

Text-messaging as a tool for Medication Adherence and Behavior Change in Disease  
Management among Patients with Coronary Heart Disease

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Thesis submitted in partial fulfillment of  
the requirements for the degree of  
Master of Science in the Global Health Program  
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ABSTRACT

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## **Abstract**

**Background:** Evidence-based medication and lifestyle modification are important for secondary prevention of cardiovascular disease but are underutilized. Mobile health strategies could address this gap but existing evidence is mixed. Therefore, we piloted a pre-post study to assess the impact of patient-directed text messages as a means of improving medication adherence and modifying major health risk behaviors among coronary heart disease (CHD) patients in Hainan, China.

**Methods:** 92 CVD patients were surveyed between June and August 2015 (before the intervention) and then between October and December 2015 (after 12 week intervention) about (a) medication use (b) smoking status,(c) fruit and vegetable consumption, and (d) physical activity uptake. Acceptability of text-messaging intervention was assessed at follow-up. Descriptive statistics, along with paired comparisons between the pre and post outcomes were conducted using both parametric (t-test) and non-parametric (Wilcoxon signed rank test) methods.

**Results:** The number of respondents at follow-up was 82 (89% retention rate). Significant improvements were observed for medication adherence ( $P<0.001$ ) and for the number of cigarettes smoked per day ( $P=.022$ ). However there was no change in the number of smokers who quitted smoking at follow-up. There were insignificant changes for physical activity ( $P=0.91$ ) and fruit and vegetable consumption.

**Conclusions:** After the use of evidence-based tailored text messages for medication use and lifestyle modification, participants showed a significant improvement in medication adherence at follow-up compared to baseline, but there was no change in physical activity or fruit and vegetable consumption. Participants were satisfied with the intervention, and thought that the intervention was helpful for achieving the specified outcomes. Further research is needed to determine the effectiveness of such programs.

## **Dedication**

To my mother, father, and fiancé for always pushing me to be the best person I can be and giving me the support I need to achieve my goals.

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## **Acknowledgements**

Thank you to Prof. Lijing Yan for supervising me in this research endeavor. Thank you for your guidance and support through the research process. Your scholarly work in the field of Non-Communicable diseases, specifically Cardiovascular Disease has further deepened my interest in the area and desire to dedicate my life to alleviating the global NCD burden.

Thank you Prof. Dear and Prof. Abu for your support throughout this process; thank you for encouraging me to think critically about my methods and analysis.

Thank you Chen Shu and Enying Gong for being part of the TAKEmeds research team: Chen Shu for traveling to Hianan with me, assisting me with the language barrier, and project management on field; Enying for helping with data cleaning. As past graduates of the global health program, you are both an example to students and aspiring global health professionals. Overall, I feel lucky to have worked with a group of successful and inspiring women.

Thank you to Ms. Shuyu Guan for always sacrificing your time to ensure our success.

You were always available to answer all our questions and never hesitated to help us.

Thank you to our collaborators, the physicians in the cardiology department at Hainan Nongken Provincial General Hospital in Hainan, China. Thank for your hospitality and the opportunity to allow this study to take place at your hospital. Specifically I will like

to thank Dr. Sun, for being my assistant and translator during the duration of this project. Hainan will always have a special place in my heart.

# 1. Introduction

Cardiovascular disease (CVD) is the leading cause of death and disease burden globally (WHO 2014) with 80% of CVD deaths occurring in Low and Middle-Income Countries (LMIC's)(Chan & Kaufman, 2009). China, like many other LMIC's, has an increasing burden of cardiovascular conditions. Currently stroke is the leading cause of death in China, followed by ischemic heart disease 14 (WHO 2014). Given that about 230 million people are estimated to have existing CVD in China, one of the greatest challenges in reducing CVD mortality is in secondary prevention (Hu et al., 2012). Secondary prevention of CVD aims to prevent the progression of already established CVD, and reduce the risk of repeat events or death (Hobbs, 2004).

Evidence-based treatments and strategies that have been proven to reduce the risk of major cardiovascular events are available. A wealth of evidence and international guidelines support the use of low-cost, evidence-based medication for management of established CVD (Rasmussen, Chong, & Alter, 2007). The utilization of preventive drugs and the modification of lifestyle factors are well accepted cost-effective secondary preventative strategies (Smith et al., 2006). CVD mortality rates have decreased in most western countries in the last few decades due to the "long term use of proven medication for the secondary prevention of CVD events, and favorable changes in underlying risk factors, such as smoking and dietary patterns" (Chen et al., 2014). In

China acute hospital management of patients with CVD is generally similar to that in most Western countries (Chen et al., 2014). However, studies suggest that secondary prevention efforts in China are sub-optimal (Chen et al., 2014; Jemma C Hopewell Elsa Valdes-Marquez Martin Landray JIANG Li-xin, Group, & Grp, 2012). The challenge remains in how to increase uptake of these evidence-based strategies among patients and apply them in routine clinical practice.

### ***1.1 The evidence-practice gap: low adherence to evidence-based medication***

Although cardiovascular medication adherence is associated with improved cardiovascular outcomes for patients with established CVD, adherence rates worldwide remain low, ranging between 50 % and 79 % (Valle & Ho, 2014). Indeed, the use of evidence based-medications for secondary prevention is sub-optimal worldwide including high-income countries-with the lowest use occurring in LMICs. Furthermore, the discontinuation of evidence-based therapies has continuously been associated with increased mortality in CVD patients (Rasmussen et al., 2007; Rublee et al., 2012).

According to the Prospective Urban Rural Epidemiological (PURE) study (Yusuf et al., 2011), among community-based patients with CVD, less than 25% in LMICs are on evidence based medication and less than 50% in high-income countries (HIC) are taking medications following the recommended guidelines. Even when patients have been

initiated on evidence-based medications at discharge, studies show that adherence to such therapies begins to decline at 30 days and falls to as low as 50% adherence at 6 month post discharge (Ahmad, Schwalm, Velianou, & Natarajan, 2005; Hudson, Richard, & Pilote, 2007; Newby et al., 2006).

An analysis of cross-sectional data from the China Kadoorie Biobank Study on the use of drug therapy for secondary prevention in people with prior Ischemic Heart Disease (IHD) and stroke found that only 1 in 3 individuals with a history of CVD received any established secondary preventive treatments (Chen et al., 2014).

Furthermore, study findings are broadly consistent with the results of the PURE study. In the PURE study, among a sample of 3,070 Chinese participants that reported having a history of IHD (5.2%) or stroke (1.9%), “18.6%, 6.2%, 8.6%, 14.3%, 14.9% and 1.7%, reported taking antiplatelet drug,  $\beta$ -blockers, ACE-I, diuretics, calcium-channel blockers and statins (Yusuf et al., 2011) compared with 10.6%, 10.1%, 7.6%, 2.3%, 18.2% and 1.4% respectively in the China Kadoorie Biobank Study” (Chen et al., 2014);

Indicating that under-use of drug therapy for secondary prevention of CVD is a problem in China.

## ***1.2 Underutilization of lifestyle programs for CVD***

In addition to medication adherence, programs aimed at modifying health behaviors including smoking cessation, exercise, and diet have also been proven to be



effective for secondary prevention and lowering the risk for recurrent cardiovascular events. Evidence shows that lifestyle modification is effective for secondary prevention; it can also “reduce blood pressure, excess bodyweight, and glycaemia impairment and prevent or delay the onset of type 2 diabetes and hypertension” (A. Rubinstein et al., 2016). In a study conducted in 41 countries, among a sample of 18,809 patients, the risk of myocardial infraction/stroke/death was 3.8-fold for those who reported persistent smoking and non-adherence to diet and exercise, compared with non-smokers who modified diet and exercise. (Clara K. Chow et al., 2010).

