Efficacy of Telemedical Interventional Management in Coronary Heart Disease Patients Undergoing Percutaneous Coronary Intervention

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Abstract

Background: To maximize adherence to prescribed treatment and lifestyle, coronary heart disease (CHD) patients should be closely followed up after percutaneous coronary intervention (PCI). Concerning the spatial accessibility of patients, telemedical interventional management may improve better patient care by providing closer follow-up than usual care.

Objective: This study was aimed to determine whether remote patient management directed by health professionals during secondary prevention would reduce clinical outcomes in CHD patients after PCI.

Methods: In this investigator-initiated, open-label, randomized controlled trial, 2086 CHD patients aged between 18 and 79 (including 18 and 79) who had received PCI in The First Affiliated Hospital of University of Science and Technology of China between December 2022 and June 2023 were randomly assigned to the remote patient management (n=1040) or usual care (n=1046) group. The usual care group received follow-up calls by healthcare providers at 1, 3, 6, and 12 months after hospital discharge. The remote patient management group received multicomponent interventions delivered on a web-based platform in addition to usual care. The primary outcome was a composite of major adverse cardiac or cerebral events (MACCE, a composite of cardiac death, recurrent myocardial infarction, ischemia-driven target vessel revascularization or stroke) within one year after discharge.

Results: During the one-year follow-up, 55 participants were found with MACCE (5.3%) in the usual care group while 36 MACCE (3.5%) in the remote patient management group. The difference was significant between the two groups (P=.044). This significance was mainly a consequence of reduction in cardiac death (1.0% vs 2.3%, P=.017) and myocardial infarction (0.8% vs 1.8%, P =.034) in the remote patient management group compared to the usual care group. Remote patient management was also associated with positive influence on blood-pressure, current drinking (11.7% vs16.5%, P=.002), adherence rates for heparin (87.8% vs 84.4%, P=.027), angiotensin-converting enzyme inhibitors/angiotensin II receptor blocker/angiotensin receptor neprilysin inhibitor (47.9% vs 43.5%, P=.045) and also BARC 3-5 bleeding events (0.6% vs 1.6%, P=.033).

Conclusions: A well-designed telemedical interventional management package could significantly reduce the risk of cardiovascular death or myocardial infarction in the secondary prevention among CHD patients. Further multicenter and randomized studies are warranted to assess the validity and efficacy of telemedical interventional management systems. Clinical Trial: registered with the Chinese Clinical Trial Registry, number ChiCTR2200065344.

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Conclusions: A well-designed telemedical interventional management package could significantly reduce the risk of cardiovascular death or myocardial infarction in the secondary prevention among

CHD patients. Further multicenter and randomized studies are warranted to assess the validity and efficacy of telemedical interventional management systems.

KEY WORDS: telemedical interventional management; coronary heart disease; secondary prevention; percutaneous coronary intervention

Introduction

Secondary prevention in coronary heart disease (CHD) is to prevent recurrent coronary events after clinical diagnosis[1, 2]. High adherence to secondary prevention interventions, especially aggressive lifestyle changes and pharmacotherapy, can lead to significant decline in recurrent coronary events [3]. Cardiac rehabilitation and secondary prevention programs, usually carried out during outpatient visits, have been underutilized because of issues such as low and limited accessibility, which is especially prevalent in China[4-8]. On the other hand, patients' self-management of the cardiovascular disease risk factors is often challenging. A previous study reported that approximately one-third of patients with acute coronary syndrome (ACS) persisted in smoking or were not adherent to the recommendations for exercise or diet [9]. As a recent study by Hejjaji et al showed, a large outpatient US registry found that only 13% patients successfully quit smoking after an atherosclerotic cardiovascular disease (ASCVD) event [10]. With the increasing burden of CHD and the aging population, new and effective intervention measures are urgently needed to improve the post-discharge management of patients with CHD [11].

Emerging technologies, such as web-based remote patient management, have been proved effective for potential better self-management by delivering health education and facilitating interaction between patients and health-care providers[12]. In the past decade, cardiac rehabilitation and secondary prevention programs using mobile health (mHealth) have been developed, with encouraging results on medication adherence, smoking cessation, weight loss, physical activity, and health education [5, 13-21]. Similarly, these programs have been shown to enhance the risk factor profile of patients with CHD and potentially reduce their mortality in the long run [22]. However, their impact on clinical outcomes, such as recurrent cardiovascular events and bleeding events, has not been fully elucidated.

Therefore, we established multi-component medical interventional measures on a web-based platform for CHD patients, based on the standardized management guidelines. This model could strengthen the current care workforce because we have embedded patients' cardiovascular health information and facilitate digital communication between healthcare professionals and patients. We hypothesized that the interventions would be more effective in improving clinical outcomes than the usual care alone among CHD patients. To test this hypothesis, we conducted a single-center, open-label and randomized trial.

Methods

Ethics and Study Site

This trial was approved by the ethics committee of the First Affiliated Hospital of the University of Science and Technology in China (2022-ky233) and registered with the Chinese Clinical Trial Registry, number ChiCTR2200065344. All the participants have signed the consent form.

This study was conducted with a single-center, open-label and randomized controlled trial design in The First Affiliated Hospital of University of Science and Technology of China (USTC), a large tertiary hospital in Anhui province, China.

Participants

Patients were included if they were eligible for all the inclusion criteria: 1) aged from 18 to 79 (including 18 and 79); 2) presented with clinical manifestations consistent with coronary artery disease and successfully underwent PCI; 3) signed the informed consent form, and were able to complete the follow-up and went to the hospital by themselves; 4) could skillfully use smart phones and WeChat, a social interaction application in China.

