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CLINICAL RESEARCH STUDY

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Mobile Health Technology for Atrial Fibrillation Management Integrating Decision Support, Education, and Patient Involvement: mAF App Trial

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ABSTRACT

BACKGROUND: Mobile Health technology for the management of patients with atrial fibrillation is unknown.
METHODS: The simple mobile AF (mAF) App was designed to incorporate clinical decision-support tools (CHA_2DS_2-VASc [Congestive heart failure, Hypertension, Age ≥75 years, Diabetes Mellitus, Prior Stroke or TIA, Vascular disease, Age 65–74 years, Sex category], HAS-BLED [Hypertension, Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile INR, Elderly, Drugs/alcohol concomitantly], SAMe-TT_2R_2 [Sex, Age <60 years, Medical history, Treatment, Tobacco use, Race] scores), educational materials, and patient involvement strategies with self-care protocols and structured follow-up. Patients with atrial fibrillation were randomized into 2 groups (mAF App vs usual care) in a cluster randomized design pilot study. Patients' knowledge, quality of life, drug adherence, and anticoagulation satisfaction were evaluated at baseline, 1 month, and 3 months. Usability, feasibility, and acceptability of the mAF App were assessed at 1 month.
RESULTS: A total of 113 patients were randomized to mAF App intervention (mean age, 67.4 years; 57.5% were male; mean follow-up, 69 days), and 96 patients were randomized to usual care (mean age, 70.9 years; 55.2% were male; mean follow-up, 95 days). More than 90% of patients reported that the mAF App was easy, user-friendly, helpful, and associated with significant improvements in knowledge compared with the usual care arm (P values for trend <.05). Drug adherence and anticoagulant satisfaction were significantly better with the mAF App versus usual care (all $P < .05$). Quality of life scores were significantly increased in the mAF App arm versus usual care, with anxiety and depression reduced (all $P < .05$).
CONCLUSIONS: The pilot mAFA Trial is the first prospective randomized trial of Mobile Health technology in patients with atrial fibrillation, demonstrating that the mAF App, integrating clinical decision support,

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Authorship: All authors had access to the data and played a role in writing this manuscript.

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education, and patient-involvement strategies, significantly improved knowledge, drug adherence, quality of life, and anticoagulation satisfaction.
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KEYWORDS: Atrial fibrillation; Drug adherence; Mobile health; Patient education

INTRODUCTION

Atrial fibrillation is the most common cardiac arrhythmia, with a global health burden of approximately 33.5 million individuals with atrial fibrillation worldwide.[1] The lifetime risk for developing atrial fibrillation is 21% to 23% in women and 17% to 26% in men.[2-4] In the past 5 decades, age-adjusted atrial fibrillation prevalence globally has increased 5-fold[5] and is expected to double by 2050.[1] Atrial fibrillation–related stroke is devastating, which has been described as an "atrial fibrillation–related stroke tsunami" without proper treatment with oral anticoagulants.[6]

The underuse or inappropriate use of oral anticoagulants is common in the population with atrial fibrillation, particularly so in many Asian countries.[7] Even in the new era of non–vitamin K antagonist oral anticoagulants,[5] many patients remain undertreated.[8] Also, 28% of high-risk patients (defined as a CHA_2DS_2-VASc [Congestive heart failure, Hypertension, Age ≥75 years, Diabetes Mellitus, Prior Stroke or TIA, Vascular disease, Age 65–74 years, Sex category] score ≥2) are not anticoagulated, whereas 51% of very low-risk patients are inappropriately anticoagulated.[9]

Nonadherence to atrial fibrillation guidelines is common across all risk strata, ranging from 33% to 68% among the high-risk population.[10] On the other hand, patients' preferences are another important reason for nonadherence to therapy.[11] Thus, efforts to streamline decision-making for stroke prevention in patients with atrial fibrillation and to improve patients' knowledge are important in the era of non–vitamin K antagonist oral anticoagulants.[12]

Novel strategies that incorporate eHealth or Mobile Health encompass the use of information and communication technologies in the management of disease, providing innovative solutions to the problem of long-term management after discharge.[13,14] However, there are limited data on the implementation of Mobile Health technology for the management of patients with atrial fibrillation, particularly in relation to its feasibility, efficacy, and safety.

CLINICAL SIGNIFICANCE

- Mobile Health technology is increasingly proposed for cardiovascular disease management.
- The feasibility, efficacy, and safety of Mobile Health technology for the management of patients with atrial fibrillation are unknown.
- The pilot mAFA Trial demonstrated that an approach integrating clinical decision support, education, and patient-involvement strategies using the mAF App would translate to significantly improved knowledge, drug adherence, anticoagulant satisfaction, and quality of life.

Our aim was to perform a randomized, controlled trial (mAFA; Clinical Trials Registry Number: ChiCTR-IOR-17010436) of a Mobile Health technology–supported atrial fibrillation management model, integrating clinical decision support tools, guideline-based treatment, and patient involvement. The mAFA Trial is the first prospective randomized trial of Mobile Health technology in patients with atrial fibrillation.

MATERIALS AND METHODS

A user-friendly mAF App was developed for smart phones based on the Android Operating System (Google Inc., Mountain View, Calif) and Apple iOS (Cupertino, Calif), which incorporated clinical decision support (clinical risk scores, ie, CHA_2DS_2-VASc, HAS-BLED [Hypertension, Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile INR, Elderly, Drugs/alcohol concomitantly], and SAMe-TT_2R_2 [Sex, Age < 60 years, Medical history, Treatment, Tobacco use, Race] score), patient educational programs, patient involvement self-care components, and structured follow-up components.

Patients with atrial fibrillation were randomized to 2 groups (mAF App vs usual care) in a cluster randomized design based in 2 hospitals, Chinese PLA General Hospital and Meishan City People's Hospital, between January 1, 2017, and May 1, 2017. Inclusion criteria included adult patients aged >18 years with atrial fibrillation diagnosed with electrocardiogram and 24-hour Holter. We excluded individuals aged <18 years, those with valvular atrial fibrillation (eg, prosthetic), and those unable to provide written informed consent (Supplementary Figure 1, available online).

Patients' knowledge, quality of life, drug adherence, and anticoagulation satisfaction were evaluated at baseline, 1 month, and 3 months. Usability, feasibility, and acceptability of the mAF App were assessed at 1 month.

Design of mAF App

The mAF App was designed with versions for patients and doctors respectively. The mAF App incorporates details such

as the Personal Health Record, stroke and bleeding risk assessment (CHA_2DS_2-VASc and HAS-BLED scores, respectively), and a clinical score to aid warfarin control prediction (SAMe-TT_2R_2), patient educational programs, patient involvement self-care items, and structured follow-up components.

Personal Health Record. The mAF App could record atrial fibrillation features, patient medical history, laboratory tests, atrial fibrillation treatments, antithrombotic drugs, and other pharmacologic treatments at baseline. Patients were recommended to upload their laboratory tests (eg, hemoglobin, platelet count, liver/renal function tests, blood lipids), electrocardiogram, and echocardiogram (if available) at 1 month and 3 months after their initial consultation.

Clinical Decision Support. The mAF App automatically calculates CHA_2DS_2-VASc, HAS-BLED, and SAMe-TT_2R_2 scores after the patient's Personal Health Record is completed (Supplementary Figure 2, available online).

