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Fixing the communication gap through MHealth: The effects of attitude, perceived usefulness, and risks of MHealth on prescribed self-care among coronary heart disease patients in Malaysia

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ABSTRACT

This study analyses the moderating role of Mobile Health (MHealth) in influencing the indirect relationship of health literacy on prescribed self-care through attitude among Coronary Heart Disease (CHD) patients in Malaysia. Through a user-experience research with concept testing, data were collected from 300 CHD patients in a tertiary hospital using a survey. Findings show a partial mediation of attitude in the relationship between health literacy and prescribed self-care. The results reveal that the perceived usefulness of MHealth significantly and positively moderates the direct effect of health literacy on attitude towards prescribed self-care. Further, the perceived risk of MHealth significantly moderates the direct effect of health literacy on prescribed self-care negatively. Lastly, the perceived risk of MHealth positively moderates the moderated mediation of perceived usefulness of MHealth on the indirect effect of health literacy on prescribed self-care. These findings suggest a new framework for the effects of MHealth on prescribed self-care that explains the importance of perceived usefulness of MHealth to create a positive attitude towards prescribed self-care; in other words, the perception of usefulness outweighs the patient's perceived risk of MHealth in practising prescribed self-care. To integrate MHealth in the CHD medication regimen, requires (1) relevant disease management functions, (2) regulations (3) audit and revisions, and (4) education, as well as the involvement of healthcare providers, policymakers, and developers.

Keywords: ***MHealth, coronary heart disease, moderated mediation, perceived usefulness, perceived risk***

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INTRODUCTION

Mobile Health, or in short MHealth, is increasingly recognised as a part of sustainable healthcare initiatives around the globe (Australian Medical Association [AMA], 2019; Braithwaite et al., 2018; PricewaterhouseCoopers [PwC], 2017; Taylor, 2015). World Health Organisation (WHO) (2019, pp. ix) defined MHealth as "the use of mobile wireless technologies for health". It serves the purpose of closing the communication gap between a healthcare provider and patient in the patient-centric healthcare delivery (Bradway et al., 2017). Providers and patients rely heavily on communication to shape health belief, attitude, and behaviour in patient self-care especially during long appointment intervals (McQuail, 2010; Tavakoly Sany et al., 2017). The long absence of provider-patient communication may result in the deterioration of self-care. Examples of important self-care aspects are medication adherence, complication self-monitoring, and lifestyle behaviour change (exercise, diet, and smoking cessation) (Piette, List, Rana, Townsend, & Striplin, 2015). Hence, there is a growing trend and market worth USD289 billion by 2025 for MHealth in both self-care disease prevention and management (Ugalmugale & Swain, 2019). This indicates the future direction of global mediated healthcare specifically with emerging opportunities for sustainable self-care. Thus self-care presents a big potential to be a part of the rehabilitation prescription mechanism, leading to the growing body of studies involving MHealth (Stephani, Opoku, & Quentin, 2016; Zhang, Babu, Jindal, Williams, & Gimbel, 2019).

Media has long been discussed and proven to be a contributing variable to health behaviour. While the discourse has moved forward to a new trend of ambient media such as MHealth, the topic remains controversial despite the high number of studies conducted. There are many reasons for this, including high validity threats, biases, and underpowered data (Athilingam & Jenkins, 2018). Furthermore, many researchers have debated about the significant contributions of MHealth to self-care among chronic disease patients (Aminuddin, Jiao, Jiang, Hong, & Wang, 2019; Bermon et al., 2019; Bradway et al., 2017; Rehman et al., 2017). However, very limited studies have elaborated in detail the fundamental understanding of the role played by MHealth in patient self-care, explicitly the cognitive factor (Ahadzadeh & Sharif, 2017; Klingberg, Sawe, Hammar, Wallis, & Hasselberg, 2020; Schuster, Tossan, & Drennan, 2017). This gap in literature demands for more comprehension on the viability of MHealth in self-care intervention.

Regardless of the developing enthusiasm for studying the effectiveness of MHealth on health outcome, self-care behaviour has only been partially examined (Asimakopoulos, Asimakopoulos, & Spillers, 2017; Dobson et al., 2017; Grant et al., 2019; Piette et al., 2015). In particular, the stages generally covered are maintenance (knowledge improvement, lifestyle behaviour, medical adherence) and monitoring (symptom identification), whereas the third stage, which is management, has been largely ignored. It is important to cover all three stages of self-care simultaneously as they comprise complete steps of self-care towards optimal health outcomes (Riegel, Jaarsma, & Stromberg, 2012). The failure to cover the whole concept of self-care may contribute to the inconsistencies of the effectiveness of MHealth in the literature, especially in randomised controlled trial studies.

In Malaysia, the majority of studies on MHealth in the context of disease management are limited to literature reviews and conceptual papers (Abdulrahman & Olaosebikan, 2017; Mohd Fadzilah & Arshad, 2015). Additionally, empirical research commonly focuses on the general perceptions of MHealth (Hussein, Oon, & Fikry, 2017), instead of its impact on chronic disease self-care. Similar to other literature, these empirical researches only partially studied the self-care concept in their MHealth studies.

Substantial evidence suggests that the perceived usefulness of ambient media such as MHealth, health literacy, and attitude significantly improves behaviour (de Vries & Backbier, 1994; Deng, Hong, Ren, Zhang, & Xiang, 2018; Klingberg et al., 2020). However, this positive relation varies according to different individual risk perceptions on the integration of MHealth in their self-care routine. The perceived risk of an ambient media such as MHealth has been significantly proven to interfere with the anticipated behaviour the ambient media is created for (Harris, Sillence, & Briggs, 2011; Schnall, Higgins, Brown, Carballo-Dieguez, & Bakken, 2015). Another reason is due to the failure to adopt MHealth as a part of their self-care regimen (Alexandrou & Chen, 2019), thus resulting in low self-care empowerment. Nevertheless, Willoughby & Smith (2016) argued that the continuous usage of MHealth is pertinent to increasing the user's engagement with self-care, as supported by the elaboration likelihood model (ELM) (Petty & Cacioppo, 1986).

In reviewing the expansive literature on MHealth for self-care, several disparities were found for some aspects. Very limited studies of MHealth intervention among coronary heart disease (CHD) patients (1) were conducted in low-income countries (LIC), (2) involved theory application, (3) studied the mechanism towards engagement that includes attitude, and (4) covered the impact of disease management using regression analysis (Bermon et al., 2019; Delva et al., 2020; Deng et al., 2018; Polite et al., 2019). This fundamental knowledge is important for an in-depth understanding of how users engage with MHealth, thus the key mechanism that leads to self-care in LIC. The failure to address this issue may result in economical and life losses as billions are continuously invested globally, including Malaysia, on this new MHealth initiative without fully understanding its mechanism (AMA, 2019; Ministry of Health Malaysia, 2020; Prime Minister's Department Malaysia, 2015; Ugalmugale & Swain, 2019; WHO, 2019).

Therefore, this study aims to fill the literature gap on MHealth in self-care among CHD patients in the Malaysian context. Specifically, this study covers a fundamental understanding of the influence of MHealth in self-care among CHD patients through a cognitive factor, which is attitude. Moreover, this study will fill the gap of past studies on the full concept of self-care by covering all three stages of self-care. The research objective of this study is to analyse the relationship between health literacy, prescribed self-care, and attitude among CHD patients with different levels of perceived usefulness and perceived risk towards MHealth.

This current study adopted the user experience research by concept testing using a semi-functional prototype among CHD patients. Before the empirical research stage, the study was framed using the theory integration approach in the conceptual phase. We integrated four theories or models from media and healthcare fields, that is, MHealth Service Adoption Model (Deng et al., 2018), Theory of Planned Behaviour (TPB) (Ajzen, 1991), Health Literacy (Nutbeam, 2000), and Middle-range Theory of Self-care of Chronic Disease (Riegel et al., 2012). More significantly, this study conceptualises the integration of MHealth in the three stages of self-care (maintenance, monitoring, and maintenance) among CHD patients in Malaysia. Next, this study measures the feasibility of the integration of MHealth in self-care prescription among CHD patients in particular, and chronic disease patients, in general.

LITERATURE REVIEW

The context of the study: Coronary Heart Disease (CHD) in Malaysia

Coronary Heart Disease (CHD) is one of the many types of heart disease that falls under the non-communicable or lifestyle disease category. Annually, CHD is identified as the

major cause of death in Malaysia with statistics as high as 37 daily deaths in 2017. A steep climb from 24 daily deaths in 2007 highlights the rapid rise of this worrying lifestyle disease in Malaysia. Overall, the statistics of the CHD mortality rate has escalated significantly at 54% in a decade, which is from 8,776 in 2007 to 13,503 in 2017 (DOSM, 2018). Following these worrying statistics, Malaysia's annual healthcare budget continues to rise every year.