Patients who were with one of the exclusion criteria would be excluded: 1) unable to basically use the smart management system; 2) classified as grade IV in New York Heart Association (NYHA); 3) had unstable condition or complications after percutaneous coronary intervention (PCI) during the current hospitalization; 4) had cardiovascular diseases such as stroke, heart failure, severe arrhythmia (high degree of atrioventricular block, ventricular tachycardia) within the last 3 months; 5) had chronic renal insufficiency (creatinine>265umol/L); 6)women who were pregnant or breastfeeding; 7) had a combination of other unsuitable for the trial, such as thyroid disease patients taking medication, acute infectious diseases, psychiatric and psychological diseases, history of tumor disease within 5 years; 8) the spouse already included in the study.

Each subject would be required to have at least one personal smartphone(s) and active WeChat (a popular social interactive application in China like Twitter) account(s), and could communicate proficiently in Chinese with the cardiac rehabilitation and secondary prevention coaches via WeChat.

All subjects who met the inclusion criteria were approached for participation before discharge. Participants were randomly assigned (1:1) through a randomization schedule created by SPSS v29.0 to either remote patient management plus usual care (remote patient management group) or to usual care alone (usual care group). They were informed that they could withdraw from the study any time they wanted. The participants did not receive any financial compensation during the trial.

Treatment

The treatment strategy and stenting techniques during the current hospitalization were all left to the treating physicians' discretion. After PCI, lifelong use of aspirin was advised, P2Y12 antagonists (clopidogrel or ticagrelor) prescribed for one year and long-term statins therapy was recommended. The use of other medications (e.g., beta-blockers, angiotensin-converting enzyme inhibitors [ACEI]、angiotensin II receptor blocker [ARB] or angiotensin receptor neprilysin inhibitor [ARNI]) was decided by doctors-in-charge.

Usual Care

Before hospital discharge, usual care, provided by a ward nurse, included instructions for lifestyle modifications and self-management strategies, as recommended for CHD patients by contemporary clinical guidelines [23, 24]. After hospital discharge, all participants would receive follow-up calls by healthcare providers at 1, 3, 6, and 12 months. Telephone follow-up consultation would recommend patients, assessed to be at high risk, to do further consultation at the local hospital outpatient clinic. All patients would receive usual care.

Telemedical Interventional Management

Telemedical interventional management was based on our web-based management platform established by the hospital and Xunfei Healthcare Technology Co., Ltd (Xunfei Healthcare) to facilitate remote interventions. The platform (**Figure 1**) had access to a patient's cardiovascular health information, including the hospitalization records, medications, laboratory results during the current hospitalization, allowing healthcare providers to make more informed decisions about diagnosis and ongoing management. Also, it provided learning resources or tools for patients' self-management and regularly managed chronic disease follow-up, supervision, medication reminder

and follow-up consultations for the majority of patients. Intelligent voice assistants could deal with the majority of chronic disease patients with reminders of medication and re-examination. This enabled patients to access individualized self-learning health management materials targeting their specific conditions (**Figure 2 and Multimedia Appendices 1**), and obtain precise recommendations for lifestyle modifications over time (**Table 3**). Patients in the intervention group were also encouraged to consult about symptoms, medications (track daily adherence, indication, and side effects, **Multimedia Appendices 2**), vital signs (heart rate, blood pressure, weight, mood, and steps, **Multimedia Appendices 3**) and lifestyle modification on the platform. Artificial intelligence (AI) responds to questions about general diseases and rehabilitation knowledge (**Multimedia Appendices 4**), but cardiovascular disease diagnosis and evaluation questions are answered by healthcare professionals and physicians. Only patients who were randomized to the intervention group received telemedical interventional management.

Outcome

The primary outcome was a composite of major adverse cardiac or cerebral events (MACCE, a composite of cardiac death, myocardial infarction, ischemia-driven target vessel revascularization, or stroke) assessed during the 1-year follow-up after randomization.

Secondary outcomes included: (1) all-cause death, (2) non-cardiac death, (3) stent thrombosis, (4) the first unplanned heart failure or angina hospitalization, (5) bleeding as defined by the Bleeding Academic Research Consortium (BARC) definition [25] , (6) smoking and drinking status, (7) office blood pressure; (8) adherence to cardio-protective medications. All secondary outcomes were assessed during the one-year follow-up after randomization.

Estimated Sample Size

The sample size was hypothesized after comparing the incidence rates of cardiovascular events following one-year treatment in previous studies [26, 27]. We assumed that the cardiovascular event rate (MACCE) after one-year treatment in the usual care group was 6.5%, and that reduced by 40% in the remote patient management group. We set a class of error for bilateral 0.05, the degree of certainty of 80%, the ratio between the usual care group and the remote management group at 1:1, so we would get 1,044 cases for the two groups, respectively. But taking into account a shedding rate of about 5%, we finally got 1100 cases in each group, totaling 2200 cases.

