FULL TITLE


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FINANCIAL DISCLOSURE:
This research was supported by Humanities and Social Sciences Seed Fund, R-608-000-137-646 and the National University Health System (NUHS) Singapore Population Health Improvement Centre (SPHERiC).

ABSTRACT

Background: Cardiovascular disease, including atherosclerotic cardiovascular disease (ASCVD), is a growing public health threat globally and many individuals remain undiagnosed, untreated and uncontrolled. Simultaneously, mobile health (mHealth) interventions using short messaging service (SMS) have gained popularity globally. There is an opportunity for innovative approaches such as mHealth to encourage and enable adherence to medications for ASCVD and its risk factors.

Objective: This study seeks to understand mobile technology acceptance, use and facilitating conditions amongst the study population ahead of the design of an mHealth intervention.

Methods: Using data from a mixed methods study conducted in Singapore we conducted a cross-sectional survey with 100 participants and in-depth semi-structured interviews with 20 patients. All participants were over the age of 40 with ASCVD and/or its risk factors. Interviews were conducted in English and Mandarin and if needed translated to English. QSR Nvivo 11 was used for analyses.
Results: Participants reported their perspectives on technology use and preferences, including low or sporadic mobile phone use and usability concerns including small screen and text size, amongst others; the benefit of previous mHealth use in creating a favourable opinion of SMS for health information; trust in both the source of mHealth SMS, as well as trust in treatment, the formation of habits and fear of sequelae or death for facilitating intention to use an mHealth intervention and adhere to medication. We also highlight a case which underscored the importance of the period after diagnosis in habit forming as an opportunity for an mHealth intervention.

Conclusion: We identify factors relating to technology use, as well as factors impacting adherence to medications, that influence a patient’s intention to use an mHealth intervention, as well as enable or inhibit their intention to adopt such an intervention. As mHealth becomes increasingly used for the management of chronic conditions, it is important that mHealth interventions are contextually appropriate and consider the breadth of factors influencing patient uptake and use.

INTRODUCTION

Cardiovascular disease, including atherosclerotic cardiovascular disease (ASCVD), is a growing public health threat globally, with mortality rates estimated to reach 23.3 million by 2030 (Bansilal et al 2015). Importantly, many individuals with risk factors for ASCVD remain undiagnosed, untreated and uncontrolled (Perel et al 2006, WHO 2013, Perel et al 2015). This points
to the need for greater attention to factors impacting adherence in these patients and innovative approaches such as mHealth to encourage and enable adherence to medications for ASCVD and its risk factors in this patient population.

Mobile health (mHealth) interventions using short messaging service (SMS) have gained popularity as the number of people using mobile technology increases globally (WHO 2011). Singapore has one of the highest mobile phone penetration and usage rates in the world, thus providing an interesting case study for such interventions (Deloitte 2017). SMS based interventions have shown promise due to affordability and wide outreach and have been applied to many aspects of health including health promotion and to enable medication adherence (Leon et al 2015; Asiimwe et al 2011; Fassnacht et al 2015; Fiordelli et al 2015; Ali et al 2016). While mHealth has provided many opportunities to reach patients, especially vulnerable groups, it is important that contextually appropriate patient preferences, usability and acceptance of technology are considered when undertaking these interventions.

Patient preferences and acceptance are of particular importance when considering mHealth interventions for chronic conditions such as cardiovascular disease (CVD), as elderly patients managing chronic conditions may face unique usability concerns (Nischelwitzer et al 2007; Holzinger et al 2007). A systematic review demonstrated evidence of the feasibility of mHealth for adherence to medications for CVD, all 10 completed trials included in the review showed improved medication adherence for
patients with cardiovascular disease; all studies also reported positive responses to mHealth use from patients however, the authors highlighted the paucity of data on studies including user input on the design of the intervention (Gandapur et al 2016, Adler et al 2017). Qualitative studies have also shown the potential of mHealth to provide education, optimise resources and improve use of health care for cardiovascular disease management (Smith et al 2015). Yet, there is a need for more contextual evidence on patient acceptance and use of mHealth interventions for adherence, specifically exploring the unique factors which influence the use and acceptance of mHealth adherence supports for medications to treat chronic conditions. To explore the needs of those with or at risk for ASCVD in Singapore our study population comprised of patients over the age of 40 identified as having ASCVD, or risk factors for ASCVD including hypertension or hyperlipidemia.

The current study is the development phase of a proposed mHealth intervention, the txt2heart trial, to support patient adherence to medications for atherosclerotic cardiovascular disease (ASCVD). The txt2heart trial is an international collaboration evaluating the efficacy and safety of SMS on clinical outcomes and adherence in different countries including Colombia, Ghana, India and Singapore. This paper seeks to explore the mobile technology acceptance, use and facilitating conditions, as well as adherence factors, amongst the Singapore study population ahead of the design of the mHealth intervention.
METHODS

Sampling (Survey):
This cross-sectional component utilised data from a locally-adapted survey. The survey used purposive sampling of an existing patient pool from the Singapore Population Health Study - Community Health Study to recruit those age 40 years old and above with established ASCVD or risk factors who fulfilled inclusion criteria (see Box 1).

Box 1. Study inclusion and exclusion criteria.