The escalating annual budget is spent on improving the healthcare system (facilities and medical professionals) and health campaigns. However, the financial aspect has yet to arrest the increasing rate of CHD mortality in Malaysia. One of the contributing reasons identified is the disparity ratio of cardiologist-patients which results in long intervals between appointments (Onn, 2015; Wan Ahmad & Sim, 2013) which in turn, causes a wider provider-patient communication gap. As a result, this leads to a decline in self-care for medication adherence and lifestyle behaviour including exercise, diet and smoking cessation (maintenance); self-monitoring of complications and symptoms (monitoring); and decision making (management) (Piette et al., 2015). Poor self-care then exacerbates heart failure, which causes multiple hospital admissions. This in turn, results in higher healthcare cost capitalised by the public hospitals, and the government as a whole. For this reason, the healthcare system requires a paradigm shift from being provider-centric to patient-centric that supports patient self-care. One of the sustainable mechanisms of a patient-centric system is the integration of technology, that is, MHealth in self-care.

The relationship between health literacy (HL) and prescribed self-care (PSC) behaviour

Health literacy (HL), as suggested by Doyle, Cafferkey, & Fullam (2012); and Sørensen et al. (2012), is represented by four competencies, which are to access, understand, appraise, and apply. While access focuses on the capacity to search, discover and acquire health-related information, understand may refer to the capacity to grasp health-related information. Appraise describes the capacity to decipher, screen, gauge and assess health-related information. Finally, apply refers to the capacity to convey and utilise the acquired information for sustainable and better well-being. These four competencies reflect an individual's ability to process information.

In Malaysia, 1/3 of adults have low HL, compared to only 10–26% in developed countries and 30–80% in other developing countries (Fabbri et al., 2018; Institute for Public Health, 2020; Malik, Zaidi, & Hussain, 2017; Yun, Abdullah, Idrus, & Keikhosrokiani, 2017). Among them are elders with chronic diseases (Li, Swee, Arasu, Kim, & Mohd Ali, 2019; Mohd Yunus et al., 2020). For the past decade, there has been a dearth of health literacy studies among chronic disease patients in developing countries especially Malaysia (Abdullah, Liew, Salim, Ng, & Chinna, 2020; Malik et al., 2017; Rajah, Hassali, & Murugiah, 2019). This is worrying as the prevalence of low HL can lead to poor self-health management and health outcome (Abdullah, Liew, Salim, Ng, & Chinna, 2019; Su, Ahmad Bahuri, & Said, 2020). However, deliberate interventions such as education and advertising campaigns may improve HL, and in tandem, health behaviour and outcome (Cheong & Mohamad Nor, 2018)

Health literacy influences health outcomes by affording the ability to practise self-care, utilise healthcare facilities, and advocate oneself to healthy lifestyle (Doyle et al., 2012). Many studies related knowledge or literacy to health decision-making and behaviour, specifically self-care for chronic illness such as CHD (Fabbri et al., 2018; Froze, Arif, & Saimon, 2019). However, many local patients practise self-care without prior knowledge of its reasons and benefits; merely adhering to the medical professional's instructions or prescription (Tan, Chong, & Chooi, 2015). As a result, they may not achieve a high level

of self-care due to their limited understanding and knowledge of their chronic illness. On the other hand, patients with adequate health literacy may choose to ignore medical professionals' self-care prescriptions due to various factors following their own rational analysis (Riegel et al., 2012).

Substantial works of the literature assert the importance of health literacy in influencing health behaviour including self-care among chronic disease patients (Fabbri et al., 2018; Geboers, de Winter, Luten, Jansen, & Reijneveld, 2014; Hsu, Chiang, & Yang, 2014; Manganello, 2008; Sallis & Owen, 2015; Seid, Abdela, & Zeleka, 2019; Shin & Lee, 2018; Suka et al., 2015; Ventura & Piña, 2018). However, for the local low socioeconomic group, HL only improves the dietary and medication regimen, and not physical activities (Cheong & Mohamad Nor, 2018). Based on this discussion, we propose that an appropriate level of health literacy leads to positive health behaviour such as self-care among chronic disease patients. Specifically, for this study, sufficient health literacy among CHD patients leads to positive self-care as prescribed by doctors.

> H1: Health literacy (HL) has a positive significant influence on prescribed self-care (PSC) among CHD patients

The mediating role of attitude in the relationship between health literacy and self-care

Theoretically, the HL model by Paasche-Orlow & Wolf (Paasche-Orlow & Wolf, 2007), the theory of environmental responsible behaviour (Akintunde, 2017; Hines, Hungerford, & Tomera, 1987), and the behaviour change model (Hungerford & Volk, 1990) suggested an indirect effect of attitude on the relationship between HL and health behaviour that affects health outcome.

Additionally, von Wagner, Steptoe, Wolf, & Wardle (2009) proposed a Health Literacy and Health Action framework for Health Psychology, which identified attitude, resulting from knowledge perception, as the motivational phase between health literacy and health management. Following this, Squiers, Peinado, Berkman, Boudewyns, & McCormack (2012) have also proposed another health literacy framework which highlights the indirect effect of health literacy on health-related behaviour and outcomes through attitude.

Health behaviour research has identified attitude as a factor leading to health behaviour or outcomes (Ahadzadeh & Sharif, 2017; Baker, 2006; Squiers et al., 2012; von Wagner et al., 2009; Wang, et al., 2014; Wrigley, Jackson, Jud, & Komiti, 2005). In a third world country, Nigeria, MHealth has managed to improve the engagement between healthcare providers and women in rural areas due to the latter's positive perception of the technology (Odetola, Ayamolow, & Ayamolow, 2018). Thus, MHealth presents a tremendous potential for countries with inadequate healthcare facilities.

Wang et al.'s (2014) study on asthma patients linked health literacy to their self-management behaviour through attitude. In other words, attitude is significantly and positively associated with health literacy. Surprisingly, this study did not find any significant direct influence of health literacy on self-management, making it necessary to involve attitude in the equation that contributes to patient's self-management.

A few other studies identified the importance of attitude in shaping health behaviour, especially among patients with a mental health problem (Kim, Yu, & Young Kim, 2020). A negative attitude towards help-seeking limit the intention to seek help from professionals. This is attributable to a negative perception from weak mental health literacy which significantly predicts patient attitude towards seeking help from professionals (Wrigley et al., 2005; Yamaguchi et al., 2020). In another study that employed TPB, attitude strongly

predicted 40% of the variance in behaviour, suggesting the importance of shaping attitude (Armitage & Conner, 2001).

Moreover, a few recent empirical studies in Taiwan, USA, and Iran have also found the significant indirect effect of attitude on the relationship between health literacy and health behaviour (Ho et al., 2019; Huang et al., 2019; Mohamadniamotlagh et al., 2020; Polite et al., 2019). Self-care behaviour is driven by the patient's attitude, that varies across different health literacy levels, including for patients with chronic diseases such as CHD. A clinical trial of a touchscreen technology conducted on 120 cancer patients confirmed the importance of health literacy in shaping a patient's attitude towards enrolling in the clinical program for disease management (Polite et al., 2019).

From these arguments, we propose attitude as a mediator between health literacy and prescribed self-care.

> H2: CHD patient's attitude significantly mediates the relationship between health literacy (HL) and prescribed self-care (PSC).

The moderating role of perceived usefulness (PU) of MHealth on the relationship between health literacy (HL) and attitude (ATT)

To the best of our knowledge, no empirical research has tested the perceived usefulness (PU) of MHealth as a moderator between health literacy and attitude. However, a number of empirical studies including clinical studies have employed MHealth as an intervention in the treatment of chronic disease patients with substantial positive outcomes (Baek et al., 2018; Delva et al., 2020; Grant et al., 2019; Hallberg, Ranerup, Bengtsson, & Kjellgren, 2018). This encouraged the adoption of MHealth as a moderating variable in the relationship between health literacy and health behaviour, as it brings a significant difference to health behaviour and outcome compared to controlled groups (Breitborde, Srihari, Pollard, Addington, & Woods, 2010). Guided by Andersson, Cuervo-Cazurra, & Nielsen (2014) and Memon et al. (2019), PU of MHealth is proposed as a moderator.

In integrating TPB (Ajzen, 1991), the technology acceptance model (TAM) (Davis, 1989), and health literacy, some empirical studies revealed a significant relationship between health literacy and attitude (Aharon, Nehama, Rishpon, & Baron-Epel, 2017). Additionally, Passche-Orlow and Wolf's (2007) theoretical HL model suggests a direct effect relationship between HL and attitude. This is supported by substantial empirical evidence that have verified the direct effect of HL on patients' attitude towards their self-care (Ho et al., 2019; Huang et al., 2019; Mohamadniamotlagh et al., 2020; Polite et al., 2019). Patients with limited HL tend to harbour negative feelings and beliefs about their self-management due to constrained knowledge and skill. This calls for a variable to buffer the outcome of the limited HL.

Conversely, some literature has revealed inconsistencies with regard to the significant effect of HL improvement on attitude (Kaper et al., 2020; Yamaguchi et al., 2020). Empirical studies including randomised control trials on medical students and teachers showed an absence of attitude change despite HL improvement. Similarly, a systematic review of mental health literacy programmes among teachers identified the degree of effect of HL on attitude ranged from absent to small (Yamaguchi, et al., 2020). Hence, this imbalanced equation of HL in relation to attitude may require an additional variable for this relationship to be fit.