Statistical Analysis

The primary analysis was performed on the full analysis set (FAS) on an intention-to-treat (ITT) basis. It only included those subjects with data at baseline and set one year as time span to analyze changes in blood pressure, medication and lifestyle of these participants at the one-year follow-up visit. SPSS v29.0 software was used for statistical analysis. Categorical variables were described as the number of cases and percentages, and continuous variables were described as the mean and standard deviation or median and interquartile range. The chi-square test or Fisher's exact test was used to compare the count data between groups, and the t-test or the Mann-Whitney U-test of nonparametric statistics was used to compare the groups of continuous variables. Kaplan-Meier (K-M) curves were used to estimate the incidence of endpoint events during the follow-up period in both groups. All tests were two-sided, and differences were considered statistically significant at $P<.05$.

Results

Between November 2022 and June 2023, our study included 2086 inpatients with coronary heart disease who had undergone PCI. They were randomly divided into the intervention group (remote patient management plus usual care）with 1040 and the control group (usual care group) with 1046.

Baseline clinical and laboratory characteristics and the use of cardiovascular medications were similar between the two groups (**Table 1** and **Table 2**).

Table 1. Basic Clinical and Medication Characteristics

Variable	Remote patient management (n〼1040)	Usual care 〼n=1046〼	P-value
Demographics			
Age(years), mean (SD)	62.24 (11.09)	62.00 (10.99)	.613
Male, n (%)	742(71.3%)	778(74.5%)	.119
Marital status, n (%)			.510
Married	872(83.8%)	888(84.9%)	
Divorced/Widowed/Singlehood	168(16.2%)	158(15.1%)	
Monthly household income, ¥, n (%)			.156
≤5,000	467(44.9%)	506(48.4%)	
5,000 to <10,000	462(44.4%)	449(42.9%)	
≥10,000	111(10.7%)	91(8.7%)	
Education, n (%)			.776
Junior high school or less	635(61.1%)	645(61.7%)	
High school or higher	405(38.9%)	401(38.3%)	
Clinical Data			
Heart rate, mean (SD)	80.90 (16.97)	79.59 (16.89)	.397
Blood pressure(mmHg), mean (SD)			
Systolic	129.90 (19.59)	129.11 (20.85)	.402
Diastolic	79.88 (12.31)	79.79 (12.89)	.926

Distribution of BP[a], n (%)

pressure.

[b] BMI: body mass index.

[c] LDL-C: low-density lipoprotein cholesterol.

[d] eGFR: estimated glomerular filtration rate. eGFR was calculated from serum creatinine (sCr) concentrations using the modified glomerular filtration rate estimating equation for Chinese population: eGFR (ml/min/1.73m^2) = 175×(sCr)-1.234×(age)-0.179× (0.79 if patient is female).

Current smokers are those who smoke no less than one cigarette per day.

[e] LVEF: left ventricular ejection fraction.

[f] STEMI: ST segment elevation myocardial infarction.

[g] NSTEMI: non-ST segment elevation myocardial infarction.

[h] Anemia was defined as hemoglobin<110 g/L for women or hemoglobin <120g/L for men.

[i] Current smokers are those who smoke no less than one cigarette per day.

[j] Current drinkers are those who drink alcohol at least once a week.

[k] ACEI: angiotensin converting enzyme inhibitor; ARB: angiotensin II receptor blocker; ARNI: angiotensin receptor neprilysin inhibitor.

Table 2. Procedural Characteristics

Outcomes	Remote patient management (n☐1046)	Usual Care (n☐1046)	P value
IRA[a], n (%)			.218
Left main	56 (5.4)	48 (4.6)	
Left anterior descending	518 (49.8)	566 (54.1)	
Left circumflex	189 (18.2)	166 (15.9)	
Right	277 (26.6)	266 (25.4)	
Disease extent, n (%)			.112
1-vessel disease	355 (34.1)	335 (32.0)	
2-vessel disease	299 (28.7)	345 (33.0)	
3-vessel disease	386 (37.1)	366 (35.0)	
Average stent number, median (IQR)	2 (1-3)	2 (1-3)	.595
Total stent length (mm), median (IQR)	57 (33-84)	57 (33-72)	.276

[a] IRA: Infarction Related Artery

Throughout the study, four health managers worked as full-time staff in the telemedical center during daytime hours, three registered nurses and three registered doctors were responsible for health education and answering patients' questions during hospitalization and online follow-up period.

During the trial, all participants in the intervention group had received health messages (text messages or videos) posted to them, while 81% of the patients had read these health messages, and 46% of the patients had made inquiries. The total number of online counseling questions in the remote management group was 1973, and the proportion of AI answers was 39%. The proportion of answers from the health managers was 53% and from the doctor was 8%. To be specific, among all the consultation questions, those about illness and cardiac rehabilitation knowledge accounted for 47%, vital signs (such as blood pressure, heart rate, etc.) and test report consultation 19%, medication guidance 14%, and physical discomfort consultation 10%.

During the one-year follow-up after discharge, a total of 91 MACCE occurred: 55 MACCE (5.3%) in the usual care group and 36 MACCE (3.5%) in the remote patient management group (see **Figure 4** and **Table 3**). The difference was significant between the two groups (*P*=.044). This significance was mainly a consequence of reduction in cardiac death (1.0% vs 2.3%, *P*=.017) and myocardial infarction (0.8% vs1.8%, *P*=.034) in the remote patient management group compared to the usual

care group. No significant difference was observed in stroke (1.0% vs 1.4%), TVR (1.4% vs 1.7%), stent thrombosis (0.6% vs 1.4%), non-cardiac death (0.9% vs 0.6%) and between the groups (*P*>.05). Additionally, no significant difference was observed in BARC 1 bleeding events (5.2% vs 5.2%). The remote patient management presented an increasing trend in BARC 2 bleeding events (3.5% vs 2.1%, *P* = .062) but a reduction in BARC 3-5 bleeding events (0.6% vs 1.6%, *P*=.033).