<table>
<thead>
<tr>
<th>Inclusion Criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Patients with a history of atherosclerotic cardiovascular disease (ASCVD): coronary artery disease, ischemic stroke, peripheral artery disease, and atherosclerotic aortic disease; OR</td>
</tr>
<tr>
<td>2. At least one risk factor such as hypertension or hyperlipidemia; in whom anti-platelet, anti-hypertensives and/or statins are recommended.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusion Criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Participants unable to participate in a verbal interview;</td>
</tr>
<tr>
<td>2. Participants who did not speak Mandarin, English, or Malay languages</td>
</tr>
</tbody>
</table>

Sampling (Qualitative):
The study took place in Singapore, we used purposive sampling from an existing patient list to recruit those age 40 years and above with established ASCVD or risk factors for ASCVD, (for complete inclusion and exclusion criteria see Box 1).

Survey, interviews and interview guide:
Trained research staff from the National University of Singapore conducted the interviews or semi-structured in-depth interviews in the participant's preferred language by staff fluent in that language. Interviewer training included description of research protocol, qualitative methods and research ethics in practice.

Both the survey and interview guide was developed as part of the larger txt2heart collaboration, which we then adapted to the Singapore context and covered topics including, patients' sociodemographic characteristics, health care access, medication adherence, mobile phone technology usage (ownership, access and utilization) and interest in mHealth. (see Table 1).

Table 1. Summary qualitative interview guide.

<table>
<thead>
<tr>
<th>Introductory Questions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Take demographic information</td>
</tr>
<tr>
<td>• To start, could you tell us a bit about your family?</td>
</tr>
<tr>
<td>• Can you tell me a bit about your living situation? Do you live with anyone? Who?</td>
</tr>
<tr>
<td>• Are you currently employed?</td>
</tr>
<tr>
<td>• Does anyone help you with your daily tasks like chores or cooking?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medical History and perception of condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Could you tell me about your health history (or medical conditions you have)? [Follow their narrative to explore the patients' journey]</td>
</tr>
<tr>
<td>• Can you tell me about how you were diagnosed with Cardiovascular/heart disease?</td>
</tr>
<tr>
<td>• Could you share with me the changes you had to make in daily life after you were diagnosed with CVD/heart disease?</td>
</tr>
<tr>
<td>• What do you think contributed to your CVD/heart disease?</td>
</tr>
<tr>
<td>• What did you know about CVD/heart disease before you were diagnosed?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perception and taking medication</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Could you share with us all the medicine you currently take? [Ask if it is possible for us to see the medication, and ask about when and how often they take it]</td>
</tr>
<tr>
<td>• What instructions were you given on how to take the medication</td>
</tr>
<tr>
<td>• Do you feel like taking the medication helps to relief of your condition?</td>
</tr>
<tr>
<td>Question</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Do you take your medication regularly?</td>
</tr>
<tr>
<td>Do you experience any problems in taking the medication?</td>
</tr>
<tr>
<td>Do you ever forget to take your medicine?</td>
</tr>
<tr>
<td>Does anyone or anything remind you to take your medication?</td>
</tr>
</tbody>
</table>

**Health System Perception**

- Moving on, can you tell me about where you go to see the doctor for your CVD/heart disease?
- How often do you see your doctor?
- Overall, what is your relationship with your doctor like?
- Do you talk to any other health care workers for your CVD/heart disease? Nurses?
- Counsellors? Can you tell me about your relationship with them?
- Do you face any difficulties accessing health services?
- How do you pay for your medical expenses?
- Do you have any problems affording for your CVD/heart disease medication?

**Support and information networks**

- Where do you seek information about how to manage your CVD/heart disease?
- What kind of information?
- Do you use this information frequently?
- Do you feel like you have enough information to help you manage your CVD/heart disease?
- Does anyone help you manage your CVD/Heart Disease?

**Use and appropriation of technology**

- Do you own a mobile phone?
- How often do you use your mobile phone?
- What do you usually use your mobile phone for?
- Do you experience any difficulties using your mobile phone?
- Would you find it useful to receive information about different aspects of your treatment through your mobile phone?
- Would you find it useful to receive reminders to take your medication through your mobile phone?
- How often would you like to receive such reminders?
- Would you like the possibility of being able to reply to these messages, where healthcare professionals can respond to your queries?

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**Participants:**

The qualitative component involved semi-structured in-depth interviews with 20 participants. Out of the 20 participants interviewed, 19 agreed to audio recording, and 1 participant declined. For the latter, detailed field notes and an extensive memo were taken for inclusion in data analysis.
One hundred patients met the inclusion criteria for the quantitative survey and were recruited over the telephone. In total, 60 in-person and 40 telephone surveys were completed following informed consent from patients. A total of 100 surveys, inclusive of 1 incomplete survey on mobile phone technology usage section, assessed patients’ sociodemographic characteristics, pattern of medication adherence, mobile phone technology usage (ownership, access and utilization), and interest in mHealth.

Ethical approval:

Ethical approval for the study was obtained from the NUS Institutional Review Board (IRB). Informed consent for participation and recording was obtained before the interview started using a Participant Information Sheet and Consent Form. Participants could refuse to answer any of the questions and/or discontinue their participation in the research at any time.

Statistical Analysis:

Statistical analyses were performed using SPSS version 24.0. Frequencies (n) and percentages (%) were used to summarize sociodemographic characteristics, clinical characteristics, patterns of mobile phone technology usage and interest in mHealth.

Qualitative Analysis:

Two research team members coded interviews using QSR Nvivo 11 Software, applying interpretive and inductive approaches, thematic analysis and
techniques from the constant comparative method, where line-by-line analysis of early interviews is used on subsequent interviews to test preliminary assumptions (Strauss 1987, Chamez 2006). Interviews were recorded and transcribed in full. Reviewers agreed on identified codes and themes. To maintain confidentiality, all names reported are pseudonyms and identifying data has been excluded.