Patients with a low stroke risk (CHA_2DS_2-VASc score 0 in men, 1 in women) were recommended no antithrombotic treatment. Patients at moderate stroke risk (1 stroke risk factor) were suggested to consider oral anticoagulants balancing against bleeding risk, and those at high stroke risk (CHA_2DS_2-VASc ≥2) were recommended oral anticoagulants. Patients with HAS-BLED ≥3 were flagged for follow-up, and modifiable bleeding risk factors were proactively addressed. Because non–vitamin K antagonist oral anticoagulants are "self-pay" drugs and not reimbursed in China, if the patients had a SAMe-TT_2R_2 score 0 to 2, they were considered to receive warfarin treatment. If the SAMe-TT_2R_2 score was >2, the patients would have additional education/counseling about warfarin and more regular review/international normalized ratio checks, or to use a non–vitamin K antagonist oral anticoagulant.

Patient's Educational Program. There were 8 components of the patient's educational program, with additional patient self-support items. Patients followed the educational program on their mobile device to improve their knowledge of atrial fibrillation and learn how to manage themselves at home (Supplementary Figure 3, available online). Patients' knowledge and understanding were assessed at baseline, 1 month, and 3 months using a 11-item questionnaire regarding atrial fibrillation.[15]

Patient Involvement with Self-Care. The patients were encouraged to monitor their heart rate and blood pressure, and feedback on their treatment using the mAF App (Supplementary Figure 4, available online). Their quality of life was assessed using the Euro EQ-5D-Y at baseline, 1 month, and 3 months.

Structured Follow-Up. Structured follow-up was planned at 1, 3, 6, 9, and 12 months after consultation/discharge, and included assessment of drug therapy, thrombotic events, bleeding events, quality of life, oral anticoagulant satisfaction, and mAF App investigations (Supplementary Figure 5, available online). A reminder "alert" was sent automatically to patients 1 week before and after the follow-up time-point by the mAF App.

The patients' drug adherence was assessed at baseline, 1 month, and 3 months with the Pharmacy Quality Alliance adherence measure, with a 3-item Adherence Estimator.[16] The Anti-Clot Treatment Scale was adapted to evaluate the satisfaction of patients with oral anticoagulants in this Chinese population with atrial fibrillation (Supplementary Table 1, available online).

Data Management, Quality Control, Data Security, and Ethics

Users had a user-sensitive password for access to their mAF App. Personal Health Records were stored as structured data on a cloud platform. For example, the medical records and laboratory tests could be uploaded to mAF App as image files, and then the image files were transferred into structured data with optical character recognition technology. Two persons independently double checked the structured data and the source documentation (ie, the image files of laboratory tests and medical records) for consistency and accuracy to achieve good-quality control of data management.

Health Insurance Portability and Accountability Act requirements were adopted to confirm data security during data transfer and data storage, in terms of the Administrative Procedures, Physical Safeguards, Technical Security Services, and Technical Security Mechanisms. Data input into analysis was performed by 2 individuals, who were blinded for the intervention groups. Data were double checked independently by a third investigator. Patient records and information were anonymized and de-identified before analysis.

The Medical Ethics Committee of PLA General Hospital and the China Food and Drug Administration (Registry Number: XZF20120145) approved the present study protocol (Approval Number: S2016-086-01). The present study was registered in the Chinese Clinical Trial Registry, International Clinical Trials Registry Platform of the World Health Organization (ChiCTR-IOR-17010436).

Statistical Analysis

Continuous variables were tested for normality by the Kolmogorov–Smirnov test. Data with a normal distribution are presented as a mean (standard deviation) and analyzed using the *t* test. Data with a non-normal distribution are presented as median (interquartile range). The comparison of discrete variables was performed using the chi-square test.

The usability, feasibility, and acceptability of the mAF App were investigated at 1 month, and the satisfaction rate was calculated. Data on patients' knowledge, quality of life scores, antithrombotic drugs, and other drugs at the 3 time-points (baseline, 1 month, and 3 months) were presented graphically to illustrate the change in these variables over time

Table 1 Baseline Characteristics

	mAF App (n = 113)		Usual Care (n = 96)		*P* Value
Age, y, mean (SD)	67.4	(10.6)	70.9	(17.4)	.066
Male, n (%)	65	57.5%	53	55.2%	.737
Medical history					
Hypertension, n (%)	71	62.8%	51	53.1%	.156
CAD, n (%)	50	44.2%	42	43.8%	.942
Diabetes mellitus, n (%)	21	18.6%	14	14.6%	.440
Heart failure, n (%)	14	12.4%	18	18.8%	.203
Prior stroke, n (%)	9	8.0%	9	9.5%	.717
PAD, n (%)	8	7.1%	3	3.1%	.202
Renal dysfunction, n (%)	8	7.1%	5	5.2%	.577
Hypertrophic cardiomyopathy, n (%)	5	4.4%	1	1.0%	.144
Liver dysfunction, n (%)	4	3.5%	1	1.0%	.239
AF treatment					
AF ablation, n (%)	12	10.6%	3	3.1%	.036
Dual-chamber pacemaker, n (%)	7	6.2%	4	4.2%	.513
Pharmacologic cardioversion, n (%)	3	2.7%	2	2.1%	.788
Electrical cardioversion, n (%)	0	0.0%	2	2.1%	.123
LAAO, n (%)	1	0.9%	1	1.0%	.908
CHA_2DS_2-VASc score	2.6	(1.5)	2.7	(1.6)	.383
HAS-BLED score	1.4	(0.9)	1.6	(0.8)	.053

AF = atrial fibrillation; CAD = coronary artery disease; CHA_2DS_2-VASc = Congestive heart failure, Hypertension, Age ≥75 years, Diabetes Mellitus, Prior Stroke or TIA, Vascular disease, Age 65–74 years, Sex category; HAS-BLED = Hypertension, Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile INR, Elderly, Drugs/alcohol concomitantly; LAAO = left atrial appendage occlusion; mAF App = mobile AF App; PAD = peripheral arterial disease; SD = standard deviation.

between the mAF App and usual care groups. Trends of improvement of patients' knowledge at baseline, 1 month, and 3 months were analyzed with Cochran's and Mantel–Haenszel statistics.

Patients' adherence to drug therapy was calculated using the 3-item Adherence Estimator scores, comparing patients with usual care and mAF App, and was analyzed with the Mann–Whitney *U* test.

Comparative analysis of Anti-Coagulation Satisfaction and Quality of Life questionnaire scores (EuroQol, EQ-5D-Y) between patients with usual care and the mAF App was performed using *t* tests, and the chi-square test was used for comparisons of improvement of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression at baseline, 1 month, and 3 months.

A sample size of 112 patients (56 in each group) allows for a 20% attrition rate in the completion of the questionnaires and would have at least 80% power to detect an 18.5% increase in knowledge about the condition between baseline and follow-up.[17] A beta = 0.20 and alpha = 0.05 were assumed.

A *P* value <.05 was considered statistically significant. The 95% confidence intervals were calculated on the basis of Poisson distribution. Statistical analysis was performed using IBM SPSS Statistics version 21.0 (SPSS, Inc, Chicago, Ill).

RESULTS

In a cluster randomization design, 113 patients were randomized to mAF App intervention (mean age, 67.4 years; 57.5% were male) with a mean follow-up of 69 days, whereas 96 patients were randomized to usual care (mean age, 70.9 years; 55.2% were male) with a mean follow-up of 95 days. Of the original cohort, 113 patients with the mAF App had a 1-month follow-up and 71 patients finished the 3-month follow-up; 96 patients with usual care had 1-month and 3-month follow-up visits.