Table 3. Adverse Events at 1-Year follow-up visit

Outcomes	Remote patient management (n☐1046)	Usual Care (n☐1046)	*P value*
MACCE[a], n (%)	36(3.5%)	55(5.3%)	.044
Cardiac death	10(1.0%)	24(2.3%)	.017
Myocardial infarction	8 (0.8%)	19(1.8%)	.034
Target vessel revascularization	14(1.4%)	17(1.7%)	.592
Stroke[b]	10(1.0%)	14(1.4%)	.410
All-cause mortality, n (%)	19(1.8%)	29(2.8%)	.150
Non-Cardiac death	9(0.9%)	5(0.5%)	.286
the first unplanned heart failure or angina hospitalization, n (%)	61(5.9%)	66(6.4%)	.645
Stent thrombosis[c], n (%)	3 (0.3%)	5 (0.5%)	.479
Any bleeding, n (%)	96(9.3%)	92(8.9%)	.676
BARC[d]1	54(5.2%)	54(5.2%)	.948
BARC[d]2	36(3.5%)	22(2.1%)	.061
BARC[d]3-5	6(0.6%)	16(1.6%)	.033

[a] MACCE: major adverse cardiac and cerebrovascular events.

[b] Stroke occurs when there is a new focal neurological deficit that was attributed to vessels. It is characterized with signs or symptoms lasting at least 24 hours after a pharmacologic or non-pharmacologic intervention. It is strongly recommended (but not required) that an imaging procedure such as a computerized tomography (CT) or Magnetic Resonance Imaging (MRI) be performed. Both ischemic and hemorrhagic stroke will be considered as an endpoint and adjudication will have to differentiate the two types of events.

[c]Stent thrombosis will be defined for additional analyses based on the modified Academic Research Consortium definitions (ARC definitions). Only definite stent thrombosis will be considered as endpoints.

[d]BARC: Bleeding Academic Research Consortium.

1021 patients in the remote patient management group and 1017 in the usual care group completed the extended follow-up. During the one-year follow-up, there were significant lifestyle changes among patients (**Table 4**). Follow-up data revealed that the remote patient management group showed significant differences compared to the usual care group in terms of alcohol consumption (11.7% vs 16.5%, *P*=.002). The remote patient management also presented a strong trend for reduction in smoking (11.2% vs 14.0%, *P* = .057).

Table 4. Changes in Blood Pressure, Medication, and Lifestyle Factors Among Participants at 1-Year follow-up visit

Lifestyle change	Remote patient	Usual Care	*P value*

	management (n⬚1021)	(n⬚1017)	
Current Smoking[a], n (%)	114(11.2%)	142(14.0%)	.057
Current Drinking[b], n (%)	119 (11.7%)	168 (16.5%)	.002
Blood pressure control achieved			
Blood pressure(mmHg), mean (SD)			
Systolic	117.74±13.80	121.46±16.85	.002
Diastolic	73.60±10.18	75.72±10.45	.017
Distribution of BP, n (%)			
Proportion of patients with BP			
⬚140/90 mmHg	123(12.0%)	188(18.5%)	⬚.001
Proportion of patients with BP			
⬚130/80 mmHg	310(30.4%)	442(43.5%)	⬚.001
Medical compliance, n (%)			
Aspirin	896(87.8%)	858(84.4%)	.027
P2Y12 antagonists	847(83.0%)	812(79.8%)	.071
Statins	810(79.3%)	776(76.3%)	.100
ACEI/ARB/ARNI[c]	489(47.9%)	442(43.5%)	.045
Beta -blockers	533(52.2%)	516(50.7%)	.508

[a] Current smokers are those who smoke no less than one cigarette per day.

[b] Current drinkers are those who drink alcohol at least once a week.

[c] ACEI: angiotensin converting enzyme inhibitor; ARB: angiotensin II receptor blocker; ARNI: angiotensin receptor neprilysin inhibitor.

Also, there were significant decrease in systolic blood pressure (117.74 vs 121.46mmHg, *P*=.002) and diastolic blood pressure (73.60 vs 75.72mmHg, *P*=.017) in the remote patient management, compared to the usual care group. The proportion of patients achieving BP⬚140/90mmHg at 1-year follow-up was 12.0% in the remote patient management group and 18.5% in the usual care group. Likewise, the proportion of patients achieving BP⬚130/80mmHg at one-year follow-up was 30.4% in the remote patient management group and 43.5% in the usual care group. Both between-group differences remained statistically significant (*P*⬚.001).

Notably, participants in the remote management group were more likely to adhere to the cardioprotective medications in terms of aspirin (87.8% vs 84.4%, *P*=.027) and ACEI/ARB/ARNI (47.9% vs 43.5%, *P*=.045) at 1 year. Also, adherence rates for P2Y12 antagonists (83.0% vs 79.8%, *P*=.071) and statins (79.3% vs 76.3%, *P* =.100) were tend to be higher in the remote patient management group. No significant difference was observed in adherence rates for beta-blockers.

Discussion
Key Findings
The remote medical interventional management showed benefits with respect to reducing the incidence of cardiac mortality and myocardial infarction over the one-year study period, as well as an improvement in BARC 3-5 bleeding events, control of blood-pressure, drug adherence, smoking and heavy drinking among coronary heart disease patients after they underwent percutaneous coronary intervention.