Additionally, many works in literature have identified the media as an important element in the relationship between health literacy and attitude (von Wagner et al., 2009). Theoretically, this is best explained by the RTI health literacy skills framework where media

is the moderator in the ecological influence category, between health literacy and attitude (Squiers et al., 2012). In line with Passche-Orlow & Wolf's (2007) framework of health literacy and health action, access to health information through MHealth influences the attitude formation process; in other words, attitude is a reflection of HL. The perception of MHealth as useful acts as a buffer or magnifier that may change the original magnitude of health literacy on the attitude towards self-care.

Based on TAM, perceived usefulness influences an individual's attitude or feeling towards carrying out a behaviour, including health behaviour (Davis, 1989). Perceived usefulness of MHealth leads to a positive attitude about health behaviour (Deng et al., 2018) including self-care or seeking online health information (Ahadzadeh & Sharif, 2017). Upon acquiring new knowledge from MHealth, patients feel more positive about managing their disease as they have acquired a guide in their decision-making process (Polite et al., 2019; Vo, Auroy & Sarradon-Eck, 2019). Similarly, a recent study on cancer patients found that the usage of interactive technology significantly improved patient attitude regardless of their health literacy level. This intervention was evaluated as very useful in improving their understanding of a cancer trial study (Polite et al., 2019). Patients believe using MHealth enables them to improve their disease management, thus improve health outcomes and reduce their dependency on doctors. Disease management can be conducted using multiple applications such as blood pressure, medication, physical activity, and diet monitoring, health information, or appointments (Lin, Bautista, & Core, 2020). Following this, patients gain a better feeling and confidence in managing their disease, compared to patients who do not get any MHealth intervention for their disease management. Furthermore, the attitude of patients with limited HL may improve with the MHealth intervention. In this respect, MHealth conditions the relationship between HL and attitude whereby it magnifies, reduces, or changes the effect of HL on attitude towards self-care (Jaarsma, Cameron, Riegel, & Stromberg, 2017). However, some patients may not find MHealth useful. Therefore, their attitude towards self-care remains aligned with their health literacy level.

Nevertheless, the enthusiasm of healthcare providers and technology providers to integrate MHealth in the healthcare system may be hampered by the ability and inclination of aging patients to adapt to this new technology, considering the biggest group of CHD patients are between the ages 40 and 60. Other impeding factors include internet literacy, innovativeness, personality, experience, MHealth design and internet access which may also be influenced by socioeconomic levels (Le Rouge, Ma, Sneha, & Tolle, 2013; Zhang, Yu, Yan, & Spil, 2015). The correlation of communication technology's evaluation towards attitude as supported by TAM, TAM2, TAM3, and UTAUT qualifies the perceived usefulness of MHealth as a moderator in the relationship between health literacy and attitude (Andersson et al., 2014; Hefner, 2017). Through these theories and models, MHealth as a channel is measured through PU. Past studies of technology usage in the healthcare environment have used these variables to study MHealth (Cocosila & Archer, 2014; Gagnon, Orruno, Asua, Abdeljelil, & Emparanza, 2012; Hung, Tsai, & Chuang, 2014; Schnall et al., 2015). These evidences have led to the following proposed hypothesis:

> H3: The perceived usefulness (PU) of MHealth significantly moderates (increases) the relationship between CHD patient's health literacy (HL) and attitude (ATT)

Influence of perceived risk (PR) on perceived self-care (PSC)

Patients and providers commonly find MHealth very useful in their self-care, where it improves their attitude towards taking better care of themselves. Through the usage of

MHealth, patients can manage their disease better by learning more about their disease and managing their medication regimen better. However, there are many concerns over the usage of MHealth as a part of the self-care mechanism. These concerns are related to the security, physiological risk, accuracy and quality of the information found on MHealth.

The first concern refers to the risk of exposure of personal information and location through MHealth. Some patients are very sceptical about providing any personal information on the internet, which can be accessed by anyone, anywhere. In this regard, many studies have identified privacy and security as the biggest barriers to the adoption of MHealth for better self-care (Vo et al., 2019). However, this risk is inevitable, similar to other technological applications (Schnall et al., 2015).

The second concern is physiological risk, which is the effect of using MHealth for self-care. Communication between patients and providers using technology is different compared to face-to-face. There is a risk of inaccurate diagnosis due to the absence of physical doctors, which makes MHealth unreliable and unable to meet expectations (Deng et al., 2018).

Third, the validity and accuracy of the information provided through MHealth which is not necessarily supported by healthcare providers. Fourth, the quality of information disseminated through MHealth. Some information is hardly understood by low literacy patients, while some is insufficient or incomplete. For these reasons, many refuse to practise self-care as advised by MHealth, making it less effective (Vo et al., 2019; Waters, McQueen, & Cameron, 2014).

Despite these numerous concerns, chronic disease patients in China have more confidence in the usefulness of MHealth. The benefits obtained from MHealth outweigh the risks associated with this technology. Further, the risks affect health behaviour decision on a very small scale (Zhu, Liu, Che, & Chen, 2018).

From the evidence mentioned earlier, we conclude an indirect relationship between health literacy and prescribed self-care through attitude, which is moderated by the usage of MHealth subject to its perception of usefulness and risks. Perceiving MHealth as highly useful for guiding prescribed self-care leads to a positive attitude towards prescribed self-care. However, the effect of this positive attitude towards self-care practice is moderated by the perception of risks towards MHealth. A patient who has a high perceived risk of using MHealth for self-care is unlikely to effectively practise self-care as prescribed by the doctor through MHealth. Therefore, we propose this hypothesis:

> H4: The perceived risk (PR) of MHealth significantly moderates (reduces) the moderating effect of perceived usefulness (PU) of MHealth on the indirect relationship between health literacy (HL) and prescribed self-care (PSC) through attitude (ATT).

Commonly, health literacy positively influences an individual's health behaviour, such as self-care. A CHD patient with a high level of health literacy is more likely to practise self-care as prescribed by the doctor. However, when MHealth is integrated into the self-care regimen, a patient's risk perception of MHealth may moderate or buffer the relationship between his/her health literacy and self-care. A patient who perceives MHealth as highly risky is unlikely to practise self-care as prescribed by a doctor through MHealth in their self-care regimen. This perception leads to poor self-disease management among patients, thus reducing the effect of health literacy on self-care. From the earlier evidence, we have proposed this hypothesis:

> H5: The perceived risk (PR) significantly moderates (reduces) the relationship between health (HL) and prescribed self-care (PSC)

METHODOLOGY

Previously, empirical research on MHealth commonly employed a cross-sectional survey without using any prototype and only referred to general MHealth usage knowledge. It is essential to include prototypes in a study to allow respondents to experience and then evaluate (Vermeeren et al., 2010). Apart from user-experience research, only intervention (Ujang & Sutan, 2018) and usability research (Ithnin et al., 2017; Othman, Mohd Halil, Mohd Yusof, & Abdullah, 2018) generally incorporate prototypes in Malaysia.

This study employed user-experience research through concept testing using a semi-functional prototype (Rohrer, 2014). For data collection, we utilised a cross-sectional study to measure health literacy, attitude towards prescribed self-care, MHealth acceptance (perceived usefulness and perceived risk), and prescribed self-care. After respondents tried and experienced the prototype, they were given questionnaires (staff-administered) to complete. In the next step, which is analysis, we utilised SmartPLS to test the measurement, the structural model, and hypotheses. This study's ethics code of conduct was approved by University of Malaya Medical Centre in 2018 (MRECID No: 2018112-6847).

Measurement

There are five main variables tested in this study, that is, health literacy (HL), perceived usefulness (PU), perceived risk (PR), attitude (ATT), and prescribed self-care (PSC). The items to measure these variables were adopted and adapted from validated items to fit in the CHD context in the Malaysian population. Details on the items for these variables are explained in Table 1. The survey also included five demographic questions in Section A. To reduce the threat validity caused by Common Method Variance (CMV), we employed procedural remedies through the survey items (Johnson, Djurdjevic, & Rosen, 2010). First, measurements were done using (1) a variety of response formats (Likert scale and bipolar Likert scale), and (2) different scale anchors ("strongly disagree vs. strongly agree" and "never vs. every day"). Second, we utilised an additional set of items, that is, Social Desirability by Crowne and Marlowe (1960) to manipulate unmeasured factor or marker, or also known as unmeasured latent marker construct (ULMC) technique. These items are required for the statistical remedy of CMV, which is an ULMC for non-covariance-based structural equation modelling (SEM) (Richardson, Simmering, & Sturman, 2009).

Considering the culture factor, this survey was prepared in two languages (English and Malay) using two-panel approach (translation by a professional translator and translator with the same mother tongue as the respondents) to overcome the inconsistent quality of the forward/backward approach (Danielsen, Pommergaard, Burcharth, Angenete, & Rosenberg, 2015; McKenna & Doward, 2005; Swaine-Verdier, Doward, Hagell, Thorsen, & McKenna, 2004). Similar to past studies, the questionnaire was then reviewed by expert panels from the media and communication, psychology, and cardiology fields (Danielsen et al., 2015) before being used.