THEORETICAL FRAMEWORK

Using a deductive approach we used the Unified Theory of Acceptance and Use of Technology (UTAUT) model to analyse our findings, this was then complemented by emergent themes on medication adherence factors which prompted us to apply the WHO adherence model to our data (Venkatesh 2003, WHO 2013). We then applied the modified and condensed UTAUT model to understand technology acceptance and use amongst participants with ASCVD and ASCVD risk factors (Fig 1). The UTAUT has been widely used to understand IT adoption in general, and has also been applied to health information technology (HIT) (Benmessaoud et al 2011; Phichitchaisopa et al 2013; Kohnke et al 2014; Cranen et al 2012; Cimperman et al 2016).

Figure 1. Modified UTAUT model for adherence factors.
The UTAUT model employs 4 constructs through which to explore user factors, these being 1) performance expectancy 2) effort expectancy 3) social influence and 4) facilitating conditions. Performance expectancy includes the perceived usefulness and personal outcome expectations associated with technology use. Effort expectancy is the perceived ease of use and complexity of the technology. Social influence includes subjective norms and technology use within a user’s social milieu, while facilitating conditions include perceived behavioural control and wider contextual circumstances that support the use of technology. We have labeled these as technology-oriented factors as they explore the users experience and preferences as oriented to their use and acceptance of technology.
Underpinning these constructs, and impacting them in multiple complex ways, are the influence of person-oriented factors including; gender, age, socioeconomic factors, experience and voluntariness of technology use. The confluence of these factors ultimately impacts one's behavioural intention and use behaviour, as well as the actual use of the mobile technology or intervention.

An important modification necessary to understand use and acceptance of an mHealth intervention for adherence are the adherence factors which may contribute to the behavioural intention and use of the intervention. As the ultimate goal of the intervention is to support patients in adhering to their medications, it is necessary to consider the adherence related factors which may ultimately inhibit patients' intention to use and acceptance of an mHealth intervention (WHO 2013). For our purposes we have adapted the WHO framework to focus on the condition-related factors and therapy-related factors impact adherence. Condition-related factors are the illness-related demands faced by the patient which ultimately impact a patient's risk perception, treatment beliefs and the priority they place on adherence (WHO 2013). Therapy-related factors include side effects, treatment duration, treatment failures and experience of side effects (WHO 2013). In seeking to understand the use and acceptance of an mHealth intervention for adherence, it is important to consider the symptomatology, side effects and beliefs or perceptions around treatment that can motivate or dissuade patients. While an intervention may meet the technology-oriented needs of a patient, their
lived experience of their condition(s) and treatments could present barriers to their behavioural intention, both to adhere to treatment, as well as to use an mHealth intervention to support treatment adherence.

In this paper we explore in detail the technology-oriented aspects of UTAUT, as well as therapy-related and condition-related adherence factors acting upon a patient's behavioural intention. Thus, we use the modified and condensed UTAUT model and key elements of the WHO framework as a way to better understand the factors impacting elderly Singaporeans acceptance and use of mobile technology for an intervention to support adherence to ASCVD medication.

RESULTS

To better contextualise our findings it is necessary to consider larger health systems factors relevant to Singapore, primarily the ubiquity of affordable and accessible health care. Singaporeans have access to largely subsidised care offered in polyclinics (government subsidised general practice clinics), private GPs and tertiary care facilities for primary care and chronic condition management. Further, within the primary care setting, doctors regularly prescribe months worth of medications thus enabling ease of access to medications. The government also provides subsidies and various schemes for the management of chronic conditions, the majority of our participants reporting availing themselves of these schemes in order to pay for their
healthcare and most reported being able to afford and access their cardiovascular disease medications.

Participant Characteristics:

The mean age of the 100 participants in the analysis sample was 65.3 ± 9.6 years (Table 2). The largest proportion of participants encompassed those aged ≥65 years (55.0%). The majority of patients were male (70.0%) and of Chinese ethnicity (66.0%), with women, and Malay, Indian and other ethnicities representing a smaller proportion of the sample. Also, the majority of patients reported having hyperlipidemia (72.0%) and hypertension (68.0%).

Table 2. Quantitative participant characteristics table

<table>
<thead>
<tr>
<th>Sociodemographic characteristics</th>
<th>Total, n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity (n = 100)</td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>66</td>
</tr>
<tr>
<td>Malay</td>
<td>19</td>
</tr>
<tr>
<td>Indian</td>
<td>14</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td>Gender (n = 100)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>70</td>
</tr>
<tr>
<td>Female</td>
<td>30</td>
</tr>
<tr>
<td>Age (years) (n = 100)</td>
<td></td>
</tr>
<tr>
<td>&lt; 65 years old</td>
<td>45</td>
</tr>
<tr>
<td>≥ 65 years old</td>
<td>55</td>
</tr>
<tr>
<td>Mean(SD) (n = 100)</td>
<td>65.3 (9.6)</td>
</tr>
<tr>
<td>Cardiovascular conditions</td>
<td></td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>72</td>
</tr>
<tr>
<td>Hypertension</td>
<td>68</td>
</tr>
<tr>
<td>Myocardial infarction/acute coronary syndrome</td>
<td>41</td>
</tr>
<tr>
<td>Stroke/Transient ischemic attack</td>
<td>14</td>
</tr>
</tbody>
</table>
We conducted 20 in-depth interviews with participants who met inclusion criteria, detailed characteristics are presented in Table 3. Participants were largely of Chinese ethnicity (n=15) with fewer participants from Indian (n=4) and Malay (n=1) ethnic groups. Participants were mostly male (n=12) with eight female participants. The average age of participants was 72.5. Majority of participants (n=19) reported a hypertension diagnosis, followed by hyperlipidemia (n=16) and myocardial infarction/acute coronary syndrome (n=8) and stroke/transient ischemic attack (n=5).