It was found that our multicomponent interventions on a web-based platform could provide real-time medical guidance to patients, increasing patients' engagement and adherence in the management of chronic coronary heart disease. More importantly, the follow-up period in this trial provides evidence with large patient populations for the medium-to-long-term clinical effects of technology-assisted cardiac rehabilitation and secondary prevention services.

Significance of Telemedical Interventional Management

People with coronary heart disease (CHD) are at a high risk of subsequent cardiovascular events such as myocardial infarction, stroke, and cardiovascular death [28, 29]. Studies have shown that the recurrence rate of acute myocardial infarction is as high as 2.5% within one year after discharge, despite advances in pharmacological treatments and invasive procedures. Nearly one-third of recurrent events occurred within 30d of discharge, but the one-year mortality rate can be as high as 2.8% [30].

It was found that secondary prevention in CHD is the prevention of occurrence of recurrent coronary events after clinical diagnosis. High level of adherence to secondary prevention interventions, especially active lifestyle changes and pharmacotherapy can lead to significant decline in recurrent coronary events International guidelines strongly advocate proven secondary prevention strategies to mitigate these risks with evidence-based pharmacological therapy, cardiovascular risk factors optimization, cardiac rehabilitation and adherence to diet and physical activity recommendations[2]. Therefore, the long-term follow-up management of patients with CHD after discharge is critical for patients[1]. However, poor adherence to treatment and low control rates of cardiovascular risk factors still existed among CHD patients [31, 32]. Often, this is due to a lack of engagement with outpatient services, which may stem from inadequate coordination, communication or access[5]. All these are consistent with our finding that telemedical interventional management contributed to the increase in engagement and efficacy of follow-up medical guidance.

Efficacy of Telemedical Interventional Management

Secondary prevention in CHD has evolved significantly with the advent of telemedical technologies, offering novel and flexible approaches to delivering care. A study of patients with acute myocardial infarction showed that those who received a digital tele-rehabilitation intervention had significantly better self-health management and a 52% lower risk of readmission within 30 days of discharge [33]. The SMART-CR/SP study[5] utilized smartphones to provide remote cardiac rehabilitation and secondary prevention guidance services for post-PCI coronary heart disease patients. The results showed that remote cardiac rehabilitation and secondary prevention based on smartphones and WeChat significantly improved coronary artery disease patients' exercise capacity, knowledge of cardiovascular disease prevention and control, blood pressure, heart rate, and lipid control, and adherence to secondary prevention medications. Similarly, a new meta-analysis[22] also illustrated that telemedical interventional management reduced readmission and out-of-hospital mortality in ACS patients.

The current study extends previous observations and demonstrates that the web-based remote patient management is a viable and powerful addition to usual secondary prevention in terms of hard cardiovascular outcomes and major bleeding complication. There are several mechanisms through which the web-based remote patient management might have contributed to improved cardiovascular outcomes.

First, our data showed promising effects on medication adherence and risk factor modification, such as blood-pressure change, cigarettes or alcohol cessation in this large cohort study. Our findings were consistent with the existing ones. There have been many trials with remote telehealth interventions to reduce risk factors and improve adherence to lifestyle changes such as medication adherence [5, 19, 22], smoking cessation[13, 20] and blood-pressure change[22, 34, 35]. After risk factors have been controlled, coronary disease complications, the risk of infarction and mortality rates were found to decrease[36].

Second, remote patient management is not just confined to monitoring of patients; it should also cover a spectrum of interventions relating to patient management including patient education, concomitant medication management, evaluation of comorbidity, and personalized recommendations [37]. Participants in the intervention group could receive education and consult with healthcare providers remotely. Healthcare providers could deliver personalized educational resources, lifestyle modification guidance, and self-management strategies through virtual platforms. That was another factor that was important in the management of patients with our remote patient management intervention and might have contributed to the success of the trial.

Third, the telemedicine platform could offer a conducive environment for patients to ask questions, seek clarifications, and receive guidance on managing their condition effectively. In cases of cardiovascular emergencies, telemedicine can be used to provide timely consultations and guidance to individuals experiencing abnormalities. In our study, we observed the remote patient management predisposed the risk of BARC 2 bleeding events (Bleeding is considered minor if BARC types 1 through 2 and was considered major/fatal if BARC types 3 through 5 occurred [25].BARC type 1 bleeding is in which the patient does not seek treatment. BARC type 2 bleeding is in which intervention or admission to hospital occurs[25]), but patients' adoption of the bleeding management and antiplatelet treatment strategy might also help in preventing a worsening bleeding episode. In this sense, the rate of BARC 3-5 bleeding events reduced unexpectedly. Similarly, online consultation platform enables healthcare providers to assess the medical risks, provide immediate recommendations to CHD patients experiencing chest pain (angina), heart failure or other serious coronary symptoms and guide patients or caregivers on appropriate actions to take before reaching a healthcare facility. This can potentially improve outcomes and reduce the incidence of death in critical situation [33].

Overall, the web-based remote patient management empowers individuals to take an active role in managing their cardiovascular health while enabling healthcare professionals to provide more personalized and timely care.

Strengths and Limitations

Our study has both strengths and limitations. This study was a relatively large-scale (2086 participants) and long-term cohort (one-year follow up) regarding the feasibility, acceptability, and impact of remote management on CHD patients. To our knowledge, this was the first study to evaluate the impact of remote health management on bleeding outcomes of CHD patients after PCI. Relatively in-depth analysis of remote health management determinants and pattern was performed, which has not only clinical implications but also contributes to the framework of remote management of CHD patients.