In a meta-regression analysis of 63 randomized control trails including 21,295 patients, secondary prevention programs reduced mortality and recurrent heart attacks by 15% to 20% (Clark, Harding, Vandermeer, & McAlister, 2005). Unfortunately secondary prevention programs are also underutilized and adherence to lifestyle recommendations is low. A study in Zhejiang, China revealed that health education was inadequate and had a sub-optimal effect among a sample 274 hypertensive patients with a high risk of CVD. Although patients had received treatment, or usual preventive care the “smoking rate among all the participants was 28%, higher than the national level (21%), and only 21% of patients exercised regularly, similar to the national level (24%). The average salt intake per family member was 7.1g, similar to the national average, but well above the WHO and nationally recommended level” (Zou et al., 2015). This was a

small study but it highlights the need for systematic and individualized health education for CVD prevention in China.

### **1.3 Barriers to Care in Secondary Prevention**

Barriers to evidence-based care for secondary prevention are complex, occurring at the provider, patient, and health system levels. Discrepancies in the perception of treatment benefits between patients and provider can contribute to medication non-adherence. For example, patients with asymptomatic conditions such as hypertension, may not see the benefit of taking medication because they do not feel different on or off the medication (Mathews et al., 2015). Furthermore, therapies with noticeable (even if minor) side effects (eg, easy bruising with antiplatelet therapy) or those with less apparent health impact (eg, statin therapy) are particularly vulnerable to non adherence (Baroletti & Dell'Orfano, 2010). From patient standpoint, lack of recall and motivation seem to be the biggest barriers to adherence. In the Longitudinal Assessment of Treatment Patterns and Events after Acute Coronary Syndrome (TRANSLATE-ACS) Study, 82% of patients with low medication adherence reported sometimes forgetting to take their heart medications (Mathews et al., 2015). Poor provider-patient relationship and difficulties accessing physicians or pharmacies are other socioeconomic factors that contribute to low adherence (Bansilal, Castellano, & Fuster, 2015).

From the caregiver standpoint, clinical inertia (failure to change or intensity treatment) is one of the most important causes of the lack of use of evidence based therapies. Clinical inertia is linked to other barriers identified at the provider level, including lack of familiarity and awareness of guidelines, disagreement with guidelines, time constraints, and self-efficacy (the physician believes he or she cannot perform guideline recommendations) (Cabana, Rand, Powe, & et al., 1999). At the health systems level, barriers limited access to health-care resources, and include lack of policy support for chronic care and prevention (Nieuwlaat, Schwalm, Khatib, & Yusuf, 2013).

#### ***1.4 mHealth intervention as a potential tool for secondary prevention of CVD***

Mobile phone-based interventions for chronic diseases could be a promising way to increase access to care and improve clinical outcomes in LMIC's and other low-resources settings (Beratarrechea et al., 2015). With the widespread use of mobile phones, mobile health (mhealth) offers the potential as an ideal tool for secondary prevention in CVD. There are 7 billion mobile phone subscriptions in the world today, with 85% of the world's population having access to a mobile phone (H. Li et al., 2014). China has the highest number of mobile phone users in the world, with 1.3 billion users in 2015 (Statista 2015). Given China's high penetration of mobile phones, researchers in China have made an urgent call to the promotion and application of

mobile health technology. In a country like China, which is the most populous country in the world and has limited healthcare resources, “mhealth has the potential to provide more convenient health care services, improve or maintain the health status and quality of life of patients and their family members, and promote the development of the health industry as well as the health environment” (H. Li et al., 2014). However, despite the promises, mhealth for NCD management remains a relatively under-explored area (David Peiris, Devarsetty Praveen, Claire Johnson, & Kishor Mogulluru, 2014).

A recent systematic review on the use of mhealth systems and tools for NCDs found that behavior change interventions through the use of text messaging systems have reported effectiveness for NCD management (D. Peiris, D. Praveen, C. Johnson, & K. Mogulluru, 2014). Although there have been a few recent studies evaluating the effectiveness of mobile phone text messaging either to change individual health behaviors such as physical activity (Maddison et al., 2015) or to improve adherence to medication (Wald, Bestwick, Raiman, Brendell, & Wald, 2014), addressing these lifestyle factors concurrently is likely to be more effective for secondary prevention of CVD. There is evidence suggesting that text messaging interventions can positively impact behaviors related to CVD (C. K. Chow, Redfern, Hillis, & et al., 2015), however such data remains limited in China and other LMIC's.

## **1.5 Specific Aims**

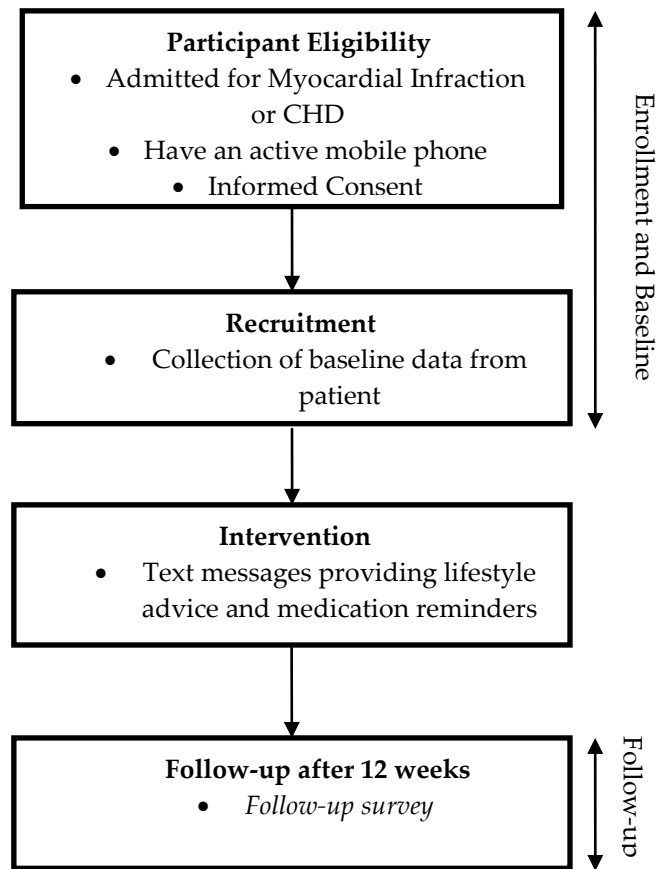
The overarching goal of this study was to contribute to improving CVD secondary prevention through the increased use of evidence-based, secondary-prevention medication, and increased adherence to lifestyle recommendations with focus on coronary heart diseases (CHD).

The aims of this pilot study with a pre-post design conducted among CHD patients in Hainan, China were:

- 1) To examine the feasibility and acceptability of the patient-directed text messaging intervention;
- 2) To assess the effect of the text messaging intervention on improving medication adherence;
- 3) To assess the effect of the text messaging intervention on modifying lifestyle risk factors (i.e. smoking, physical activity, and fruit and vegetable intake);

## **2. Methods and Study Design**

This was a short-term, exploratory, single-arm pre-post intervention study with 12 weeks of follow-up that evaluated the usefulness of a multi-faceted, information technology-enabled intervention to improve adherence to medication for secondary prevention, and to promote behavior change among 92 CVD patients, in a tier three hospital in Haikou, Hainan province, China (Figure 1). Ethical approval for this pilot study was obtained from Duke University IRB, and from the Hainan Provincial Nongken General Hospital (HPNGH) IRB.