Table 3. Qualitative participant characteristics table

<table>
<thead>
<tr>
<th>Sociodemographic characteristics</th>
<th>Total, n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity (n = 20)</td>
<td></td>
</tr>
<tr>
<td>Chinese</td>
<td>15</td>
</tr>
<tr>
<td>Indian</td>
<td>4</td>
</tr>
<tr>
<td>Malay</td>
<td>1</td>
</tr>
<tr>
<td>Gender (n = 20)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
</tr>
<tr>
<td>Age (years) (n = 20)</td>
<td></td>
</tr>
<tr>
<td>61-70</td>
<td>7</td>
</tr>
<tr>
<td>71-80</td>
<td>8</td>
</tr>
<tr>
<td>81-90</td>
<td>4</td>
</tr>
<tr>
<td>Missing*</td>
<td>1</td>
</tr>
<tr>
<td>Mean (n = 19)</td>
<td>72.5</td>
</tr>
<tr>
<td>Cardiovascular conditions</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>19</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>16</td>
</tr>
<tr>
<td>Myocardial infarction/acute coronary syndrome</td>
<td>8</td>
</tr>
<tr>
<td>Stroke/Transient ischemic attack</td>
<td>5</td>
</tr>
</tbody>
</table>
A quantitative survey of 100 patients meeting the same criteria outlined above provided our study with descriptive data on our target population (Figure 3). Of 99 participants who fully completed the survey, 90 (90.9%) owned a mobile phone. Of those mobile phone owners, 70 (77.8%) reported accessing their mobile phones in general at least once a day and the same proportion of patients (77.8%) reported using SMS at least once a day. In general, participants predominantly used their phones for phone calls (97.8%), SMS (65.6%) and other text messaging services such as Whatsapp (61.1%).

Figure 3. Phone usage activities amongst mobile phone owners.

Of those who owned a mobile phone, 48 (53.3%) indicated their interest in receiving medication information through their mobile phones.

Figure 4. Interest in receiving medication information via mobile phone
Amongst those 48 interested in mHealth services, SMS (83.3%) was the preferred mode of delivery of information on medication; followed by other text messaging services (68.8%), phone calls (66.7%) and, social media such as Facebook (31.1%) and e-mail (31.3%) (Figure 5).
Findings: Modified UTAUT

We report our findings classified into six main themes as per the modified UTAUT model. In terms of technology-oriented factors, the first theme explores performance expectancy including perceived usefulness of the mHealth intervention and personal outcome expectations. The second theme explores effort expectancy, including perceived ease of use, as well as other usability issues experienced by our elderly population. Next, we explore the social influences shaping technology use including the role of family and friends, as well as the impact of social isolation. Then, we look at facilitating conditions for technology use including trust and previous mHealth use. We next explore adherence factors influencing behavioral intention, including therapy-related factors such as regime complexity, therapy duration, inconvenience, and adverse effects. Finally, we look at condition-related factors including symptoms and effects of condition on functional and mental state. Table 4 illustrates our key themes and examples of evidence.

Table 4. Key themes and examples of evidence.

<table>
<thead>
<tr>
<th>Modified UTAUT Constructs</th>
<th>Examples of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology-Oriented Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Performance Expectancy</td>
<td>Perceived usefulness</td>
</tr>
<tr>
<td>Personal outcome</td>
<td>“People won’t bother. You ask me to do it, give it to me, you can’t incentivize me to do it because it’s a</td>
</tr>
<tr>
<td>Effort Expectancy</td>
<td>Perceived ease of use</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Usability issues</td>
<td>“Firstly, the numbers are very small, my fingers are very thick, so two numbers would be dialled at the same time.” IDI002_M-81-85_Chinese</td>
</tr>
<tr>
<td>Social Influence</td>
<td>Family/friends technology use</td>
</tr>
<tr>
<td>Facilitating Conditions</td>
<td>Previous mHealth use</td>
</tr>
<tr>
<td>Trust</td>
<td>“With apps, you don’t know who’s on the other side, a person with no name.” IDI007_M_61-65_Indian</td>
</tr>
<tr>
<td>Adherence Factors</td>
<td>Therapy Related Factors</td>
</tr>
<tr>
<td>Complexity of medication regime</td>
<td>“I told them best not to ask me to take 1.5 pills. It’s hard to cut a pill...” IDI005_F_81-85_Chinese</td>
</tr>
<tr>
<td>Duration of therapy</td>
<td>“No, cannot be [confusing to take]. ‘Coz I’m already used to them. I’ve been taking them for 14 plus years.” IDI010_M_71-75_Indian</td>
</tr>
<tr>
<td>Inconvenience with lifestyle</td>
<td>“I tend to forget my medications in the morning on weekends. I take care of my grandchildren, I go to Woodlands where my daughter stays, and so I forget.”</td>
</tr>
</tbody>
</table>
### Technology-Oriented Factors

Technology-oriented factors include performance expectancy, effort, social influence and facilitating conditions which may either facilitate or inhibit mobile technology use and the uptake of an mHealth intervention. In order to design an appropriate mHealth intervention it is necessary to understand patients’ technology use, preferences and expectations.