Participants and sampling

We used multistage sampling, starting with a cluster sampling to select one out of the five hub hospitals within the MySTEMI network. MySTEMI is a network of five hub hospitals in Klang Valley with the best facilities for patients who suffer from myocardial infarction. These hub hospitals (Serdang Hospital, National Heart Institute, UKM Medical Centre, University Malaya Medical Centre, and MARA University of Technology) are equipped with cardiac catherisation laboratory for primary Percutaneous Coronary Intervention (PCI) care (National Heart Association of Malaysia, 2016). We selected University of

Malaya Medical Centre (UMMC) which has the biggest number of heart patients in central Peninsular Malaysia (Wan Ahmad, 2017).

At the next stage, we employed purposive sampling with the following inclusion criteria: (1) CHD patient (also known as ischemic heart disease or coronary artery disease); (2) age 30 – 80 years; (3) smartphone user; (4) average Malay or English language comprehension level. To calculate sample size, we used G Power with a high-range setting to increase data reliability and accuracy ($f^2 = 0.15$ (medium), $\alpha = 0.05$, power = 0.99, n predictors = 7). Referring to the R-squared method, and result from a moderated mediation study (0.138) (Haider, Jabeen, & Ahmad, 2018 ; Kock & Hadaya, 2018), the G power effect size was set at 0.15 (medium) (Cohen, 1988; Meyvis & Van Osselaer, 2017). This bigger effect size will lead to a bigger threshold of hypothesis significance. Power was set high at 0.990 to reduce bias (Kock & Hadaya, 2018). The number of sample size generated was 136. However, we collected data from 300 patients to increase the statistical power (Prajapati, Dunne, & Armstrong, 2010).

The majority of our sample comprised males (76.3%), aged 51–60 years old (35.7%), high school leavers (50.7%), and earned a monthly salary of RM0 to RM2000 (50.7%). The CHD prevalence factors found in the sample were hypertension (75.3%), dyslipidemia (70.7%), family history (59.0%), diabetes (54.7%), sedentary lifestyle (47.0%), smoking (38.7%) and obesity (13.0%).

Cross-sectional procedure

The sample selection was done at the selected hospital's outpatient cardiac clinic, and inpatients including those who were scheduled to undergo an angiogram procedure. The respondents can opt for either staff- or self-administered cross-sectional questionnaire survey. For the sample selection, we screened through patients' scheduled treatment procedures such as angiogram, Percutaneous Coronary Intervention (PCI), Coronary Artery Bypass Surgery (CABG), or Optimal Medical Therapy (OMT). Next, the patients were screened with additional questions to confirm their suitability based on the inclusion and exclusion criteria. For additional confirmation, we also cross-checked their medical records with UMMC's database.

Data analysis

We adopted the analysis method used by Roldán, Leal-Rodríguez, & Felipe (2015), whereby the measurement and structural model are tested by employing Partial Least Squares (PLS). PLS is suitable due to (1) medium sample size (n=300); (2) prediction model using the dependent variable; (3) the complexity of the research model which is a moderated mediation with hierarchical constructs as explained in the hypothesis and framework; and (4) use of latent variable scores for a disjoint two-stage approach to analyse the hierarchical component model. Following this analysis, we tested the hypothesis of the moderated moderated mediation analysis, using SPSS PROCESS Macro 3.4 model 28 (Hayes, 2018).

Data collection

We tested the outliers and multivariate normality of the data using the Mardia's test (Ramayah, Yeap, Ahmad, Abdul Halim, & Rahman, 2017). The test results reported a significant skewness ($\beta = 65.087$, $p < 0.01$) and kurtosis ($\beta = 431.314$, $p < 0.01$), indicating the abnormality of the data collected. Hence, SmartPLS is the best software for this non-parametric analysis (Hair, Hult, & Sastedt, 2017). The ULMC test indicated that R^2 differed at 0.1% with the addition of a unmeasured construct, indicating an absence of the CMV issue.

Measurement model analysis

The measurement model analysis employed confirmatory factor analysis (CFA) with a

disjoint two-stage approach for the hierarchical constructs of the reflective-formative model. We set the path analysis of bootstrapping exercise at 5000 resamples, significant at 0.05 and one-tailed. The results of the CFA test (Hair, et al., 2017) as shown in Tables 2, 3, and 4 confirmed that the study met the satisfactory level of internal consistency and convergent reliability. All constructs also demonstrated discriminant validity through the Fornell-Larcker criterion whereby all squared AVE values were higher (0.690–0.996) than the correlations of other constructs (Fornell & Larcker, 1981; Hair, Hult, & Sastedt, 2017).

RESULTS

Structural model analysis

We used the disjoint two-stage approach to test the structural model (Sarstedt, Hair Jr, Cheah, Becker, & Ringle, 2019). Observing Figure 1 and Table 5, all paths except for the control variables (gender, age, and education) are significant. Table 5 summarises the four models for structural model assessment. The first hypothesis (H1) test reported in Model 1 shows the path of direct effect between HL and PSC, indicating a significant positive relationship (β = 0.600, T = 12.745) in the presence of control variables (age, gender, and education). PSC increased significantly with the influence from HL, which fully supports H1.

Next, the second hypothesis (H2) for the indirect effect of HL on PSC through ATT as a mediator is reported in Model 2 of Table 5. All paths in Model 2 are significant, including *c'* indicating the potential of ATT as a mediator of the indirect effect of HL on PSC. The results in Table 6 show further analysis of the indirect effect of HL on PSC (ab_1) through the mediating effect test. The result shows a significant and positive value of indirect effect (β = 0.136, T-value = 5.462, BCI = 0.092 – 0.189) indicating it as a complementary mediation. This result fully supports H2 of the study (Haider et al., 2018) Next, the variance accounted for (VAF) obtained from the calculation of the percentage of indirect effect from the total effect is reported at 29.7%. This implies a partial mediation of ATT between HL and PSC (Hair et al., 2017). In additional observations, the path coefficient of HL to PSC in Model 2 (*c'*) has been substantially reduced compared to the path in Model 1 (*c*) suggesting a partial mediation (Haider et al., 2018; Muller, Judd, & Yzerbyt, 2005). Therefore, the indirect effect of HL on PSC through ATT is categorised as a partial mediation relationship.

The third hypothesis test (H3) is reported by Model 4. The path of an interaction term between HL and PU to ATT (a_3) significantly and positively moderated the relationship between HL and ATT (β = 0.088, T-value = 2.109, $p < 0.05$). In other words, as PU increased, ATT increased too. We support this result with the PROCESS Macro analysis in Table 7. The model's stage 1 reports the positive significance of the interaction term of HL and PU towards ATT (β = 0.1053, BCCI = 0.0172, 0.1933). Therefore, H3 is fully supported.

Next is the fourth hypothesis (H4) that tests PR as a moderator to the moderated mediation relationship between HL and PSC. From Model 4 in Table 5, the path of the interaction term between ATT and PR (b_2) to PSC is significant (β = 0.146, T-value = 2.743, $p<0.05$), where PR positively moderated the relationship between ATT and PSC, improving the impact of ATT on PSC. This result indicates the potential of PR being a moderator for path ATT→PSC. To further analyse the moderated moderated mediation model of HL to PSC, we employed SPSS PROCESS Macro by Hayes (2018) using latent variable scores from SmartPLS as our data. The results are reported in Tables 7 and 8.

From the conditional moderated mediation indices shown in Table 7, the indirect effect of HL is seen significantly and positively related to PU at a different scenario of PR. At both high (1 SD above mean) and low levels of PR (1 SD below mean), HL is positively related with PU (low PR: index = 0.0424, BCCI = 0.0104, 0.0775; high PR: index = 0.0212, BCCI = 0.0015, 0.0531). The index that differentiates the moderated moderated

mediation of PR on the indirect effect of HL on PSC among different levels of PR is very low, at 0.0106. This insignificance index (LLCI = –0.013, ULCI = 0.0250) shows that the moderated moderated mediation of H4 is not significant. This indicates that the moderation of the indirect effect of HL by PU does not differ at the different levels of PR.

Further analysis in Table 8 shows the conditional indirect effect of HL on PSC in this moderated moderated mediation model (first-stage moderator is PU and the second-stage moderator is PR). The indirect effect of HL on PSC is the strongest and significantly positive during the high-level presence of both PU (1 SD above mean) and PR (1 SD above mean) towards MHealth (effect = 0.1564, BBCI = 0.0936, 0.2296). On the contrary, at a low level of PU (1SD below mean) and PR (1SD below mean), HL affected PSC the least, significantly positive (effect = 0.0356, BBCI = 0.0036, 0.0829). These further details on the moderated moderated mediation analysis indicate that H4 is partially supported. This shows that PR positively moderated the moderated mediation of PU on the indirect effect of HL on PSC, but not in a significant manner.

The fifth hypothesis (H5) is decided from model 4 in Table 5. The path from interaction term 3 between HL and PR to PSC (c_3) shows a significant negative moderation potential of PR on the direct effect of HL on PSC (β = –0.146, T-value = 2.987). To conclude, as the value of PR increases, the value of PSC decreases. Further analysis results from PROCESS Macro analysis are shown in Table 9. When the direct relationship of HL on PSC is conditioned with PR, HL significantly and negatively affects PSC. At different values of PR, HL affected PSC significantly, where the effect is the highest at a low level of PR (1SD below: effect = 0.5607, BCCILL = 0.4298, BCCIUL = 0.6916). At a high level of PR, HL affected PSC the lowest (1 SD above: effect = 0.2930, BCCILL = 0.1665, BCCIUL = 0.4195). Therefore, H5 is fully supported.