**Figure 1: Study Design and Flow**

## 2.1 Setting

China has a 3-tier healthcare system comprising of tertiary hospitals (grade 3), secondary facilities (grade 2), and community healthcare centers for primary care (grade 1)(X. Li, Huang, & Zhang, 2008). Patients tend to choose to go to higher level facilities because they often believe that they can receive more professional and high quality medical care there. Therefore tertiary hospitals are usually overwhelmed with too many

patients. Given the current burden placed on tertiary facilities we chose to test a technology-enabled intervention in a tertiary hospital in Haikou, Hainan, China (Figure 2). Furthermore there is great difference between urban and rural hospitals in China, with rural hospitals having limited healthcare resources. Although Haikou is an urban area and is the most populous city in the island, the hospital itself is located in a suburban area within the city of Haikou and serves the patients from the surrounding rural areas. Given that the current intervention was already being tested in Shanghai, which is one of the most developed cities in China, we sought to test the same intervention in a contrasting city within China where healthcare resources are limited.



**Figure 2:** Map of Haikou, Hainan Province, China. Source: The New York Times 2010

The study was conducted at the Cardiology Department at Hainan Provincial Nongken General Hospital (HPNGH), a tertiary Hospital in Haikou, Hainan Province, PR China. A new institutional relationship was established between Duke Kunshan



University and HPNGH to carry out this study. The hospital has 1,800 beds and 36 departments. The cardiology department has 14 Doctors and 27 nurses. Including the Coronary Care Unit (CCU), there are 79 beds in the department. The patient turnover rate is about 8-10 patients every day.

## **2.2 Participants and Data Collection Team**

The director of the cardiology department at HPNGH invited all the physicians in the department on behalf of the research team to collaborate in the study by assisting with recruitment and data collection. The cardiologists could participate in the study if they (i) owned an android mobile telephone, (ii) took care of MI or other CHD patients, and (iii) were willing to provide informed consent to their patients. All providers underwent training on using the mobile application, recruiting patients for the study, obtaining patient consent, and following ethical principles. Ultimately, 8 providers chose to collaborate on the study including the director of the cardiology department and 7 attending physicians. The participants were surveyed via a convenience sampling method; physicians would recruit and survey patients during routine appointments or at the point-in-time while they received usual care, provided that the patient met the eligibility criteria.

*The Inclusion criteria for patients* included: (i) If they had suffered from MI or there is clear clinical evidence/physicians' confirmation of the presence of other CHDs,

(ii) if they own a mobile telephone with the ability to read text messages or receive voice messages, and (iii) if they provide informed consent. *Exclusion criteria* for patients are: (i) not being able to use a cell phone, (ii) severe mental impairment or illness that that would inhibit their ability to answer the questions accurately, or (iii) current participation in another study.

### **2.3 Intervention**

This study adopted the intervention from the TAKEmeds study which is an ongoing study under the leadership of Dr. Yan Lijing from Duke Kunshan University. The TAKEmeds study developed a multi-faceted, information technology-enabled intervention directed at both the patient and health care provider. The phone app is available in Chinese and English. Physicians used a mobile application that they downloaded to their phone. The app was used to recruit and enroll patients in the TAKEmeds program, and to collect information about the patient. At the point-of-care, this mobile-based app also provided physicians with recommendations based on the NICE (National Institute for Health and Care Excellence) guidelines in secondary prevention. Upon enrollment, the physician would enter the patient's cell phone number into the app, which allowed the system to send out SMS automatically to the patient. Information collected on the app about patients include their name, age, sex, phone number, and time since the onset of MI. Other optional information (depending on

physicians' willingness to ask and patients' willingness to answer) includes smoking status, whether they have hypertension or diabetes, height, weight, diastolic blood pressure and systolic blood pressure.

Patients who were eligible and agreed to participate, received automated, periodic evidence-based, text messages about consistent medication use and lifestyle modification via text-messaging, starting from the second day after their information was entered into the app. They received standard ongoing care as well as regular text messages via SMS over a 12 week period. These messages were unidirectional and served as reminders to patients. They did not allow two-way communication with a researcher or health professional about clinical management. Each participant in the study received four or five messages depending on individual characteristics, per week for 12 weeks randomly at 9:00 am, 12:00 pm, 3:00pm or 5:00 pm. The message bank (Appendix A) covered five domains to help CVD patients with medication adherence and lifestyle modification: 1) medication adherence; 2) diet; 3) exercise; 4) smoking cessation; 5) general heart health. The messages were tailored based on patients' smoking status. Non-smokers received four messages including one general heart health message, one medication adherence message, one nutritional message and one physical activity message. Smokers received an additional smoking cessation message. Considering that reading texts might be difficult for some patients, we also had voice

calls option for patients to choose. The content for both the texts and voice messages were identical.

## ***2.4 Data Collection Procedures and Materials***

A structured questionnaire was used to collect baseline and follow-up data from patients. Data were collected by the physicians. Physicians were trained by the DKU research team on how to fill in the survey specifically designed for the study. The baseline survey consisted of two sections: Medication adherence and health behaviors (smoking, diet, exercise) (Appendix B). On average the questionnaire took ten minutes to complete and each participant was given an in-kind gift valued at 30 Chinese Yuan, such as laundry detergent as compensation for his or her time.

The follow-up survey was the same as the baseline survey, with the exception of one additional domain: intervention evaluation (Appendix C). The purpose of the intervention evaluation section was to obtain feedback and general satisfaction with the intervention from patients. The follow-up survey took about 15 minutes to complete and participants were given a monetary compensation of 50 RMB, which was a slightly higher value than the gift at baseline in order to encourage participation in the follow-up; participants that withdrew from the study were still compensated. The responses were entered into Epidata for future analysis.

## **2.5 Measures**

### **2.5.1 Adherence**

The main measure of interest is medication adherence. Medication adherence refers to whether patients take their medications as prescribed (eg, twice daily), as well as whether they continue to take a prescribed medication (Ho, Bryson, & Rumsfeld, 2009). To measure adherence we employed the Morisky Medication Adherence Scale: MMAS-4, which consists of 4 items (Morisky, Ang, Krousel-Wood, & Ward, 2008). It is a generic self-reported, medication-taking behavior scale, validated for hypertension but used for a wide variety of medical conditions. The MMAS consists of four items with a scoring scheme of “Yes” = 1 and “No” = 0. Items are summed to give a range of scores from 0 to 4 and the scores are classified into three categories: low adherence (score 3-4), medium adherence (1-2), and high adherence (0). Furthermore, the MMAS-4 has been shown to be adaptable to China, and its validity has been proven in a Chinese population (Yan et al., 2014).

### **2.5.2 Current smoking status, quitting attempts-self reported**

Two variables account for smoking: Current smoking status and the number of cigarettes smoked per day.

### **2.5.3 Physical activity**

Based on the international physical activity questionnaire (IPAQ) (Booth et al., 2003), four items were used to assess participant's level of physical activity. The IPAQ is a self-administered questionnaire that assesses the level of health enhancing physical activity during a 7 day period. The specific types of activity that are assessed are walking, moderate-intensity activities and vigorous intensity activities; frequency (measured in days per week) and duration (time per day) are collected separately for each level of activity.

### **2.5.4 Fruit and vegetable intake**

The fruit and vegetable module from the Behavior Risk Factor Surveillance Survey (BRFSS) survey was used to formulate our questions and was modified to fit the local context (CDC 2015). The fruit and vegetable module is a brief dietary assessment tool. This tool was appropriate for our study because it has a low response burden and has been shown to be moderately valid and reliable and able to detect population-level change. The module assesses the frequency of consumption of 100% fruit juice, fruit, beans (legumes), dark green vegetables, orange vegetables, and other vegetables over the past month (CDC 2015).