Hypertension, coronary artery disease, diabetes, and heart failure were the most common comorbidities in both groups (**Table 1**). The patients with the mAF App had more prior atrial fibrillation ablation therapy (*P* = .036).

Usability, Feasibility, Acceptability of the mAF App

More than 90% of patients agreed that the mAF App was easy, user-friendly, and helpful, and they had good feedback with the doctors on the mAF App (Supplementary Figure 6, available online).

Patients' Knowledge on Atrial Fibrillation

Patients' knowledge was improved greatly in those with the mAF App over time (all *P* < .05), whereas this was not observed in the patients with usual care (**Figure 1**).

Quality of Life Improvement in Patients with the mAF App

Quality of life scores were significantly increased in the mAF App arm compared with usual care at baseline and 1 and 3

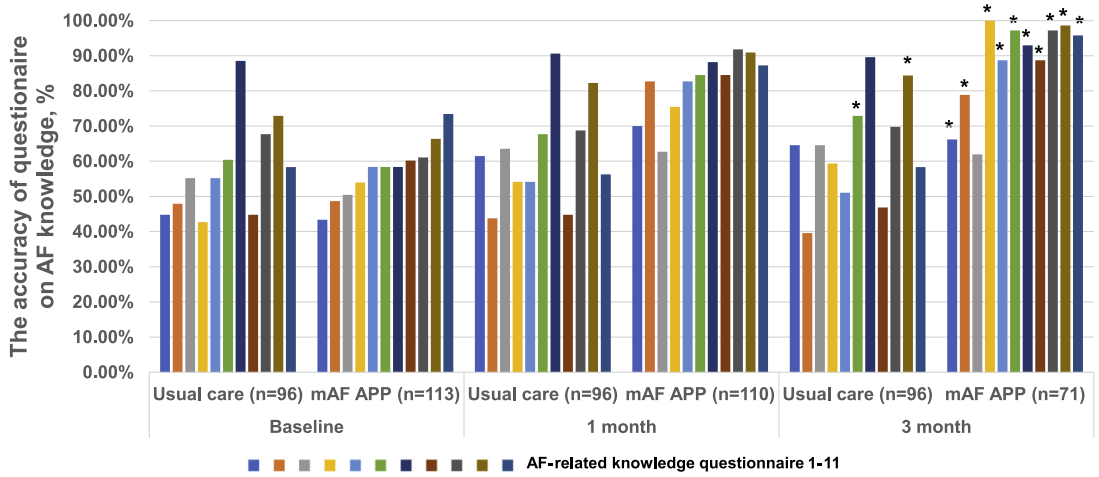

Figure 1 Patients' knowledge of atrial fibrillation with usual care and mAF App at baseline, 1 month, and 3 months. *P for trend <.05 at baseline, 1 month, and 3 months after discharge.

months (all $P < .05$) (**Figure 2**). Self-care improved significantly over time with the mAF App, but not in usual care (all $P < .05$). Anxiety and depression also tended to be ameliorated for patients using the mAF App compared with usual care over time (all $P < .05$) (**Table 2**).

Drug Adherence to Therapy

Compared with patients with usual care, drug adherence was significantly better with the mAF App at 1 month and 3 months (all $P < .05$) (**Table 3**). Patients with the mAF App were more likely to receive non–vitamin K antagonist oral anticoagulants, ranging from 40.7% to 44.2%, compared with those with usual care ($P < .001$). There was a slight increase in non–vitamin K antagonist oral anticoagulant use (3.52%) over time in patients using the mAF App (**Figure 3**). Secondary prevention of comorbidities for atrial fibrillation was improved in patients with the mAF App compared with patients with usual care (Supplementary Figure 7, available online).

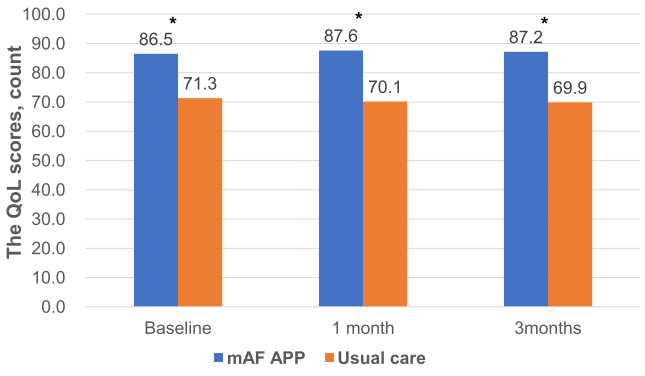

Figure 2 Time trends for quality of life scores of patients with the mAF App. *Quality of life questionnaire was cited from the EuroQol. Compared with patients with usual care, patients with the mAF App, $P < .05$.

Anticoagulation Satisfaction

Patients with usual care expressed more anticoagulant "burden," whereas patients with the mAF App reported more anticoagulant "benefit" (all $P < .05$) (**Table 4**).

DISCUSSION

To our knowledge, the mAFA Trial is the first prospective randomized trial of Mobile Health technology in patients with atrial fibrillation, demonstrating that the mAF App, integrating clinical decision support, education, and patient-involvement strategies, significantly improved knowledge, drug adherence, quality of life, and anticoagulation satisfaction.

Clinical decision support provided by the mAF App streamlined guideline-based decision-making for stroke prevention in patients with atrial fibrillation and was easily handled by doctors and understood by patients. The clinical decision support tools in the mAF App automatically assessed stroke and bleeding risk, and stratified the patients with high-risk stroke/thromboembolism to anticoagulant treatment, while balancing the bleeding risk. Bleeding risk factors were labeled and could be reviewed by doctors and patients. Personalized choice of oral anticoagulants would be advised on the basis of the SAMe-TT_2R_2 score, resulting in rational decision-making on anticoagulant management options.

Suboptimal thromboprophylaxis in patients with atrial fibrillation is highly prevalent, contributed to by an inappropriate evaluation of the risks versus benefits of oral anticoagulants, despite various guidelines on atrial fibrillation management.[18,19] Indeed, guideline-adherent antithrombotic management is associated with significantly better outcomes.[20] One barrier to adherence to guideline-optimized therapy could be the challenges of a "real-world" busy clinical practice, and the clinical decision-making tool in the mAF App could make the process of guideline implementation easier.

To help access to guidelines for the *clinician*, a pocket guideline App for European guidelines has been developed.