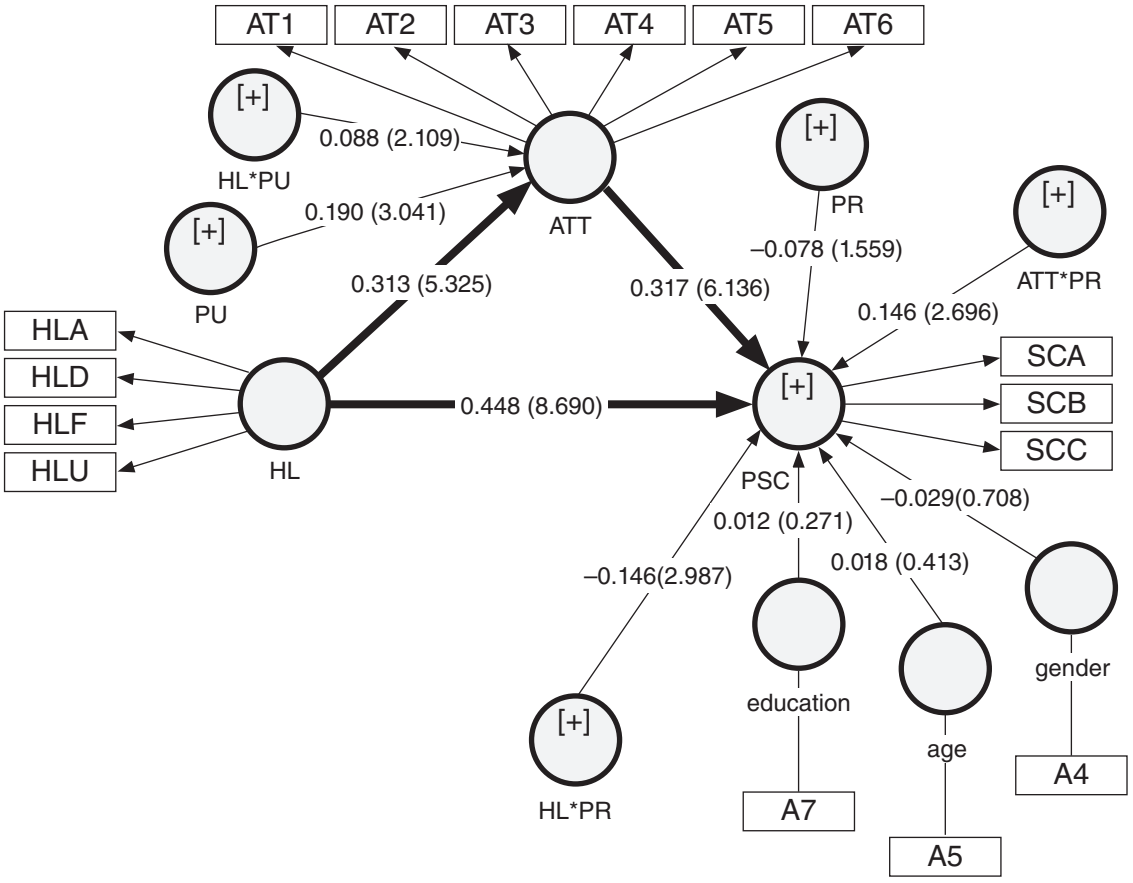

Figure 1. Structural equation modelling of the relationship between health literacy, attitude and prescribed self-care of model 4

DISCUSSION

This study aimed to explore the role of MHealth in affecting CHD patients' attitudes on their prescribed self-care. We analysed MHealth using its prescribed usefulness and risk. Additionally, we analysed the control variables of gender, age, and education in the same framework. We proposed 5 hypotheses, where 4 are fully supported and 1 is partially supported. The main findings of the study are discussed as follows.

First, H1 is fully supported where health literacy has a significant and substantial influence on CHD patient's prescribed self-care practice. Both health literacy and control variables explained the weak to moderate variance size for the prescribed self-care (R^2 = 0.350; β = 0.600; T-value = 12.745). Similar to many other empirical research and theories, health literacy has proven to be very significant in improving patient's health behaviour (Matsuoka et al., 2016; Nutbeam, 2000; Riegel & Dickson, 2008; Riegel et al., 2012). Hence, WHO and healthcare providers around the world continue to organise health campaigns globally. Practically, limited health literacy can be improved through education. In USA, 851 illiterate CHD and heart failure patients who participated in an intervention study to improve their knowledge saw a drop in the number heart-related cases such as hospital readmission or myocardial infarction (Bell et al., 2016).

However, sufficient health literacy may not result in positive health behaviour. For example, the complexity of information about heart disease may hinder a patient with sufficient health literacy from practising disease management (Zaben & Khalil, 2019). To illustrate, 189 patients who were deemed to have sufficient health literacy died within 12 months of a randomised control study in Spain (León-González et al., 2018). These mixed results indicate that while health literacy is significant for disease self-management, the outcome may be controlled by other contributing factors too.

Second, the fully supported H2 indicates a cognitive factor, that is, attitude plays a significant role in explaining the impact of health literacy on prescribed self-care behaviour. Similar to past studies, an attitude projected from health literacy further impacts a CHD patient's decision in prescribed self-care practice (Odetola et al., 2018; von Wagner et al., 2009; Wang et al., 2014; Wrigley et al., 2005). Possessing a higher level of health literacy builds up a more positive attitude towards practising prescribed self-care, hence becomes the behaviour. The capacity to access, understand, appraise, and apply health knowledge for decision-making is important for generating positive feelings in a CHD patient so as to feel empowered in disease management. On the contrary, a systematic review on mental health literacy intervention programmes among youths and teachers at schools revealed insignificant effects of health literacy programmes on attitude, hence the need to seek assistance regarding their mental health (Wei, Hayden, Kutcher, Zygmunt, & McGrath, 2013; Yamaguchi et al., 2020).

Third, H3 is fully supported, indicating the natural connection between health literacy and attitude may be improved with the presence of MHealth in the medication regimen when MHealth is perceived useful. In this study, MHealth was perceived as being useful and magnified the attitude of patients towards practising prescribed self-care. This finding is similar to those found in existing literature (Campbell et al., 2017; Miyamoto & Young, 2016). MHealth is useful in many ways such as provider-patient communication, education, and disease management (e.g. doctor appointments, medication adherence, symptom monitoring, motivation). MHealth may act as a virtual coach, motivator, or virtual care with regular reminders and encouragements that can improve a patient's lifestyle (Sullivan & Lachman, 2017; Willcox et al., 2015). Young chronic disease patients prefer MHealth because its functionality gives them full autonomy, control over their disease management, and empowerment during doctor's consultations. However, despite its usefulness as virtual care, some patients regard MHealth as a secondary source, where medical providers remain as their primary source of reference (Vo et al., 2019).

MHealth plays an important role with continuous information dissemination and monitoring in a patient's daily life which creates a positive feeling and self-care engagement. However, too frequent or overstimulation usually leads to sensory adaptation where the absolute threshold then proceeds to rise. The patient tends to get used to messages or cluttered prompts in MHealth that they barely detect or notice the stimulus (Schiffman, O'Cass, Paladino, & Carlson, 2014). Hence, the efficiency of the reminders or prompts or functions of MHealth declines as the patient stops responding to stimulus such as medication reminders. Additionally, some patients may feel overwhelmed with the use of MHealth, from being monitored and dependent on a digital device. They may feel that the dependence on such device limits their freedom and creates a negative feeling about their disease, which eventually leads to resistance to its use (Dobson et al., 2017; Vo et al., 2019).

Fourth, the impact of perceived risk towards MHealth on prescribed self-care, that is, H5, is fully supported. Similar to other studies, MHealth is perceived as risky by CHD patients in this study as well, which results in their refusal to practise prescribed self-care (Schnall et al., 2015; von Wagner et al., 2009; Waters et al., 2014). These risks include the privacy and performance of MHealth itself. Privacy involves data abuse such as leakages, unconsented disclosure or usage by third parties; and theft that are beyond control (Breward, 2007; Deng et al., 2018). Furthermore, users tend to have uncertainties on the ability of MHealth to perform as anticipated or in delivering its outcomes (Deng et al., 2018; Nepomuceno, Laroche, & Richard, 2014). However, when the patient's perception of the usefulness of MHealth changes their attitude positively, the perceived risk of MHealth does not significantly matter. This refers to H4 which is partially supported. The usefulness and benefits obtained from MHealth outweigh the risks associated with this technology. Further, patients' concerns about MHealth only affects their health behaviour decision on a very small scale. This is similar to the behaviour of chronic disease patients in China (Zhu et al., 2018). For this reason, it is essential to educate patients on the usefulness of MHealth before it is integrated into their daily self-care of disease management.

Implications

Theoretically, a new framework of understanding MHealth's role in CHD prescribed self-care has been developed from this study. Based on this framework in Figure 2, perceived usefulness plays a big role in creating a positive attitude towards self-care among CHD patients. Without acknowledging the usefulness of MHealth, patients' perceived risk of MHealth will affect their self-care negatively. This framework signifies the importance of the perceived usefulness of MHealth among CHD patients as it leads to positive self-care.