### **2.5.5 Acceptability of a multifaceted intervention among patients**

In addition to the main outcomes, feedback was collected about the intervention from the patients during the follow-up survey. Patients were asked how helpful the intervention was for achieving each outcome and they were asked to rate their overall satisfaction with the intervention. Patients were also asked about the mode, time, and ideal frequency for receiving messages.

### **2.5.6 Covariates**

Other variables included in the survey were: whether patients are taking any heart medication, time of diagnosis, if they have suffered from a heart attack, and number of times they have visited the physician over the past 3 months. Demographic information and additional information related to health status is collected on the app: it includes age, sex, whether they have hypertension or diabetes, height, weight, diastolic blood pressure and systolic blood pressure.

## **2.6 Analysis**

Descriptive analysis was used to describe patient information at baseline and follow-up. To assess the change between baseline and follow-up, paired comparisons between the pre and post outcomes were conducted using both parametric (t-test) and non-parametric (Wilcoxon signed rank test) statistics as appropriate. As this was a pilot study all tests were exploratory, and a 5% significant level was used. Data was entered

in Epidata and stored on DukeBox. All modeling and significance testing has been performed using Stata 12 (StataCorp, College Station, Texas, USA).

### **2.6.1 Aim One**

The primary outcome is medication adherence. Medication adherence level was provided at baseline and follow-up. Inferential statistics, Wilcoxon Signed Rank Test, was used to examine the difference between the median pre-post MMAS-4 scores.

### **2.6.2 Aim Two:**

The secondary outcome is smoking, physical activity, fruit and vegetable consumption. For smoking, the number of cigarettes smoked per day is provided and t-test is used to assess the change. Given the non-normal distribution of energy expenditure in many populations and that self-reported physical activity data was highly skewed and was therefore analyzed using nonparametric tests. The sign test was used to examine the paired differences in physical activity levels pre-post intervention. For fruit and vegetable consumption, the differences on the frequency of consumption pre-and post-intervention are provided but no test will be conducted based on BRFSS's suggestion. Due to the non-normal distribution of the data median intake rather than mean intake is reported.



## **3. Results**

### ***3.1 Sample Characteristics***

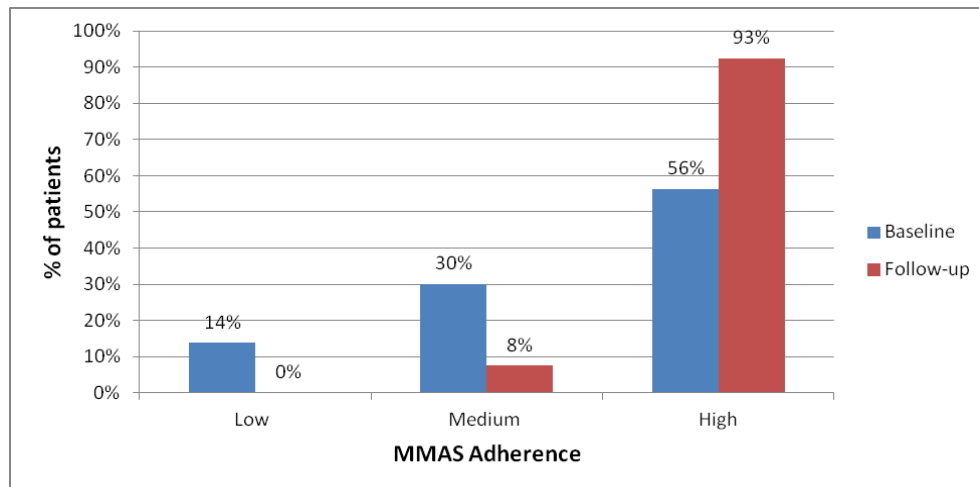
Sample characteristics were collected from the app and the baseline questionnaire. A total of 92 patients were surveyed at baseline. Due to the nature of the recruitment strategy, it was not known how many potential participants were approached at baseline; therefore the response rate could not be calculated. Out of the 92 participants, 82 participants were surveyed at follow-up (89% response rate); 10 patients were unable to be contacted. All individual respondent data entries were complete at baseline, with the exception of BMI since this was optional information collected on the app by the physicians. Among total baseline population, the mean age was 64.4 years, 72% were men, and 63% had MI. 59% had been diagnosed within the last 12 months, and 97% were on 3 or more medications. The characteristics of all baseline participants in comparison to those who were lost to follow-up and those who were surveyed at follow-up are summarized in Table 1.

**Table 1:** Demographic and Health Status of all Baseline Respondents

Characteristics n(%)	Total number of Number of respondents (n=92)	Number of respondents at follow-up (N=82)	Lost to follow-up (N=10)
<b>Demographics</b>			
Age , mean (SD)	64.4 (11.9)	64.0 (11.4)	67.6 (16.5)
Gender			
Male	67 (72.8)	59 (71.9)	8 (80.0)
Female	25 (27.1)	23 (28.0)	2 (20.0)
<b>Clinical Data</b>			
Time of diagnosis of ACS			
Within 1 year	55 (59.7)	48 (58.5)	6 (60.0)
More than 1 year	37 (40.2)	34 (41.5)	4 (40.0)
Type of ACS			
MI	58 (63.0)	52 (63.4)	6 (60.0)
Non-MI	34 (36.9)	30 (36.5)	4 (40.0)
Suffered heart attack	85.8	70 (85.3)	9 (90.0)
Number of medications taking			
None	1 (1.0)	1 (1.2)	0
One	1 (1.0)	1 (1.2)	0
Three and more	90 (97.8)	80 (97.5)	10 (100)
No. of physician visits in the past 3 months, mean	1.7	1.6	2.4
Diagnosed with Hypertension	43 (46.7)	38 (46.3)	5 (50.0)
Diagnosed with Diabetes	21 (22.8)	19 (23.1)	2 (20.0)
BMI (optional)			
Underweight	5 (6.7)	5 (7.5)	
Normal	32 (43.2)	30 (45.4)	2 (25.0)
Overweight	25 (33.7)	20 (30.3)	5 (62.5)
Obesity	12 (16.2)	11 (16.6)	1 (12.5)

### **3.2 Aim 1: To assess the effect of patient-directed text messages as a means of improving medication adherence among CHD patients in Hainan, China.**

Figure 3 presents the study participants' medication adherence level before and after the intervention for 80 participants. We observed significant difference between pre-post intervention scores for medication adherence,  $z = 4.739$ ,  $p < 0.0001$  (pre-intervention scores  $M = 0.90$ ,  $SD = 1.21$ ; post-intervention scores  $M = 0.08$ ,  $SD = 0.30$ ). 43% (34/80), who had low or medium medication adherence at baseline showed an increase in adherence. All the participants that had low adherence at baseline ( $n=11$ ) had high adherence at follow-up. However 5 participants (6.3%) regressed from high to medium level adherence.



**Figure 3:** Table 2 Pre-post comparison of Medication Adherence

### **3.3 Aim 2: Assessing the effect of text message reminders aimed at modifying major health risk behaviors**

Table 2 presents changes in lifestyle behaviors, comparing baseline to the post-test, completed 12 weeks after the TAKEmeds intervention. 70 participants reported not smoking at follow-up (86.4%) compared to baseline (80%). Significant improvements were observed for the number of cigarettes smoked per day ( $P=.022$ ). There was a statistically non-significant change in MET min/wk following the intervention ( $P=0.9063$ ). The median fruit consumption at baseline was 0.48, while the median fruit consumption at follow-up was 0.68.

