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Rationale and Design of the Improving Care for Cardiovascular Disease in China (CCC) Project: A National Registry to Improve Management of Atrial Fibrillation

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Rationale and Design of the Improving Care for Cardiovascular Disease in China (CCC) Project:

A National Registry to Improve Management of Atrial Fibrillation

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Short title: Rationale and Design of CCC-AF

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Abstract

Introduction: Inadequate management of patients with atrial fibrillation (AF), the commonest sustained arrhythmia, has been reported in China for anticoagulation therapy and treatment for concomitant diseases. An effective quality improvement program has been lacking to promote the use of evidence-based therapies and improve outcome in patients with AF.

Methods and analysis: The Improving Care for Cardiovascular Disease in China (CCC)-AF program is a collaboration of the American Heart Association and the Chinese Society of Cardiology. This program was designed to improve adherence to AF guidelines and clinical outcomes for hospitalized patients with AF in China. Launched in February 2015, 150 hospitals were recruited by geographic-economic regions across 30 provinces in China. Each month, 10-20 inpatients with AF are enrolled in each hospital. A web-based data collection platform is used to collect clinical information for patients with AF, including patients' demographics, admission information, medical history, in-hospital care and outcomes, and discharge medications for managing AF. The quality improvement initiative included monthly benchmarked reports on hospital quality, training sessions, regular webinars, and recognition of hospital quality achievement. Primary analyses will include adherence to performance measures and guidelines. A generalized estimating equation model was used to account for within-hospital correlation when site-specific variance was a concern. As of March 2017, 28 801 AF inpatients have been enrolled.

Ethics and dissemination: The study protocol was approved by the Ethics Committee of Beijing Anzhen Hospital, Capital Medical University. Results will be published in peer-reviewed medical journals.

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Trial registration: NCT02309398 (www.clinicaltrials.gov).

Key words: Atrial fibrillation, quality improvement, healthcare, registry study

Strengths and limitations of this study

- CCC-AF is a national hospital-based quality improvement program with unique tools including monthly benchmarked reports on hospital quality, training sessions, regular webinars, and recognition of hospital quality achievement.

- Data accuracy and completeness in this study is ensured by training sessions, standardized web-based data collection platform, onsite quality control and monitoring of data completeness.

- Experience from this program will help to guide development of the national health quality improvement system.

- Participation is voluntary and only tertiary hospitals were recruited in the CCC-AF program.

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INTRODUCTION

Atrial fibrillation (AF) is the commonest sustained arrhythmia and responsible for major morbidity and health care costs. It is associated with a 4–5-fold increased risk for stroke, a 40%–90% increased risk for overall mortality, and impaired quality of life.[1-2] The prevalence of AF is estimated to be 0.77% in China, and more than 5 million Chinese adults aged older than 35 years currently have AF.[3-6] There is wide availability of evidence-based guidelines with effective treatments for improving outcomes of AF.[7-9] However, studies have indicated that there is low compliance with evidence-based therapies in China, including assessment of thromboembolic risk, anticoagulation therapy, heart rate control, rhythm control, and adequate treatment of concomitant diseases.[10,11] Multiple studies using a range of methodologies have consistently documented that over 60% of patients who are candidates for anticoagulant therapy do not receive appropriate risk stratification or therapy.[10-13]

Although previous registries have expanded understanding of clinical practice of AF in China, they have been limited in the representativeness of hospitals and lack of quality improvement components.[10,12,13] To promote the use of guidelines of recommended therapies and to evaluate the effectiveness of quality improvement efforts in China, the American Heart Association (AHA) and the Chinese Society of Cardiology (CSC) launched the Improving Care for Cardiovascular Disease in China (CCC) project – AF program. The CCC-AF was modeled in part of the AHA Get With The Guidelines (GWTG) program.[14] It focuses on quality improvement efforts with timely feedback for care of patients with AF. This program will advance the quality of AF care by providing unique tools for quality improvement, following trends in the adoption of evidence-based therapies in routine clinical practice, and by observational treatment comparisons.

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The purpose of this paper is to describe the objectives, organizational framework, recruitment of hospitals and patients, data collection and management, quality control of data collection, quality improvement tools for AF care, and progress to date of the CCC-AF program.

METHODS AND ANALYSIS

Study objectives

The overall objective of the CCC-AF program is to improve patient care for AF by development and implementation of quality improvement tools. This program aims to promote the use of evidence-based guidelines throughout the healthcare system and improve cardiovascular health, using rapid cycle of data collection, analysis, feedback, and process improvement. The specific aims of the CCC-AF program are to: (1) understand the current situation and main problems for management of patients hospitalized with AF in China; (2) evaluate the effectiveness of the continuous quality improvement efforts on the quality of care and outcomes of AF; and (3) explore and optimize quality improvement strategies for care of AF in China. The timing and dynamic monitoring of AF management will provide an opportunity to identify the potential needs of further evidence in management of AF. Experience from this program may also help to guide development of the national health quality improvement system and provide a blueprint for adaptation to other regions of the world.

Organizational framework

As a collaborative program of the AHA and the CSC, the CCC-AF is implemented by the Beijing Institute of Heart, Lung and Blood Vessel Diseases. AHA secures the

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project funding and CSC provided hospital network for CCC-AF. As a continues

quality improvement program launched in February 2015, CCC-AF has secured its

funding up to December 2018 currently. This program consists of a senior

management group (SMG) and a project management group. The senior management

group comprises 6 volunteer senior clinician leaders from AHA (Prof. Smith, Prof.

Fonarow and Prof. Taubert) and CSC (Prof. Huo, Prof. Ge and Prof. Ma). The SMG

members communicate frequently via teleconference, emails and face-to-face meeting

to ensure the scientific integrity and supervise the implementation of CCC-AF

program. The project management group is led by an international director (Ms.

Morgan) and a national director (Prof. Zhao), and oversees the day-to-day

development and implementation of the program. There are 4 subgroups under the

management of a project coordinator (Prof. Jing Liu), including day-to-day

management (Ms. Jun Liu and Ms. Zhou), data (Dr. Hao and Ms. Guo), and advisory

and education groups. Data collection and analysis are managed by day-to-day

management group and data group, with guidance from SMG.

Hospital recruitment

Because hospital volumes and clinical capacities differ among geographic and

economic regions, we recruited hospitals that are stratified by geographic-economic

regions[15]. Mainland China includes 7 geographical regions: Northern, Northeast,

Eastern, Central, Southern, Southwest, and Eastern China. In each geographical region,

provinces are grouped into low, medium-low, medium-high, and high levels according

to gross domestic product per capita. A detailed hospital sampling frame is shown in

Supplemental Table 1. In each geographic-economic region, 10% of the tertiary

hospitals were recruited for our study in a voluntary manner, with a total of 150

hospitals. We prioritized tertiary hospitals that met specific criteria as follows: (1) the

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average AF inpatient number per month was no less than 10; and (2) the director of the Cardiology Department was willing to participate in the program. Traditional Chinese medicine hospitals and specialized hospitals without cardiology wards were not included in CCC-AF program. The 150 hospitals were recruited in 2 phases. Hospitals that were recruited in phases 1 and 2 are listed in Supplemental Table 2 and Supplemental Table 3.

Patient recruitment

In each hospital, the first 10-20 AF inpatient cases of each month were consecutively enrolled in the study, as identified based on discharge diagnosis through review of the inpatient list. Study inclusion of AF was based on electrocardiograph results, which were documented by 12-lead electrocardiogram, 24-hour Holter monitoring, or other cardiac rhythm monitors. Patients with AF secondary to reversible condition (eg, untreated thyroid disease and pulmonary embolism) were excluded from the study.

Clinical data elements were collected based on American College of Cardiology (ACC)/AHA recommendations on the clinical data standard for AF.[16,17] As a quality improvement initiative, the CCC-AF program has high priority for collection of data elements that are involved in assessment for quality of care. Moreover, additional data elements were gathered to facilitate in-depth analysis. Data elements included patients' demographics, admission information, medical history, in-hospital care and outcomes, and discharge medications for management of AF. The case report form is shown in Supplemental Table 4 (online only data supplement). Participating hospitals were instructed to submit data for consecutive eligible patients to the CCC-AF database via a web-based data collection platform (Oracle Clinical Remote Data Capture, Oracle Corporation). Each hospital assigned a data abstractor who was responsible for data collection and entering the data elements abstracted from medical

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charts. Online data entry for cases that were recruited for a particular month was finished before the middle of the following month.

Quality control of data collection

Similar to the CCC-Acute Coronary Syndrome (ACS) program,[18] data accuracy and completeness of the CCC-AF program were ensured by the following 4 strategies. (1) Training sessions were held before the launch of the program with item-by-item explanations for all data elements. (2) The standardized web-based data collection platform has automatic data checks and queries. (3) Data accuracy was also secured by onsite quality control by third-party clinical research associates. Recruited cases were compared with the inpatient list to ensure that cases were reported consecutively rather than selectively, and 5% of reported cases were randomly selected and compared with the original medical records. (4) Data completeness was calculated as number of data elements filled in the database divided by number of data elements that should be filled. Each month, data completeness was monitored and reports were provided as feedback to hospitals. For hospitals with data completeness less than 90%, local investigators were contacted to improve quality of data.

Performance measures

Performance measures were developed to evaluate the quality of care for inpatients with AF in the CCC-AF program. These performance measures were constructed based on the statement of the ACC/AHA on AF performance measures[19-21] integrating recommendations from the most updated ACC/AHA guideline and Chinese statement for AF.[7,22] The quality of care presented in the monthly reports was defined as primary and secondary performance measures. There are 6 primary

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performance measures, including assessment of thromboembolic risk, anticoagulant

drug at discharge, prothrombin time (PT)/ international normalized ratio (INR)

planned follow-up, angiotensin-converting enzyme inhibitor (ACEI)/ angiotensin

receptor blocker (ARB) at discharge, beta-blockers at discharge, and statins at

discharge in AF inpatients with indications (Table 1). The full measure specifications

are shown in Supplemental Table 5. Eight secondary performance measures are

shown in Table 2 with their full measure specifications shown in Supplemental Table

6. Measure-specific inclusion and exclusion criteria were applied so that only eligible

patients without documented intolerance or other contraindications for that specific

measure were included in the denominator.

The hospital composite score for primary performance measures was calculated in

an opportunity-based manner. This score was defined as the sum of total instances for

correct care given divided by the total number of eligible opportunities based on the 6

primary measures.[23] Each patient at a CCC-AF hospital contributes care opportunities

to the relevant hospital's composite performance scores. In the same way, the

composite score for secondary performance measures was calculated based on 8

secondary performance measures.

The CCC team will update the performance measures and keep them aligned with

the new or updated clinical guidelines for management of AF when necessary. After

the new or updated AF guidelines are released, clinical experts will evaluate whether

applying these changes in guidelines to CCC-AF performance measures and data

elements associated with them in the case report form is necessary. When changes are

adopted in the performance measures, hospitals have a transition period that allows

them to have flexibility in meeting recognition criteria for the updated performance

measures.

Quality improvement tools

Improvement in adherence to guideline recommendations was facilitated through monthly hospital quality reports, recognition of hospitals for achievement, training programs, and online educational materials.

Monthly hospital quality reports

Each month, hospitals received quality reports on performance measures for AF via online platform, accessed with a username and password. The content of hospital quality reports included individual and composite scores for primary and secondary performance measures, as well as data completeness of the reported AF cases. Hospital-specific data were summarized and compared against a variety of internal and external benchmarks. Internal benchmarks included the trend of performance measures over time. External benchmarks provided reasonable national performance thresholds to help identify areas for potential improvement of performance. Two external benchmarks were provided: overall national benchmarks and an achievable benchmark of care that describes the composite guideline-recommended treatment provided at top-performing hospitals (e.g., the top 15%). These benchmarking quality reports helped hospitals to identify areas for improvement and refine treatment processes to ensure they are in line with the guidelines. Frequencies of website visits and downloads were tracked to evaluate engagement of each participating hospital.

Regional workshops

Regional workshops corresponding with CSC regional meetings occurred once or twice per year to summarize progress, share experiences, discuss the problems that may be encountered, and introduce state-of-the-art evidence-based medicine and clinical guidelines. These face-to-face meetings served as venues where the

knowledge were shared, with discussion forums enabling delegates to identify

personal and local actions needed to improve clinical practice for AF. Educational

materials, such as flyers, pamphlets, or pocket guidelines, and measures with

CCC-AF program branding were distributed to participating hospitals.

Hospital recognition

Hospitals demonstrating best practice received recognition through an announcement

ceremony at CSC annual meetings. There were 6 levels of recognition: gold, silver,

and bronze medals for AF performance measures, and awards for data reports,

progress, and active participation. Qualification criteria for recognition were the

same as those in the CCC-ACS program.[18] Hospitals with best practice shared their

processes behind the achievement of good clinical practice for AF.

Online educational materials

The CCC websites provided a variety of online educational materials in the education

source center for healthcare professionals in the participating hospitals to view and

download. These web-based training materials included updated clinical guidelines

and scientific statements for AF and webinars.

Data management

All data were treated as protected health information and securely stored in a

password-protected computer system at the coordinating center. Ongoing data

cleaning was performed systematically. Data managers regularly queried data for

invalid and illogical values, identifying potential invalid values by searching for

outliers in continuous data distributions. When a potential error was detected, data

managers traced and reviewed the relevant records to resolve the issue.

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Statistical considerations

Recruitment of 1500 patients (10 in each of the 150 hospitals) with AF per month will

detect an improvement in the primary composite score from 45% at baseline to an

expected score of 51%, with 91% power at a significance level of 0.05 at a two-sided

test. The projected 6% improvement (from 45% to 51%) in primary composite score

means that more 6% guideline recommended treatments will be correctly given for

AF patients. Continuous variables were expressed as mean ± SD or median

(interquartile range) and categorical variables as frequency and percentage. Missing

data were addressed on an analysis-specific basis. The chi-square trend test was

performed to evaluate the temporal trend of performance measures. Univariate and

multivariable approaches were used to identify factors associated with measures of

interest, including the use of guideline-indicated therapies and in-hospital clinical

outcomes. Associations between patients' characteristics and outcomes of interest

were reported with odds ratios and 95% confidence intervals using logistic regression.

Multivariable adjustments were used to limit the influence of confounding factors.

Additionally, a generalized estimating equation model was used to account for

within-hospital correlation when site-specific variance was a concern. A two-sided P

value < 0.05 was considered statistically significant. Statistical analyses were

performed by SAS 9.2 (SAS Institute, Inc., Cary, NC)

Progress to date

In total, 150 public tertiary hospitals were recruited into the program, with 75 centers

in each of the 2 phases. Among them, 96 (64%) hospitals were from provincial

capitals and municipalities, while the other 54 (36%) were from prefecture level

cities (regional cities). The locations of participating centers are displayed in Figure 1.

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A total of 28,801 AF inpatients were recruited from February 2015 to March 2017.

Table 3 shows the baseline demographic and clinical characteristics of the overall

population. The mean age of the population was 68.6 years and 15,738 (54.6%) were

men. Hypertension was the most prevalent concomitant disease, with a prevalence of

65.4%, followed by coronary artery disease (31.4%), heart failure (20.1%), and

diabetes mellitus (17.9%).

The overall quality of care for the cohort of patients enrolled to date by the

composite performance measure score was 46.8%. The quality of care varied

between hospitals (Figure 2), with a wide range of composite scores ranging from

8.2% to 89.4% for primary performance measures. The composite score of the AF

secondary performance measures for all hospitals was 51.4%, with a wide range of

1.8%–96.2% (Figure 3). Adherence rates to each of the primary and secondary

performance measures are presented in Table 1 and Table 2. Data for quality reports

were exported for analysis each month, and quality reports were uploaded on the

CCC website (www.ccc-heart.com). AF quality reports for February 2015 to March

2017 have been uploaded to the website.