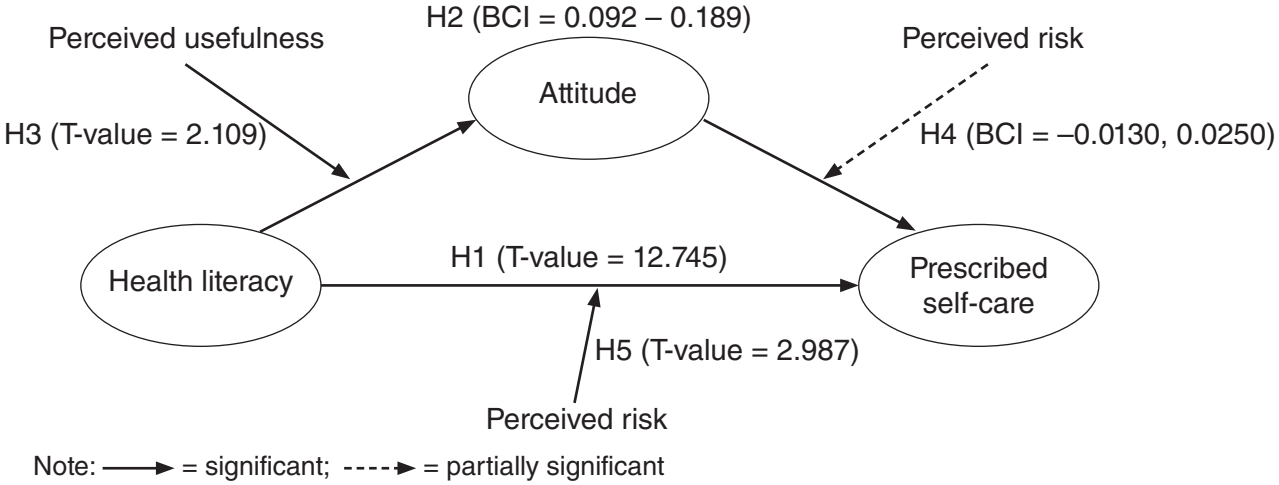

Figure 2. Framework of effects of MHealth on CHD prescribed self-care

MHealth has been recognised for its potential as a part of a sustainable mechanism in healthcare practice by being a solution to the root cause of declining global health status, which is, communication gap. As a part of the patient-centric system, the patient is the main actor to be changed or empowered. It is imperative to compose a favourable perception of the usefulness of MHealth in disease management among patients, as it will positively lead to affirmative health behaviour change.

In this regard, the main factor in enabling positive behaviour change is the perception of the usefulness of MHealth. To project this, it requires the involvement and support of many parties such as healthcare providers, regulators, and developers. The prognosis of MHealth being positive is possible through (1) relevant disease management functions, (2) regulations (3) audit and corrections, and (4) education.

To this end, MHealth must provide relevant functions for patients including treatment compliance, appointment management, social support, disease monitoring, speedy access to healthcare providers, health information, lifestyle and diet monitoring and management as well as many others. With a wearable monitoring device, the patient is relieved from manual symptom monitoring, and an accessible record enables healthcare providers to continuously conduct remote symptom monitoring. These useful functions improve patient's maintenance, monitoring, and thus management as evidenced from a drop in relapse, hospitalisation and false emergency visits as well as better health outcome. However, the usefulness and positive implications of MHealth may only be realised through its adoption as a part of the prescribed medication regimen.

As such, the regulator is the most important player as it controls all aspects of MHealth's development and implementation, towards the realisation of the technology's outcomes in the healthcare system. Policies need to be formulated with the welfare of the users of MHealth in mind to protect their economic capacity. Policies should also address the improvement of Hospital Information System's (HIS) security, tiered access to medical records, the accuracy of information provided in any health-related sites or applications, and the approval of technological applications or publications by selected regulatory bodies.

In this context, a HIS-connected MHealth risks personal record leakage, which has been a raging global debate for many years. Any improvement or upgrade of HIS security commonly faces economic constraints, which is normally attributed to the regulator's bureaucracy and developer's fee. Nevertheless, both developers and corporations compete for an economic share in this new lucrative MHealth business (Ugalmugale & Swain, 2019). Due to this, healthcare is regarded as a pot of gold among capitalist developers and healthcare providers, diverting the focus from humanity to financial (Sharon, 2018).

As a result, many developers have and continue to develop systems or technologies as a part of self-care intervention for both disease prevention and management without any guarantee of its efficiency (Collier, 2018). This does not guarantee a safe environment for users, especially chronic disease patients and calls for regulatory bodies to regulate or ensure that these technologies are properly tested before they are made available to the public.

The integration of MHealth into self-care prescription should be a part of a holistic and comprehensive strategy for sustainable self-care among patients. This strategy should include audits and revisions for any MHealth integration programme. A scheduled audit to assess the effectiveness of the programme, with the inclusion of feedback from patients provides room for continuous improvement and tweaking of the system or the programme.

One of the most important strategies which can lead to MHealth's perception of usefulness is education and awareness. Training and campaigns are vital in educating

patients on the usefulness of MHealth as a part of their disease management. This mechanism also contributes to alleviating their concerns over security and privacy issues on MHealth. Apart from this, training on the usability of MHealth promotes a better understanding of MHealth, specifically those who are health illiterates.

Limitations

This study has a few limitations that may influence the results of this study. The first limitation is the type of prototype employed for concept testing. We employed a semi-functional prototype, whereas a fully functional prototype may have provided the full experience of using MHealth for participants. This limitation might have limited the respondents' experience and perception, thus influencing their answers in the distributed survey. Future studies are suggested to develop a full prototype of MHealth for self-care so that participants can experience its complete functionality and are able to provide a more accurate assessment.

The second limitation is the type of data collection selected for this cross-sectional study. A longitudinal study may be more suitable as it enables participants to have more time to use and experience the prototype prepared for this study. The experience of using the prototype for a short duration may influence their perception and responses for the items measured in the survey distributed. Future studies may use a data collection method suitable for longitudinal study so that participants can experience the developed prototype for a longer duration to provide a better assessment. A randomised controlled trial may be the next type of study following the full development of the prototype to analyse the effectiveness of MHealth.

CONCLUSION

The consequences of the existing communication gap between providers and patients due to the inefficiency of the current healthcare system is evident in the mortality statistics of CHD in Malaysia. This communication gap leads to poor disease management among patients. However, the integration of MHealth in disease management among chronic disease patients such as CHD patients can potentially improve the provider-patient communication gap. It is a good behaviour change tool that has the potential to monitor and control patients' self-care behaviour. Thus awareness and education of the usefulness of MHealth is essential in promoting a positive attitude towards it. The perceived usefulness of MHealth outweigh common concerns about MHealth such as privacy, security, information accuracy, physiological risk, and others, which may limit or control patients' engagement, and in tandem, their appropriate self-care practice. MHealth's perception of usefulness is possible through its relevant functions for disease management, scheduled audit and feedback, education, and regulatory control of its development.

Regardless of the numerous efforts and regulations by healthcare players, if technological applications such as MHealth is not accessible to marginalised or disadvantaged communities (lower income), which also make up the majority of the population, the goal to create a healthier population through any deliberate communication technology strategy cannot be realised.

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Appendix 1: Survey Items

Items		Factor loading
Health literacy (1 = strongly disagree, 5 = strongly agree)		
HL Access		
HLF1	It is easy to find information from various media about symptoms of illnesses that concern you?	0.953
HLF2	It is easy to find information from various media on treatments of illnesses that concern me	0.953
HLF3	It is easy to find out from various media what to do in case of a medical emergency	0.946
HLF4	It is easy to find out from various media where to get professional help when I am ill?	0.942
HLF5	It is easy to find information from various media about how to manage unhealthy behaviour such as smoking, low physical activity and drinking too much	0.895
HLF6	It is easy for me to find information from various media on how to manage problems like stress or depression	0.833
HLF7	It is easy to find information from various media on how to prevent or manage conditions like being overweight, high blood pressure or high cholesterol	0.930
HLF8	It is easy to find information from various media on healthy activities such as exercise, healthy food and nutrition	0.884
HLF9	It is easy to find out from various media about activities that are good for my mental well-being (e.g: stress, depression)	0.828
HL Understand		
HLU1	It is easy to understand what my doctor says to me	0.586
HLU2	It is easy to understand the leaflets that come with my medicine	0.704
HLU3	It is easy to understand from various media what to do in a medical emergency	*Dropped*
HLU4	It is easy to understand my doctor's or pharmacist's instruction on how to take a prescribed medicine	*Dropped*
HLU5	It is easy to understand health warnings from various media about behaviour such as smoking, low physical activity and drinking too much	0.892
HLU6	It is easy to understand information in the media on how to get healthier	0.900
HLU7	It is easy to understand information from various media on how to keep my mind healthy from stress or depression	0.828
HL Appraise		
HLA1	It is easy to judge how information from my doctor applies to me	*Dropped*
HLA2	It is easy for me to judge the advantages and disadvantages of different treatment options	0.654
HLA3	It is easy for me to judge when I may need to get a second opinion from another doctor	0.647
HLA4	It is easy for me to judge if the information about illness in the media is reliable	0.763
HLA5	It is easy to judge how reliable health warnings from various media are, such as smoking, low physical activity and drinking too much	0.757
HLA6	It is easy to judge when I need to go to a doctor for a check-up	0.580
HLA7	It is easy to judge if the information on health risks in the media is reliable	0.810
HLA8	It is easy to judge which everyday behaviour is related to my health	0.581