Certainly, our study was kind of insufficient from the following aspects. First, the findings may not be applicable for all cultures because it is characteristic of Chinese contexts and patients from different cultures or geographic locations may have totally different healthcare management practices. Second, data on some indicators that involved in the development of CHD such as patients' lipids, glycated hemoglobin, BMI, etc. was not collected at follow-up consultations, so we failed to discuss those value changes. Luckily, evidence could be found from previous studies to confirm the association of reduced cardiovascular risk with telemedicine interventions [13, 14, 39]. Third, some data like the assessment of lifestyle changes and medication adherence were patients' self-reported, which could lead to recall bias. Future studies could consider using objective biomarkers or electronic monitoring devices to track lifestyle. Fourth, we used a multi-component intervention design, but we were unable to accurately assess the independent contributions of each intervention component and the mechanisms that adequately capture change. Future studies could employ more comprehensive analytic methods to probe deeper into the associations between different intervention

components, determining which factor plays a key role in improving patient prognosis.

Conclusion

A well-designed telemedical interventional management was compared with the usual care to assess how telemedicine could exert influence on the secondary prevention of coronary heart disease after percutaneous coronary intervention therapy. It was found that remote telemedical health management significantly reduced the risk of cardiovascular death or myocardial infarction in the one-year follow-up period, as well as an improvement in BARC 3-5 bleeding events, control of blood-pressure, drug adherence, smoking and heavy drinking, which highlights the role of telemedical interventional management of patients with coronary heart disease. Further multicenter, randomized studies are warranted to further explore the different telemedical interventional management systems and thus maximize the benefits for not only patients but also the healthcare industry.

Author Contributions

XY and LM conceived and designed the study. HC, DY, QX, JX, YH, AO, and JC were involved in data collection, interpretation, analysis. YH, AO, and JC were involved in telephone follow-up. XY wrote the manuscript. LM was involved in the editing of the manuscript.

Conflicts of Interest

None declared.

Abbreviation

CHD: coronary heart disease
PCI: percutaneous coronary intervention
MACCE: major adverse cardiovascular and cerebrovascular events
ACS: acute coronary syndrome
NYHA: New York Heart Association
BARC: bleeding academic research consortium
ACEI: angiotensin converting enzyme inhibitor
ARB: angiotensin II receptor blocker
ARNI: angiotensin receptor neprilysin inhibitor
BP: blood pressure
BMI: body mass index
LVEF: left ventricular ejection fraction.
STEMI: ST-segment elevation myocardial infarction

NSTEMI: non-ST segment elevation myocardial infarction.
LDL-C: low-density lipoprotein cholesterol
eGFR: estimated glomerular filtration rate
sCr: serum creatinine

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Supplementary Files

Figures

Overview of the components of the web-based management platform.
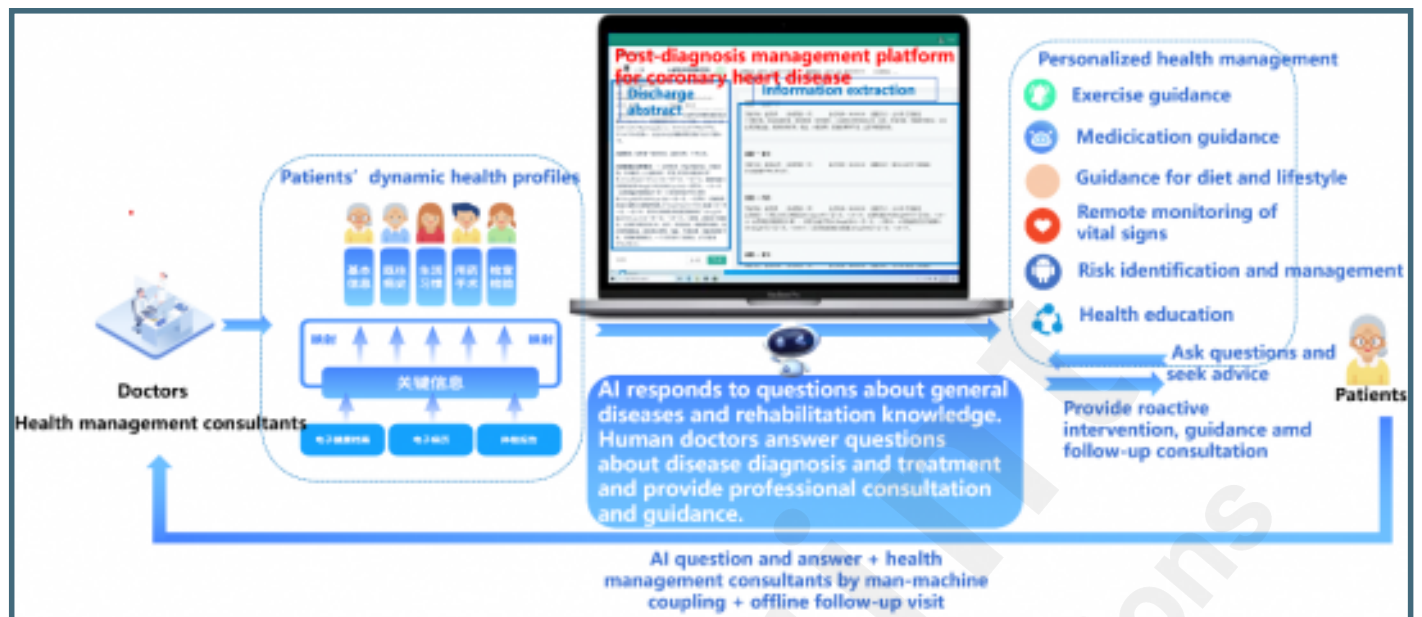
Topic list of the health education, personalized to the individual needs of patients with diagnosed coronary heart disease.