DISCUSSION

The growing AF population and increased recognition of mortality, morbidity,

diminished quality of life, and high healthcare costs associated with AF have led to

development of more effective treatments for AF and its complications. Currently,

there are several evidence-based, highly effective, guidelines of recommended

therapies that can significantly improve long-term care outcomes. The AHA, ACC,

and European Society of Cardiology (ESC) have compiled these therapies into

published guidelines.[7,8] Despite the wide availability of these guidelines, studies have

indicated that there is low compliance with evidence-based therapies in China, even

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among tertiary hospitals.[10,11] Reasons for low compliance to guideline-based therapies include a lack of timely feedback, poor communication, and a lack of knowledge, financial resource, or time.[24,25]

Accordingly, a variety of methods for increasing adherence to guidelines have been initiated. Among them, three methods are widely used, which are increasing reporting of the data, providing incentives to improve guideline adherence, and providing hospitals and physicians with the tools and infrastructure that necessary to increase adherence.[26] In 2008, the National Health and Family Planning Commission of China launched a project for quality management of single diseases for acute myocardial infarction, heart failure, and coronary artery bypass grafting. This project aimed to enhance the reporting of these diseases and promote improvement in quality.[27] However, reporting without timely feedback and a lack of necessary infrastructure for quality improvement prevented quality management of this single diseases program from effective improvement in care.

Previous registry studies have provided information on treatment and outcomes for patients with AF in China (Table 4) [10,12,13,28-31] and worldwide.[31-35] Zhang et al enrolled 2016 patients with AF in 20 hospitals from 2008 to 2011.[10] Among patients with non-valvular AF, only 12.7% of those with a $CHADS_2$ score of ≥ 2 were prescribed oral anticoagulants, and this percentage was much lower than that in developed countries reported by international registries.[32,36-39] As an ongoing registry, the Chinese Atrial Fibrillation Registry was launched in 2011 with an enrollment goal of 20,000 patients with AF in 32 hospitals in Beijing, with a follow-up of every 6 months until 2020.[12] Although these registries have expanded understanding for clinical practice and long-term outcomes of AF, they have been limited in a finite number of hospitals and lack of quality improvement components.

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In 2014, the AHA and CSC launched the CCC-AF program, aiming to improve quality of care for AF with timely feedback and quality improvement tools. The CCC-AF program is similar to the CCC-acute coronary syndrome program.[18] This program will provide important national data for the characteristics and care of AF inpatients. Through iterative assessment of guideline-based care, the CCC-AF program provides opportunities for improving adherence to clinical practice guidelines and other performance measures at a hospital level. Performance feedback reports may help hospitals to identify opportunities to improve patient care across a broad range of performance measures. This program provides specific resources, such as webinars and regional workshops to address the identified gaps. The CCC-AF program will also help in tracking the rate of diffusion of new knowledge and the adoption of new guideline recommendations, highlighting areas for further quality improvement.

The CCC-AF program aims to improve adherence to guideline recommendations through monthly benchmarked hospital quality reports, recognition of achievement of hospital quality, training programs, and regular webinars. As shown in the improve treatment with oral anticoagulants in atrial fibrillation (IMPACT-AF) study, multifaceted educational intervention significantly increased the proportion of patients treated with oral anticoagulants and has the potential to improve stroke prevention for patients with AF.[40] Currently, guideline-based therapies for AF mainly focus on antithrombotic management, rate and rhythm control, and therapy of concomitant cardiac diseases. For antithrombotic management, risk stratification is an essential step for recognizing candidate patients for therapy and deciding which patients have sufficient risk to warrant oral anticoagulation. Quality improvement tools of the CCC-AF program are designed to prompt assessment of thromboembolic risk based

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on easily used risk stratification scores, as well as the use of anticoagulant drugs at

discharge, PT/INR planned follow-up, and therapy of concomitant cardiac diseases

using ACEIs/ARBs, beta-blockers, and statins at discharge in patients with AF and

indications. Because patients with AF are usually admitted with concomitant

cardiovascular diseases, careful consideration of co-prescription of anticoagulants

with antiplatelet therapy is warranted, balancing the bleeding risk and stroke risk. The

CCC-AF program will provide important insight for patterns of current clinical practice

for patients with AF and concomitant cardiovascular diseases (e.g., ACS) and

procedures (e.g., percutaneous coronary intervention).

The CCC-AF program is distinguished by its unique resources, which include a

large hospital network and an international research team. These will facilitate the

translation of study findings to improvement of quality care for AF. Tertiary hospitals

provide the highest level of medical care in China, and affect secondary hospitals and

primary care centers. Improvement in the quality of care for AF among these tertiary

hospitals may lead to spreading their experience to secondary hospitals and primary

care centers and enhance the dissemination of evidence-based interventions.

There are several limitations that should be mentioned. Participation is voluntary

and only tertiary hospitals were recruited in the CCC-AF program. The current

participating hospital profile tends to be that larger centers may have better baseline

performance than smaller centers possessing fewer resources. While participating

hospitals are instructed to include all consecutive AF admissions, identifying patients

with AF uniformly and accurately can be challenging, so there is the potential for

selection bias. Patient data are collected by medical chart review and thus dependent

on the quality, accuracy, and completeness of documentation. The inpatient focus of

the CCC-AF program is a further limitation. The ability to track patients over time is

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necessary to develop a more thorough understanding of downstream resource use, as well as outcomes associated with specific therapies and procedures. Collection of follow-up information and linking with administrative outcome databases will further promote research on effectiveness of this project for improving quality. Also, results presented here are preliminary and should be interpreted with caution.

As a national hospital-based quality improvement program, CCC-AF aims to provide an opportunity to improve adherence to clinical practice guidelines for managing AF. This program has unique tools for quality improvement which could improve patients' outcomes.

Ethics and dissemination

Central institutional review board (IRB) approval was granted for the aggregate dataset for research and quality improvement by the Ethics Committee of Beijing Anzhen Hospital, Capital Medical University. Participating sites were granted a waiver of patient consent under the common rule. One hundred and eleven hospitals accepted central ethics approval and the other 39 sites applied IRB approval from their own ethics committees. The study is listed at www.clinicaltrials.gov (NCT02309398). Results will be published in peer-reviewed medical journals.

Acknowledgments

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Authors' contributions:

The manuscript was prepared on behalf of the CCC-AF Investigators. SS, Y Huo, GF, JG, KT, CM and DZ conceived the study idea. Jing L, Jun L, LM, YG and MZ made substantial contributions to the development of the study protocol. Y Hao drafted the manuscript and all authors contributed to critical revisions of the paper. This final manuscript was read and approved by all authors.

Disclosures

The authors declare that they have no competing interests.

Figure Legends

Figure 1. Distribution of hospitals for the CCC-AF program.

Numerals on the map indicate the number of hospitals in the area. Adapted from

reference 18.

Figure 2. Distribution of CCC-AF composite scores of primary performance measures

across hospitals from February 2015 to March 2017.

The composite scores were calculated based on the 6 primary performance measures,

using the sum of total instances when a required measure was performed (correct care

provided) divided by the total number of eligible opportunities.

Figure 3. Distribution of CCC-AF composite scores of secondary performance

measures across hospitals from February 2015 to March 2017.

The composite scores were calculated based on 8 secondary performance measures,

using the sum of total instances when a required measure was performed (correct care

provided) divided by the total number of eligible opportunities.

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1   Table 1. Primary Performance Measures for the CCC-AF Project

Title of Performance Measure	Proportion,% (Numerator/ denominator)
Proportion of patients with nonvalvular AF in whom assessment of thromboembolic risk	23.6 (5384/22864)
[a]Proportion of AF patients with indication prescribed an anticoagulant drug at discharge	42.3 (6413/15150)
Proportion of patients discharged on warfarin who have PT/INR follow-up planned at discharge	87.2 (7721/8857)
[b]Proportion of AF patients with indications receiving ACEI/ARB at discharge	53.1 (1794/3382)
[c]Proportion of AF patients with indication prescribed a beta blocker at discharge	57.0 (1245/2184)
[d]Proportion of AF patients with indication prescribed a statin at discharge	61.2 (8524/13925)
Composite scores of primary performance measures	46.8 (31081/66362)

2   PT, prothrombin time; INR, international normalized ratio; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

3   [a] indications refer to nonvalvular AF patients with $CHA_2DS_2\text{-}VASc \geq 2$

4   [b] indications refer to AF patients with AMI; or coronary heart disease with comorbidity of hypertension, diabetes mellitus or chronic kidney

1 disease; or LVEF<40% according to the case records.

2 [c] indications refer to AF patients with heart failure

3 [d] indications refer to AF patients with coronary heart disease, ischemic stroke/TIA, peripheral vascular disease or diabetes mellitus.

1 Table 2. Secondary Performance Measures for the CCC-AF Project

Title of Performance Measure	Proportion,% (Numerator/ denominator)
Proportion of nonvalvular AF patients who had a CHADS$_2$ score reported	15.0 (3422/22864)
Proportion of nonvalvular AF patients who had a CHA$_2$DS$_2$-VASc score reported	19.2 (4397/22864)
Proportion of AF patients who have a documented resting heart rate of <80 bpm closest to discharge	65.0 (7140/10989)
Proportion of AF patients that receiving anticoagulation therapy education	89.4 (10941/12243)
Proportion of AF patients that receiving conventional medical education	88.3 (25547/28615)
[a] Proportion of AF patients with indication prescribed aldosterone antagonist at discharge	72.2 (888/1230)
Proportion valvular AF patients prescribed warfarin at discharge	52.4 (2010/3838)
Proportion of AF patients who are given smoking cessation advice or counseling	22.5 (1263/5623)
Composite scores of primary performance measures	51.4 (55608/108266)

2 AF, atrial fibrillation

3 [a] indications refer to AMI patients with LVEF<40% or heart failure or diabetes mellitus; or the heart failure patients with LVEF<35%.

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1   Table 3. Characteristics of Enrolled Patients with AF

	Men n=15738	Women n=13063	Overall n=28801
Age			
mean (SD), y	67.0(12.7)	70.6(11.2)	68.6 (12.1)
Age group, n (%)			
<65 y	6528(41.5)	3823(29.3)	10351(35.9)
65-74 y	4512(28.7)	4079(31.2)	8591(29.8)
≥75 y	4698(29.9)	5161(39.5)	9859(34.2)
Healthcare insurance, n (%)			
Urban employees-basic insurance	6823(43.4)	5045(38.6)	11868(41.2)
Urban residents-basic insurance	2817(17.9)	2782(21.3)	5599(19.4)
New rural cooperative insurance	2696(17.1)	2830(21.7)	5526(19.2)
Self-paying	1654(10.5)	1186(9.1)	2840(9.9)
Others	1748(11.1)	1220(9.3)	2968(10.3)
Medical history, n (%)			
Hypertension	9973(63.4)	8874(67.9)	18847(65.4)
CAD	5050(32.1)	3991(30.6)	9041(31.4)
Heart failure	2994(19.0)	2788(21.3)	5782(20.1)
Diabetes mellitus	2694(17.1)	2473(18.9)	5167(17.9)
Stroke/TIA	2187(13.9)	1843(14.1)	4030(14)
PAD	1647(10.5)	915(7.0)	2562(8.9)
Myocardial infarction	1191(7.6)	551(4.2)	1742(6.0)
Previous bleeding	96(0.6)	74(0.6)	170(0.6)

Current smoker	5241(33.3)	413(3.2)	5654(19.6)
AF type			
Newly diagnosed	1742(11.1)	1330(10.2)	3072(10.7)
Paroxysmal	6143(39.0)	5053(38.7)	11196(38.9)
Persistent	4256(27.0)	3405(26.1)	7661(26.6)
Permanent	2447(15.5)	2327(17.8)	4774(16.6)
Unknown	1150(7.3)	948(7.3)	2098(7.3)

1   AF, atrial fibrillation; SD, standard deviation; CVD, cardiovascular disease; CAD,

2   coronary artery disease; PCI, percutaneous coronary intervention; TIA, transient

3   ischemic attack; PAD, peripheral artery disease.

1   Table 4. Characteristics of AF Registries Involving Sites in China

Studies	Countries	Sites	Population	Sample size	QI measure	Follow up	Study period
Sun Y et al. 2015 [28]	China only	50	Outpatient	3017	No	No	2012
CAFR[12]	China only	32	Outpatient/inpatient	11496	No	Up to 2020	2011- present
GLORIA-AF II [31]	42	736	Outpatient	10871	No	2 year	2011- present
Nanchang AF Project[13]	China only	1	Inpatient	2442	No	No	2011-2013
GARFIELD-AF [30]	30	858	Outpatient/inpatient	17184	No	1 year	2010-2013
Chinese AF registry [10]	China only	20	Emergency department	2016	No	1 year	2008-2011
Sun et al. [29]	China only	18	Inpatient	3425	No	No	2000-2004

2   CAFR, Chinese Atrial Fibrillation Registry Study; GLORIA-AF, Global Registry on Long-term Oral Antithrombotic Treatment in Patients with

3   Atrial Fibrillation; GARFIELD-AF, Global Anticoagulant Registry in the FIELD-Atrial Fibrillation; QI, quality improvement.

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Rationale and Design of the Improving Care for Cardiovascular Disease in China (CCC) Project: A National Registry to Improve Management of Atrial Fibrillation

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Rationale and Design of the Improving Care for Cardiovascular Disease in China (CCC) Project:

A National Registry to Improve Management of Atrial Fibrillation

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Short title: Rationale and Design of CCC-AF

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Abstract

Introduction: Inadequate management of patients with atrial fibrillation (AF) has been reported in China for anticoagulation therapy and treatment for concomitant diseases. An effective quality improvement program has been lacking to promote the use of evidence-based treatments and improve outcome in patients with AF.

Methods and analysis: The Improving Care for Cardiovascular Disease in China (CCC)-AF program is a collaboration of the American Heart Association and the Chinese Society of Cardiology. This program is designed to promote adherence to AF guideline recommendations and outcomes for inpatients with AF. Launched in February 2015, 150 hospitals are recruited by geographic-economic regions across 30 provinces in China. Each month, 10-20 inpatients with AF are enrolled in each hospital. A web-based data collection platform is used to collect clinical information for patients with AF, including patients' demographics, admission information, medical history, in-hospital care and outcomes, and discharge medications for managing AF. The quality improvement initiative includes monthly benchmarked reports on hospital quality, training sessions, regular webinars, and recognitions of hospital quality achievement. Primary analyses will include adherence to performance measures and guidelines. To address intra-hospital correlation, generalized estimating equation models will be applied. As of March 2017, 28 801 AF inpatients have been enrolled.

Ethics and dissemination: This study protocol was approved by the Ethics Committee of Beijing Anzhen Hospital, Capital Medical University. Results will be published in peer-reviewed medical journals.