Items		Factor loading
HL Apply		
HLD1	It is easy for me to use information the doctor gives me to make decisions about my illness	0.840
HLD2	It is easy for me to follow the instructions on medication	0.879
HLD3	It is easy to call an ambulance in an emergency	0.564
HLD4	It is easy to follow instructions from my doctor or pharmacist	0.863
HLD5	It is easy to decide how I can protect myself from illness based on information in the media	*Dropped*
HLD6	It is easy to make decisions to improve my health	0.615
Attitude		
AT1	Very tiresome/ very stimulating (1 = very tiresome, 5 = very stimulating)	0.808
AT2	Very unpleasant/ Very pleasant (1= very unpleasant, 5 = very pleasant)	0.837
AT3	Very bad/ Very good (1 = very bad, 5 = very good)	0.783
AT4	Very harmful/ Very beneficial (1 = very harmful, 5 = very beneficial)	0.782
AT5	Very unnecessary/ Very essential (1 = very unnecessary, 5 = very essential)	0.712
AT6	Very inconvenient/ Very convenient (1 = very inconvenient, 5 = very convenient)	0.797
Perceived Usefulness of MHealth (1 = strongly disagree, 5 = strongly agree)		
PU1	Using MHealth in self-managing my CHD would enable me to accomplish task more quickly	0.992
PU2	Using MHealth would improve the efficiency of my CHD self-care	0.996
PU3	Using MHealth would enhance the effectiveness of my CHD self-care	0.996
PU4	Using MHealth would make it more convenient to self-manage my CHD	0.998
PU5	Using MHealth would make it easier to self-manage my CHD	0.996
PU6	Overall, I think MHealth would be useful for self-managing CHD	0.995
Perceived Risk of MHealth (1 = strongly disagree, 5 = strongly agree)		
PR1	I am afraid that MHealth providers cannot guarantee the confidentiality of user information	0.916
PR2	I am worried that my personal privacy information will be used for other purposes if I use MHealth services	0.926
PR3	Because of security issue, I am worried about personal information leakage	0.911
PR4	I am worried that using MHealth services cannot satisfy my health needs	0.946
PR5	I am afraid that the health information from MHealth services cannot well address my health concerns	0.932
PR6	I am worried that the services provided by MHealth may not match my expectations	0.926
Prescribed self-care		
PSC maintenance (1 = never, 5 = every day)		
SCA1	I avoid/ reduce cigarettes and/ or smokers	0.440
SCA2	I often maintain routine physical health activity: For general patients – Min 30 mins/daily, 5 days/week of moderate intensity activity (150 mins weekly) Min 15 mins/daily, 5 days/week of vigorous intensity activity (75 minutes weekly) For obesity patients – Moderate intensity physical activity 250-450 minutes and 2-3 times strength training weekly– 60-150 minutes for unfit or inactive patients 3 days/week *refer to table 9 from CPG	0.710
SCA3	I often maintain healthy daily diet • #QuarterQuarterHalf Plate diet *refer to table 5 from CP	0.831

Items		Factor loading
SCA4	I often maintain healthy daily diet • 5 servings of fruits/vegetables • 30 grams unsalted nuts • < 12 teaspoon sugar (50g) • Healthy oils (blended, peanut, sunflower, olive, canola, corn oil) • Low fat dairies • Eat fish often 2-4 servings/ weekly (oily/marine – kembung, patin, keli, terubuk) • Reduced processed food • Minimise processed food (sausages, salami, burgers, nugget, serunding, pizza, biscuits, crackers, cookies, margarine, spreads) • <1 tablespoon (200 mg) salt • <200 mg beef, pork, eggs • Alcohol 0-2 servings daily *refer to table 6 from CPG	0.837
SCA5	I often adhere to condition-specific medication *refer to table 21 from CPG and the CPG stable CAD	0.827
SCA6	I often consume all medications prescribed	0.841
SCA7	I often attend cardiac/other types of rehabilitation	0.421
SCA8	I often keep scheduled appointments and contact healthcare providers as needed	0.654
PSC monitoring (1 = strongly disagree, 5 = strongly agree)		
SCB1	I am aware of common signs and symptoms of CHD e.g chest pain/ shortness of breath	0.893
SCB2	I am aware of signs and symptoms of worsening CHD (increasing angina or breathing difficulty, unable to carry out normal daily activities)	0.922
SCB3	I am aware of signs and symptoms of medication complications (eg, bleeding tendencies such as nose/gum bleed, muscle pain, hypotension)	0.796
SCB4	I establish routine to monitor my health condition every day (morning/ afternoon/evening/no specific time)	0.854
PSC monitoring (1 = never, 5 = every day)		
SCB5	I follow the established routine to monitor my health condition every day (morning/afternoon/evening)	0.904
SCB6	I do routine blood pressure measurement at home every day (maintain <130/80 mmHg, >140/90 mmHg on multiple readings and occasions is a sign of hypertension)	0.916
SCB7	I keep a record of BP measurement at home every day (maintain <130/80 mmHg, >140/90 mmHg on multiple readings and occasions is a sign of hypertension)	0.857
SCB8	I do routine weight measurement every day For diabetes and obesity- • 0.5kg/weekly weight loss for obesity and diabetes) • Have a targeted weight loss/ know the range for an ideal weight for obesity For diabetes – • Finger-prick home sugar monitoring	0.769
PSC management (1 = strongly disagree, 5 = strongly agree)		
SCC1	I can distinguish between CHD related symptoms and non-CHD related symptoms (e.g pneumonia-chest infection/association with fever/pain/ pressure or discomfort in the centre or upper body during exercise/ progressive angina/prolonged chest pain)	0.780

Items		Factor loading
SCC2	I have an immediate plan of action when signs and/or symptoms occur outside of hospital: Take nitroglycerin/ aspirin and rest	0.443
SCC3	I can evaluate the effectiveness of medication in achieving CV risk targets (eg BP, sugar, weight)	0.872
SCC4	I have plan to intensify lifestyle modification if CV risk targets are not achieved (lifestyle changes e.g increase physical activity frequency/consume healthy diet following recommended diet/stop smoking/ improve medication adherence)	0.768
SCC5	I have identified when and which healthcare centre to attend at any occurrence of signs and/or symptoms:	
SCC 5i	To choose either outpatient clinic or emergency department	0.895
SCC 5ii	To choose different healthcare centre for different urgencies/severity?	0.853
SCC 5iii	To choose to go by appointment or walk in	0.891

Appendix 2: List of Tables

Table 1. Source of measurement items

Variable	Source of adopted or adapted measurement item
Health literacy	European Health Literacy Survey Questionnaire (HLS-EU-Q) (Sørensen et al., 2012)
Prescribed self-care	Self-care of Coronary Heart Disease Inventory (SC-CHDI) by Dickson et al. (2017) and Riegel et al. (2017) with additional items to fit the context of this study, which is Malaysia healthcare where CHD self-care adheres to the Clinical Practice Guidelines of Stable Coronary Artery Disease 2018 (National Heart Association of Malaysia, 2018) and Clinical Practice Guideline on Primary & Secondary Prevention of Cardiovascular Disease 2017 (Ministry of Health, 2017)
Perceived usefulness	Perceived usefulness (Hoque, 2016; Zhu, Liu, Che, & Chen, 2017)
Perceived risk	Perceived risk (Deng, Hong, Ren, Zhang, & Xiang, 2018)
Attitude	Attitude (Bane, Hughes, & McElnay, 2006; Bondreau & Godin, 2009)

Table 2. Internal consistency reliability of first-order constructs

Construct	N items	Cronbach's Alpha	AVE	CR
HLA	7	0.812	0.476	0.862
HLD	5	0.810	0.584	0.872
HLF	9	0.973	0.825	0.977
HLU	5	0.845	0.626	0.891
*Health Literacy		0.954	0.491	0.960
ATT	6	0.879	0.620	0.907
PR	6	0.967	0.858	0.973
PU	6	0.998	0.991	0.999
SCA Adherence	4	0.627	0.499	0.789
SCA HealthBehaviour	4	0.671	0.522	0.806
*Perceived Self-care Maintenance		0.721	0.344	0.804
SCB Awareness	3	0.840	0.760	0.905
SCB Routine	5	0.912	0.742	0.935
*Perceived Self-care Monitoring		0.875	0.541	0.903
SCC DelayedResponse	4	0.778	0.630	0.865
SCC EarlyRecognition	3	0.732	0.653	0.849
*Perceived Self-care Management		0.838	0.517	0.880
Total:	67			

*Note: AVE = average variance extracted; CR = composite reliability; *Italics used for higher-order constructs*