Table 2 Quality of Life Questionnaire Responses in Patients with mAF App and Usual Care*

	On Discharge			1 Month After Discharge			3 Months After Discharge		
	mAF App	Usual Care	*P* Value	mAF App	Usual Care	*P* Value	mAF App	Usual Care	*P* Value
Mobility	(n = 113)	(n = 96)		(n = 113)	(n = 96)		(n = 71)	(n = 96)	
No problems	70.80%	26.04%	<.001	76.36%	26.04%	<.001	77.46%	27.08%	<.001
Slight problems	23.89%	32.29%	.180	15.45%	35.42%	.001	15.49%	36.46%	<.001
Moderate problems	5.31%	31.25%	<.001	7.27%	31.25%	<.001	5.63%	29.17%	<.001
Severe problems	-	5.21%	.014	-	2.08%	.123	-	2.08%	.221
Unable to walk about	-	5.21%	.014	0.91%	5.21%	.062	1.41%	5.21%	.062
Self-care									
No problems	77.88%	55.21%	<.001	83.64%	65.63%	<.001	87.32%	68.75%	<.001
Slight problems	18.58%	21.88%	.449	15.45%	15.63%	.908	11.27%	11.46%	.272
Moderate problems	1.77%	9.38%	<.001	-	8.33%	.002	-	9.38%	.001
Severe problems	1.77%	4.17%	.301	-	2.08%	.123	-	2.08%	.221
Unable to wash or dress	-	9.38%	.001	0.91%	8.33%	.008	1.41%	8.33%	.008
Usual activities									
No problems	69.91%	37.50%	<.001	78.18%	45.83%	<.001	77.46%	53.13%	<.001
Slight problems	27.43%	30.21%	.659	20.00%	27.08%	.252	19.72%	18.75%	.203
Moderate problems	2.65%	19.79%	<.001	0.91%	16.67%	<.001	1.41%	16.67%	.001
Severe problems	-	3.13%	.001	-	2.08%	.123	-	3.13%	.133
Unable to do usual activities	-	9.38%	.001	0.91%	8.33%	.008	1.41%	8.33%	.050
Pain/discomfort									
No pain or discomfort	63.70%	35.42%	<.001	59.09%	41.67%	.016	63.38%	40.63%	.006
Slight pain or discomfort	25.66%	39.58%	.046	33.64%	41.67%	.231	25.35%	45.83%	.007
Moderate pain or discomfort	10.62%	20.83%	.041	6.36%	12.50%	.114	9.86%	10.42%	.906
Severe pain or discomfort	-	1.04%	.277	0.91%	2.08%	.468	1.41%	1.04%	.829
Extreme pain or discomfort	-	3.13%	.058	-	2.08%	.123	-	2.08%	.221
Anxiety/depression									
Not anxious or depressed	50.44%	52.08%	.831	62.70%	62.50%	.935	57.75%	61.46%	.629
Slightly anxious or depressed	40.71%	21.88%	.005	31.82%	19.79%	.048	32.39%	20.83%	.091
Moderately anxious or depressed	8.85%	20.83%	.014	5.45%	14.58%	.023	9.86%	14.58%	.363
Severely anxious or depressed	-	-	-	-	-	-	-	1.04%	.388
Extremely anxious or depressed	-	5.21%	.013	-	3.13%	.058	-	2.08%	.221

mAF App = mobile AF App.
*Quality of Life questionnaire was cited from the EuroQol.

The CATCH-ME treatment manager is integrated into the atrial fibrillation section, but has yet to be prospectively tested or evaluated.[21] Another option is the Atrial Fibrillation Decision Support Tool, which is a patient-specific decision analytic model composed of a 29-state Markov simulation, using information from the Electronic Health Record to integrate patient-specific risk factors for stroke and hemorrhage in its calculations.[22] However, the intervention with the Atrial Fibrillation Decision Support Tool did not result in significant improvements in discordant antithrombotic therapy in a population with atrial fibrillation.[23] Other Apps have been developed to provide stroke and bleeding risk calculations; for example, the Computerised Antithrombotic Risk Assessment Tool Version 2 could calculate the $CHADS_2$ (Congestive heart failure, Hypertension, Age over 75 years, Diabetes Mellitus, Stroke), CHA_2DS_2-VASc, HAS-BLED, and $HEMORR_2$-HAGES (Hepatic or renal disease, Ethanol abuse, Malignancy, Older age, Reduced platelet count or function, Rebleeding risk, Hypertension, Anemia, Genetic factors, Excessive fall risk, Stroke) scores.[24] Another clinical decision support tool, which could calculate the CHA_2DS_2-VASc score and alter the clinician prescription of oral anticoagulants therapy, is being studied.[25] However, these Apps/tools are focused on doctors and not the follow-up and day-to-day management of patients with atrial fibrillation.

Table 3 Drug Adherence at Baseline, 1 Month, and 3 Months*

	mAF App	Usual Care	*P* Value
Baseline	n = 113	n = 96	
	4 (4-11)	4 (4-11)	.870
1 mo	n = 113	n = 96	
	0 (0-4)	4 (0-11)	<.001
3 mo	n = 71	n = 96	
	2 (0-4)	4 (0-11)	<.001

mAF App = mobile AF App.
*Pharmacy Quality Alliance adherence measures: 3-item Adherence Estimator. Low risk = score of 0, moderate risk = score of 2-7, and high risk = score of 8-36.

The mAF App not only calculates the clinical risk scores but also automatically makes a follow-up plan, permitting the patient's self-monitoring and timely feedback. We also show that the mAF App–based self-monitoring and feedback enhanced compliance and adherence to drug therapy and

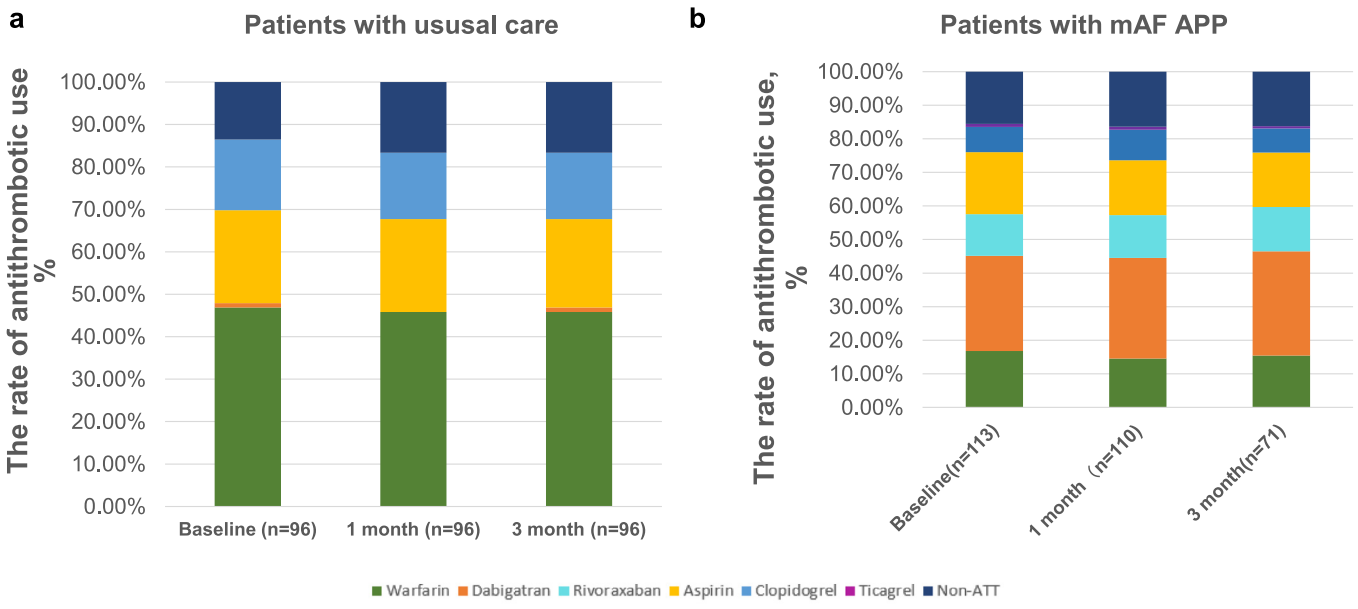

Figure 3 Antithrombotic treatment in patients with the mAF App and usual care at baseline, 1 month, and 3 months after discharge. **A,** Usual care. **B,** mAF App.

anticoagulant satisfaction. With the planned follow-up by the mAF App, the clinician receives the patient's updated clinical condition, reevaluates the patient's clinical risk profile (especially because stroke and bleeding risks are not static), and regulates the dosage and use of various drugs. Meanwhile, patients have their questions clarified, become involved in their self-management, and benefit overall from their treatment plan.