Trial registration: NCT02309398 (www.clinicaltrials.gov).
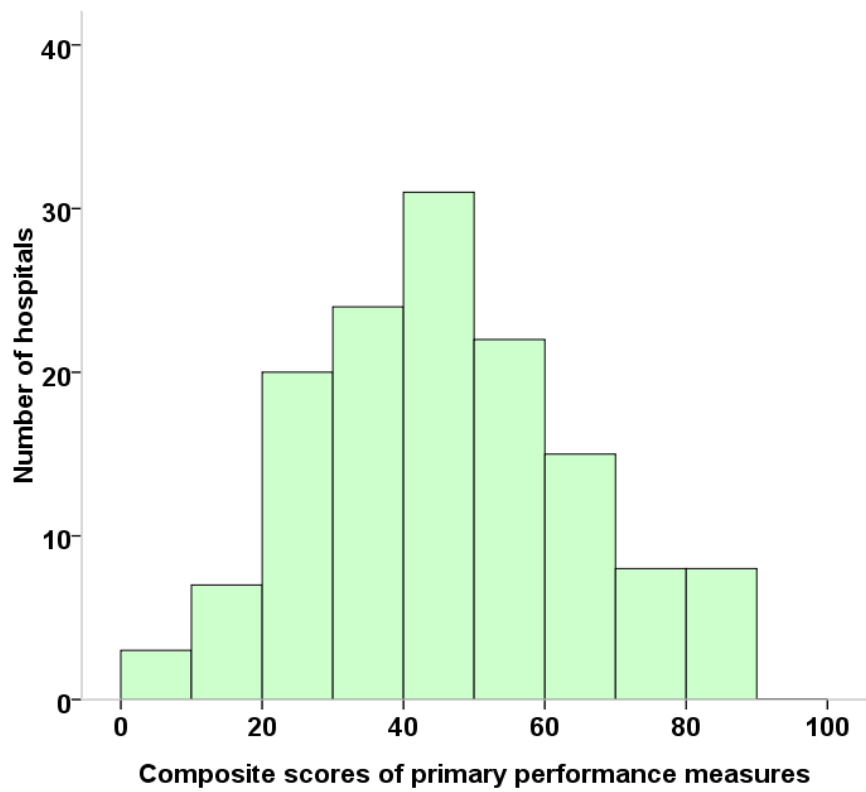
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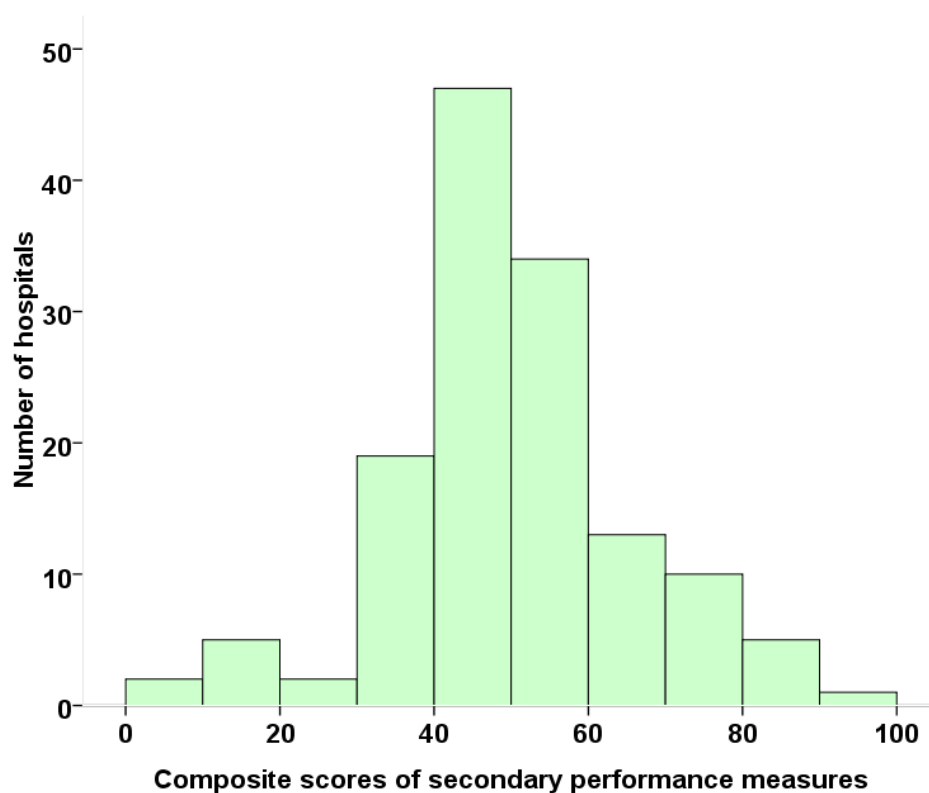44
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Key words: Atrial fibrillation, quality improvement, healthcare, registry study

Strengths and limitations of this study

- CCC-AF is a nationwide quality improvement project with tools including monthly benchmarked reports on hospital quality, training sessions, regular webinars, and recognition for quality achievement.

- Data accuracy and completeness of this study is ensured by training sessions, standardized web-based data collection tool, onsite quality control and monitoring of data completeness.

- Experience from this program will help to guide development of the national health quality improvement system.

- Participation is voluntary and only tertiary hospitals are recruited in the CCC-AF program, which may not be able to represent the care quality for the China overall.

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INTRODUCTION

As the commonest sustained arrhythmia, atrial fibrillation (AF) is responsible for major morbidity and health care costs. It is associated with a 4–5-fold increased risk for stroke, a 40%–90% increased risk for overall mortality, and impaired quality of life.[1-2] The prevalence of AF is estimated to be 0.77% in China, and more than 5 million Chinese adults aged older than 35 years currently have AF.[3-6] There is wide availability of evidence-based guidelines with effective treatments for improving outcomes of AF.[7-9] However, poor compliance with evidence-based therapies have been reported in China, including assessment of thromboembolic risk, anticoagulation therapy, heart rate control, rhythm control, and adequate treatment of concomitant diseases.[10,11] Several studies with diversified methodologies have reported that more than 60% of patients with AF that eligible for anticoagulant treatment receive no risk stratification for stroke or therapy.[10-13]

Although previous registries have expanded understanding of clinical practice of AF in China, they have been limited in the representativeness of hospitals and lack of quality improvement components.[10,12,13] To promote the use of guidelines of recommended therapies and to assess the performance of quality improvement efforts, the Chinese Society of Cardiology (CSC) and the American Heart Association (AHA) initiated the Improving Care for Cardiovascular Disease in China (CCC) project – AF program. The CCC-AF is on the Get With The Guidelines (GWTG) initiative of AHA.[14] As a quality improvement initiative with timely feedback for care of patients with AF, CCC-AF will enhance the quality of care for AF through furnishing specially designed tools for quality improvement.

This paper aims to present the objectives, organizational framework and governance, hospital and patient enrollment, data collection, quality improvement

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tools for AF care, and current progress of the CCC-AF program.

METHODS

Study objectives

The CCC-AF program aims to promote implementation of guideline-recommended therapies for AF patients using rapid cycle of data collection, analysis, feedback, and process improvement. The objectives of the CCC-AF program include understand the current situation and main problems for management of AF inpatients , assess the performance of the current strategy on quality improvement for AF management, as well as explore and refine the optimal approach to improve clinical management of AF. The timing and dynamic monitoring of AF management will provide an opportunity to identify the potential needs of further evidence in management of AF. Experience from this program may also help to guide development of the national health quality improvement system and provide a blueprint for adaptation to other regions of the world.

Organizational framework and governance

As a collaborative project of the CSC and the AHA , the CCC-AF is conducted by the Beijing Institute of Heart, Lung and Blood Vessel Diseases. AHA secured the initial project funding and CSC provided hospital network for CCC-AF. As a continuous quality improvement program launched in February 2015, CCC-AF has secured its funding up to December 2018. This program consists of a senior management group (SMG) and a project management group (Figure S1). Six senior clinician volunteers from AHA (Prof. Smith, Prof. Fonarow and Prof. Taubert) and CSC (Prof. Huo, Prof. Ge and Prof. Ma) in the SMG communicate frequently via teleconferences, emails and face-to-face meetings to ensure the scientific integrity and supervise the

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implementation of the CCC-AF program. Under the leadership of the international and national directors (Ms. Morgan and Prof. Zhao), the project management group oversees the operation of the CCC-AF project. The project coordinator (Prof. Jing Liu) supervises for functional groups, namely daily routine management (Ms. Jun Liu and Ms. Zhou), data (Dr. Hao and Ms. Guo), and advisory and education groups. Data collection and analysis are managed by daily routine management group and data group, with guidance from SMG. Researchers from SMG, daily routine management group and participating hospitals have the access to analysis the data for publications.

Hospital recruitment

Hospitals were recruited by geographic-economic regions[15] and the detailed hospital sampling frame is shown in Supplemental Table 1. A total of 150 hospitals were recruited, accounting for about 10% of the tertiary hospitals in China. Tertiary hospitals in the CCC- AF program meet following criteria: (1) the annual number of patients hospitalized with AF was over 120; and (2) the director of the Cardiology Department agreed to join the program. Traditional Chinese medicine hospitals and specialized hospitals without cardiology wards were not included in CCC-AF program. Supplemental Table 2 and Supplemental Table 3 provide the information of the 150 CCC - AF hospitals recruited in phases one and two.

Patient recruitment

In each hospital, the first 10-20 hospitalized patients with AF are enrolled in a consecutive manner. Study inclusion of AF is based on electrocardiograph results, which are recorded by 12-lead electrocardiography (ECG), 24-hour Holter ECG , or other cardiac rhythm monitors. Patients with AF secondary to reversible condition (e.g., untreated thyroid disease and pulmonary embolism) are excluded from the

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study.

Clinical data elements are collected referring to American College of Cardiology (ACC)/AHA recommendations on the data standards for clinical research of AF.[16,17] As a quality improvement initiative, the CCC-AF program has high priority for collection of data elements that are involved in assessment for quality of care. Moreover, additional data elements are gathered to facilitate in-depth analysis. Data elements include patients' demographics, admission information, medical history, in-hospital care and outcomes, and discharge medications for management of AF, as presented in the case report form (Supplemental Table 4). Collection of personal identifiers allows the potential for linking our dataset to other health records including death and hospitalization data in the future. Eligible patients with AF are reported to the database using Oracle Clinical Remote Data Capture system (Oracle Corporation). Each participating center assigns a data abstractor responsible for data collection. The data abstractor collects the clinical information from medical records and enter it into the online data reporting system before middle of the month after discharge of the patient.

Quality control of data collection

Similar to the CCC-Acute Coronary Syndrome (ACS) program,[18] four approaches are adopted to secure the accuracy and completeness of data in the CCC-AF program. (1) Face-to-face training workshops are conducted prior to the data entry, with interpretations for each data item. (2) The standardized online reporting tool checks the data automatically for invalid values and sends the system generated error messages to data abstractor for validation. (3) Onsite quality control from the third party is performed to ensure the data accuracy. Recruited cases are compared with the inpatient list to make sure that cases are reported in a consecutive manner, and

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five percent of the records are chosen at random for comparison with the medical

charts. (4) Data completeness is calculated as number of data elements filled in the

database divided by number of data elements that should be filled. Each month, data

completeness is inspected and sent to participating sites as feedback in the monthly

reports. For hospitals with data completeness less than 90%, local investigators are

contacted to improve quality of data.

Performance measures

Primary and secondary performance measures are designed to evaluate the quality of

care for patients hospitalized with AF in the CCC-AF program. They are constructed

referring to the ACC/AHA statements on AF performance measures[19-21] integrating

recommendations from the most updated ACC/AHA guideline and Chinese statement

for AF.[7,22] The six primary performance measures are assessment of thromboembolic

risk, anticoagulant drug at discharge, prothrombin time (PT)/ international

normalized ratio (INR) planned follow-up, angiotensin-converting enzyme inhibitor

(ACEI)/ angiotensin receptor blocker (ARB), statins and beta-blockers at discharge

in AF inpatients with indications (Table 1). The full measure specifications are

shown in Supplemental Table 5. Eight secondary performance measures are shown in

Table 2 with their full measure specifications shown in Supplemental Table 6. For

each performance measure, specialized inclusion and exclusion criteria are utilized

and only appropriate tolerable patients with no contraindications are counted as

denominators.

The hospital composite scores of primary performance measure are constructed

using an opportunity-based method. These scores are defined as the total number of

treatments correctly given divided by the sum of eligible opportunity of treatments

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among the six primary performance measures.[23] Patients at a CCC-AF hospital

contribute eligible opportunities for care to the composite performance scores of this

hospital. In the same way, the composite score for secondary performance measures is

constructed using the eight secondary performance measures.

The CCC team will update the performance measures and keep them aligned with

the new or updated clinical guidelines for management of AF when necessary. After

the new or updated AF guidelines are released, clinical experts will evaluate whether

applying these changes in guidelines to CCC-AF performance measures and data

elements associated with them in the case report form is necessary. When changes are

adopted in the performance measures, hospitals have a transition period that allows

them to have flexibility in meeting recognition criteria for the update.

Quality improvement tools

Several quality improvement tools are designed to promote the adherence to AF

guidelines including monthly hospital quality report, annual hospital recognition,

training session, as well as online educational materials.

Monthly hospital quality report

Each month, hospitals receive site-specific feedback reports on quality of care for AF

through the CCC website. The content of hospital quality report includes individual

and composite scores for primary and secondary performance measures, as well as

data completeness of the reported AF cases. External and internal benchmarks are

provided and compared with the hospital-specific data in the report. External

benchmarks are designed to present rational nation level of performance thresholds

and help to find out the areas for further enhancement of performance. The monthly

hospital quality report provides two external benchmarks: the nation-level

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benchmark and the attainable benchmark of performance describing the composite

performance of care delivered by the 15% hospitals with top-performing. Internal

benchmark presents the time trend of performance measures using hospital specific

data. These benchmarking quality reports help hospitals to identify areas for

improvement and refine treatment processes to ensure they are in line with the

guidelines. Frequencies of website visit and download are recorded to assess

involvement of these participating hospitals.

Regional workshop

Regional workshops in line with CSC meetings occur once or twice each year to

outline the project update, exchange experience, consult the obstacles confronted,

and share the most recent advances in therapies of AF. These face-to-face meetings

serve as venues where the knowledge are shared, with discussion forums enabling

delegates to identify personal and local actions needed to improve clinical practice

for AF. Recourses for education of AF healthcare professionals, including handout,

bulletin, pocket guideline and booklet are delivered to attendees.

Hospital recognition

Participating hospitals with best practice are awarded during the annual scientific

sessions of CSC. Six types of awards are issued each year, including gold, silver, and

bronze prizes for AF performance measures, and recognitions for active

participation, progress, and data quality. Recognition criteria are the same as those in

the CCC-ACS program.[18] Hospitals with best practice share their processes behind

the achievement of good clinical practice for AF.

Online educational materials

The CCC website provides a variety of online educational materials in the education

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source center for healthcare professionals in the participating hospitals to view and download. These web-based training materials include updated clinical guidelines and scientific statements for AF and webinars. Webinars are specially designed by clinical experts, focusing on the areas with gaps between clinical practice and guideline recommendations identified in the program.

Data management

Data reported by hospitals is reserved at the central office in solidly protected computer systems. Data managers perform regular data cleaning inspecting for the potential illogical and invalid values. Invalid values are defined as outliers in numeric variables and unexpected values in character variables. Once the data manager detect the illogical and invalid values, they will review the related observations and trace to solve the potential errors.

Statistical considerations

Recruitment of 1500 patients (10 in each of the 150 hospitals) with AF per month will detect an improvement in the primary composite score from 45% at baseline to an expected score of 51%, with 91% power in a two-sided test with a significant level of 0.05. The projected 6% improvement (from 45% to 51%) in primary composite score means that more 6% guideline recommended treatments will be correctly given for AF patients. Researchers from SMG, project management group and participating hospitals have the access to analysis the data in a de-identified way, in both hospital level and patient level. Categorical variables are presented as frequencies and percentages and continuous variables are as means and standard deviations or medians and interquartile ranges. Missing data are managed based on the purpose of the study and analysis method used. The chi-square trend test is performed to evaluate

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the temporal trend of performance measures. Univariate and multi-variable analysis are performed to recognize the element related with outcomes concerned, e.g. the implement of specific treatments and in-hospital events. To address intra-hospital correlation, generalized estimating equation models will be applied. All statistical analyses are performed by SAS version 9.2 (SAS Institute, Inc., Cary, North Carolina). Two-sided P values < 0.05 are considered statistically significant.

Progress to date

A total of 150 tertiary hospitals were recruited into the program in two phases, with 96 (64%) sites in municipalities or provincial capitals, and 54 (36%) in regional cities. The locations of participating centers are displayed in Figure 1. A total of 28 801 AF inpatients were recruited from February 2015 to March 2017. The demographic and clinical information of the overall population is presented in Table 3. The mean age of the population was 68.6 years and 15 738 (54.6%) were men. These patients had high prevalence of the concomitant diseases, including hypertension (65.4%), coronary artery disease (31.4%), heart failure (20.1%) and diabetes mellitus (17.9%).

The composite score for primary performance measures was 46.8% in the AF patients recruited (Figure 2). There were remarkable variations in composite scores for AF across centers, ranging from 8.2% to 89.4%. The composite score of the AF secondary performance measures for all hospitals was 51.4%, with a wide range of 1.8%–96.2% (Figure 3). Table 1 and Table 2 present the adherence rates to each of the primary and secondary performance measures. Hospital-specific AF monthly quality reports between February 2015 and March 2017 are deposited on the website (www.ccc-heart.com).

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Patient and public involvement

Public and patients have not been engaged in proposal of the research question, design, recruitment and implement of the study. The results will be dispersed to study participants by public reporting.

DISCUSSION

The growing population with AF and expanded awareness of AF related mortality, morbidity and impaired quality of life lead to development of further therapies for AF. Currently, there are several evidence-based, highly effective, guidelines of recommended therapies that can significantly improve long-term care outcomes. The ACC, AHA and European Society of Cardiology have compiled these treatments into clinical practice guidelines.[7,8] Although these guidelines are widely available, studies have suggested that the compliance with guideline-recommended treatments is low in China, even among tertiary hospitals.[10,11] Reasons for low compliance to guideline-based therapies include a lack of timely feedback, poor communication, and a lack of knowledge, financial resource, or time.[24,25]

Accordingly, multiple strategies for improving adherence for clinical guideline are developed. Among them, three strategies are widely used, which are increasing reporting of the data, offering incentives to increase adherence for guideline, and providing hospitals and healthcare professionals with framework and instruments which are essential for adherence improvement.[26] In 2008, the National Health and Family Planning Commission of China (currently known as National Health Commission) launched a project for quality management of single diseases for heart failure, acute myocardial infarction and coronary artery bypass grafting. This project aimed to enhance the reporting of these diseases and promote improvement in

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quality.[27] However, reporting without timely feedback and a lack of necessary infrastructure for quality improvement prevented quality management of this single diseases program from effective improvement in care.