Day 1 after hospital discharge	Day 2 to 14 after hospital discharge	Day 15 to 30 after hospital discharge	Day 31 to 60 after hospital discharge	Day 61 to 90 after hospital discharge
Primary concern	**Primary concern**	**Exercise guidance + exercise reminders**	**Dietary advice**	**Exercise guidance + exercise reminders**
Risk avoidance + regular reexamination + daily monitoring of vital signs	Risk avoidance + medical safety norms + patient safety education	Exercise assessment + exercise recommendations + exercise intensity + exercise precautions (to send exercise reminders to encourage patients to do exercises)	Dietary principles + dietary recommendations + dietary guidance	Exercise assessment + exercise recommendations + exercise intensity + exercise precautions
Medication guidance	**Home-based health care**	**Reminder for follow-up visits**	**Exercise guidance + exercise reminders**	**Dietary advice**
Drug usage, dosage, measures for missed medication and drug storage	Guidance for smoking, alcohol, sleep, emotion and home safety	Reminder for follow-up reexamination (to determine whether it is required by the medical professionals)	Exercise assessment + exercise recommendations + exercise intensity + exercise safety rules	Dietary principles + dietary recommendations + dietary instructions
Dietary advice	**Public health education**	**Results tracking of follow-up visits**	**Psychological counseling**	**Doctor's reminders/reminders for reexamination**
Dietary principles + dietary recommendation + dietary guidance	Common risk factors of coronary heart disease + specialized guidance for daily lifestyle + importance of rehabilitation	Follow up blood pressure and heart rate	**Smoking cessation**	Reminders of follow-up visits after hospital discharge
Movement guidance	**Movement guidance**		**Medication guidance**	
Movement assessment + exercise recommendations + exercise intensity + exercise safety	Exercise assessment + exercise recommendations + exercise intensity + exercise precautions (to send exercise reminders to encourage patients to do exercises)			