Table 3 pre-post comparison of lifestyle variables

<b>Variables<sup>a</sup></b>	<b>Baseline</b>	<b>Follow-up</b>	<b>P-value</b>
<b>Smoking</b>			
Mean number of cigarettes/day (n=17)	21.9 (15.6)	10.9(11.4)	0.0220
Current smoking (n=81)			
Everyday	10 (12.4)	10 (12.4)	
Seldom	6 (7.4)	1 (1.2)	
Never	65 (80.3)	70 (86.42)	
<b>Physical activity (Percentage) (n=82)</b>			
HEPA active	7 (8.5)	9 (10.9)	0.5637
Minimally Active	44 (53.7)	43 (52.4)	0.8840
Inactive	31 (37.8)	30 (36.6)	0.8728
<b>Fruit Consumption (n=80)</b>			
Median Frequency/day	0.48	0.68	
<1 time/day (percentage)	59 (73.8)	53 (65.4)	

<b>Vegetables consumption (n=81)</b>		
Median frequency/day	2.13	2.30
<1 time/day (Percentage)	2 (2.47)	2 (2.47)
<2 times per day	37 (45.7)	29 (35.8)
ªData are mean (SD), n (%), or median.		

### ***3.4 Aim 3: To examine the feasibility and acceptability of the patient-directed text messaging intervention***

Results on the perceived acceptability and feedback are summarized in Table 4. Among 82 intervention participants, 61 (74 %) responded to all the feedback questions, while some respondents only answered a few. Among the 82 participants, 76% said text messages received were helpful with respect to diet, 75 % said messages were helpful for physical activity, and 85% said messages were helpful for facilitating communication with their physician. For the question on helpfulness of messages for medication adherence the response rate was 61 (74%); for which 90% said the messages for medication adherence were helpful. Among those that smoke (n=17), the response rate was 82% (n=14); of which 86% said the messages help them to quit smoking. The large majority said they were satisfied with the text-message support program (96%) among 81 respondents. Despite that 96% of all participants at baseline (n=92) opted to receive messages via SMS, 66% of respondents at follow-up (n=80) said they preferred to receive messages via voice call. The preference for two-way messages between the physician

and patients was 84%. In order to determine the best “dosage” of text messages that could lead to better outcomes, we asked participants what was the preferred frequency for receiving text messages. 49% said they would rather receive messages 1 to 2 times per week, while 44% said once day. The timing of messages varied with the majority at 40%, saying that they would rather receive messages in the morning between 8:00am-11:59pm.

**Table 4:** Perceived Acceptability of Text-Message Support Program by Intervention Participants<sup>a</sup>

<b>Characteristic</b>	<b>No. /(%)<sup>b</sup></b>
<b>Helpfulness</b>	
Helpfulness of messages for medication adherence (response rate)	61 (74.3)
Messages help to remind to take medications	55 (90.1)
Messages help to quit smoking n(%) (response rate)	14 (82.3)
Message help to quit smoking	12 (85.7)
Messages helpful on diet	63 (76.7)
Messages helpful on exercise	62 (75.5)
Messages helpful on facilitating communication with physician	70 (85.4)
<b>Message Characteristics</b>	
Method to receive messages	80 (97.5)
SMS	27 (33.8)
Voice Mail	53 (66.3)
Time period for receiving messages	
8:00-11:59	33 (40.2)
12:00-12:59	1 (1.2)
13:00-16:59	9 (10.9)
17:00-21:00	15 (18.2)
After 21:00	
Doesn't matter	24 (29.2)

Frequency of receiving message	80 (97.6)
>=2 times per day	1 (1.3)
Once a day	11 (43.8)
5-6 times per week	2 (2.5)
3-4 times per week	8 (10.0)
1-2 times per week	39 (48.8)
1-3 times per month	19 (23.8)
Preference for two way messages	79 (96.4)
Willing	66 (83.5)
Not willing	13 (16.5)
Overall Satisfaction	81 (98.8)
Very dissatisfied	0
Dissatisfied	0
Neutral	3 (3.70)
Satisfied	58 (71.6)
Very Satisfied	20 (24.7)
<p><sup>a</sup>Response options were “not helpful at all, not very helpful, neutral, helpful, and very helpful” for items 2, 3, 4, 5, 6. The proportion of those that think it’s helpful and very helpful is reported.</p> <p><sup>b</sup>For the variables that had missing values the response rate is noted. Otherwise the response rate was 82 (100%).</p>	

## **4. Discussion**

### **4.1 Summary of Results**

This paper assessed change in medication adherence, physical activity, and intake of fruits and vegetables within a Chinese population that has CHD, after participating in a multi-faceted, information technology-enabled program. There was preliminary evidence of improvements in medication adherence and a high level of acceptability of the intervention, with an overwhelming number of participants perceiving the messages to be helpful for achieving desired outcomes. However no changes were seen in levels of physical activity or in the consumption of fruits or vegetables per day. There was only a minimal difference between the number of smokers at baseline and follow-up, but there was a significant decrease in the number of cigarettes smoked per day.

### **4.2 Aim 1: Assessing the effect of patient-directed text messages as means of improving medication adherence**

This pilot study demonstrated that for this sample, there was a significant increase in adherence to medication among patients after 3 months. A systematic review on the efficacy of mobile phone interventions to improve medication adherence across a wide range of conditions (e.g., diabetes, asthma, HIV/AIDS) reported statistically significant improvements in medication adherence rates or biomarkers in 18 out of 29



studies using text-messaging interventions (TMIs)(Park, Howie-Esquivel, & Dracup, 2014). Furthermore, there have been attempts to establish a scientific basis for text messages as an intervention to improve medication adherence across multiple diseases. In a integrative review of the evidence for mobile health Short Message Service text messages as an innovative and emerging intervention to promote medication adherence, DeKoekkoek and colleagues, provide clinicians with the state of the science with regard to text messaging interventions that promote medication adherence(DeKoekkoek et al., 2015). They found that text messages that were standardized, tailored, one-or two-way and timed either daily to medication regimen, weekly or monthly showed improvement in medication adherence.

Our messages were standardized, tailored, one way non repetitive messages. We tried to keep our method simple and scalable, but future versions of the intervention could allow further customization. For example text messages could be customized to the time of day that patients take their medication. Although there are multiple barriers to medication adherence, our intervention only addresses barriers at the patient level such the lack of recall and the perception of treatment benefits through the use of evidence-based text messages. In this pilot study medication use was high because the main method of recruitment involved hospital patients. Although we do not have the

exact numbers, many of the patients were believed to be receiving inpatient care at the time of recruitment.

### ***4.3 Aim 2: Assessing the effect of text message reminders aimed at modifying major health risk behaviors.***

There was only change in some lifestyle factors. Although the number of smokers only changed slightly there was significant change in the number of cigarettes smoked per day. No changes were seen in levels of physical activity, the consumption of fruits and vegetables per day. Studies for these 3 outcomes have shown mixed results, which is consistent with our results. According to the most recent meta-analyses for smoking cessation, text message interventions have been said to be as effective as other smoking cessation interventions (Spohr et al., 2015). The insignificant change for the number of smokers between baseline and follow-up was likely due to the short term of the intervention.

Given that our results showed no improvement in diet quality and physical activity, interventions based only on text-messages without personal contact with a health provider might not be intensive enough to promote change in health-related lifestyles and behaviors, as evidence to support the effects of mobile phone-based interventions on diet and physical activity remains unclear (Free et al., 2013). This type of intervention could be more effective if paired with face-to-face behavioral

interventions than as a standalone intervention strategy, as shown to be effective in another study (Adolfo Rubinstein et al., 2016).