Previous registry studies have provided information on clinical management of patients with AF in China (Table 4) [10,12,13,28-31] and worldwide.[31-35] Zhang et al enrolled 2016 patients with AF in 20 hospitals from 2008 to 2011.[10] Among patients with non-valvular AF, only 12.7% of those with a $CHADS_2$ score of ≥ 2 received treatments with oral anticoagulants, which was much lower than that in developed countries reported by international registries.[32,36-39] As an ongoing registry, the Chinese Atrial Fibrillation Registry was launched in 2011 with an enrollment goal of 20,000 patients with AF in Beijing from 32 hospitals, with a follow-up of every six months up to 2020.[12] Although these registries have expanded understanding for clinical practice and long-term outcomes of AF, they have been limited in a finite number of hospitals and lack of quality improvement components.

In 2014, the AHA and CSC launched the CCC-AF program, aiming to promote the quality of care for AF using timely feedback and quality improvement tools. The CCC-AF program is similar to the CCC-ACS program.[18] This program will contribute essential nationwide information regarding characteristic, management and in-hospital outcomes of AF inpatients. It supports hospitals for improvement in use of guideline-recommended treatments with providing hospital-specific monthly quality reports. Targeted tools, including regional workshops and webinars, can further help to narrow the gaps identified between clinical practice and guideline recommendations. As an ongoing registry, the CCC-AF program have the potential to track the expansion of new evidence-based therapies and highlight the fields calling for additional quality improvement efforts.

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The CCC-AF program aims to improve implement of guideline-recommended therapies for AF with multiple quality improvement tools. As shown in the improve treatment with oral anticoagulants in atrial fibrillation (IMPACT-AF) study, educational intervention with integrative education increased the percentage of patients receiving oral anticoagulant treatments and can potentially improve stroke prevention for patients with AF.[40] Currently, guideline-based therapies for AF mainly focus on antithrombotic management, rate and rhythm control, and therapy of concomitant cardiac diseases. For antithrombotic management, risk stratification is an essential step for recognizing candidate patients for therapy and deciding which patients have sufficient risk to warrant oral anticoagulation. Quality improvement tools of the CCC-AF program are designed to prompt assessment of thromboembolic risk based on easily used risk stratification scores, as well as the use of anticoagulant drugs at discharge, PT/INR planned follow-up, and therapy of concomitant cardiac diseases using ACEIs/ARBs, beta-blockers, and statins at discharge in AF patients with indications. Because AF patients are usually admitted with concomitant cardiovascular diseases, careful consideration of co-prescription of anticoagulant and antiplatelet therapies is warranted, balancing the risk of stroke and bleeding. The CCC-AF program will provide important insight for patterns of current clinical practice for patients with AF and concomitant cardiovascular diseases (e.g., ACS) and procedures (e.g., percutaneous coronary intervention).

The CCC-AF program has several strengths, including involvement of international research team and nationwide network of tertiary hospitals. It helps to translate the research findings into action of quality improvement for care of AF. In China, tertiary hospitals deliver top-level healthcare and affect clinical practice in primary and secondary healthcare facilities. Quality improvement in these tertiary

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hospitals will lead to spreading the experience to healthcare facilities of other levels

and promote the diffusion of guideline-recommended therapies. Moreover, data

quality of our study is ensured by multiple strategies including training, standardized

data collection platform, onsite quality control and monitoring of data completeness.

There are several limitations of CCC-AF program that should be mentioned.

Participation is voluntary and only tertiary hospitals are enrolled in this study. These

centers tend to be bigger hospitals possessing more resources, which may

overestimate the care quality. While participating centers are trained to report the

eligible AF patients consecutively, selection bias may exist as it is challenging to

identify all AF patients in an accurate and uniform manner. As clinical information are

abstracted from inpatient records, quality of documentation has potential impact on

the current study. Moreover, CCC-AF program only collects information during

hospitalization, future work tracking patients after discharge will promote further

researches regarding effectiveness of specific treatments on long-term outcomes.

Also, results presented here are preliminary and should be interpreted with caution.

As a nationwide quality improvement program, CCC-AF aims to provide an

opportunity to improve implement of guideline-recommended therapies in managing

AF. This program has diversified tools for quality improvement which could improve

patients' outcomes.

Ethics and dissemination

This study has been approved by the by the Ethics Committee of Beijing Anzhen

Hospital, with the waiver of patient consent. One hundred and eleven hospitals

accepted central ethics approval and the other 39 sites applied IRB approval from

their own ethics committees. The protocol is listed on www.clinicaltrials.gov

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(NCT02309398). Results will be published in peer-reviewed medical journals.

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Authors' contributions:

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Figure Legends

Figure 1. Distribution of hospitals for the CCC-AF program.

Numerals on the map indicate the number of hospitals in the area. From Hao Y, Liu J, Liu J, et al: Rationale and Design of the Improving Care for Cardiovascular Disease in China (CCC) Project: a National Effort to Prompt Quality Enhancement for Acute Coronary Syndrome. American Heart Journal. 2016 ;179:107-15.

Figure 2. Distribution of CCC-AF composite scores of primary performance measures across hospitals from February 2015 to March 2017.

The composite scores were calculated based on the 6 primary performance measures, using the sum of total instances when a required measure was performed (correct care provided) divided by the total number of eligible opportunities.

Figure 3. Distribution of CCC-AF composite scores of secondary performance measures across hospitals from February 2015 to March 2017.

The composite scores were calculated based on 8 secondary performance measures, using the sum of total instances when a required measure was performed (correct care provided) divided by the total number of eligible opportunities.

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Table 1. Primary Performance Measures for the CCC-AF Project

Reference	Title of Performance Measure	Proportion,% (Numerator/ denominator)
7, 22	Proportion of patients with nonvalvular AF in whom assessment of thromboembolic risk	23.6 (5384/22864)
7, 22	[a]Proportion of AF patients with indication prescribed an anticoagulant drug at discharge	42.3 (6413/15150)
7, 22	Proportion of patients discharged on warfarin who have PT/INR follow-up planned at discharge	87.2 (7721/8857)
7, 22	[b]Proportion of AF patients with indications receiving ACEI/ARB at discharge	53.1 (1794/3382)
7, 22	[c]Proportion of AF patients with indication prescribed a beta blocker at discharge	57.0 (1245/2184)
7	[d]Proportion of AF patients with indication prescribed a statin at discharge	61.2 (8524/13925)
--	Composite scores of primary performance measures	46.8 (31081/66362)

AF, atrial fibrillation; PT, prothrombin time; INR, international normalized ratio; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

[a] indications refer to nonvalvular AF patients with $CHA_2DS_2-VASc \geq 2$.

[b] indications refer to AF patients with acute myocardial infarction; or coronary heart disease with comorbidity of hypertension, diabetes mellitus or chronic kidney disease; or left ventricular ejection fraction <40% according to the case records.

[c] indications refer to AF patients with heart failure.

[d] indications refer to AF patients with coronary heart disease, ischemic stroke/transient ischemic attack, peripheral vascular disease or diabetes mellitus.

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Table 2. Secondary Performance Measures for the CCC-AF Project

Reference	Title of Performance Measure	Proportion,% (Numerator/ denominator)
22	Proportion of nonvalvular AF patients who had a CHADS$_2$ score reported	15.0 (3422/22864)
7, 22	Proportion of nonvalvular AF patients who had a CHA$_2$DS$_2$-VASc score reported	19.2 (4397/22864)
7, 22	Proportion of AF patients who have a documented resting heart rate of <80 bpm closest to discharge	65.0 (7140/10989)
7, 22	Proportion of AF patients that receiving anticoagulation therapy education	89.4 (10941/12243)
7, 22	Proportion of AF patients that receiving conventional medical education	88.3 (25547/28615)
20	[a] Proportion of AF patients with indication prescribed aldosterone antagonist at discharge	72.2 (888/1230)
7, 22	Proportion valvular AF patients prescribed warfarin at discharge	52.4 (2010/3838)
20	Proportion of AF patients who are given smoking cessation advice or counseling	22.5 (1263/5623)
	Composite scores of secondary performance measures	51.4 (55608/108266)

AF, atrial fibrillation.

[a] indications refer to acute myocardial infarction patients with left ventricular ejection fraction (LVEF)<40% or heart failure or diabetes mellitus;

or the heart failure patients with LVEF<35%.

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Table 3. Characteristics of Enrolled Patients with AF enrolled from February 2015 to

March 2017

	Men n=15738	Women n=13063	Overall n=28801
Age			
mean (SD), y	67.0(12.7)	70.6(11.2)	68.6 (12.1)
Age group, n (%)			
<65 y	6528(41.5)	3823(29.3)	10351(35.9)
65-74 y	4512(28.7)	4079(31.2)	8591(29.8)
≥75 y	4698(29.9)	5161(39.5)	9859(34.2)
Healthcare insurance, n (%)			
Urban employees-basic insurance	6823(43.4)	5045(38.6)	11868(41.2)
Urban residents-basic insurance	2817(17.9)	2782(21.3)	5599(19.4)
New rural cooperative insurance	2696(17.1)	2830(21.7)	5526(19.2)
Self-paying	1654(10.5)	1186(9.1)	2840(9.9)
Others	1748(11.1)	1220(9.3)	2968(10.3)
Medical history, n (%)			
Hypertension	9973(63.4)	8874(67.9)	18847(65.4)
CAD	5050(32.1)	3991(30.6)	9041(31.4)
Heart failure	2994(19.0)	2788(21.3)	5782(20.1)
Diabetes mellitus	2694(17.1)	2473(18.9)	5167(17.9)
Stroke/TIA	2187(13.9)	1843(14.1)	4030(14)
PAD	1647(10.5)	915(7.0)	2562(8.9)
Myocardial infarction	1191(7.6)	551(4.2)	1742(6.0)

Previous bleeding	96(0.6)	74(0.6)	170(0.6)
Current smoker	5241(33.3)	413(3.2)	5654(19.6)
AF type			
Newly diagnosed	1742(11.1)	1330(10.2)	3072(10.7)
Paroxysmal	6143(39.0)	5053(38.7)	11196(38.9)
Persistent	4256(27.0)	3405(26.1)	7661(26.6)
Permanent	2447(15.5)	2327(17.8)	4774(16.6)
Unknown	1150(7.3)	948(7.3)	2098(7.3)

AF, atrial fibrillation; SD, standard deviation; CVD, cardiovascular disease; CAD,

coronary artery disease; PCI, percutaneous coronary intervention; TIA, transient

ischemic attack; PAD, peripheral artery disease.

Table 4. Characteristics of AF Registries Involving Sites in China

Studies	Countries	Sites	Population	Sample size	QI measure	Follow up	Study period
Sun Y et al. 2015 [28]	China only	50	Outpatient	3017	No	No	2012
CAFR[12]	China only	32	Outpatient/inpatient	11496	No	Up to 2020	2011- present
GLORIA-AF II [31]	42	736	Outpatient	10871	No	2 year	2011- present
Nanchang AF Project[13]	China only	1	Inpatient	2442	No	No	2011-2013
GARFIELD-AF [30]	30	858	Outpatient/inpatient	17184	No	1 year	2010-2013
Chinese AF registry [10]	China only	20	Emergency department	2016	No	1 year	2008-2011
Sun et al. [29]	China only	18	Inpatient	3425	No	No	2000-2004

CAFR, Chinese Atrial Fibrillation Registry Study; GLORIA-AF, Global Registry on Long-term Oral Antithrombotic Treatment in Patients with Atrial Fibrillation; GARFIELD-AF, Global Anticoagulant Registry in the FIELD-Atrial Fibrillation; QI, quality improvement.

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Figure 1. Distribution of hospitals for the CCC-AF program.
Numerals on the map indicate the number of hospitals in the area. Adapted from reference 18.

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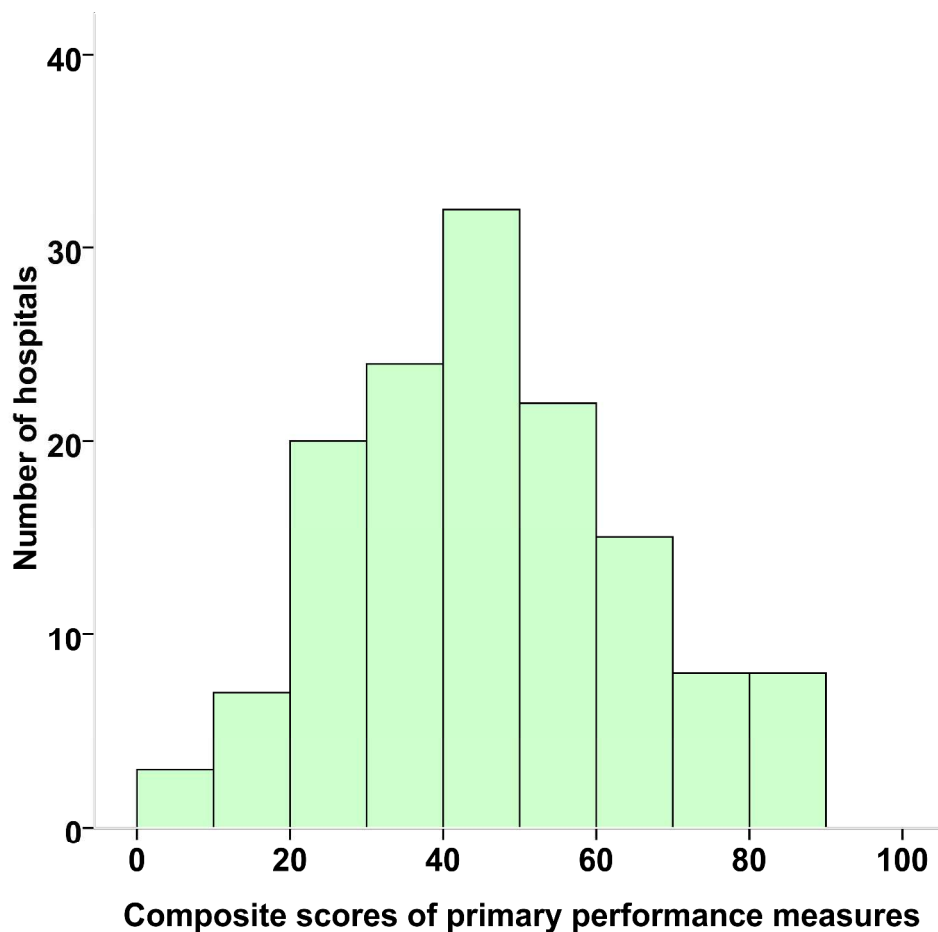
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Figure 2. Distribution of CCC-AF composite scores of primary performance measures across hospitals from February 2015 to March 2017.
The composite scores were calculated based on the 6 primary performance measures, using the sum of total instances when a required measure was performed (correct care provided) divided by the total number of eligible opportunities.