#### Performance Expectancy

<table>
<thead>
<tr>
<th>Condition Related Factors</th>
<th>Lack of symptoms</th>
<th>Effect on functional status or mental state</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IDI004_F_66-70_Chinese</strong></td>
<td>&quot;Yes. I would feel unwell when I took previous medications. The doctor asked me about side effects. I told the doctor after I took the medication I would feel pain here, so I wouldn’t dare to eat the medications.&quot;</td>
<td>&quot;For blood pressure, I usually don’t take the medications unless my blood pressure is high.&quot;</td>
</tr>
<tr>
<td><strong>IDI014_M_71-75_Chinese</strong></td>
<td>&quot;It is helpful for your knowledge but sometimes it makes you worried when you look at the medicine, you know? It affects you in that way, you know? ‘Am I killing myself by taking the medicine, or..?”</td>
<td>&quot;It is helpful for your knowledge but sometimes it makes you worried when you look at the medicine, you know? It affects you in that way, you know? ‘Am I killing myself by taking the medicine, or..?”</td>
</tr>
</tbody>
</table>

**IDI011_F_61-65_Indian**
Performance expectancy relates to how users expect the mHealth intervention to work for them and includes perceived usefulness and personal outcome expectations associated with technology use. Whether users believe that a technology or intervention will work for them and provide favourable outcomes ultimately impacts their behavioural intention and use behaviour towards the technology.

Perceived usefulness

Participants reported on their perception of the usefulness of having a reminder system to take their medications. Most participants reported that they saw no need for such a system as they did not have difficulties remembering. As Yong Liat reported,

“I can’t forget. Every time I put it on top, and I write down there. So I know. People don’t need to tell me. I know myself.” IDI006_M_81-85_Chinese

However, some participants did agree that hypothetically having reminders may be good for others who forget to take their medications. As Kim Huat explained,

“They should see the message and it should help. After all the reminder for them to take the medication is actually beneficial for them, and they should heed the reminders.” IDI009_M_71-75_Chinese
Some participants also voiced that low phone usage may inhibit the usefulness of an SMS intervention. As Irene described, “I don’t look at my phone. I only look at my phone during the day. Sometimes people call me to remind me that they sent me an SMS. Sometimes when I’m very busy, when the phone beeps with an SMS I’ll think of checking it later, but I’ll forget. Do you see how many unread and unanswered SMSes and WhatsApp message I have?”

IDI004_F_66-70_Chinese

Personal outcomes expectations
The majority of participants explained that they personally felt an SMS intervention would not be useful or provide a useful outcome, Partly this is due to some participants having low reliance on their phones, meaning the vehicle for delivery may not be aligned with the population’s mobile uses. Further, some participants expressed that the intervention does not address what they perceive to be the root causes of non-adherence, which they feel to be beyond the reach of mHealth. For example, an SMS intervention would not help those who intentionally do not take their medication. As Ah Siew explained, “If they want to take medication, they will. Some people they’re not taking it on purpose. I don’t take some of my medication too. We take only the important medicine and don’t take those that we feel aren’t important.” IDI020_F_71-75_Chinese
Another participant highlighted that regardless of the proposed intervention, a key factor in adherence is patient agency and responsibility in placing importance on their health. Yan Ting explained, “I think whatever method you want to use, it’s nothing compare to convincing that patient that it is in their own interest and it is important for them to take the medicine regularly according to the schedule... I think if they are serious looking after themselves, it becomes a habit already. It becomes a habit or schedule and they will have no problem of following.” IDI018_M_76-80_Chinese

However, some participants reported on factors which may be modifiable by an mHealth intervention; Irene summed up her perspective of the main factors for non-adherence – forgetfulness, dependency on others and being busy.

“Interviewer: How do you think we can use mobile phones to remind people to take their medication?”

“Participant: When people forget to take their medications it’s the following three reasons. First, they’re forgetful, like me. I tell myself it’s time to take my medication and walk to the kitchen. When I’m in the kitchen, I can’t remember why I came into the kitchen. Second, they’re dependent. They wait for people to tell them. Third, they are too busy. Just these three types of people.” IDI004_F_66-70_Chinese
Effort Expectancy

As mHealth interventions predicate on patients being able to interact with SMS, it is important to understand their perceptions of basic mobile technologies as well as their perceptions on their ability to learn how to use such technologies. Further, we explore reported functional issues which may prevent uptake of an mHealth intervention.

Perceived ease of use

Some participants described difficulty using a mobile phone, thus preventing them for being interested in an mHealth intervention. Wen Cheng reported,

“There is a lot of stuff in the mobile phone but it’s very difficult for us to learn how to use them. It’s not easy… I’ve attempted but it’s not easy.”

IDI001_M_71-75_Chinese

However, others were keen to keep up with technology and expressed initiative and interest in learning about their phones. Safiah explained how she previously did not know how to use some features of her phone but now is able to,

“Previously I SMS right-- previously aunty don’t know how to SMS. I SMS one straight row without stopping. So you cannot read anything, right? I know but I don’t know where to stop, how to space, all I don’t know. Then I learn from them (my grandchildren). Then they teach me. So WhatsApp, all these I learn from them. So now everything I know.
You live in the world of today, you cannot sit at home like Malay saying, you cannot be a frog under the stone. Every now and then, you must go out and learn everything. What the youngsters can do, the old also can do.” IDI012_F_71-75_Malay

Amongst those who are comfortable using technology, a few reported that SMS is a good and convenient way to convey health information.

“It’s also good via SMS or WhatsApp since it’s more convenient and the information is in the phone. Sometimes we might not have time to answer a call.” IDI009_M_76-80_Chinese

Usability Issues

Many participants, however, reported on functional issues preventing them from comfortably using a mobile phone.