Instruments for measuring outcomes must also be considered when trying to understand results. Although similar instruments such as the Food frequency questionnaire (FFQ) have been validated in the Chinese population, the BRFSS fruit and vegetable module hasn't been validated in the Chinese population. The instrument could be improved to fit the local population or a different instrument could have been used to assess change in diet.

#### ***4.4 Aim 3: Examining the acceptability of a multifaceted, information technology-enabled intervention among patients***

There was a high level of satisfaction with the intervention, with an overwhelming number of participants perceiving the messages to be helpful for improving their medication adherence and modifying lifestyle factors. In addition to overall satisfaction and helpfulness of the messages received, we explore specific TMI delivery characteristics: such as frequency of messaging, interactivity of SMS interventions, timing, and method of delivery. In our study, participants received messages 4 to 5 times a week. However 49% said they would rather receive messages 1 to 2 times a week, while 44% said they preferred once day; this suggests that participants might have not perceived the amount of messages to be appropriate. Meta-

analysis and reviews of text-messaging for health indicate that there is large variability of intervention characteristics across studies with no clear and consistent association between intervention characteristics and intervention effects (Hall, Cole-Lewis, & Bernhardt, 2015). This can further explain the mixed results in the literature and our study. The fact that usability of mobile technologies across different outcomes received mixed results from study participants indicates that research is also necessary to determine the features of mobile technologies that are functional for users.

#### ***4.5 Study strengths and limitations***

There are limitations to this study. First, the sample size was small and came from only one hospital in China; the generalizability of our study was limited. Second, we used an exploratory, pre-post study design, which did not include a control group. The lack of a control group limits the possibility of drawing firm conclusions as to the causality of the measured effects. Further research is needed to validate the effectiveness of a mobile phone messaging intervention with a larger sample of Chinese participants using a rigorous research design, such as a randomized controlled trial. The high number of missing values for different variables in the follow-up survey can be attributed to the suboptimal quality of the data collection which was collected by the physicians. Furthermore due to their work load, physicians delegated the follow-up survey duty to their residents. Having physicians collect data might also be problematic

because patients may not be willing to be completely honest with their physician, resulting in response bias. Medication adherence (MMAS-4) and lifestyle factors were measured through self-report scales and answers could have been influenced by social desirability. Nevertheless, the scales were all validated, reliable, simple, and low-cost instruments used in previous studies. Another limitation is that the intervention was evaluated for only 3 months, and the durability of the observed benefit is unknown.

Despite the limitations, there are several strengths. An important strength of our study is that it targets multiple risk factors rather than individual risk factors. With the exception of a recent publication of a randomized clinical study that looked at multiple risk factors (C. K. Chow et al., 2015), most mhealth studies have focused on single risk factors. This is a mhealth project that targets both physicians and patients. Although for the purpose of this study we only focused on the patient side of the intervention.

#### ***4.6 Implications for further research***

This study adds to the existing evidence regarding the effectiveness of mobile phone text messaging in changing individual health behaviors. Despite the fast growth as a research area, since the first study was published in 2002, this area of research and practice is said to be in its “adolescence,” (Hall et al., 2015). Although there have been a number of randomized clinical trials demonstrating the effectiveness of mobile phone text messaging to promote behavior change, evidence that mobile technologies can

indeed facilitate improvements in health is still needed (Eapen & Peterson, 2015). The call for further research on the use of mobile health for CVD prevention has been made by many researchers, including the American Heart Association. As summarized in a recent editorial in JAMA, “Very few applications have undergone rigorous evaluation, and those that have often lacked a randomized comparator. Some of these evaluations were also conducted only in selected patients and specialized settings and rarely assessed long-term patient adherence, behavior change, costs, or benefits on clinical outcomes” (Eapen & Peterson, 2015). Likewise there have been a growing number studies in China assessing text-messaging interventions on a diverse range of topics including weight loss (Lin et al., 2014), maternal and infant health (Y. Li et al., 2013), and smoking cessation (Shi, Jiang, Yu, & Zhang, 2013) to name a few, but many are feasibility studies with no effectiveness data available. We agree with the authors that more research needs to be done to determine which intervention characteristics are the most effective. We must also assess longer-term effects in more specific populations to determine the cost-benefit and cost-effectiveness of TMIs. Given the complexity of behavior change, use of behavior change theories for TMIs has also been suggested.

There is a mismatch between the timing of technology development which is fast paced and the slow pace of research. Researchers have recommended “developing and implementing innovative funding scaffolding and research designs that promote rapid

turnaround”(O’Reilly & Spruijt-Metz, 2013). Adaptive experimental designs such as the Multiphase Optimization Strategy (MOST) and the Sequential Multiple Assignment Randomized Trial (SMART) could provide study design and evaluation methods that are suitable for the development and evaluation of mHealth interventions(O’Reilly & Spruijt-Metz, 2013).

## **5. Conclusion**

The TAKEMeds pilot study tested a multi-facet patient focused intervention among a Chinese population to improve use of evidence-based medication and promote behavior modification for secondary prevention of CVD. The finding supports its usability for medication adherence, but not change for physical activity and fruit and vegetable intake. Results in the literature are mixed and given the pilot nature of this study further research with large sample size is needed to assess the effectiveness of the TAKEMeds program.



## Appendix A SMS Bank (English)

### Smoking:

1. It's never too late to stop smoking. Did you know that quitting smoking after a heart attack can significantly improve your health and prevent future heart attacks? (Hall and Lorenc, Redfern, Rigotti and Clair).
2. Most people who smoke cigarettes, do it in certain situations. Try to be aware and avoid them if you can (Redfern).
3. Don't be discouraged after one failed attempt to quit smoking. It's important to keep trying (Redfern).
4. Smoking doubles your risk of dying from a stroke as compared with non-smokers. Quitting can make a difference. (Rigotti and Clair).
5. Even one cigarette a day can put you at a higher risk for a future heart attack or stroke (Rigotti and Clair).
6. Research shows it's easier for smokers to quit when they use nicotine replacements such as a nicotine patch, gum, lozenge, or spray. In addition to nicotine replacements, also ask your doctors for medicines to help you quit smoking (Rigotti and Clair).
7. Regular exercise can help you quit smoking by reducing your craving for cigarettes. Do remember to talk to your doctor before starting to exercise. (Ussher)
8. Possible nicotine withdrawal symptoms include a craving for cigarettes, irritability, anger, restlessness, anxiety, depressed mood, difficulty concentrating, insomnia, and increased hunger. Talk to your doctor for help in relieving these symptoms (Rigotti et Clair).
9. For more information on how to quit smoking, call the quit-smoking-hotline operated by WHO China office at 4008885531.
10. Set a quit date and telling your friends, family and co-workers is a first step to successful quitting.
11. To help cope with cigarette cravings, keep your mind busy by reading a book, keep your mouth busy by taking a mint, and keep your hands busy by squeezing a ball.
12. Even low-tar cigarettes can increase your risk of a future heart attack or stroke compared with non-smokers (Ambrose).

### Adherence:

1. It is important to keep taking your heart medicines even when you are feeling well. They help you maintain your health and live longer (Hall and Lorenc, Chow).
2. A blood thinner pill, like aspirin helps prevent another heart attack. Ask your doctor about it! (Hall and Lorenc, Chow)
3. It's important to keep taking your cholesterol lowering medicines, because they can lower the chance of a future heart attack and stroke (Hall and Lorenc).
4. Don't be discouraged if you occasionally forget to take a medication, but don't stop them altogether! Take all medications as recommended by your doctor and pharmacist.