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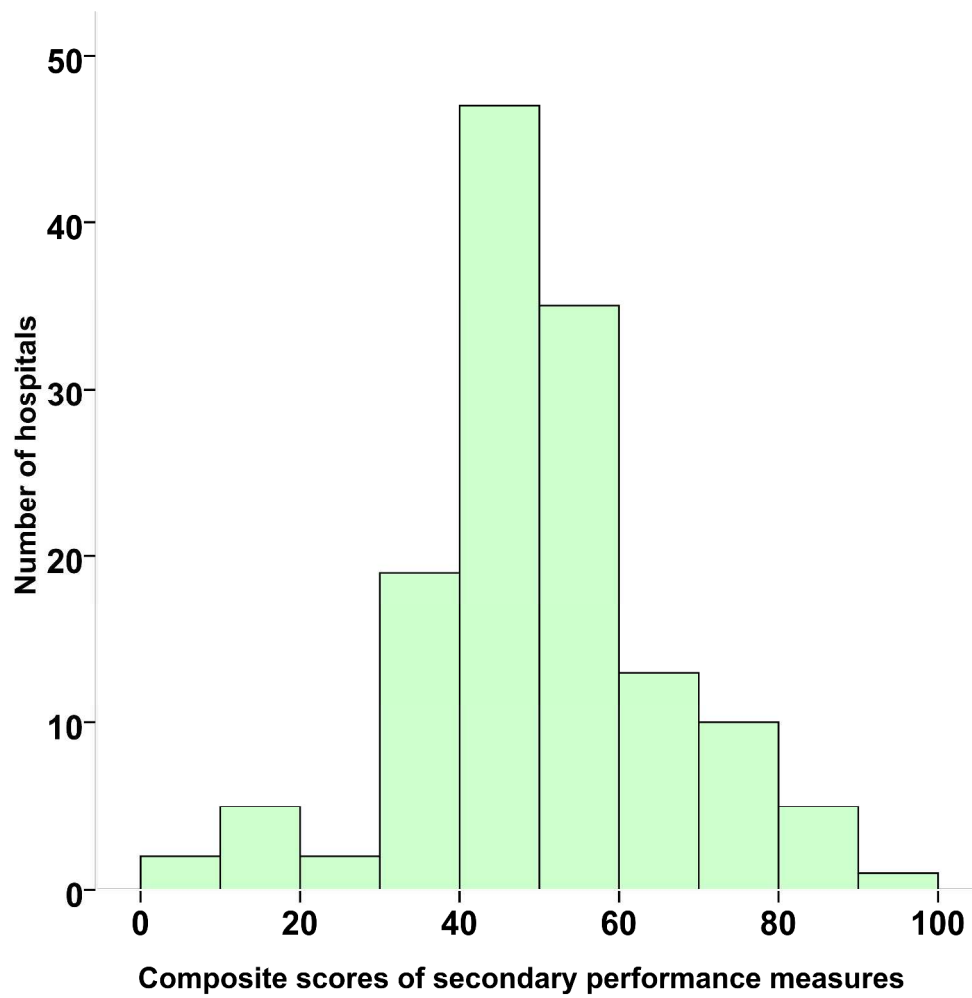
Figure 3. Distribution of CCC-AF composite scores of secondary performance measures across hospitals from February 2015 to March 2017.
The composite scores were calculated based on 8 secondary performance measures, using the sum of total instances when a required measure was performed (correct care provided) divided by the total number of eligible opportunities.

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SUPPLEMENTAL MATERIAL

Contents

Supplemental Tables

Supplemental Figures

Table S1. Hospital Sampling Frame of CCC-AF

Territories[&]	GDP per capital [*]	Provinces	No. of hospitals in the area[#]	No. of hospitals needed（10%）	Enrolled hospitals in Phase 1	Enrolled hospitals in Phase 2
Northern China	Low	NA	--	--	--	--
	Medium-low	Shanxi	49	5	4	1
	Medium-high	Hebei	55	5	4	2
	High	Beijing, Tianjin, Inner Mongolia	123	12	13	1
Northeast China	Low	NA	--	--	--	--
	Medium-low	Heilongjiang	77	7	1	5
	Medium-high	Jilin	39	4	2	1
	High	Liaoning	101	10	2	9
Eastern China	Low	Anhui, Jiangxi	84	8	3	5
	Medium-low	NA	--	--	--	--
	Medium-high	Fujian, Shandong	129	12	1	12
	High	Shanghai, Jiangsu, Zhejiang	240	23	13	11
Central China	Low	NA	--	--	--	--
	Medium-low	Henan, Hunan	134	13	7	7
	Medium-high	Hubei	60	6	0	5
	High	NA	--	--	--	--
Southern China	Low	Guangxi	50	5	2	2
	Medium-low	Hainan	11	1	2	0
	Medium-high	NA	--	--	--	--
	High	Guangdong	105	10	5	4
Southwest China	Low	Guizhou, Yunnan, Tibet	82	8	3	2
	Medium-low	Sichuan	83	8	0	5
	Medium-high	Chongqing	22	2	3	0
	High	NA	--	--	--	--
Western China	Low	Gansu	34	3	2	0
	Medium-low	Qinghai, Xinjiang	29	3	5	0
	Medium-high	Shaanxi, Ningxia	51	5	3	3
	High	NA	--	--	--	--
Total			**1558**	**150**	**75**	**75**

[&]Mainland China includes seven geographical regions: Northern, Northeast, Eastern, Central, Southern,

Southwest, and Western China. *GDP per capital is from National Bauru of Statistical, provinces are

grouped into quadruplets according to GDP per capital, low:<29608.00 RMB, medium-low:

29608.00-36393.00 RMB, medium-high: 36394.00-54095.00 RMB, high: >54095.00 RMB.

#Numbers of hospitals are from China Statistical Yearbook 2013.

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Table S2. List of Hospitals for Phase One

Hospitals	Territories	Provinces	City	Investigator
Shanxi Cardiovascular Hospital	Northern China	Shanxi	Taiyuan	Bao Li
Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School	Eastern China	Jiangsu	Nanjing	Biao Xu, Guangshu Han
Hainan General Hospital	Southern China	Hainan	Haikou	Bin Li
The Second Hospital of Jilin University	Northeast China	Jilin	Changchun	Bin Liu
The 2nd Affiliated Hospital of Harbin Medical University	Northeast China	Heilongjiang	Harbin	Bo Yu
The Ninth Hospital Affiliated to Shanghai Jiaotong University School of Medicine	Eastern China	Shanghai	Shanghai	Changqian Wang
Henan Provincial People's Hospital	Central China	Henan	Zhengzhou	Chuanyu Gao
Shanxi Provincial People's Hospital	Northern China	Shanxi	Taiyuan	Chunlin Lai
Xinqiao Hospital, Third Military Medical University	Southwest China	Chongqing	Chongqing	Cui Bin, Lan Huang
China Meitan General Hospital	Northern China	Beijing	Beijing	Di Wu
The 309th Hospital of Chinese People's Liberation Army	Northern China	Beijing	Beijing	Fakuan Tang, Jun Xiao
Zhongda Hospital, Southeast University	Eastern China	Jiangsu	Nanjing	Genshan Ma
The First Affiliated Hospital of Liaoning Medical University	Northeast China	Liaoning	Jinzhou	Guizhou Tao
Xinjiang Uygur Autonomous Region People's Hospital	Northwest China	Xinjiang	Urumchi	Guoqing Li
Sir Run Run Shaw Hospital, College of Medicine, Zhejiang University	Eastern China	Zhejiang	Hangzhou	Guosheng Fu
Beijing Friendship Hospital, Capital Medical University	Northern China	Beijing	Beijing	Hongwei Li
The First Affiliated Hospital of Bengbu Medical College	Eastern China	Anhui	Bengbu	Honhju Wang
General Hospital of TISCO	Northern China	Shanxi	Taiyuan	Huifeng Wang

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Hospitals	Territories	Provinces	City	Investigator
Dongguan People's Hospital	Southern China	Guangdong	Dongguan	Jianfeng Ye
Panyu Hospital of Chinese Medicine	Southern China	Guangdong	Guangzhou	Jianhao Li
Peking University First Hospital	Northern China	Beijing	Beijing	Jie Jiang
Sun Yat-sen Memorial Hospital, Sun Yat-sen University	Southern China	Guangdong	Guangzhou	Jingfeng Wang
Guangdong General Hospital	Southern China	Guangdong	Guangzhou	Jiyan Chen
Hospital of Xinjiang Production & Construction Corps	Northwest China	Xinjiang	Urumchi	Junming Liu
The Military General Hospital of Beijing PLA	Northern China	Beijing	Beijing	Junxia Li
The First Affiliated Hospital of Guangxi Medical University	Southern China	Guangxi	Nanning	Lang Li
Tongren Hospital Affiliated to Shanghai Jiaotong University School of Medicine	Eastern China	Shanghai	Shanghai	Li Jiang
Binzou City Center Hospital	Eastern China	Shandong	Binzhou	Lijun Meng
The First Affiliated Hospital of Zhengzhou University	Central China	Henan	Zhengzhou	Ling Li
Xijing Hospital	Northwest China	Shaanxi	Xi'an	Ling Tao
The Affiliated Hospital of Guizhou Medical University	Southwest China	Guizhou	Guiyang	Lirong Wu
First Affiliated Hospital of the People's Liberation Army General Hospital	Northern China	Beijing	Beijing	Miao Tian
The Second People's Hospital of Yunnan Province	Southwest China	Yunnan	Kunming	Minghua Han
Haikou People's Hospital	Southern China	Hainan	Haikou	Moshui Chen
Gansu Provincial Hospital	Northwest China	Gansu	Lanzhou	Ping Xie
The First Affiliated Hospital of Henan University of Science and Technology	Central China	Henan	Luoyang	Pingshuan Dong
Chenzhou First People's Hospital	Central China	Hunan	Chenzhou	Qiaoqing Zhong
People's Hospital of Qinghai Province	Northwest China	Qinghai	Xining	Rong Chang

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Hospitals	Territories	Provinces	City	Investigator
Affiliated Hospital of Ningxia Medical University	Northwest China	Ningxia	Yinchuan	Shaobin Jia
Beijing Anzhen Hospital, Capital Medical University	Northern China	Beijing	Beijing	Shaoping Nie, Xiaohui Liu
North Jiangsu People's Hospital	Eastern China	Jiangsu	Yangzhou	Shenghu He
Shanghai Sixth People's Hospital	Eastern China	Shanghai	Shanghai	Shixin Ma
The First Hospital of Handan	Northern China	Hebei	Handan	Shuanli Xin
Huai'an First People's Hospital	Eastern China	Jiangsu	Huai'an	Shuren Ma
The First Affiliated Hospital of Chongqing Medical University	Southwest China	Chongqing	Chongqing	Suxin Luo
Navy General Hospital	Northern China	Beijing	Beijing	Tianchang Li
Zhejiang Provincial Hospital of TCM	Eastern China	Zhejiang	Hangzhou	Wei Mao
The Third Xiangya Hospital of Central South University	Central China	Hunan	Changsha	Weihong Jiang
Affiliated Hospital of Qinghai University	Northwest China	Qinghai	Xining	Weijun Liu
Teda International Cardiovascular Hospital	Northern China	Tianjin	Tianjin	Wenhua Lin
The Second Hospital of Hebei Medical University	Northern China	Hebei	Shijiazhuang	Xianghua Fu
Changhai Hospital of Shanghai	Eastern China	Shanghai	Shanghai	Xianxian Zhao
The Second Affiliated Hospital to Nanchang University	Eastern China	Jiangxi	Nanchang	Xiaoshu Cheng
Hebei General Hospital	Northern China	Hebei	Shijiazhuang	Xiaoyong Qi
Inner Mongolia People's Hospital	Northern China	Inner Mongolia	Hohhot	Xingsheng Zhao
The General Hospital of Shenyang Military Region	Northeast China	Liaoning	Shenyang	Yaling Han
The First Hospital of Jilin University	Northeast China	Jilin	Changchun	Yang Zheng
Tianjin Chest Hospital	Northern China	Tianjin	Tianjin	Yin Liu
Hunan Provincial People's Hospital	Central China	Hunan	Changsha	Ying Guo

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Hospitals	Territories	Provinces	City	Investigator
People's Hospital of Yuxi City	Southwest China	Yunnan	Yuxi	Yinglu Hao
The People's Hospital of Guangxi Zhuang Autonomous Region	Southern China	Guangxi	Nanning	Yingzhong Lin
The First Teaching Hospital of Xinjiang Medical University	Northwest China	Xinjiang	Urumchi	Yitong Ma
Baogang Hospital	Northern China	Inner Mongolia	Baotou	Yongdong Li
Tianjin Medical University General Hospital	Northern China	Tianjin	Tianjin	Yuemin Sun
The Second Affiliated Hospital of Zhengzhou University	Central China	Henan	Zhengzhou	Yulan Zhao
Nanfang Hospital of Southern Medical University	Southern China	Guangdong	Guangzhou	Yuqing Hou
The First Affiliated Hospital to Nanchang University	Eastern China	Jiangxi	Nanchang	Zeqi Zheng
The First Affiliated Hospital of Lanzhou University	Northwest China	Gansu	Lanzhou	Zheng Zhang
The Third Hospital of Shijiazhuang	Northern China	Hebei	Shijiazhuang	Zhenguo Ji
Wuxi People's Hospital	Eastern China	Jiangsu	Wuxi	Zhenyu Yang
Jiangsu Province Hospital	Eastern China	Jiangsu	Nanjing	Zhijian Yang
The Second Hospital of Shanxi Medical University	Northern China	Shanxi	Taiyuan	Zhiming Yang
The Affiliated Hospital of Xuzhou Medical College	Eastern China	Jiangsu	Xuzhou	Zhirong Wang
Southwest Hospital, Third Military Medical University	Southwest China	Chongqing	Chongqing	Zhiyuan Song
The First Affiliated Hospital of Xi'an Jiaotong University	Northwest China	Shaanxi	Xi'an	Zuyi Yuan

Table S3. List of Hospitals for Phase Two

Hospitals	Territories	Provinces	City	Investigator
Yangzhou First People's Hospital	Eastern China	Jiangsu	Yangzhou	Aihua Li
Hospital 463 of Chinese People's Liberation Army	Northeast China	Liaoning	Shenyang	Bosong Yang
The Central Hospital of Mianyang	Northwest China	Sichuan	Mianyang	Caidong Luo
Liaocheng People's Hospital	Eastern China	Shandong	Liaocheng	Chunyan Zhang
Yancheng Third People's Hospital	Eastern China	Jiangsu	Yancheng	Chunyang Wu
The Second Xiangya Hospital of Central South University	Central China	Hunan	Changsha	Daoquan Peng
The Central Hospital of Panzhihua	Northwest China	Sichuan	Panzhihua	Dawen Xu
The First Hospital of Qiqihaer City	Northeast China	Heilongjiang	Qiqihaer	Gang Xu
The Third the People's Hospital of Bengbu	Eastern China	Anhui	Bengbu	Gengsheng Sang
The First Hospital of Jiamusi	Northeast China	Heilongjiang	Jiamusi	Guixia Zhang
Zhoushan People's Hospital	Eastern China	Zhejiang	Zhoushan	Guoxiong Chen
Dalian Municipal Central Hospital	Northeast China	Liaoning	Dalian	Hailong Lin
Renmin Hospital of Wuhan University	Central China	Hubei	Wuhan	Hong Jiang
Ningxia People's Hospital	Northwest China	Ningxia	Yinchuan	Hong Luan
The First People's Hospital of Yunnan Province (Kunhua Hospital)	Northwest China	Yunnan	Kunming	Hong Zhang
The Central Hospital of Zhoukou	Central China	Henan	Zhoukou	Hualing Liu
Anyang District Hospital	Central China	Henan	Anyang	Hui Liu
Sichuan Provincial People's Hospital	Northwest China	Sichuan	Chengdu	Jianhong Tao
Mudanjiang Cardiovascular Disease Hospital	Northeast China	Heilongjiang	Mudanjiang	Jianwen Liu
Yichang Central Hospital	Central China	Hubei	Yichang	Jiawang Ding
Qilu Hospital of Shandong	Eastern China	Shandong	Jinan	Jifu Li

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Hospitals	Territories	Provinces	City	Investigator
University				
Affiliated Hospital of Jiangsu University	Eastern China	Jiangsu	Zhenjiang	Jinchuan Yan
The First People's Hospital of Nanning City	Southern China	Guangxi	Nanning	Jinru Wei
The First Affiliated Hospital of Fujian Medical University	Eastern China	Fujian	Fuzhou	Jinzi Su
Chengdu Third People's Hospital	Northwest China	Sichuan	Chengdu	Jiong Tang
Yantaishan hospital	Eastern China	Shandong	Yantai	Juexin Fan
Qingdao Municipal Hospital	Eastern China	Shandong	Qingdao	Jun Guan
Zhongshan Hospital Affiliated to Fudan University	Eastern China	Shanghai	Shanghai	Junbo Ge
Longyan First Hospital	Eastern China	Fujian	Longyan	Kaihong Chen
Affiliated Hospital of Guangdong Medical College	Southern China	Guangdong	Guangzhou	Keng Wu
Jiangxi Provincial People's Hospital	Eastern China	Jiangxi	Nanchang	Lang Ji
Anhui Provincial Hospital	Eastern China	Anhui	Hefei	Likun Ma
Xiangtan City Central Hospital	Central China	Hunan	Xiangtan	Lilong Tang
The First Hospital of Haerbin City	Northeast China	Heilongjiang	Harbin	Lin Wei
Central Hospital Affiliated to Shenyang Medical College	Northeast China	Liaoning	Shenyang	Man Zhang, Kaiming Chen
The Central Hospital of Wuhan	Central China	Hubei	Wuhan	Manhua Chen
Hangzhou First People's Hospital	Eastern China	Zhejiang	Hangzhou	Ningfu Wang
The Central Hospital of Xuzhou	Eastern China	Jiangsu	Xuzhou	Peiying Zhang
The Second hospital of Dalian Medical University	Northeast China	Liaoning	Dalian	Peng Qu
The First Affiliated Hospital of Liaoning University of Traditional Chinese Medicine	Northeast China	Liaoning	Shenyang	Ping Hou
Beijing Tsinghua Changgung Hospital	Northern China	Beijing	Beijing	Ping Zhang
Guizhou Provincial People's Hospital	Northwest China	Guizhou	Guiyang	Qiang Wu