Many reported that a small screen or font size is a barrier to reading SMS messages. As Cheng Han explained,

“Our eyesight is also failing. Sometimes we see an “8” as an “S”. It also makes it difficult to read our SMS. Our senses all deteriorate after 70 years old.” IDI014_M_71-75_Chinese

Others reported that they may miss SMS messages due to being hard of hearing or not carrying their phone with them. As Yu Yan described,
“I usually cannot hear it. As I put it in my bag, I don’t know if it’s because my hearing is bad, but sometimes others remind me that my phone is ringing.” IDI008_F_71-75_Chinese

Another usability concern raised by many participants was that of language of the intervention, most participants agreed the SMS reminders should be sent in local languages, as Kim Huat reported,

“It would help if it’s in Chinese, Malay, Tamil. Those of us who are older don’t understand English, and thus the content in the SMS.” IDI009_M_76-80_Chinese

While Sow Tin explained that some older people had lower literacy and thus require simplified SMS content.

“Firstly, I didn’t really go to school. So I can only read really simple English and Chinese. I can speak better, but not write… I will just reply “Ok”. If I don’t know how to text back my response, I will send them a voice message. It’s easier like that.” IDI004_F_66-10_Chinese

Social Influence

Another important component of technology uptake and use is that of social influence. Those with stronger social networks who use and look favourably
on technology may use technology to connect and stay in touch, and these networks may in turn enable them to adopt technology.

Family and friends technology use

Some participants reported lack that the social support system is a reason for not being interested in using a mobile phone and others reported using the phone less as their friends had passed away. As Wen Cheng explained,

“I don’t have many friends. I don’t need to talk a lot now, or I just use the home telephone.” IDI001_M_71-75_Chinese

Amongst those who had stronger social supports, many described that their friends were an important factor in their ability to learn and keep up with technology. As Kim Huat reported,

“I ask friends who use the iPhone too. So I can ask them when I don’t know something.” IDI009_M_76-80_Chinese

Others described how technology had enabled them to keep in touch with friends from abroad and that these groups were helpful to them, thus giving them a favourable impression of mobile technology. As Micheal said,

“All the time, Whatsapp. We have a group of school friends from Penang and Singapore all together in one Whatsapp group. We

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actually have 3 different group -- 1 Singapore based, 1 Malaysian based ,etc. Everybody helps each other.” IDI0015_M_61-65_Chinese

One participant described how technology and social support played a role in her adherence. As Kavita reported,

“She [friend] every time calls me, you know, because she know I forget. “Hey, take medicine already?” She don’t know which medicine I take but she give me a reminder, “Hey, did you take medicine already?”. Then I said, “Yeah, Yeah, now I go make coffee, eat some biscuit and take”. Every time she gives me call and I remember.” IDI013_F_61-65_Indian

Facilitating Conditions

Beyond expectations, usability and a favourable social milieu, there are other factors which create facilitating conditions for users to uptake and use technology, our participants highlighted the importance of previous exposure to mHealth services and trust.

Previous mHealth use

A majority of participants reported positive experiences with previous mHealth applications, namely SMS appointment reminders. Participants felt these were useful and helped them to remember their appointments. Kim Huat explained,
“They will send SMS to me, and they also give me a paper with the
appointment date. They usually remind me via SMS a week before my
appointment...It's a good reminder so that you don’t forget.”

IDI009_M_76-80_Chinese

One participant, Kamal, highlighted that patients may not be an appropriate
audience to target the SMS reminders to and it would be more useful to
engage primary caregivers in mHealth interventions.

Tell the person looking after the patient to remind them to take their
medication...The person cannot remember. Sometimes they forget or
they're lazy to take out (medicine), so if you tell the children or
(caregiver) they will make sure they take the medication, as if the
orders come from the doctor the caregiver will scared and make sure
they take.” IDI010_M_71-75_Indian

Trust

An important facilitating factor reported by patients was that of trust. Some
patients explained that they do not trust all the information that they get online
or shared through Whatsapp groups. As Kim Huat said,

“There are a lot of fake information there (on the phone), not all are
ture.” IDI009_M_76-80_Chinese
Kim Huat went on to explain how underlying trust in treatment is important in an mHealth intervention for adherence to medications.

“Interviewer: Who do you think this service will help?

Participant: Those that believes that their medication is effective. After all if you face any issues while taking the medication, the doctor and change it for you. Also, those who are concerned about their health when they see these messages.” IDI009_M_76-80_Chinese

This highlights the need to not only understand user preferences and behaviours, but to take into consideration the various adherence factors which influence patient decision making and ability to adhere to medications.

Adherence Factors

Adherence factors include therapy related factors such as complexity of medication regime, therapy duration, lifestyle inconveniences and adverse effects which may either facilitate or inhibit adherence to medications. This also includes condition related factors, such as lack of symptoms or effects on functional status or mental state, which may facilitate or inhibit adherence to medications. In order to design an appropriate mHealth intervention it is
important to understand how both the medication itself and the condition may limit or enable adherence to medication.

Therapy Related Factors

Complexity of medication regime

Some patients reported adjusting their medication to cope with a complex regime and to facilitate their ability to adhere to their medications. As Sow Tin described,

"The doctor did tell me to take the blue pills before food. I thought it was troublesome to split them, so I took all my pills before food. So I can remember whether I’ve taken my medication... The doctor did say I was cheating. But it’s okay. It’s more time efficient for me and also so that I won’t forget the other pills after breakfast. I have to take 2 pills before breakfast, then I’ll have to take 4 and a half pills after breakfast. I might as well take all 6 and a half pills altogether." IDI004_F_66-70_Chinese

Nearly all patients described how using a pillbox and the ritual surrounding taking their medication had enabled them to form habits. Sow Tin went on to say,