5. Taking your heart medications as directed by doctors can help you feel better and live longer. (Kronish and Ye).
6. Tell your family and friends about your medicines so they can help to remind you to take them as recommended by your doctor (Kronish and Ye).
7. If you have any concerns about your medications, like a possible side-effect, please talk to a doctor. Do not stop taking these medications before consulting your doctor (Kronish and Ye).
8. Remember to bring enough medications with you when travelling (Kronish and Ye).
9. Taking your medications as part of your daily routine is very important. Think about when, where, and how you will remember to take your medications.
10. Keeping a daily record of your medication-taking can help you remember to take all your medications and avoid skipping doses (NICE).
11. Many patients are reluctant to express their concerns about medications because they fear it will displease the doctor. It is important to have honest and open discussions because it will encourage you to stick to the medication schedule (NICE)
12. Take an active role in managing your illness - read about your condition and medications to understand the disease more. You are in charge of your own health! (Barloletti).

Diet:

1. Eating a diet rich in fruits and vegetables along with low-fat dairy products can reduce your blood pressure and maintain your cardiac health (Chow, Kromhout et al.).
2. When cooking, try to limit the amount of cooking oil and salt you use (Hall and Lorenc, Chow, Kromhout et al).
3. Maintain a healthy weight as this can be good for your heart health. Try diet with less noodles, rice, and starch-based foods. (Walker and Reamy).
4. Try eating foods rich in omega-3 fatty acids, such as oily fish (salmon, tuna or sardines) at least twice a week (Walker and Reamy).
5. Having a healthy diet that is low in fat and sugars, along with exercise can help to keep you body healthy and improve the blood flow to your heart. Do remember to talk to your doctor before starting to exercise. (Walker)
6. Try limiting the amount of red meat you eat! (Walker)
7. If you are craving dessert, try fruits and nuts instead of baked goods (Walker).
8. Looking for good fats and fiber? Try legumes, tree nuts, and seeds like peanuts, walnuts and pumpkin seeds! (Olendzki)
9. Craving meat? Try skinless poultry and fish (Olendzki).
10. Craving juice? Try eating fruits as a healthy alternative (Olendzki).
11. Many fried foods, baked goods and snacks such as potato chips contain trans fatty acids, a bad fat that can increase the risk of cardiovascular disease. Try to read the nutrition facts labels and avoid trans fatty acids next time you are grocery shopping (Mozaffarian et al).
12. Try meatless meals a couple of times a week, using beans or lentils, because they have less unhealthy fat. (DASH)

#### Exercise:

1. Think of fun ways to exercise in your daily routine especially if you are mostly inactive, such as getting off the bus one stop early and walking the rest of the way, practicing Tai Chi, or dancing (Chow).
2. After confirming with your physician that your health conditions allow you to have exercise, try to start in a safe way because as little as 30 minutes of brisk walking a day can help lower your cholesterol and blood pressure. (Hall et Lorenc)
3. Make an exercise plan that starts with 10 minutes of exercise and gradually increase your effort and time. Make sure that you talk about this plan with your physician and get his permission on its safety before you start (Chow).
4. Try keeping an exercise diary to record your daily physical activities (Chow, Redfern).
5. Ask your doctor if you can access cardiac rehabilitation services, which provide advice and help for exercise routines for patients like you.
6. There are many potential benefits of exercise - it can lower cholesterol levels, lower blood pressure, help you maintain a healthy weight, help with stopping smoking, and reduce your risk of death from heart disease (Lavie et al).
7. Exercise may improve symptoms of depression and anxiety, which are risk factors for heart disease (Lavie et al).
8. Regular daily walking is usually a safe exercise you can do. Nevertheless, ask your doctor about exercise advice specific to you (Levie et al).
9. Be cautious about exercise if you feeling unwell. Ask your doctor for advice on how to become physically active if you have any concerns (Levie et al).
10. If your physician tells you that it is safe to exercise given your current health conditions, try to take 15 minutes, if possible, to do some warm-up activities every time before exercise.
11. After discussing with your doctor, aim to get slightly out of breath, but exercise sensibly and stop the activity if you feel unwell.
12. Time spent sitting down to watch TV, use a computer, read or listen to music is bad for your health, even for those who are achieving 150 minutes of exercise a week. After talking with your doctor, please get up and move more! (CMO UK guidance 2011).

#### General:

1. High blood pressure can damage your heart and your body. Be sure to check your blood pressure frequently (Hall and Lorenc).
2. Ask your family and friends for support after a heart attack, they can help you to maintain a healthy lifestyle (Chow).
3. Depression is 3 times more common in people who experienced a heart attack. Don't be afraid to talk about it, especially with your doctor (Hall and Lorenc, Kromhout et al).
4. If you are sad, down, or unhappy, and no longer interested in activities that you usually enjoy most of the day for at least 2 weeks, you may be experiencing depression. Ask your doctor for medication and counseling support (DSM-V).

5. If you have any health-related questions, call the 24/7 hotline: 12320 to talk to a health care specialist.
6. Ask your doctor if you have been screened for diabetes, since uncontrolled blood sugar level can harm the blood vessels in your body (Dasgupta et al).
7. If your blood pressure is regularly greater than 140/90, you are at an increased risk of heart attack or stroke. Talk to your doctor about how to control your blood pressure.
8. Remember that pain in your chest, back, or neck may be symptoms of a heart attack. Some patients do not experience chest pain, only shortness of breath. Remember to call 120 immediately if you experience any of these symptoms and are concerned you are having a heart attack.
9. Remember that difficulty with speech, weakness of one arm, or an asymmetric face may be the first signs of a stroke. Remember to call 120 right away if you are worried you are having a stroke. Time is critical to stroke management – call right away!
10. Taking your medications regularly, exercising (with permission from your doctor), and making healthy food choices are the best ways to prevent another heart attack or stroke.
11. By taking your medications every day, exercising regularly (with permission from your doctor), and making healthy food choices you can become a role model for your children and for other patients with heart disease.
12. Take charge of your own heart health! If you have any questions about your medications or diet, be sure to ask your doctor!

## Appendix B Baseline Survey (English)

### TAKEmeds Program: Medical Adherence and Behavioral Change Questionnaire

Patient ID: \_\_\_\_\_

Patient name: \_\_\_\_\_

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#### **I. Medical Adherence**

1. Have you ever suffered a heart attack? Yes No
2. When were you diagnosed with heart disease? \_\_ \_\_Months ago
3. What is the type of heart disease that you are diagnosed with?  
MI Non-MI, please specify\_\_\_\_\_
4. Are you taking any heart medications? Include those both prescribed and purchased over the counter.  
 Yes  No
5. What heart medications are you taking? (Please ask patients to bring their pill bottles and fill in the blanks below)  
1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_ 4) \_\_\_\_\_ 5)  
\_\_\_\_\_
6. Do you ever forget to take your medicine? Yes No
7. Are you carelessly at times about taking your medicine? Yes No
8. Sometimes if you feel worse when you take the medicine, do you stop taking it?  
Yes No
9. When you feel better do you sometimes stop taking your medicine? Yes No
10. Over the last 28 days, how many days do you estimate did you miss your heart medications?  
\_\_ \_\_Days

#### **II. Health Behaviors**

11. During the last 7 days, on how many days did you do vigorous physical activities like heavy weight lifting, fast cycling, running, swimming, or basketball

or soccer? Think only about those physical activities that you did for at least 10 minutes at a time.