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Hospitals	Territories	Provinces	City	Investigator
The First Affiliated Hospital of Xiamen University	Eastern China	Fujian	Xiamen	Qiang Xie
Quanzhou First Hospital	Eastern China	Fujian	Quanzhou	Rong Lin
Wuzhou People's Hospital	Southern China	Guangxi	Wuzhou	Shaowu Ye
The Central Hospital of Jilin	Northeast China	Jilin	Changchun	Shuangbin Li
Xiangya Hospital Central South University	Central China	Hunan	Changsha	Tianlun Yang
Guangzhou Red Cross Hospital	Southern China	Guangdong	Guangzhou	Tongguo Wu
The First Affiliated Hospital of Guangzhou Medical College	Southern China	Guangdong	Guangzhou	Wei Wang
The First Affiliated Hospital of Wenzhou Medical University	Eastern China	Zhejiang	Wenzhou	Weijian Huang
The Second Affiliated Hospital of Soochow University	Eastern China	Jiangsu	Suzhou	Weiting Xu
Wuhan Asia Heart Hospital	Central China	Hubei	Wuhan	Xi Su
The First Affiliated Hospital of Soochow University	Eastern China	Jiangsu	Suzhou	Xiangjun Yang
Affiliated Hospital of Yan'an University	Northwest China	Shaanxi	Yan'an	Xiaochuan Ma
The First People's Hospital of Jining	Eastern China	Shandong	Jining	Xiaofei Sun
The Central Hospital of Taiyuan	Northern China	Shanxi	Taiyuan	Xiaoping Chen
West China Hospital of Sichuan University	Northwest China	Sichuan	Chengdu	Xiaoping Chen
The Third Affiliated Hospital of Guangzhou Medical College	Southern China	Guangdong	Guangzhou	Ximing Chen
The First Affiliated Hospital of Wannan Medical College	Eastern China	Anhui	Wuhu	Xingsheng Tang
Tangdu Hospital of The Fourth Military Medical University	Northwest China	Shaanxi	Xi'an	Xue Li
Shanghai East Hospital Affiliated to Tongji University	Eastern China	Shanghai	Shanghai	Xuebo Liu
Xiamen Cardiovascular Disease Hospital	Eastern China	Fujian	Xiamen	Yan Wang

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Hospitals	Territories	Provinces	City	Investigator
Zhongnan hospital of Wuhan University	Central China	Hubei	Wuhan	Yanggan Wang
Fujian Provincial Hospital	Eastern China	Fujian	Fuzhou	Yansong Guo
The First Affiliated hospital of Dalian Medical University	Northeast China	Liaoning	Dalian	Yanzong Yang
The First People's Hospital of Changde	Central China	Hunan	Changde	Yi Huang
The First Affiliated Hospital of China Medical University	Northeast China	Liaoning	Shenyang	Yingxian Sun
The Fourth Affiliated Hospital of China Medical University	Northeast China	Liaoning	Shenyang	Yuanzhe Jin
Cangzhou Central Hospital	Northern China	Hebei	Cangzhou	Zesheng Xu
The Central Hospital of Shaoyang	Central China	Hunan	Shaoyang	Zewei Ouyang
The People's Hospital of Liaoning Province	Northeast China	Liaoning	Shenyang	Zhanquan Li
The First Affiliated Hospital of Jiamusi University	Northeast China	Heilongjiang	Jiamusi	Zhaofa He
Tangshan Gongren Hospital	Northern China	Hebei	Tangshan	Zheng Ji
Huaibei Miners General Hospital	Eastern China	Anhui	Huaibei	Zhenqi Su
Linyi People's Hospital	Eastern China	Shandong	Linyi	Zhihong Ou

Table S4. Case Report Form of CCC-AF

Improving Care for Cardiovascular Disease in China : A collaborative project of AHA and CSC **Atrial Firbrillation-CRF**

A. Demographics

Name: _____	**Sex :** O Male O Female	**Date of Birth:** _____ _____ _____
Medical Record ID: _____	Personal ID: _____ O Unknown	Other ID: _____
Tel.: _____	Relationship of Contact Person with Patient: _____	Name of Contact Person: _____
Tel. of the contact person:_____	Ethnic Group: O Han O Manchu O Zhuang O Hui O Mongol O Uyghur O Kazak O Other	
Address: ___Province___City___District___Street____No. O Unknown		Zip code: _____ O Unknown
Education: O Primary school or below O Middle school O High school O University/college undergraduate O Master's degree or above O Unknown		
Occupation: O Managerial, administrative or official O Professional and technical O Service O Agriculture O Manufacturing O Retired O Unemployed O Others		
Marriage Status : O Single O Married O Divorced O Widowed O Other		

Medical Insurance: O Urban employees-basic medical insurance   O Urban residents - basic medical insurance
   O New rural cooperative medical insurance   O Commercial medical insurance   O Full government-paying
   O Self-paying O Other medical insurance O Other		

B. Arrival and Admission Information

Department：O Cardiology O Internal medicine O Other: _____	Ward Number: _____	Doctor in Charge: _____
Arrival Date and Time： ___/___/_____ ___: ____ O MM/DD/YYYY only O Unknown		
Admit Date： ___/___/_____	Intra-hospital transportation: O No O Yes	
Point of Origin for Admission or Visit: O Clinic O Emergency room O Transferred from another hospital O Unknown		

C. Medical History

Medical History
(Select all that apply)
	□ None
	□ Smoker
	□ Alcohol use
	□ Hypertension history
	  □ Uncontrolled, SBP > 160 mmHg
	□ Diabetes
	□ Coronary artery disease
	□ Prior MI
	□ Prior PCI
	  □ Bare metal stent
	  □ Drug eluting stent
	□ CRT-D (cardiac resynchronization therapy w/ICD)
	□ CRT-P (cardiac resynchronization therapy-pacing only)
	□ Pacemaker
	□ Sinus node dysfunction/ sick sinus syndrome
	□ LAA occlusion device
		□ Heart failure
		□ Family history of AF
		□ Cardiac transplantation
		□ Cardiomyopathy
		  □ Ischemic
		  □ Non-Ischemic
		□ Rheumatic heart disease
		□ Mechanical prosthetic heart valve
		□ Mitral stenosis
		□ CVA/TIA
		  □ Ischemic stroke
		  □ ICH
		  □ TIA
		□ Cognitive impairment
		□ Depression
		□ Peripheral arterial disease
		□ Deep vein thrombosis
		□ PIulmonary embolism
			□ Upper gastrointestinal hemorrhage
			  □ Gastrointestinal
			  □ Other
			□ Obstructive sleep apnea
			  O CPAP
			□ COPD
			□ Renal Disease
			  □ Dialysis
			  □ Transplant
			  □ Cr >2.6 mg/dL or >200, μmol/L
			□ Liver disease (Cirrhosis, Bilirubin >2x Normal, AST/ALT/AP >3x Normal)
			□ Thyroid Disease
			  □ Hyperthyroidism
			  □ Hypothyroidism
			□ Anemia
			□ Cancer
			□ Prior major bleeding or predisposition to bleeding (bleeding diathesis, anemia, etc.)

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Labile INR?	O Yes	O No	O Unknown		

Prior AF Procedures	□ None	□ Cardioversion	□ Ablation	□ AF surgery (Surgical MAZE)

D. Diagnosis

Atrial Arrhythmia Type	□ Valvular atrial fibrillation □ Nonvalvular atrial fibrillation □ Atrial flutter
	If Atrial Fibrillation: If Atrial Flutter:
	O First detected atrial fibrillation O Typical atrial flutter
	O Paroxysmal atrial fibrillation O Atypical atrial flutter
	O Persistent atrial fibrillation O Unknown
	(If Persistent Atrial Fibrillation, the type of your first detected atrial fibrillation
	is: O Paroxysmal atrial fibrillation
	O Persistent atrial fibrillation)
	O Permanent/long standing persistent atrial fibrillation
	O Unknown

Was Atrial Fibrillation/Flutter the patient's primary diagnosis?	O No O Yes	

If not, what was the patient's primary diagnosis?	O Acute MI O Surgery O CVA/TIA	
	O Heart Failure O COPD O Other	

Were any of the following first detected on this admission?	□ None	□ Heart failure	□ Ischemic stroke
	□ Acute MI	□ Liver disease	□ ICH
	□ Coronary artery disease	□ Mitral stenosis	□ TIA
	□ Diabetes	□ Peripheral aterial disease	□ Pulmonary embolism

E. Medications at Admission

Medications Used Prior to Admission (Select all that apply)	□ Patient on no meds prior to admission	□ Aspirin
	□ Beta blocker	Aspirin was used for
	Beta blocker was used for	□ Atrial fibrillation
	□ Heart failure	□ Acute coronary syndrome
	□ Antihypertension	□ Primary prevention of CVD
	□ Arrhythmia	□ ACE inhibitor
	□ Ca channel blocker	□ Aldosterone antagonist
	O Dihydropyridine	□ Alpha blockers
	O Non-dihydropyridine	□ Angiotensin receptor blocker (ARB)
	□ Antiarrhythmic	□ Anticoagulation Therapy
	□ Amiodarone	□ Warfarin (Coumadin)
	□ Dofetilide	□ Dabigatran (Pradaxa)
	□ Dronedarone	□ Argatroban
	□ Flecainide	□ Apixaban (Eliquis)
	□ Propafenone	□ Desirudin (Iprivask)
	□ Sotalol	□ Fondaparinux (Atrixa)
	□ Other (Beta blocker and Ca channel blocker	□ Rivaroxaban (Xarelto)
	not included)	□ Lepirudin (Refludan)
	□ Antiplatelet agent (not aspirin)	□ Other anticoagulant
	□ Aggrenox (Dipyridamole)	□ Digoxin
	□ Brilinta (Ticagrelor)	□ Diuretic
	□ Clopidogrel	□ Hydralazine Nitrate
	□ Prasugrel (Effient)	□ NSAIDS/COX-2 Inhibitor
	□ Ticlid (Ticlopidine)	□ Statin
	□ Other	

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F. Exam/ Labs at Admission

Presentation Symptoms Related to AF (Select all that apply)	□ No reported symptoms □ Syncope □ Fatigue	□ Chestpain/tightness/discomfort □ Weakness □ Palpitations dyspnea at rest	□ Exercise intolerance □ Dyspnea at exertion □ Lightheadedness/dizziness

Classification of AF-related Symptoms (EHRA score)	O EHRA I No symptoms O EHRA II Mild symptoms; normal daily activity not affected O EHRA III Severe symptoms; normal daily activity affected O EHRA IV Disabling symptoms; normal daily activity discontinued

Initial Vital Signs	Height _____ cm □ Unknown		Weight _____ kg □ Unknown
	Heart Rate _____bpm □ Unknown	**BP** _____/_____mmHg (SBP/DBP) □ Unknown	

Initial Presenting Rhythm(s) (Select all that apply)	□ Atrial fibrillation □ Atrial flutter	□ Sinus rhythm □ Atrial tachycardia	□ Paced □ Other

If Paced, underlying Atrial Rhythm	O Sinus Rhythm O Atrial fib/flutter O Sinus arrest O Not available

If Paced, Pacing Type	O Atrial pacing O Ventricular pacing O Atrial pacing

Automated ECG	O No O Yes

Initial EKG Findings	Resting Heart Rate (bpm)___ □ Not Available	QTc (ms) _____ □ Not Available
	QRS duration (ms)_____ □ Not Available	PR interval(ms)_____ □ Not Available

Echocardiography Result	**LVEF** _____% □ Not available **Obtained:** O This Admission O W/in the last year O > 1 year ago Left ventricular end-diastolic diameter (LVEDD):___ mm □ Not available Left ventricular end-systolic diameter(LVESD):____ mm □ Not available Thrombus: O No O Yes Atrium Size:_____ mm □ Not available

Labs (closest to admission)	**Platelet Count** _____ g/L □ Not available	Hematocrit _____% □ Not available
	Hemoglobin _____g/L □ Not available	**INR** _____ □ Not available
	SCr _____ O mg/dL O μmol/L □ Not available	BUN _____ o mg/dL oμmol/L □ Not available
	K ____O mEq/L O mmol/L O mg/dL □ Not available	Mg _____ O mg/dL Ommol/L □ Not available
	TSH _____ mIU/L □ Not available	BNP_____ O pg/mLO pmol/L O ng/L □ Not available
	NT-BNP _____ (pg/mL) □ Not available	

G. In-Hospital Care

Procedures during this hospitalization	□ No procedures
	□ A-Fib ablation
	□ A-Flutter ablation
	If A-Fib or A-Flutter ablation selected above:
	  O Cryoablation
	  O Radio frequency ablation
	□ Cardioversion *(check all that apply below)*
	  □Chemical
	  □Electrical
	  □TEE guided
		□ CRT-D (cardiac resynchronization therapy w/ICD)
		□ CRT-P (cardiac resynchronization therapy-pacing only)
		□ ICD only
		□ LAA occlusion device
		□ Mechanical prosthetic heart valve
		□ Pacemaker
		□ PCI/Cardiac catheterization
		  □ Bare metal stent
		  □ Drug eluting stent
		□ Surgical MAZE

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Oral Medications during hospitalization
Select all that apply
	□None
	□Antiarrhythmic
	   □ Amiodarone
	   □ Dofetilide
	□ Dronedarone
	□ Flecainide
	□ Propafenone
	□ Sotalol
	□ Other
		□ Antiplatelet agent (not aspirin)
		   □ Aggrenox (Dipyridamole)
		   □ Brilinta (Ticagrelor)
		   □ Clopidogrel
		   □ Prasugrel (Effient)
		   □ Ticlid (Ticlopidine)
		   □ Other
		□ Aspirin
			□ Anticoagulant
			   □ Warfarin
			   □ Dabigatran
			   □ Apixiban
			   □ Rivaroxiban
			□ Ca channel blocker
			□ Beta Blocker
			□ Digoxin

Parenteral In-Hospital Anticoagulation	O None O Unfractionated Heparin iv. O LMW Heparin O Other iv. Anticoagulant		
CHADS2 reported?(in medical record) If yes, total reported score in medical record	O No O Yes, Score_____		

H. Discharge Information

Discharge Date/Time___/___/_____ ___: ____	□ MM/DD/YYYY only		
Vital Signs (closest to discharge)	BP-Supine _____/_____mmHg (systolic/diastolic) □ Not documented		
	Heart Rate _____ bpm	□ Not documented	
Discharge Rhythm(s) (closest to discharge)	□ Atrial Fibrillation	□ Sinus Rhythm	□ Paced
	□ Atrial Flutter	□ Atrial Tachycardia	□ Other
EKG findings (closest to discharge):	Resting Heart Rate (bpm) □ Not Available	QTc (ms) □ Not Available	
	QRS duration(ms) □ Not Available	PR interval(ms) □ Not Available	
Discharge EKG QRS Morphology	O Normal O RBBB O LBBB O NS-TVCD O Not Available		
Labs (closest to discharge)	Platelet Count _____ g/L □ Not Available	INR _____ □ Not Available	
	SCr _____O mg/dL O μmol/L □ Not Available		

I. Discharge Medication

Anticoagulation Therapy	Prescribed?	O No O Yes		
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day		
		Medication: _____ Dosage: _____mg Frequency:_____ times/day		
	Contraindicated?	O No O Yes		