Clinical follow-up ensures effective and safe anticoagulant therapy in patients with atrial fibrillation. A systematic review of drug adherence, thromboembolism, bleeding events, any adverse effects, renal or hepatic function, and so forth, is recommended for non–vitamin K antagonist oral anticoagulants,[26,27] although anticoagulation tests are not needed. In one study, approximately two thirds of practitioners adhered to recommendations on clinical and blood test (creatinine and hemoglobin) follow-ups.[28] Clinical risk monitoring is important, particularly for bleeding risk management after discharge/prescription of non–vitamin K antagonist oral anticoagulants, and the mAF App allows a practical tool to monitor the patient's clinical risk profile in "real time" allowing a dynamic assessment (and reassessment) of patient risks and changes over time. Moreover, the educational programs provided by the mAF App improved atrial fibrillation–related knowledge and patient's quality of life. Patient anxiety and depression also were attenuated.

Contemporary atrial fibrillation clinical guidelines advocate incorporation of patient preferences for treatment and support, as well as patient engagement in management decisions.[21,29] Nonetheless, patient beliefs and misconceptions about their treatment and atrial fibrillation could affect their ability and willingness to adhere to treatment recommendations.[29] A prior study

Table 4 Anticoagulation Satisfaction in Patients with mAF App and Usual Care*

	Usual Care (n = 46)		mAF App (n = 65)		*P* Value
Baseline					
Burden Scale, mean (SD)	20.83	(6.61)	17.58	(8.10)	.028
Benefit Scale, mean (SD)	13.31	(3.39)	14.11	(3.65)	.256
1 mo	Usual care (n = 44)		mAF App (n = 63)		*P*
Burden Scale, mean (SD)	19.40	(6.05)	16.04	(7.50)	.018
Benefit Scale, mean (SD)	14.19	(3.18)	15.09	(2.38)	.013
3 mo	Usual care (n = 45)		mAF App (n = 42)		*P*
Burden Scale, mean (SD)	19.30	(6.39)	15.57	(6.57)	.008
Benefit Scale, mean (SD)	14.21	(3.37)	15.60	(2.73)	.052

mAF App = mobile AF App; SD = standard deviation.

*Compared with the patients with usual care, $P < .05$. The Anti-Clot Treatment Scale was adapted to evaluate the satisfaction of patients with anticoagulant therapy in this Chinese population with atrial fibrillation. The adapted Anti-Clot Treatment Scale included a 15-item questionnaire, comprising 11 burden items and 4 benefit items. For every question, there are 5 item responses: "1, not at all" was calculated as 1 points; "2, a little" was calculated as 2 points; "3, moderately" was calculated as 3 points; "4, quite a bit" was calculated as 4 points; and "5, extremely" was calculated as 5 points.

has confirmed that a bespoke education intervention significantly improved anticoagulation control of warfarin.[30] A higher patient education level has been associated with non–vitamin K antagonist oral anticoagulant selection.[31] The mAF App provides the specific educational components, in terms of warfarin, non–vitamin K antagonist oral anticoagulants, and specific conditions, that may help patients with self-management.

Study Limitations

Some limitations of this study need to be addressed. This was a clustered randomized study, and a selection bias could exist; however, the distribution of comorbidities between the mAF App and the usual care arms were not significantly different. Moreover, the clinician's preference for oral anticoagulants may have contributed to a higher rate of non–vitamin K antagonist oral anticoagulant use in the mAF App group. The educational program could have made the patients more aware and thus be more likely to receive non–vitamin K antagonist oral anticoagulants. Finally, the impact on the clinical outcomes (stroke, death, bleeds) of the mAF App needs to be ascertained in a long-term prospective study with clinical outcome data, which was not the principal objective of the present study.

Despite these limitations, the present study still shows that the clinical decision support, evidence-based clinical follow-up, and patients' involvement in self-care can help clinical management for the population with atrial fibrillation, highlighting for the first time an effective Mobile Health–support management strategy in such patients.

CONCLUSIONS

The pilot mAFA Trial is the first prospective randomized trial of Mobile Health technology in patients with atrial fibrillation, demonstrating that an approach integrating clinical decision support, education, and patient-involvement strategies will translate to significantly improved knowledge, drug adherence, anticoagulant satisfaction, and quality of life.

