>When participant mentions the need to consider age when thinking about usability of phones</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Perceived patient preferences</td>
<td>When participant says that patients would prefer to use mobile phones in healthcare</td>
<td>(2,4,7)</td>
</tr>
<tr>
<td>Phones expensive</td>
<td>When participant mentions the expense of using their phone</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Phones not expensive</td>
<td>When participant says phone use is not expensive</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Phones not a disturbance</td>
<td>When participant states that phones are not a disturbance to him/her</td>
<td>(2,4,7)</td>
</tr>
<tr>
<td>Positive effect on job</td>
<td>When participant states that mobile phone use would have a positive effect on their job</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Negative effect on job</td>
<td>When participant states that mobile phone use would have a negative effect on their job</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Phones will benefit patients</td>
<td>When participant says that mobile phone use will benefit patient’s health</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Phones save money</td>
<td>When participant mentions phones saving money</td>
<td>(2,4,7)</td>
</tr>
<tr>
<td>Phones save time</td>
<td>When participant mentions phones saving time</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Phones save travel</td>
<td>When participant mentions phones saving travel</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Direct patient contact preferred</td>
<td>When participant says that they would rather have direct contact than use mobile phones</td>
<td>(2,3,5)</td>
</tr>
<tr>
<td>Radiation fears</td>
<td>When participant mentions harmful effects from radiation as a barrier</td>
<td>(2,3,5)</td>
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