	□ Are there any relative or absolute contraindications to oral anticoagulant therapy? (Check all that apply)
	
	  □ Allergy
	  □ Occupational risk
	  □ Prior intracranial hemorrhage
	  □ Bleeding Event
	  □ Frequent falls/frailty
	  □ Physician preference
	  □ Recent operation therapy
		□ Unable to adhere/monitor
		  □ High bleeding risk
		  □ Comorbid illness (e.g. renal/liver)
		  □ Need for dual antiplatelet
		  □ Patient refusal/preference
		  □ Current pregnancy		

Aspirin	Prescribed?	O No O Yes		
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day		
	Contraindicated?	O No O Yes		
Other Antiplatelet(s)	Prescribed?	O No O Yes		
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day		
		Medication: _____ Dosage: _____mg Frequency:_____ times/day		

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	Contraindicated?	O No O Yes
Beta Blocker	Prescribed?	O No O Yes
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day
	Contraindicated?	O No O Yes
Calcium Channel Blocker	Prescribed?	O No O Yes
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day
	Contraindicated?	O No O Yes
Other Antiarrhythmic	Prescribed?	O No O Yes
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day
	Were Dofetilide or Sotalol newly initiated or dose increased this hospitalization? O No O Yes	
	If yes, was a QT interval documented after 5 doses and prior to discharge? O No O Yes	
ACEI	Prescribed?	O No O Yes
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day
	Contraindicated?	O No O Yes
ARB	Prescribed?	O No O Yes
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day
	Contraindicated?	O No O Yes
Aldosterone Antagonist	Prescribed?	O No O Yes
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day
	Contraindicated?	O No O Yes
Digoxin	Prescribed?	O No O Yes
	If yes,	Medication: _____ Dosage: _____mg Frequency:_____ times/day
	Contraindicated?	O No O Yes
Statin Therapy	Prescribed?	O No O Yes
	Contraindicated?	O No O Yes
Hydralazine Nitrate	Prescribed?	O No O Yes
	Contraindicated?	O No O Yes
Other Medications at Discharge	☐ Diuretic O No O Yes ☐ NSAIDS/COX-2 Inhibitor O No O Yes	

3. Risk Interventions

Smoking Cessation Counseling Given	O No/ Not Documented O Yes O Not Applicable
Rhythm Control/Rate Control Strategy Planned/Intended	O Rhythm Control Strategy Planned O Rate Control Strategy Planned O No Documentation of Strategy
Patient and/or caregiver received education and/or resource materials regarding all of the following:	☐ All were addressed (Check all yes)
	Risk factors O No O Yes Stroke Risk O No O Yes
	Management O No O Yes Medication Adherence O No O Yes
	Follow-up O No O Yes When to call provide O No O Yes
Anticoagulation Therapy Education Given	O No O Yes

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PT/INR Planned Follow-up	O No O Yes	→	Who will be following patients INR? O Home INR Monitoring
			O Anticoagulation Warfarin Clinic
			O Managed by Physician associated with hospital
			O Managed by outside physician
			O Not documented
		→	Date of INR test planned post discharge: ___/___/_____ □ Not Documented
		→	System Reason for no PT/INR Planned Follow-up O No O Yes
TLC (Therapeutic Lifestyle Change) Diet	O No/ Not Documented	O Yes	O Not Applicable
Obesity Weight Management	O No/ Not Documented	O Yes	O Not Applicable
Activity Level/Recommendation	O No/ Not Documented	O Yes	O Not Applicable
Screening for obstructive sleep apnea (Berlin Questionnaire)	O No/ Not Documented	O Yes	O Not Applicable
Referral for evaluation of obstructive sleep apnea if positive screen	O No/ Not Documented	O Yes	O Not Applicable
Discharge medication instruction provided	O No/ Not Documented	O Yes	O Not Applicable

K. Admin

Principal Diagnosis:_____   Principal Diagnosis Code:_____

Other Diagnose 1: _____   Other Diagnose Code1:_____

Other Diagnose 2: _____   Other Diagnose Code2:_____

Other Diagnose 3: _____   Other Diagnose Code 3:_____

Other Diagnose 4: _____   Other Diagnose Code 4:_____

Other Diagnose 5: _____   Other Diagnose Code 5:_____

Other Diagnose 6: _____   Other Diagnose Code 6:_____

Other Diagnose 7: _____   Other Diagnose Code 7:_____

Principal Procedure:_____   Principal Procedure Code:_____   Date: ___/___/____   □ Date UTD

Other Procedure 1:_____   Other Procedure Code 1:_____   Date: ___/___/____   □ Date UTD

Other Procedure 2:_____   Other Procedure Code 2:_____   Date: ___/___/____   □ Date UTD

Other Procedure 3:_____   Other Procedure Code 3:_____   Date: ___/___/____   □ Date UTD

Other Procedure 4:_____   Other Procedure Code 4:_____   Date: ___/___/____   □ Date UTD

During this hospital stay, was the patient enrolled in a clinical trial in which patients with the same condition as the measure set were being studied?   O No   O Yes

L. CHADS2 Calculation Tool

(Enabled if "No" is selected for CHADS$_2$ Reported (in medical record)?)

   □ Prior stroke or TIA

   □ Age> 75

   □ Hypertension

   □ Diabetes

   □ Congestive Heart Failure

M. Other Risk Scores

NOTE: CHADS$_2$-VASc is an extension of the CHADS$_2$ score. It contains additional risk categories and can be used as a complimentary tool in the assessment of thromboembolic risk in atrial fibrillation patients. The AHA/ACC Guidelines support the use of the CHADS$_2$ score in assessment of thromboembolic risk and

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indication for anticoagulation therapy is stratified using the CHADS$_2$ score.

CHADS$_2$-VASc Score	☐ Congestive Heart Failure
	☐ Diabetes
	☐ Hypertension (blood pressure consistently above 140/90 or treated with hypertension medication)
	☐ Prior stroke/TIA/Thromboembolism
	☐ Age≥75
	☐ Vascular Disease History (CAD, Prior MI, or PAD)
	☐ Age 65-74
	☐ Female Gender

Adapted from a methodology used by the American College of Chest Physicians: Lip GY, Niewlatt R, Pisters R, Lane DA, Crijns HJ, et al. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the euro heart survey on atrial fibrillation. CHEST 2010 Feb;137(2):263-72. doi: 10.1378/chest.09-1584. Epub 2009 Sep 17. http://journal.publications.chestnet.org/article.aspx?articleid=1045174

DISCLAIMER: These tools (ATRIA and HAS-BLED) are presented for informational purposes only and not as an endorsement of their use in clinical decision making. Many of the same risk factors for warfarin-related hemorrhage are also risk factors for AF-associated ischemic stroke. The use of these tools as an exclusion for anticoagulation not part of AHA/ACC guideline-recommended care for patients with AF. Additionally, some of the component elements in the HAS-BLED score, such as Labile INR and Prior Major Bleeding or Pre-Disposition to Bleeding may be difficult to reliably ascertain from the information available in the health record. The HAS- BLED score should be interpreted with this in mind.

ATRIA Risk Score	☐ Age ≥ 75 years
	☐ Anemia (Defined as Hemoglobin < 13 g/dL in men and < 12 g/dL in women)
	☐ History of Hypertension
	☐ Severe Renal Disease (defined as a GFR < 30ml/min or on dialysis)
	☐ Prior hemorrhage (intracranial, gastrointestinal, other hemorrhage)

Adapted from a methodology used by the American College of Cardiology: Fang MC, Go AS, Chang Y, et al. A New Risk Scheme to Predict Warfarin-Associated Hemorrhage: The ATRIA (Anticoagulation and Risk Factors in Atrial Fibrillation) Study. J Am Coll Cardiol 2011;58(4):395-401. doi:10.1016/j.jacc.2011.03.031. http://content.onlinejacc.org/article.aspx?articleid=1146658#Abstract

HAS-BLED Score	
	☐ Hypertension History (uncontrolled, >160 mmHg systolic)
	☐ Renal Disease (Dialysis, transplant, Cr >2.6 mg/dL or >200 μmol/L)
	☐ Liver Disease (Chronic Hepatic Disease, including (e.g.) Cirrhosis, Bilirubin >2x Normal, AST/ALT/AP >3x Normal)
	☐ Stroke History
	☐ Prior Major Bleeding or Predisposition to Bleeding (bleeding diathesis, anemia, etc.)
	☐ Labile INR (Unstable/high INRs or time in therapeutic range <60%)
	☐ Age > 65
	☐ Medication Usage Predisposing to Bleeding (Antiplatelet agents, NSAIDs)
	☐ Alcohol Usage History (>20 units per week)

Adapted from a methodology used by the American College of Chest Physicians: Pisters R, Lane DA, Nieuwlaat R, de Vos CB, Crijns HM, Lip GH. A novel user-friendly score (has-bled) to assess 1-year risk of major bleeding in patients with atrial fibrillation: the euro heart survey. *Chest,* 2010;138(5):1093-1100. http://journal.publications.chestnet.org/article.aspx?articleid=1086288

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Table S5. Definition of Primary Performance Measures

Primary performance measure 1: **Proportion of patients with nonvalvular atrial fibrillation in whom assessment of thromboembolic risk**	
The proportion of patients with nonvalvular atrial fibrillation in whom assessment of thromboembolic risk using CHADS$_2$ or CHA$_2$DS$_2$-VASc score have been documented in medical records.	
Numerator	AF patients reporting CHADS$_2$ or CHA$_2$DS$_2$-VASc risk score to assess the thromboembolic risk factors. **Relevant data elements:** (CHADS$_2$="Yes" and CHADS$_2$ score is not NA), or(CHA$_2$DS$_2$-VASc score="Yes" and CHA$_2$DS$_2$ –VASc score is not NA）
Denominator	**Include:** Nonvalvular AF patients Relevant data elements: Atrial arrhythmia type="Nonvalvular atrial fibrillation" **Exclude:** ① Patients with a medical history of mitral stenosis or a mechanical prosthetic heart valve ② Patients who are newly diagnosed with mitral stenosis this hospitalization ③ Patients who have a mechanic prosthetic heart valve implanted during their hospitalization ④ Patients for whom there is a documented contraindication to anticoagulation therapy Relevant data elements: ① Medical history of mitral stenosis="Yes" or mechanic prosthetic heart valve="Yes" ② Mitral stenosis ="Yes" ③ Mechanic prosthetic heart valve="Yes" ④ Contraindication to anticoagulation therapy="Yes"
Evaluation time	At discharge
Data sources	Case records
Reasons for evaluation	
The assessment of thromboembolic risk factors according to baseline characters is the foundation to make right decisions for anticoagulation therapy.	

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Guidelines
AHA/ACC 2014 AF guidelines
Class I
In patients with nonvalvular AF, the CHA_2DS_2-VASc score is recommended for assessment of stroke risk. (*Level of evidence: B*)
In patients with AF, antithrombotic therapy should be individualized based on shared decision making after discussion of the absolute and RRs of stroke and bleeding, and the patient's values and preferences. (*Level of Evidence: C*)
For patients with atrial flutter, antithrombotic therapy is recommended according to the same risk profile used for AF. (*Level of Evidence: C*)
ESC 2010 AF guidelines
Class I
The $CHADS_2$ [cardiac failure, hypertension, age, diabetes, stroke (doubled)] score is recommended as a simple initial (easily remembered) means of assessing stroke risk in non-valvular AF. (*Level of Evidence: A*)
Ways of reporting
Percentages and numerator/denominator

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Primary performance measure 2 :

Proportion of AF patients with indication prescribed an anticoagulant drug at hospital discharge

Numerator	AF patients receiving warfarin, dabigatran, argatroban or rivaroxaban at discharge **Relevant data elements:** Anticoagulation therapy="Yes", and Warfarin="Yes" or dabigatran="Yes" or argatroban="Yes" or rivaroxaban="Yes"
Denominator	**Include:** Nonvalvular AF patients with CHA_2DS_2-VASc≥2 Relevant data elements: Atrial arrhythmia type="Nonvalvular atrial fibrillation", and CHA_2DS_2-VASc score ≥2 **Exclude:** ① Patients with a medical history of mitral stenosis or a mechanical prosthetic heart valve ② Patients who are newly diagnosed with mitral stenosis this hospitalization ③ Patients who have a mechanic prosthetic heart valve implanted during their hospitalization ④ Patients for whom there is a documented contraindication to anticoagulation therapy ⑤ Expire during hospitalization Relevant data elements: ① Mitral stenosis="Yes"or mechanic prosthetic heart valve="Yes" ② Mitral stenosis="Yes" ③ Mechanic prosthetic heart valve="Yes" ④ Contraindication to anticoagulation therapy="Yes" or any of the following is "Yes": allergy, occupational risk, prior intracranial hemorrhage, bleeding event, frequent falls/frailty, recent operation therapy, unable to adhere/monitor, high bleeding risk, comorbid illness (e.g. renal/liver), patient refusal/preference, or current pregnancy ⑤ Expire="Yes"
Evaluation time	At discharge
Data sources	Case records

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	Reasons for evaluation

The reasonable anticoagulation therapy can better the quality of life and long-term prognosis of AF patients.

	Guidelines

AHA/ACC 2014 AF guidelines
Class I
For patients with nonvalvular AF with prior stroke, transient ischemic attack (TIA), or a CHA_2DS_2-VASc score of 2 or greater, oral anticoagulants are recommended. Options include:
- Warfarin (INR 2.0 to 3.0) (*Level of Evidence: A*)
- Dabigatran, rivaroxaban or apixaban (*Level of Evidence: B*)

For patients with atrial flutter, antithrombotic therapy is recommended according to the same risk profile used for AF. (*Level of Evidence: C*)

Class IIa
For patients with nonvalvular AF and a CHA_2DS_2-VASc score of 0, it is reasonable to omit antithrombotic therapy (81, 82). (*Level of Evidence: B*)

Class IIb
For patients with nonvalvular AF and a CHA_2DS_2-VASc score of 1, no antithrombotic therapy or treatment with an oral anticoagulant or aspirin may be considered. (*Level of Evidence: C*)

ESC 2010 AF guidelines
Class I
For the patients with a $CHADS_2$ score of >= 2, chronic oral anticoagulant (OAC) therapy with a vitamin K antagonist (VKA) is recommended in a dose adjusted regimen to achieve an INR range of 2.0–3.0 (target 2.5), unless contraindicated. (*Level of Evidence: A*)

	Ways of reporting

Percentages and numerator/denominator

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Primary performance measure 3：

Proportion of patients discharged on warfarin who have PT/INR follow-up planned prior to hospital discharge

The proportion of patients discharged on warfarin who have PT/INR follow-up planned prior to hospital discharge.

Numerator	Patients who have PT/INR follow-up planned prior to hospital discharge **Relevant data elements:** PT/INR follow-up plan="Yes"
Denominator	**Include:** Patients discharged on warfarin Relevant data elements: Anticoagulation therapy="Yes",　and warfarin="Yes" **Exclude:** ① System reason for no PT/INR planned follow-up ② Expire during hospitalization Relevant data elements: ① System reason for no PT/INR planned follow-up="Yes" ② Expire="Yes"
Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation

Regular anticoagulation therapy, PT/INR planned follow-up and systematic anticoagulation management can lower the risk of thromboembolism and bleeding events.

Guidelines

AHA/ACC 2014 AF guidelines
Class I
Among patients treated with warfarin, the INR should be determined at least weekly during initiation of antithrombotic therapy and at least monthly when anticoagulation (INR in range) is stable. (*Level of Evidence: A*)

For patients with nonvalvular AF unable to maintain a therapeutic INR level with warfarin, use of a direct thrombin or factor Xa inhibitor (dabigatran, rivaroxaban, or apixaban) is recommended. (*Level of Evidence: C*)

Ways of reporting

Percentages and numerator/denominator

22

Primary performance measure 4：

Proportion of AF patients with indications receiving ACEI/ARB at discharge

The proportion of AF patients with indications receiving ACEI/ARB at discharge

The indications refer to: the diagnosis with AMI during this hospitalization; the diagnosis with coronary heart disease during this hospitalization and the comorbidity of hypertension, diabetes mellitus or chronic kidney disease; LVEF<40% according to the case records.