ACKNOWLEDGMENTS

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References

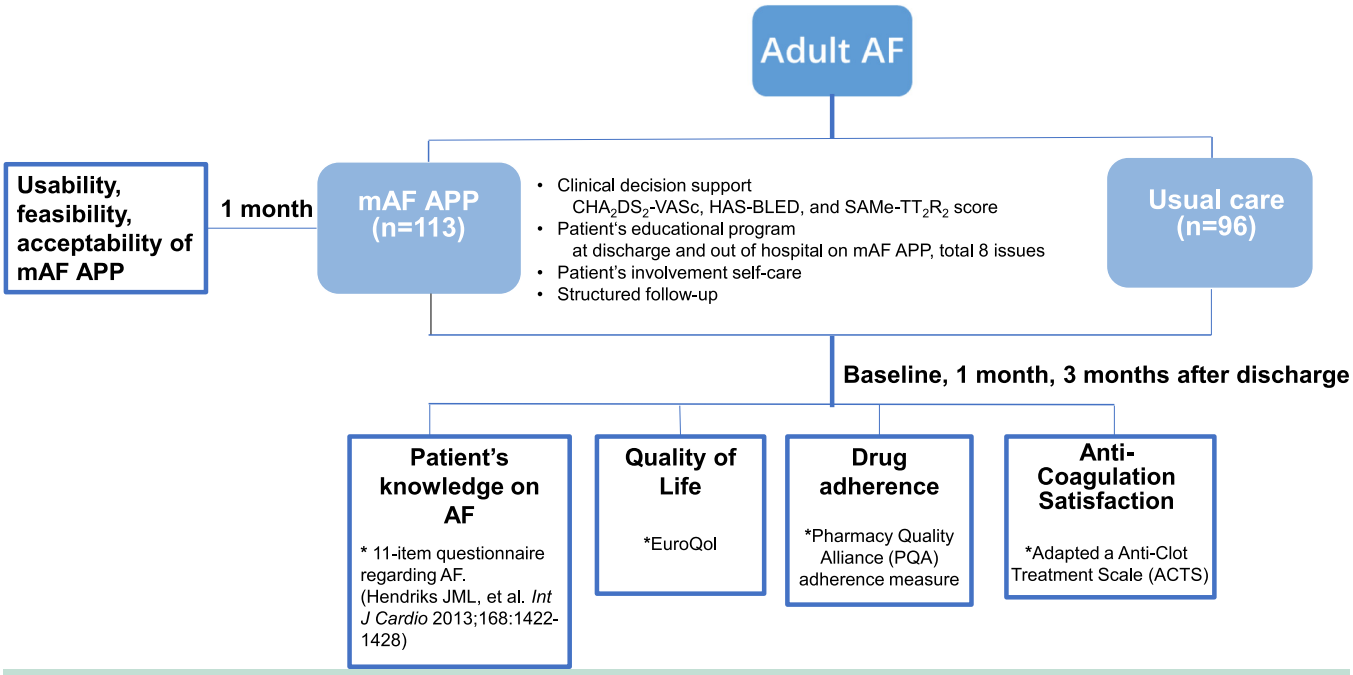
1. Chugh SS, Havmoeller R, Narayanan K, et al. Worldwide epidemiology of atrial fibrillation: a Global Burden of Disease 2010 Study. *Circulation*. 2014;129:837-847.
2. Lloyd-Jones DM, Wang TJ, Leip EP, et al. Lifetime risk for development of atrial fibrillation: the Framingham Heart Study. *Circulation*. 2004;110:1042-1046.
3. Heeringa J, van der Kuip DA, Hofman A, et al. Prevalence, incidence and lifetime risk of atrial fibrillation: the Rotterdam study. *Eur Heart J*. 2006;27:949-953.
4. Guo Y, Tian Y, Wang H, et al. Prevalence, incidence, and lifetime risk of atrial fibrillation in China: new insights into the global burden of atrial fibrillation. *Chest*. 2015;147:109-119.
5. Schnabel RB, Yin X, Gona P, et al. 50 year trends in atrial fibrillation prevalence, incidence, risk factors, and mortality in the Framingham Heart Study: a cohort study. *Lancet*. 2015;386:154-162.
6. Cerasuolo JO, Montero-Odasso M, Ibañez A, et al. Decision-making interventions to stop the global atrial fibrillation-related stroke tsunami. *Int J Stroke*. 2017;12:222-228.
7. Guo Y, Wang H, Tian Y, et al. Time trends of aspirin and warfarin use on stroke and bleeding events in Chinese patients with new-onset atrial fibrillation. *Chest*. 2015;148:62-72.
8. Huisman MV, Rothman KJ, Paquette M, et al. The changing landscape for stroke prevention in AF: findings from the GLORIA-AF registry phase 2. *J Am Coll Cardiol*. 2017;69:777-785.
9. Camm AJ, Accetta G, Ambrosio G, et al. Evolving antithrombotic treatment patterns for patients with newly diagnosed atrial fibrillation. *Heart*. 2017;103:307-314.
10. Gamra H, Murin J, Chiang C-E, et al. Use of antithrombotics in atrial fibrillation in Africa, Europe, Asia and South America: insights from the International RealiseAF Survey. *Arch Cardiovasc Dis*. 2014;107:77-87.
11. Raparelli V, Proietti M, Cangemi R, et al. Adherence to oral anticoagulant therapy in patients with atrial fibrillation. Focus on non-vitamin K antagonist oral anticoagulants. *Thromb Haemost*. 2017;117:209-218.
12. Lip G, Lip GYH, Freedman B, et al. Stroke prevention in atrial fibrillation: past, present and future. Comparing the guidelines and practical decision-making. *Thromb Haemost*. 2017;117:1230-1239.
13. Burke LE, Ma J, Azar KM, et al. Current science on consumer use of mobile health for cardiovascular disease prevention: a scientific statement from the American Heart Association. *Circulation*. 2015;132:1157-1213.
14. Cowie MR, Bax J, Bruining N, et al. e-Health: a position statement of the European Society of Cardiology. *Eur Heart J*. 2016;37:63-66.
15. Hendriks JM, Crijns HJ, Tieleman RG, et al. The atrial fibrillation knowledge scale: development, validation and results. *Int J Cardiol*. 2013;168:1422-1428.
16. McHorney CA. The Adherence Estimator: a brief, proximal screener for patient propensity to adhere to prescription medications for chronic disease. *Curr Med Res Opin*. 2009;25:215-238.
17. Khan TI, Kamali F, Kesteven P, et al. The value of education and self-monitoring in the management of warfarin therapy in older patients with unstable control of anticoagulation. *Br J Haematol*. 2004;126:557-564.
18. Camm AJ, Lip GY, De Caterina R, et al. 2012 focused update of the ESC Guidelines for the management of atrial fibrillation: an update of the 2010 ESC Guidelines for the management of atrial fibrillation. Developed with the special contribution of the European Heart Rhythm Association. *Europace*. 2012;14:1385-1413.
19. January CT, Wann LS, Alpert JS, ACC/AHA Task Force Members, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. *Circulation*. 2014;130:2071-2104.
20. Lip GY, Laroche C, Popescu MI, et al. Improved outcomes with European Society of Cardiology guideline-adherent antithrombotic treatment in high-risk patients with atrial fibrillation: a report from the EORP-AF General Pilot Registry. *Europace*. 2015;17:1777-1786.
21. Kirchhof P, Benussi S, Kotecha D, et al. 2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS. *Eur Heart J*. 2016;37:2893-2962.
22. Eckman MH, Lip GY, Wise RE, et al. Using an atrial fibrillation decision support tool for thromboprophylaxis in atrial fibrillation: effect of sex and age. *J Am Geriatr Soc*. 2016;64:1054-1060.

23. Eckman MH, Lip GY, Wise RE, et al. Impact of an atrial fibrillation decision support tool on thromboprophylaxis for atrial fibrillation. *Am Heart J*. 2016;176:17-27.
24. Wang Y, Bajorek B. Pilot of a computerised antithrombotic risk assessment tool version 2 (CARATV2.0) for stroke prevention in atrial fibrillation. *Cardiol J*. 2017;24:176-187.
25. Karlsson LO, Nilsson S, Charitakis E, et al. Clinical decision support for stroke prevention in atrial fibrillation (CDS-AF): rationale and design of a cluster randomized trial in the primary care setting. *Am Heart J*. 2017;187:45-52.
26. Heidbuchel H, Verhamme P, Alings M, et al. Updated European Heart Rhythm Association Practical Guide on the use of non-vitamin K antagonist anticoagulants in patients with non-valvular atrial fibrillation. *Europace*. 2015;17:1467-1507.
27. Sauter TC, Melis C, Hautz WE, et al. Direct new oral anticoagulants: follow-up, guidelines and bleeding complications in general practice-a survey of Swiss general internal medicine practitioners. *Springerplus*. 2016;5:2030.
28. Lane DA, Aguinaga L, Blomström-Lundqvist C, et al. Cardiac tachyarrhythmias and patient values and preferences for their management: the European Heart Rhythm Association (EHRA) consensus document endorsed by the Heart Rhythm Society (HRS), Asia Pacific Heart Rhythm Society (APHRS), and Sociedad Latinoamericana de Estimulación Cardíaca y Electrofisiología (SOLEACE). *Europace*. 2015;17:1747-1769.
29. Clarkesmith DE, Lip GYH, Lane DA. Patients' experiences of atrial fibrillation and non-vitamin K antagonist oral anticoagulants (NOACs), and their educational needs: a qualitative study. *Thromb Res*. 2017;153:19-27.
30. Clarkesmith DE, Pattison HM, Lip GY, et al. Educational intervention improves anticoagulation control in atrial fibrillation patients: the TREAT randomised trial. *PLoS One*. 2013;8:e74037.
31. Steinberg BA, Shrader P, Thomas L, et al. Factors associated with non–vitamin K antagonist oral anticoagulants for stroke prevention in patients with new-onset atrial fibrillation: results from the Outcomes Registry for Better Informed Treatment of Atrial Fibrillation II (ORBIT-AF II). *Am Heart J*. 2017;189:40-47.