"The doctor recommended me to put the medicine into a pill box as I forget to take my medication often. Putting the medicine in a pill box simply serves as a reminder that I forget to eat... It helps with my
memory, so I won’t keep forgetting to take my medications. And since
the medication is already packed, so I won’t forget to eat one or two
medication.” IDI004_F_66-70_Chinese

Patients also reported that they did not feel the need to have an mHealth
intervention to remind them since their current habits and pillbox use enabled
them to ensure they had taken medications and prevented them from taking a
double dose. As Vidhya described,

“Sometimes you forget! ‘Did I take the medication or not?’ and you look
into it [the pillbox]. If you look at it and it has disappeared that means
you have already taken it.” IDI011_F_61-65_Indian

Duration of Therapy

The majority of patients also reported how the long duration of therapy for
chronic conditions facilitated their ability to adhere to their medications. Thus
they felt that an mHealth intervention would not be of use, as they had already
established habits over the course of managing their chronic conditions. As
Karen reported,

“I just follow… because I have been using it for long, it’s no problem to
me… Also I can tell which one I need to eat, which one I have taken
how many tablets, what time I have to take. It’s all very systematic. No
problem.” IDI003_F_NA_Chinese
Inconvenience with Lifestyle

While most patients reported they largely adhered to their medications and had habits to support their medication taking, some patients reported how lifestyle factors disrupted their routines on occasion. Largely, patients reported how going out of the house or travelling was disruptive as they would not bring their medications along. As Ah Siew described,

“But if I go out, I won’t bring and eat it. It’s very troublesome to take it when I’m on the bus or mrt. I’ll just miss taking it. For instance, I went to Ipoh Malaysia the other day, I brought my medicine but I didn’t take it for two days, as it’s too troublesome. As we sometimes take car late in the night so it’s troublesome taking medicine, also sometimes simply forget after eating meals.” IDI020_F_71-75_Chinese

Adverse Effects

Some patients reported how adverse effects caused them to be non-adherent to their medications. One participant reported that while the doctor wanted to titrate the dose, he decided to stop entirely. As Yong Liat reported,

“Just recently. Because I told the doctor, I feel giddy then doctor say maybe this one caused… he asked me to take half… so I stopped.” IDI006_M_81-85_Chinese

Condition Related Factors
Patients reported few condition related factors as impacting their ability to adhere to their medications for ASCVD and its risk factors. One patient reported being prescribed various doses of medication and not taking it unless his blood pressure is high. As Cheng Han described,

“Yes. I may forget my blood pressure medications. It’s packed separately from my other medications. If my blood pressure very high I take this (10mg amlodipine), if my blood pressure not that high, I take this (5mg amlodipine)... For blood pressure, I usually don’t take the medications unless my blood pressure is high.” IDI014_M_71-75_Chinese

A few participants also reported how taking medications impacted their mental state, as they felt fearful of sequelae or death. For some participants this caused them to titrate or change medications. As Sow Tin described,

“You see, this cholesterol medication was given to me in March, and I still have so much leftover. If I show the doctor, he/she is going to scold me. So I won’t tell the doctor... My sister told me that if I take a lot of these cholesterol medication, it will affect my kidneys... So I’ve stopped taking that one and take this one instead. I’m not as afraid of kidney trouble with this one.” IDI004_F_66-70_Chinese

While others reported fear of disability and death motivated them to continue their habits and be adherent to their medications. As Yu Yan explained,
“I take them right after washing my face as I scared I forget. And I will remember to take before I sleep. It’s okay to die, it’s not okay to be disabled. So I take my medications… Because I’m scared to die, it motivates me to eat my medication, without even any reminder.”

IDI008_F_71-75_Chinese

The Learning Curve and Mobile Technology

One participant highlighted in detail the learning curve after diagnosis and commencement of treatment as a potential opportunity for mHealth interventions for adherence to medications, (see Box 2).

Box 2: Case study on the learning curve
This case explores how the uncertainty of a new diagnosis and discharge from hospital care is an opportunity for mHealth to provide adherence supports to patients where they have a high intention to uptake adherence behaviours. Patients who have managed their chronic conditions for years may not be as receptive as they have established habits, however, newly diagnosed patients or newly discharged patients may be primed to receive support in their care.

DISCUSSION

David, a 64 year old male, had no history of heart disease before having a severe heart attack which required the insertion of an Left Ventricular Assist Device. He was admitted to the intensive care unit for over a month before being discharged. While in hospital, David reported being on 14 different types of medication, which were reduced to 11 upon discharge after he reported adverse side effects. Presently he is only on 2 medications.

David explained the role of his care coordinators, who taught him about his medications prior to discharge. He also explained how they interceded on his behalf with the doctors to reduce the number of medications he was prescribed. Importantly he described how they were available to call or SMS when he has questions.

When asked about the use of an mHealth intervention to remind patients to take their medications he explained “It will be useful for patients who just came out of the ward. But not for long-term patients, because we know what to do.” IDI007_M_61-65_Indian; David reported that in the days following discharge the care coordinators would check in daily and ask on his adherence and other required activities (dressing changes, etc); and now they check in every two weeks, and he is able to reach out to them should he require.
This qualitative study explored mobile technology acceptance, use and facilitating conditions, as well as adherence factors amongst older Singaporeans ahead of an mHealth intervention to promote adherence to ASCVD medications.

Participants reported variable acceptance of mobile technology. Some participants were tech savvy and used mobile technology regularly and broadly to connect with their social networks, whereas others reported decreasing social connectedness as a reason for not using mobile technology. Participants widely reported usability concerns including reading difficulty due to screen and font size and hearing difficulties limiting their awareness of notifications. This is in line with other research on mobile technology use for health interventions with older participants (Isaković et al 2015). These technology oriented factors impact on users’ behavioural intention to use technology, as well as their intention or interest in using an mHealth intervention for adherence to medications. Indeed, amongst our study population, who’s mean age was 72 years old for the qualitative component, participants were largely disinterested in SMS reminders often citing low mobile phone usage or usability concerns as a barrier to uptake.