\_\_\_\_\_ Days per week

Don't know/Not Sure

Refused

12. How much time did you usually spend doing vigorous physical activities on one of those days?

\_\_\_\_\_ Minutes per day

Don't know/Not Sure

Refused

13. During the last 7 days, how many days did you do moderate physical activities like speed walking, light weight lifting, dancing, or normal cycling? Think only about those physical activities that you did for at least 10 minutes at a time.

\_\_\_\_\_ Days per week

Don't know/Not Sure

Refused

14. How much time did you usually spend doing moderate physical activities on one of those days?

\_\_\_\_\_ Minutes per day

Don't know/Not Sure

Refused

15. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

\_\_\_\_\_ Days per week

Don't know/Not Sure

Refused

16. How much time did you usually spend walking on one of those days?

\_\_\_\_\_ Days per week

Don't know/Not Sure

Refused

17. During the last 7 days, how much time did you usually spend sitting on a week day?  
 \_\_\_\_\_ Hours \_\_\_ Minutes per weekday  Don't know/Not Sure
- Refused
18. At the present time, do you smoke cigarettes?  Daily  Occasionally  
 Not at all
19. On days that you smoke, how many cigarettes do you usually have? \_\_\_ \_\_ \_\_  
 Cigarettes
20. During the past 12 months have you tried to stop smoking?  Yes  No
21. How often do you eat fruit? Count any kind of fruit-canned, fresh, and frozen.  
 Do not include fruit juice.  Never  1-3 times per **month**  1-2  
 times per **week**  3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
22. How often do you drink fruit juice?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
23. How often do you eat did you eat cooked or canned beans such as soybeans,  
 edamame, tofu or lentils?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
24. How often did you eat dark green vegetables for example broccoli or dark leafy  
 greens including romaine, chard, collard greens or spinach?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
25. How often did you eat orange colored vegetables such as sweet potatoes,  
 pumpkin, winter squash, or carrots?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**

- 5-6 times per **week**  1 time per **day**  2 or more times per **day**
26. How often do you eat OTHER vegetables? Examples of other vegetables include tomatoes, corn, eggplant, peas, lettuce, cabbage, and white potatoes that are not fried.
- Never  1-3 times per **month**  1-2 times per **week**
- 3-4 times per **week**
- 5-6 times per **week**  1 time per **day**  2 or more times per **day**
27. During the past three months, how many times did you visit your physician?  
\_\_\_\_\_ Times
- 

**Thanks for your participation!**



## Appendix C Follow-up Survey (English)

TAKEmeds Program: Medical Adherence and Behavioral Change Questionnaire

Patient name: \_\_\_\_\_

Patient ID: \_\_\_\_\_

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### I. Medical Adherence

1. Are you taking any heart medications? Include those both prescribed and purchased over the counter.  
 Yes    No
2. What heart medications are you taking? (Please ask patients to bring their pill bottles and fill in the blanks below)  
1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_ 4) \_\_\_\_\_ 5)  
\_\_\_\_\_
3. Do you ever forget to take your medicine?    Yes    No
4. Are you careless at times about taking your medicine?    Yes    No
5. Sometimes if you feel worse when you take the medicine, do you stop taking it?  
 Yes    No
6. When you feel better do you sometimes stop taking your medicine?    Yes    No
7. Over the last 28 days, how many days do you estimate did you miss your heart medications?  
    \_\_ \_\_ Days

### II. Health Behaviors

13. During the last 7 days, on how many days did you do vigorous physical activities like heavy weight lifting, fast cycling, running, swimming, or basketball or soccer? Think only about those physical activities that you did for at least 10 minutes at a time.  
    \_\_\_\_\_ Days per week                       Don't know/Not Sure  
  
 Refused

14. How much time did you usually spend doing vigorous physical activities on one of those days?

\_\_\_\_\_ Minutes per day

Don't know/Not Sure

Refused

15. During the last 7 days, how many days did you do moderate physical activities like speed walking, light weight lifting, dancing, or normal cycling? Think only about those physical activities that you did for at least 10 minutes at a time.

\_\_\_\_\_ Days per week

Don't know/Not Sure

Refused

16. How much time did you usually spend doing moderate physical activities on one of those days?

\_\_\_\_\_ Minutes per day

Don't know/Not Sure

Refused

17. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

\_\_\_\_\_ Days per week

Don't know/Not Sure

Refused

18. How much time did you usually spend walking on one of those days?

\_\_\_\_\_ Days per week

Don't know/Not Sure

Refused

19. During the last 7 days, how much time did you usually spend sitting on a week day?

\_\_\_\_\_ Hours \_\_\_ Minutes per weekday  Don't know/Not Sure

Refused

20. At the present time, do you smoke cigarettes?  Daily  Occasionally  
 Not at all
21. On days that you smoke, how many cigarettes do you usually have? \_\_\_ \_\_\_ \_\_\_  
 Cigarettes
22. During the past 12 months have you tried to stop smoking?  Yes  No
23. How often do you eat fruit? Count any kind of fruit-canned, fresh, and frozen.  
 Do not include fruit juice.  Never  1-3 times per **month**  1-2  
 times per **week**  3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
24. How often do you drink fruit juice?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
25. How often do you eat did you eat cooked or canned beans such as soybeans,  
 edamame, tofu or lentils?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
26. How often did you eat dark green vegetables for example broccoli or dark leafy  
 greens including romaine, chard, collard greens or spinach?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
27. How often did you eat orange colored vegetables such as sweet potatoes,  
 pumpkin, winter squash, or carrots?  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**  
 5-6 times per **week**  1 time per **day**  2 or more times per **day**
28. How often do you eat OTHER vegetables? Examples of other vegetables include  
 tomatoes, corn, eggplant, peas, lettuce, cabbage, and white potatoes that are not  
 fried.  
 Never  1-3 times per **month**  1-2 times per **week**  
 3-4 times per **week**

- 5-6 times per **week**    1 time per **day**                       2 or more times per **day**
29. Did the text messages/voice calls help remind you to take your medications?  
 Very helpful       Helpful       Neutral       Not very helpful  
 Not helpful at all
30. Does the text messages/voice calls help you on diet?  
 Very helpful       Helpful       Neutral       Not very helpful  
 Not helpful at all
31. Does the text messages/voice calls help you on exercise?  
 Very helpful       Helpful       Neutral       Not very helpful  
 Not helpful at all
32. Does the text messages/voice calls help you to quit smoking? (non-smokers skip this question)  
 Very helpful       Helpful       Neutral       Not very helpful  
 Not helpful at all
33. By participating in this project, do you think it helpful in facilitating the interaction with your physicians?  
 Very helpful       Helpful       Neutral       Not very helpful  
 Not helpful at all
34. During the past three months, how many times did you visit your physician?  
 \_\_\_\_\_ Times
35. Would you like to receive the messages via:  
 Texts       Voice-mail       Mail       Emails       Other  
 please specify \_\_\_\_\_
36. What do you think is the best time of receiving the messages?  
 8:00-11:59 am                       12:00-12:59 pm                       1:00-4:59 pm  
 5:00-9:00 pm                       After 9:00 pm                       It does not matter
37. What do you think is the ideal frequency of receiving the messages?  
 1-3 times per month                       1-2 times per week                       3-4 times per week  
 5-6 times per week                       1 time per day                       2 or more times per day

38. Do you want the texts/voice-mails be two-way?

Yes  No, reason\_\_\_\_\_

39. If you were asked to rate your overall satisfaction to the function of text messages/voice calls, you would say it is:

Very satisfied  Satisfied  Neutral  Dissatisfied  
 Very dissatisfied

34. Do you have other comments on the content of the texts/voice-mails? Is there any way that we can do better?

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**Thanks for your participation!**

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