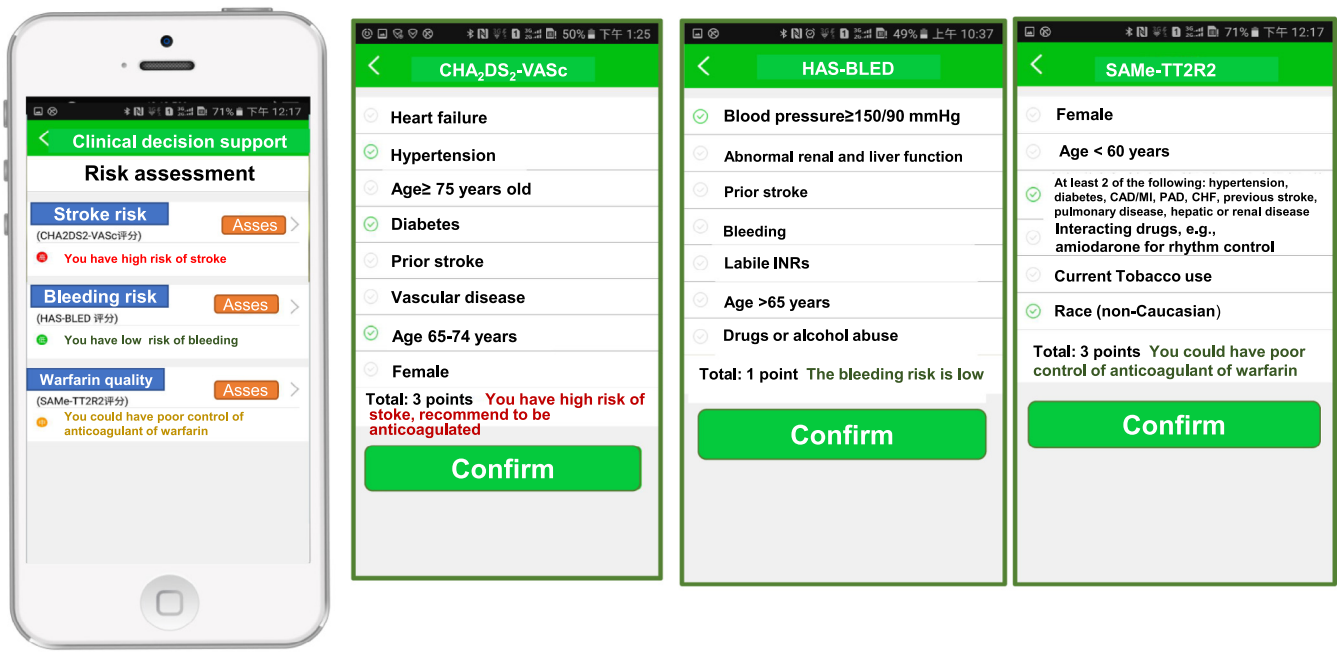
SUPPLEMENTARY DATA

Supplementary Material accompanying this article can be found in the online version at doi: 10.1016/j.amjmed.2017.07.003.

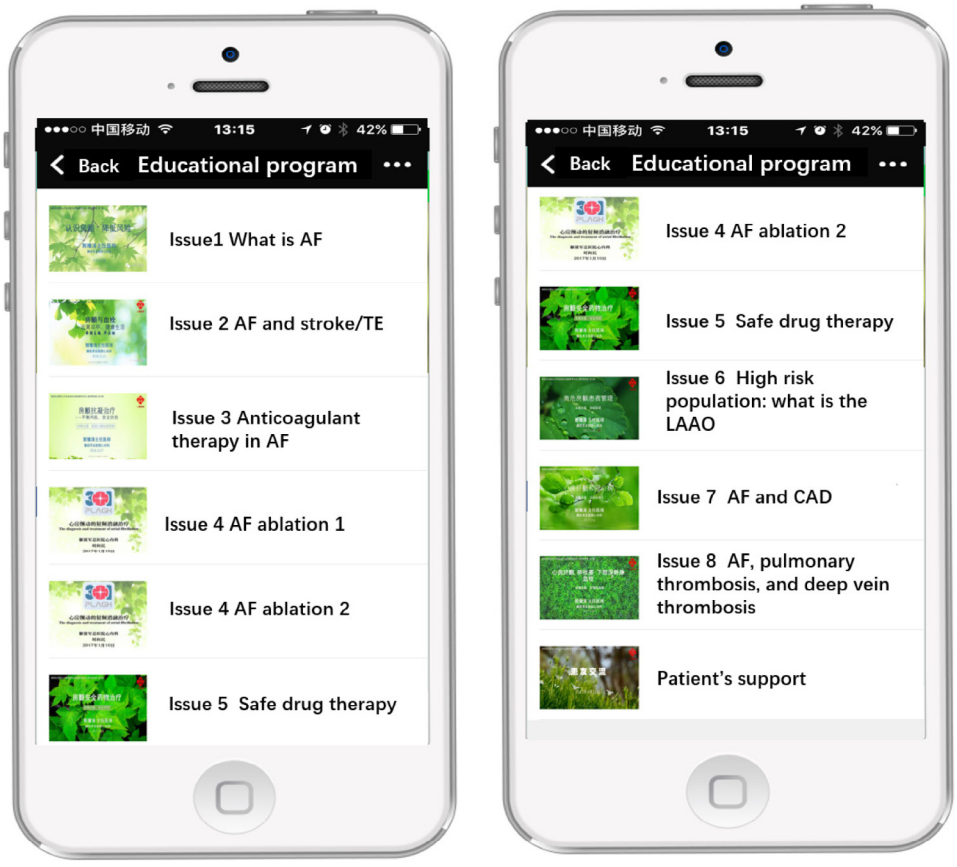
APPENDIX



Supplementary Figure 1 Flow chart.

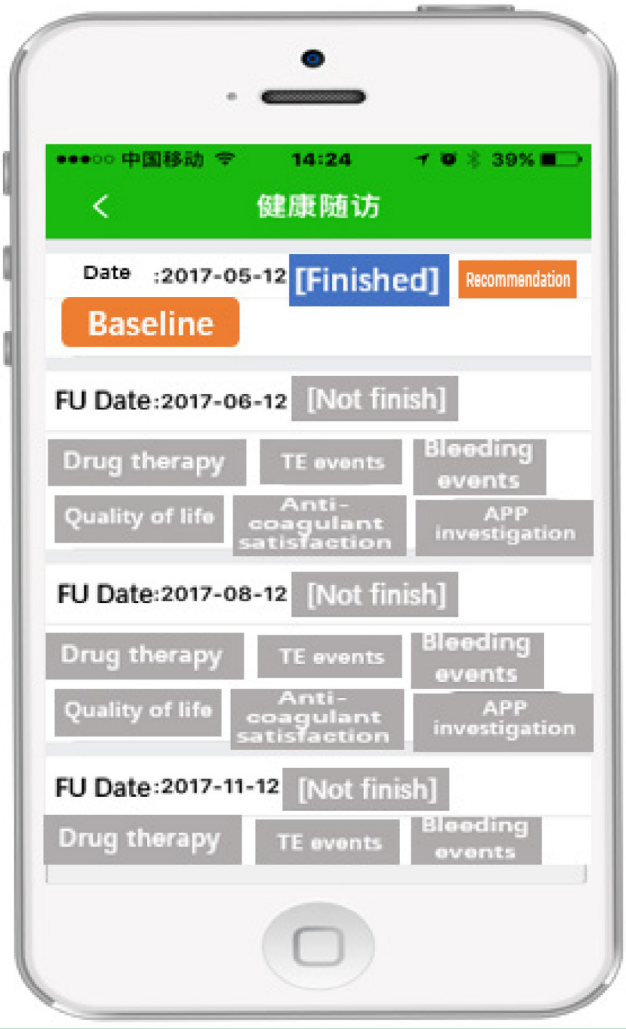


Supplementary Figure 2 Clinical decision support.