Suboptimal adherence to medications for ASCVD and its risk factors are well documented (Bansilal et al 2015; Zhang et al 2017, Rashid et al 2014; Legido-Quigley et al 2015); however most of our participants reported not needing reminders to take their medication as they have their own established habits and report themselves as being adherent. Yet, some participants reported
self-titration and non-adherence when lifestyle factors interfered with their ability to have medications on hand. Thus, caution is warranted in these self-reports of adherence. These reports of adherence may impact patients behavioural intention to use an mHealth intervention, as many participants reported no interest in an mHealth intervention for adherence to medication as they did not see personal benefit to such a service.

Despite these concerns, some participants did report that SMS was a good avenue through which to receive health information, this is in line with findings from other studies across health research where it has been shown that despite perceived usability issues or dissatisfaction with available options, patients believe in the capacity of mHealth interventions to facilitate better health outcomes (Sanger et al 2014; Marciel et al, Rodrigues et al 2015, Lithgow 2017). In our study a contributor to a favourable opinion of the proposed intervention was previous mHealth use. Participants who received appointment reminders from health care providers were more open to the idea of health content delivered through SMS, although they were ambivalent on the utility of medication reminders.

Another factor facilitating a positive perception of mHealth was that of trust – both trust in the SMS sender, and trust in the treatment plan. Participants described caution in believing online sources for health information, reported receiving spam SMS messages and underscored the importance of wanting a trusted source for any mHealth SMS. Other studies have shown that trust is an integral part of intent to use technology and predicates on the belief that
the other party will not exploit the vulnerability of the user (Jarvenpaa et al 1999, Schnall et al 2017). Participants also linked the success of any mHealth intervention to whether patients trusted their medications. There is ample evidence on the role of trust, both in treatment and in provider, in medication adherence (Schoenthaler et al 2014; Abel and Efird 2013; Lee and Lin 2009) and these facets of trust in treatment are important in establishing the behavioural intention to use an mHealth intervention for adherence to medication.

While technology-oriented factors directly influence a patient's ability and motivation to use and follow an mHealth intervention, adherence factors also play a role in determining if a patient is able to translate the behavioural intention triggered by the SMS into a use behaviour. The use of habits and reminders is well documented in facilitating adherence to medications (Phillips et al 2013; Wu et al 2008; Haynes et al 1976). Our study adds to this evidence showing that patients perceive they are able to cope with treatment complexity by establishing their own habits and rituals and that given the length of treatment required they become accustomed to taking their medications. Importantly however, patients did report self-titration due to adverse effects, as well as lifestyle factors which disrupted their ability to adhere to medications. These are important factors which may not be modifiable by an mHealth intervention but warrant consideration.

The unique case of David highlights the importance of the learning curve wherein patients develop these habits and rituals for medication taking. After
diagnosis patients may require additional support and be open to receiving that support, as they begin to develop habits and adopt behaviours relating to medication-taking and lifestyle adjustment. Although, as is the case with David, this support may taper off over time once adherence behaviours are established, or the perceived utility diminishes, it also presents the opportunity to reintroduce the intervention should new medications be introduced or the patient requests additional supports. Although technology-oriented factors, adherence factors and contextual factors may pose challenges to uptake of an mHealth intervention, this case highlights the importance of identifying opportunities where the barriers to mHealth uptake may be lower as patients are actively seeking support as they take ownership of their care.

Strength and Limitations

A strength of our study is the use of in-depth interviews for the exploration of patients' perspectives on both medication taking, as well as technology use and the opportunities and challenges for mHealth interventions. Further, the inclusion of participants from multiple ethnic backgrounds and older participants adds to the diversity of experiences reported.

A limitation of this study is that it excluded individuals with disabilities which prevented them from participating in verbal interviews. Also, our participants were all over age 60 years old, thus we are not capturing the perspectives of those middle-aged persons taking medications for ASCVD and its risk factors who may have differing adherence patterns or mobile technology use behaviours. The fact that Singapore has a high mobile phone penetration rate,
has a small geographical size (relative to geographically expansive countries like Canada whereby mhealth serves isolated rural areas) and is a 100% urbanised city state may limit its generalisability to other countries with differences in such characteristics. Further, contextually, health systems factors in Singapore, including high accessibility and availability of care may account for some of the patient accounts of not needing reminders, as they are able to easily access follow-up care. Our study also did not include caregivers, and as reported by one participant, caregivers may be a more appropriate end user for the intervention, particularly amongst those older persons who rely on caregivers for their medication taking. Further, we relied on self-reported adherence measures thus some participants may have reported higher adherence to medication. A final limitation is that of desirability bias, whereby participants may be reporting more favourably on their experiences.

**CONCLUSION**

Our study has identified several important technology-oriented and adherence related factors from the patient perspective that warrant consideration in the design of an mHealth intervention to support adherence to medications for ASCVD and its risk factors in Singapore. We also highlight the importance of finding the right opportunity to engage with patients and promote an mHealth intervention, such as immediately following diagnosis when patients are establishing medication taking habits. As health care professionals increasingly leverage on innovative approaches such as mHealth to promote adherence to medications for chronic conditions, it will be important to better
understand both the technology related behaviours that impact a patient's intention and ability to use an mHealth intervention, as well as therapy and condition related factors that may enable or inhibit successful adoption of such an intervention.

Word Count: 5629

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