Randomised controlled trial flowchart.
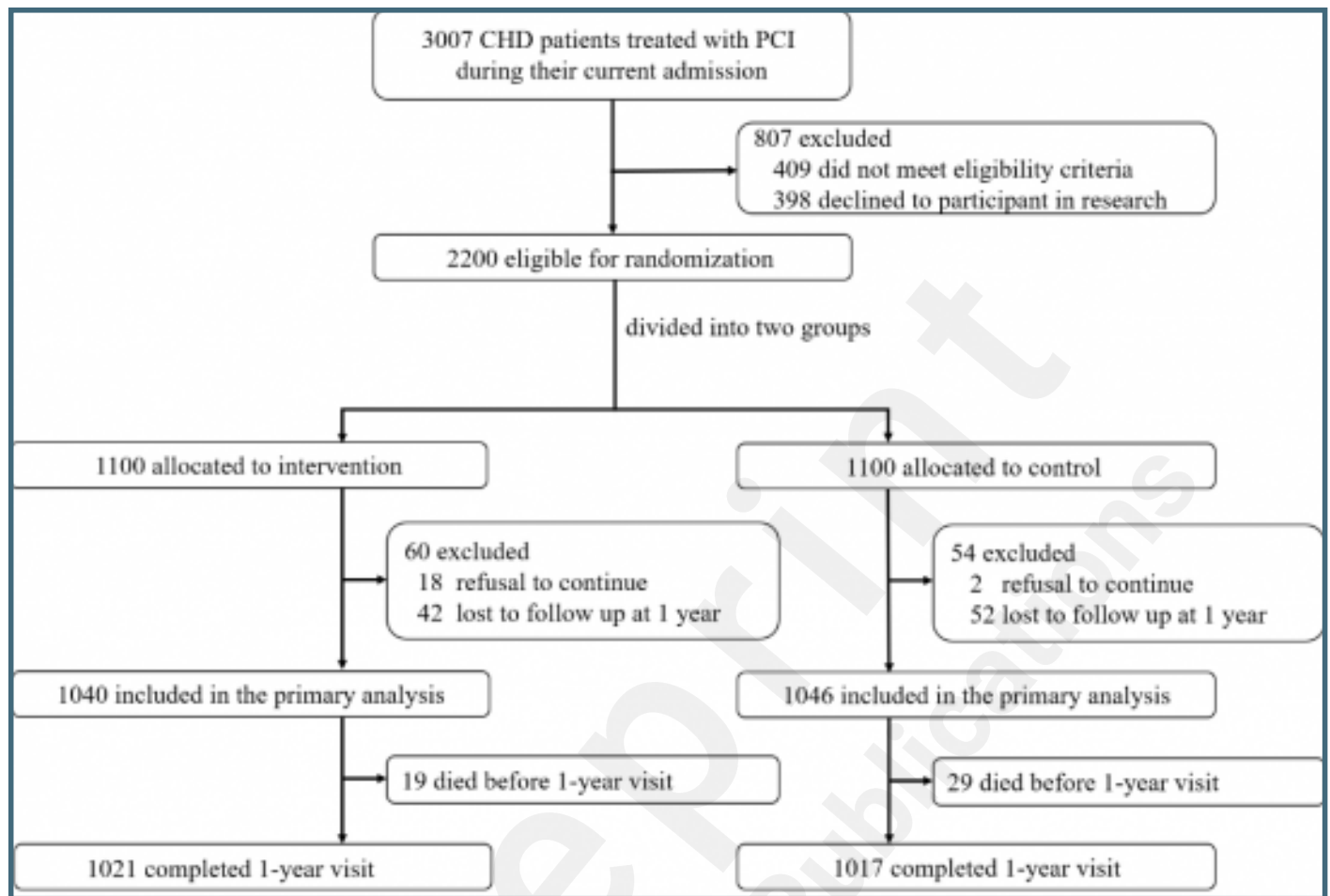
Kaplan-Meier curve of MACCE at 1-Year follow-up. MACCE: major adverse cardiovascular and cerebrovascular events.
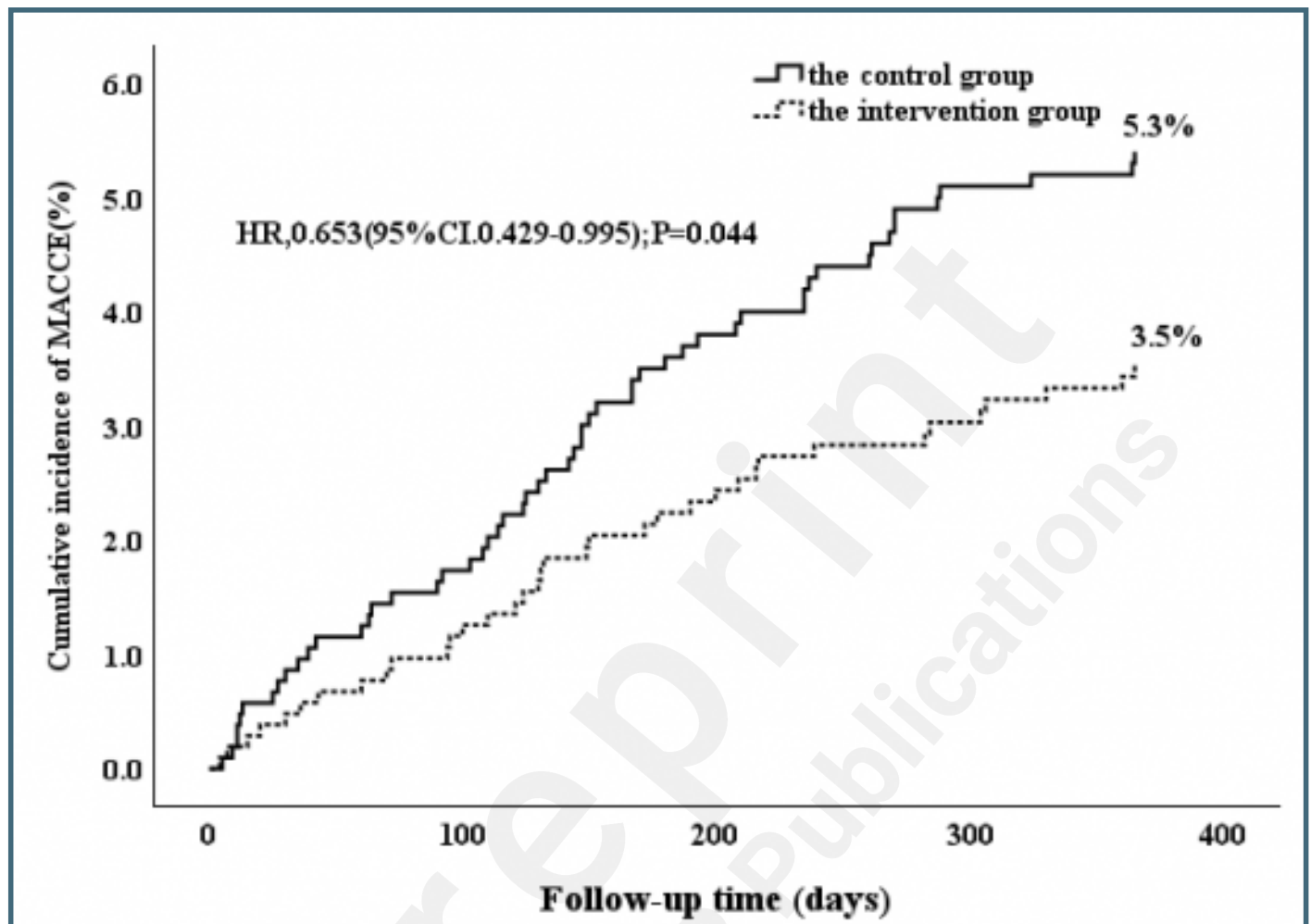
Multimedia Appendixes

A patient with coronary heart disease received educational resources, lifestyle modification guidance, and self-management strategies on his phone after discharge.
URL: http://asset.jmir.pub/assets/845b5e3ab85149d93d1aa882eef7244d.png

Example of medication management.
URL: http://asset.jmir.pub/assets/5d944b4949f0b4a06c97127ed657f961.png

Example of remote monitoring and follow-up care for chronic cardiovascular conditions.
URL: http://asset.jmir.pub/assets/e92782b30abedd9bf28daf31882165fb.pdf

Example of AI responds to questions about general diseases and rehabilitation knowledge.
URL: http://asset.jmir.pub/assets/413d0b992df1ad8a19d3fbb3a236d613.png