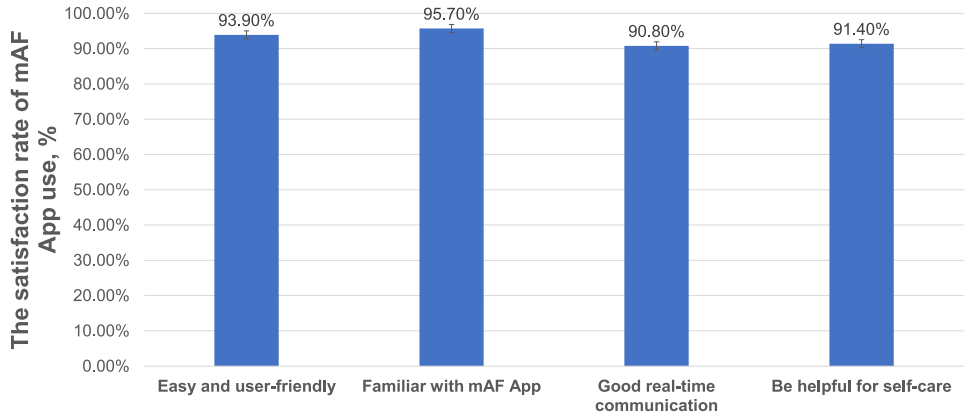


Supplementary Figure 3 Patients' educational program. *Patients followed the educational program on their mobile device to improve their knowledge of atrial fibrillation and learn how to manage themselves at home.

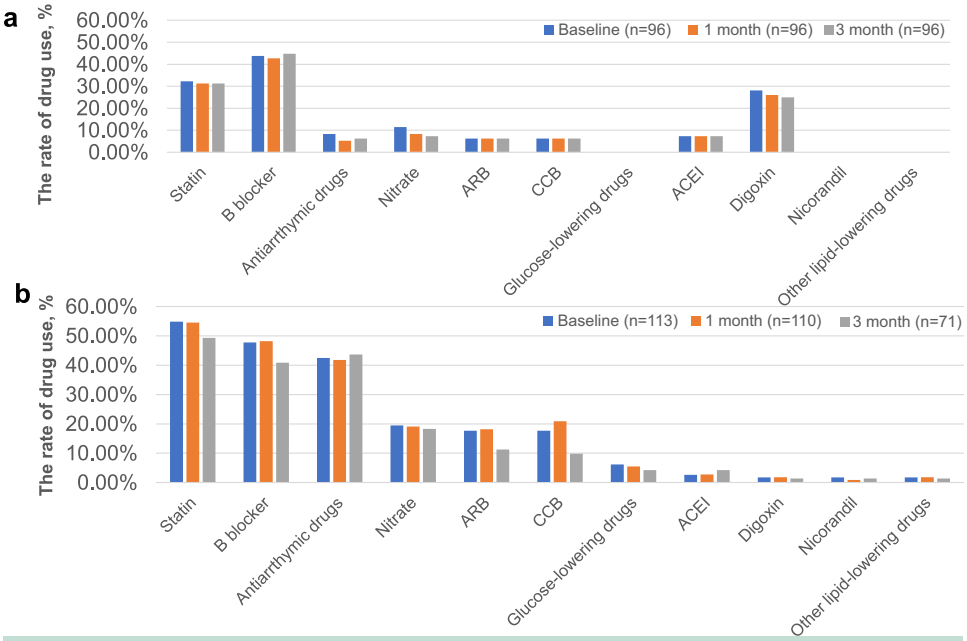
Supplementary Figure 4 Patients' involvement in self-care. *Patients could monitor their blood pressure and pulse rate, and be involved in their management.



Supplementary Figure 5 Structured follow-up in patients with the mAF App. *The structured follow-up was planned at 1, 3, 6, 9, and 12 months after consultation/discharge, and included drug therapy, thrombotic events, bleeding events, quality of life, anti-coagulant satisfaction, and mAF App investigation. A reminder alert was sent automatically to patients 1 week before and after the follow-up time-point by the mAF App.



Supplementary Figure 6 Usability, feasibility, and acceptability of the mAF App at 1 month. *A total of 110 patients with the mAF App fulfilled the investigation.



Supplementary Figure 7 Drugs in patients with the mAF App and usual care at baseline, 1 month, and 3 months. **A,** Usual care. **B,** mAF App. ACEI = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor inhibitor; CCB = calcium channel blocker. Antiarrhythmic drugs: propafenone and amiodarone. Glucose-lowering drugs: insulin, acarbose, glimepiride, and metformin. Other lipid-lowering drugs: ezetimibe and probucol.

Supplementary Table 1 Adapted Anticoagulant Satisfaction Questionnaire*

	A Not at All	B A Little	C Moderately	D Quite a Bit	E Extremely
1. How much does the possibility of bleeding as a result of anticlot treatment limit you from taking part in vigorous physical activities (eg, exercise, sports, dancing)?	1	2	3	4	5
2. How much does the possibility of bleeding as a result of anticlot treatment limit you from taking part in your usual activities (eg, work, shopping, housework)?	1	2	3	4	5
3. How bothered are you by the possibility of bruising as a result of anticlot treatment?	1	2	3	4	5
4. How bothered are you by having to avoid other medicines (eg, aspirin) as a result of anticlot treatment?	1	2	3	4	5
5. How much does anticlot treatment limit your diet (eg, food or drink, including alcohol)?	1	2	3	4	5
6. How much of a hassle (inconvenience) are the daily aspects of anticlot treatment (eg, remembering to take your medicine at a certain time, taking the correct dose of your medicine)?	1	2	3	4	5
7. How much of a hassle (inconvenience) are the occasional aspects of anticlot treatment (eg, the need for blood tests, going to or contacting the clinic/doctor)?	1	2	3	4	5
8. How difficult is it to follow your anticlot treatment?	1	2	3	4	5
9. How much do you worry about your anticlot treatment?	1	2	3	4	5
10. How much of a burden is your anticlot treatment?	1	2	3	4	5
11. Overall, how much of a negative impact has your anticlot treatment had on your life?	1	2	3	4	5
Total (scores)					

	A Not at All	B A Little	C Moderately	D Quite a Bit	E Extremely
12. How confident are you that your anticlot treatment will protect you from the stroke?	1	2	3	4	5
13. How safe do you feel because of your anticlot treatment?	1	2	3	4	5
14. How satisfied are you with your anticlot treatment?	1	2	3	4	5
15. Overall, how much of a positive impact has your anticlot treatment had on your life?	1	2	3	4	5
Total (scores)					

*"1, Not at all" was calculated as 1 points. "2, A little" was calculated as 2 points, "3, Moderately" was calculated as 3 points. "4, Quite a bit" was calculated as 4 points. "5, Extremely" was calculated as 5 points.