Table 3. Measurement model assessment of second-order constructs

Second-order construct	First-order construct	Weight	SD	T-value	VIF
Health Literacy	HLA	0.233	0.016	14.454*	2.349
	HLD	0.195	0.012	15.894*	2.058
	HLF	0.494	0.018	27.268*	5.081
	HLU	0.223	0.008	28.293*	6.804
Perceived Self-care Maintenance	SCAA	0.550	0.044	12.423*	1.152
	SCAHB	0.659	0.035	18.885*	1.152
Perceived Self-care Monitoring	SCBA	0.395	0.019	21.353*	1.183
	SCBR	0.776	0.022	35.840*	1.183
Perceived Self-care Management	SCCDR	0.625	0.021	29.312*	1.604
	SCCER	0.486	0.022	22.048*	1.604

*Note: * One-tailed p-value < 0.001, T-value > 3.092; p-value < 0.01, T-value > 2.327; p-value < 0.05, T-value > 1.645; p-value < 0.10, T-value > 1.282*

Table 4. Measurement model assessment of third-order constructs

	Second-order construct	Weight	SD	T-value	VIF
Perceived Self-care	Self-care Maintenance	0.342	0.017	19.589*	1.753
	Self-care Monitoring	0.370	0.013	28.324*	2.375
	Self-care Management	0.442	0.015	30.363*	2.432

*Note: * One-tailed p-value < 0.001, T-value > 3.092; p-value < 0.01, p-value > 2.327; p-value < 0.05, T-value >1.645; p-value < 0.10, T-value > 1.282*

Table 5. Structural model assessment

Model	β	T-value	BCILL	BCIUL	VIF	f^2	Support
Model 1 $R^2 = 0.350$, $Q^2 = 0.246$							
H1: HL → PSC (*c*)	0.600	12.745*	0.514	0.670	1.088	0.515	Yes
Control variables							
Age	0.023	0.474	–0.057	0.103	1.016	0.001	
Gender	–0.015	0.086	–0.095	0.063	1.016	0.000	
Education	0.004	0.322	–0.078	0.094	1.090	0.000	
Model 2 $R^2_{ATT} = 0.156$, $Q^2 = 0.090$ $R^2_{PSC} = 0.446$, $Q^2 = 0.315$							
HL → PSC (*c'*)	0.463	9.061**	0.359	0.559	1.275	0.309	Yes
HL → ATT (a_1)	0.398	8.508**	0.302	0.487	1.000	0.188	Yes
ATT → PSC (b_1)	0.342	6.450**	0.236	0.443	1.195	0.179	Yes
Control variables							
Age	0.018	0.423	–0.067	0.100	1.016	0.001	
Gender	–0.037	0.869	–0.087	0.046	1.022	0.002	
Education	0.002	0.048	–0.087	0.090	1.090	0.000	

Model	β	T-value	BCILL	BCIUL	VIF	f^2	Support
Model 3 R^2_{ATT} = 0.177, Q^2 = 0.102 R^2_{PSC} = 0.452, Q^2 = 0.318							
HL → PSC (c_1)	0.438	8.587*	0.351	0.519	1.363	0.262	Yes
HL → ATT (a_1)	0.317	5.424*	0.217	0.408	1.274	0.097	Yes
ATT → PSC (b_1)	0.335	6.369*	0.248	0.420	1.205	0.174	Yes
PU → ATT (a_2)	0.175	2.869*	0.076	0.278	1.274	0.030	Yes
PR → PSC (c_2)	–0.089	1.974*	–0.164	–0.015	1.121	0.013	Yes
Control variables							
Age	0.021	0.484	–0.057	0.087	1.018	0.001	
Gender	–0.036	0.867	–0.105	0.034	1.021	0.002	
Education	0.005	0.107	–0.073	0.082	1.092	0.000	
Model 4 R^2_{ATT} = 0.185, Q^2 = 0.107 R^2_{PSC} = 0.476, Q^2 = 0.336							
HL → PSC (c_1)	0.448	8.690*	0.355	0.525	1.370	0.287	Yes
HL → ATT (a_1)	0.313	5.325*	0.207	0.402	1.276	0.095	Yes
ATT → PSC (b_1)	0.317	6.136*	0.228	0.399	1.218	0.162	Yes
PU → ATT (a_2)	0.190	3.041*	0.088	0.293	1.297	0.035	Yes
PR → PSC (c_2)	–0.078	1.559*	-0.159	0.005	1.187	0.010	Yes
H3: HL*PU → ATT (a_3)	0.088	2.109*	0.016	0.152	1.019	0.012	Yes
ATT*PR → PSC (b_2)	0.146	2.696*	0.050	0.229	1.351	0.038	Yes
H5: HL*PR → PSC (c_3)	–0.146	2.987*	-0.221	–0.059	1.393	0.041	Yes
Control variables							
Age	0.018	0.430	-0.052	0.092	1.018	0.001	
Gender	–0.029	0.708	-0.096	0.039	1.028	0.002	
Education	0.012	0.271	-0.059	0.089	1.095	0.000	

*Note: * One-tailed p-value < 0.001, T-value > 3.092; p-value < 0.01, T-value > 2.327; p-value < 0.05, T-value > 1.645; p-value < 0.10, T-value > 1.282*
*** two-tailed p-value < 0.001, T-value > 3.292; p-value < 0.01, T-value > 2.577; p-value < 0.05, T-value > 1.960; p-value < 0.10, T-value > 1.645*

Table 6. Summary of mediating effects test

Mediating effect test	β	T-value	BCILL	BCIUL	VAF
Total effects on PSC (model 1)					
HL → PSC (c)	0.600	12.745**	0.514	0.67	
Control variables					
Age	0.023	0.474	–0.057	0.103	
Gender	–0.015	0.086	–0.095	0.063	
Education	0.004	0.322	–0.078	0.094	
Direct effects on PSC (model 2)					
HL → PSC (c')	0.463	9.061**	0.359	0.559	
Control variables					
Age	0.018	0.423	–0.067	0.100	
Gender	–0.037	0.869	–0.087	0.046	
Education	0.002	0.048	–0.087	0.090	
Indirect effect on PSC (model 2)					
H2: HL → ATT → PSC (ab_1)	0.136	5.462**	0.092	0.189	29.37%

*** two-tailed p-value < 0.001, T-value > 3.292; p-value < 0.01, T-value > 2.577; p-value < 0.05, T-value > 1.960; p-value < 0.10, T-value > 1.645*

Table 7. Moderated moderated mediation results using PROCESS Macro analysis (Model 28)

	Outcome							
	First stage - M: Attention $R^2 = 0.1769$, F (3,296) = 21.2057, p<0.05				Second stage - Y: Prescribed self-care $R^2 = 0.4425$, F (5,294) = 46.6676, p<0.05			
Moderated mediation results	β	T-value	BCCILL**	BCCIUL**	β	T-value	BCCILL**	BCCIUL**
Constant	–0.0512	–0.8982	–0.1633	0.0609	–0.0209	–0.4623	–0.1099	–0.0681
X: HL	0.2825	4.6743*	0.1636	0.4015	0.4269	8.7636*	0.3310	0.5227
W: PU	0.2094	3.4196*	0.0889	0.3299				
Z: PR					–0.0893	–1.8994*	–0.2197	0.0032
M: ATT					0.3021	6.3732*	0.2088	0.3954
XW: HL x PU	0.1053	2.3530*	0.0172	0.1933				
XZ: HL x PR					–0.1338	–3.0668*	–0.2197	–0.0480
MZ: ATT x PR					0.1011	2.2470*	0.0125	0.1896

		index	BCCILL**	BCCIUL**
H4: Moderated moderated mediation		0.0106	–0.0130	0.0250
Conditional moderated mediation				
By perceived usefulness (W) among patients with	High perceived risk (+1SD)	0.0212	0.0018	0.0531
	Average perceived risk (0SD)	0.0318	0.0074	0.0619
	Low perceived risk (–1SD)	0.0424	0.0104	0.0775

*Note: * One-tailed p-value < 0.001, T-value > 3.092; p-value < 0.01, T-value > 2.327; p-value < 0.05, T-value > 1.645; p-value < 0.10, T-value > 1.282,*

***95% percentile CI bootstrap on 5000 samples*

Table 8. Conditional indirect effects of health literacy on prescribed self-care

Perceived usefulness	Perceived risk	Effect	BCCILL	BCCIUL	Support
-1SD	-1SD	0.0356	0.0036	0.0829	Yes
-1SD	MeanSD	0.0535	0.0118	0.0980	Yes
-1SD	+1SD	0.0715	0.0154	0.1282	Yes
MeanSD	-1SD	0.0568	0.0122	0.1182	Yes
MeanSD	MeanSD	0.0854	0.0455	0.1322	Yes
MeanSD	+1SD	0.1139	0.0645	0.1687	Yes
+1SD	-1SD	0.0779	0.0165	0.1629	Yes
+1SD	MeanSD	0.1172	0.0639	0.1814	Yes
+1SD	+1SD	0.1564	0.0936	0.2296	**Yes**

Table 9. Conditional direct effects of health literacy on prescribed self-care

Perceived risk	Effect	BCCILL	BCCIUL	Support
-1SD	0.5607	0.4298	0.6916	Yes
MeanSD	0.4269	0.3210	0.5227	Yes
+1SD	0.2930	0.1665	0.4195	Yes