Numerator	AF patients receiving ACEI or ARB at discharge **Relevant data elements:** ACEI＝"Yes"， or ARB＝"Yes"
Denominator	**Include:** AF patients with the following indications: ① Patients who are newly diagnosed with AMI this hospitalization；or ② Patients who are diagnosed with coronary heart disease during their hospitalization and the comorbidity of hypertension, diabetes mellitus or chronic kidney disease；or ③ LVEF<40% according to the case records Relevant data elements: ① AMI="Yes"；or ② Coronary heart disease="Yes", and （a medical history of hypertension="Yes"， or diabetes mellitus="Yes"， or kidney disease="Yes"）；or ③ LVEF< 40% **Exclude:** ① Contraindication to ACEI and ARB ② Expire during hospitalization Relevant data elements: ① Contraindication to ACEI="Yes"， and Contraindication to ARB ="Yes" ② Expire="Yes"
Evaluation time	At discharge
Data sources	Case records
Reasons for evaluation	

ACEI/ARB can lower the recurrence risk of AF.

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Guidelines

AHA/ACC 2014 AF guidelines

Class IIa

An ACE inhibitor or angiotensin-receptor blocker (ARB) is reasonable for primary prevention of new-onset AF in patients with HF with reduced LVEF. (*Level of Evidence: B*)

Class IIb

Therapy with an ACE inhibitor or ARB may be considered for primary prevention of new-onset AF in the setting of hypertension (34, 151). (*Level of Evidence: B*)

Class III: No Benefit

Therapy with an ACE inhibitor, ARB, or statin is not beneficial for primary prevention of AF in patients without cardiovascular disease. (*Level of Evidence: B*)

AHA/ACC 2014 NSTE-ACS guidelines

CLASS I

1. ACE inhibitors should be started and continued indefinitely in all patients with LVEF less than 0.40 and in those with hypertension, diabetes mellitus, or stable CKD, unless contraindicated. (*Level of Evidence: A*)

2. ARBs are recommended in patients with HF or MI with LVEF less than 0.40 who are ACE inhibitor intolerant . (*Level of Evidence: A*)

3. Aldosterone blockade is recommended in patients post-MI without significant renal dysfunction (creatinine >2.5 mg/dL in men or >2.0 mg/dL in women) or hyperkalemia (Kþ >5.0 mEq/L) who are receiving therapeutic doses of ACE inhibitor and beta blocker and have a LVEF 0.40 or less, diabetes mellitus, or HF. (*Level of Evidence: A*)

Ways of reporting
Percentages and numerator/denominator

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Primary performance measure 5:

Proportion of AF patients with indication prescribed a beta blocker at hospital discharge

The proportion of AF patients with indication prescribed a beta blocker at hospital discharge.

The indication refers to heart failure.

Numerator	AF patients receiving beta blocker at discharge **Relevant data elements:** Beta blocker="Yes"

Denominator	**Include:**
	
	  AF patients with heart failure
	
	Relevant data elements:
	  Were any of the following first detected on this admission? Heart failure ="Yes"
	
	Exclude:
	  ① Contraindication to beta blocker
	  ② Expire during hospitalization
	
	Relevant data elements:
	  ① Contraindication to beta blocker="Yes"
	  ② Expire="Yes"

Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation
Beta blocker can lower the all-cause mortality and cardiovascular mortality of AF patients.

Guidelines

ESC 2010 AF guidelines
Class I
Blockers are recommended as first-line therapy to control the ventricular rate in patients with heart failure and low LVEF. (*Level of Evidence: A*)

AHA/ACC 2014 AF guidelines
Class I
Control of resting heart rate using either a beta blocker or a nondihydropyridine calcium channel antagonist is recommended for patients with persistent or permanent AF and compensated HF with preserved EF (HFpEF) (96). (*Level of Evidence: B*)

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In the absence of pre-excitation, intravenous beta blocker administration (or a nondihydropyridine calcium channel antagonist in patients with HFpEF) is recommended to slow the ventricular response to AF in the acute setting, with caution needed in patients with overt congestion, hypotension, or HF with reduced LVEF (180-183). (*Level of Evidence: B*)

Ways of reporting

Percentages and numerator/denominator

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Primary performance measure 6:		
Proportion of AF patients with indication prescribed a statin at hospital discharge		

The proportion of AF patients with coronary heart disease, ischemic stroke/TIA, peripheral vascular disease (or diabetes mellitus) prescribed a statin at hospital discharge

Numerator	AF patients receiving statin at discharge **Relevant data elements:** Statin="Yes"

Denominator	**Include:**
	     AF patients with coronary heart disease, ischemic stroke/TIA,
	     peripheral vascular disease (or diabetes mellitus)
	Relevant data elements:
	     In the medical history, coronary heart disease, peripheral vascular
	     disease, ischemic stroke, TIA or diabetes mellitus="Yes" or during
	     this hospitalization, coronary heart disease, diabetes mellitus,
	     peripheral vascular disease, ischemic stroke or TIA="Yes"
	Exclude:
	     ① Contraindication to statin
	     ② Expire during hospitalization
	Relevant data elements:
	     ① Contraindication to statin="Yes"
	     ② Expire="Yes"

Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation
NA

Guidelines

AHA/ACC 2014 AF guidelines
Class IIb
Statin therapy may be reasonable for primary prevention of new-onset AF after coronary artery surgery. (*Level of Evidence: A*)

Class III: No Benefit
Therapy with an ACE inhibitor, ARB, or statin is not beneficial for primary prevention of AF in patients without cardiovascular disease. (*Level of Evidence: B*)

ACC F/ AHA 2013 STEMI guidelines
Class I
High-intensity statin therapy should be initiated or continued in all patients with STEMI and no

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contraindications to its use. (Level of Evidence: B)

AHA/ACC 2014 NSTE- guidelines

Class I

High-intensity statin therapy should be initiated or continued in all patients with NSTE-ACS and no contraindications to its use. (Level of Evidence: A)

Ways of reporting
Percentages and numerator/denominator

Table S6. Definition of Secondary Performance Measures

Secondary performance measure 1 :

Proportion of nonvalvular AF patients who had a CHADS$_2$ score reported

The proportion of nonvalvular AF patients who had a CHADS$_2$ score reported to assess the risk of thromboembolism

Numerator	The nonvalvular AF patients who had a CHADS2 score reported **Relevant data elements:** CHADS$_2$="Yes" and CHADS$_2$ score is not NA
Denominator	**Include:** Nonvalvular AF patients Relevant data elements: Atrial arrhythmia type="Nonvalvular atrial fibrillation" **Exclude:** ①Patients with a medical history of mitral stenosis or a mechanical prosthetic heart valve ②Patients who are newly diagnosed with mitral stenosis this hospitalization ③Patients who have a mechanic prosthetic heart valve implanted during their hospitalization ④Patients for whom there is a documented contraindication to anticoagulation therapy Relevant data elements: ① Mitral stenosis="Yes"or mechanic prosthetic heart valve="Yes" ② Mitral stenosis="Yes" ③ Mechanic prosthetic heart valve="Yes" ④ Contraindication to anticoagulation therapy="Yes"
Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation

The assessment of thromboembolic risk factors according to baseline characters is the foundation to make right decisions for anticoagulation therapy.

Guidelines

ESC 2010 AF guidelines

Class I

The CHADS$_2$ [cardiac failure, hypertension, age, diabetes, stroke (doubled)] score is recommended as a simple initial (easily remembered) means of assessing stroke risk in non-valvular AF. (*Level of Evidence: A*)

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Ways of reporting
Percentages and numerator/denominator

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	Secondary performance measure 2 :
	Proportion of nonvalvular AF patients who had a CHA$_2$DS$_2$-VASc score reported
	The proportion of nonvalvular AF patients who had a CHA$_2$DS$_2$-VASc score reported to assess the risk of thromboembolism
Numerator	The nonvalvular AF patients who had a CHA$_2$DS$_2$-VASc score reported
	Relevant data elements:
	CHA$_2$DS$_2$-VASc score="Yes", and CHA$_2$DS$_2$-VASc score is not NA
Denominator	**Include:**
	Nonvalvular AF patients
	Relevant data elements:
	Atrial arrhythmia type="Nonvalvular atrial fibrillation"
	Exclude:
	① Patients with a medical history of mitral stenosis or a mechanical prosthetic heart valve
	② Patients who are newly diagnosed with mitral stenosis this hospitalization
	③ Patients who have a mechanic prosthetic heart valve implanted during their hospitalization
	④ Patients for whom there is a documented contraindication to anticoagulation therapy
	Relevant data elements:
	① Medical history of mitral stenosis="Yes"or mechanic prosthetic heart valve="Yes"
	② Mitral stenosis ="Yes"
	③ Mechanic prosthetic heart valve="Yes"
	④ Contraindication to anticoagulation therapy="Yes"
Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation

The assessment of thromboembolic risk factors according to baseline characters is the foundation to make right decisions for anticoagulation therapy.

Guidelines

AHA/ACC 2014 AF guidelines

Class I

In patients with nonvalvular AF, the CHA$_2$DS$_2$-VASc score is recommended for assessment of stroke risk. (*Level of evidence: B*)

In patients with AF, antithrombotic therapy should be individualized based on shared decision making after discussion of the absolute and RRs of stroke and bleeding, and the patient's values and preferences. (*Level of Evidence: C*)

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For patients with atrial flutter, antithrombotic therapy is recommended according to the same risk profile used for AF. (*Level of Evidence: C*)
Ways of reporting
Percentages and numerator/denominator

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Secondary performance measure 3:

Proportion of AF patients who have a documented resting heart rate of <80 bpm closest to hospital discharge

The proportion of AF patients who have a documented resting heart rate of <80 bpm closest to hospital discharge

Numerator	AF patients who have a documented resting heart rate of <80 bpm closest to hospital discharge **Relevant data elements:** Resting heart rate(bpm) <80
Denominator	**Include:** Nonvalvular AF patients Relevant data elements: Atrial arrhythmia type ="Nonvalvular atrial fibrillation" **Exclude:** ① Data missing of resting heart rate closest to hospital discharge ② Expire during hospitalization Relevant data elements: ① Resting heart rate(bpm) is NA ② Expire="Yes"
Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation

Rate control can better cardiac function and lower the risk of thromboembolism.

Guidelines

AHA/ACC 2014 AF guidelines
Class IIa
A heart rate control (resting heart rate <80 bpm) strategy is reasonable for symptomatic management of AF. *(Level of Evidence: B)*

Class IIb
A lenient rate-control strategy (resting heart rate <110 bpm) may be reasonable as long as patients remain asymptomatic and LV systolic function is preserved. *(Level of Evidence: B)*

Ways of reporting

Percentages and numerator/denominator

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Secondary performance measure 4 : **Proportion of providing anticoagulation therapy education**	
The proportion of AF patients who receive anticoagulation drugs at discharge that receiving anticoagulation therapy education during the hospitalization The anticoagulation therapy education refers to receiving education about anticoagulation therapy or education materials: the effect of anticoagulation drugs, the meaning of TNR planned follow-up and the side effect of anticoagulation drugs.	
Numerator	AF patients that receiving anticoagulation therapy education **Relevant data elements:** Anticoagulation therapy education="Yes"
Denominator	**Include:** Patients that receiving anticoagulation therapy at discharge Relevant data elements: Anticoagulation therapy="Yes" **Exclude:** Expire during hospitalization Relevant data elements: Expire="Yes"
Evaluation time	At discharge
Data sources	Case records
Reasons for evaluation	
Regular anticoagulation therapy, PT/INR planned follow-up and systematic anticoagulation management can lower the risk of thromboembolism and bleeding events. The anticoagulation therapy education is helpful to patients' compliance and prognosis.	
Guidelines	
NA	
Ways of reporting	
Percentages and numerator/denominator	

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Secondary performance measure 5: **Proportion of AF patients that receiving conventional medical education**	

The proportion of AF patients that receiving the following conventional medical education: risk factors, risk of stroke, management, compliance of drugs, follow-up and when to seek medical help

Numerator	AF patients that receiving three or more of the following medical education during hospitalization: risk factors, stroke risk, management, medication adherence, follow-up and when to call provide. **Relevant data elements:** Three or more of risk factors, management, follow-up, stroke risk, medication adherence and when to call provide are "Yes"
Denominator	**Include:** AF patients **Exclude:** Expire during hospitalization Relevant data elements: Expire="Yes"
Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation

The medical education during hospitalization about risk factors, stroke risk, management, medication adherence, follow-up and when to call provide is helpful to patients' compliance and prognosis.

Guidelines
NA

Ways of reporting
Percentages and numerator/denominator

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Secondary performance measure 6:

Proportion of AF patients with indication prescribed aldosterone antagonist at discharge

The proportion of AF patients with indication prescribed aldosterone antagonist at discharge.

The indications refer to: the patient was diagnosed with AMI during this hospitalization with LVEF<40% or heart failure or diabetes mellitus; OR, the heart failure patients with LVEF<35%.

	AF patients prescribed aldosterone antagonist
Numerator	**Relevant data elements:**
	Aldosterone antagonist ="Yes"
Denominator	**Included:**
	① The patient was diagnosed with AMI during this hospitalization with LVEF<40% or heart failure or diabetes mellitus; or
	② The heart failure patients with LVEF<35%.
	Relevant data elements:
	① AMI="Yes", and (LVEF < 40% , or a medical history of heart failure="Yes" or a medical history of diabetes mellitus="Yes", or heart failure="Yes" or diabetes mellitus="Yes"）; or
	② LVEF< 35% , and (a medical history of heart failure="Yes" or heart failure="Yes")
	Excluded population:
	① Contraindication to aldosterone antagonist
	② Expire during hospitalization
	③ With chronic kidney disease
	Relevant data elements:
	① Contraindication to aldosterone antagonist= "Yes"
	② Expire="Yes"
	③ Kidney disease="Yes"
Evaluation time	At discharge
Data sources	Case records
Reasons for evaluation	
NA	
Guidelines	

ACC F/ AHA 2013 STEMI guidelines

Class I

An aldosterone antagonist should be given to patients with STEMI and no contraindications who

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are already receiving an ACE inhibitor and beta blocker and who have an EF less than or equal to 0.40 and either symptomatic HF or diabetes mellitus. (*Level of Evidence: B*)

AHA/ACC 2014 NSTE-ACS guidelines

CLASS I

Aldosterone blockade is recommended in patients post-MI without significant renal dysfunction (creatinine >2.5 mg/dL in men or >2.0 mg/dL in women) or hyperkalemia (Kþ >5.0 mEq/L) who are receiving therapeutic doses of ACE inhibitor and beta blocker and have a LVEF 0.40 or less, diabetes mellitus, or HF. (*Level of Evidence: A*)

Ways of reporting
Percentages and numerator/denominator

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Secondary performance measure 7：

Proportion valvular AF patients prescribed warfarin at hospital discharge

The proportion valvular AF patients prescribed warfarin at hospital discharge

Numerator	The valvular AF patients prescribed warfarin at hospital discharge **Relevant data elements:** Anticoagulation therapy="Yes", and warfarin="Yes"
Denominator	**Include:** Valvular AF patients Relevant data elements: Atrial arrhythmia type="valvular atrial fibrillation" **Exclude:** ① Contraindication to anticoagulation therapy ② Expire during hospitalization Relevant data elements: ① Contraindication to anticoagulation therapy="Yes" ② Expire="Yes"
Evaluation time	At discharge
Data sources	Case records

Reasons for evaluation
NA

Guidelines

ESC 2010 AF guidelines

Class I

Oral anticoagulant therapy (INR 2.0–3.0) is indicated in patients with mitral stenosis and AF
(paroxysmal, persistent, or permanent). (*Level of Evidence: C*)

Oral anticoagulant therapy (INR 2.0–3.0) is recommended in patients with AF and clinically
significant mitral regurgitation. (*Level of Evidence: C*)

Ways of reporting
Percentages and numerator/denominator

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Secondary performance measure 8：

Proportion of AF patients who are given smoking cessation advice or counseling

The proportion of AF patients with a history of smoking who are given smoking cessation advice or counseling

The history of smoking refers to that the patients smoked one year before hospitalization.

Numerator	The patients with a history of smoking who are given smoking cessation advice or counseling **Relevant data elements:** 　　In the smoking cessation advice or counseling, distribution of publicity materials="Yes", or making smoking cessation plans with patients/families="Yes", or　prescription　of anti-tobacco remedy
Denominator	**Include:** 　　Patients with a history of smoking Relevant data elements: 　　Smoking="Yes" **Exclude:** 　　Expire during hospitalization Relevant data elements: 　　Expire="Yes"
Evaluation time	At discharge
Data sources	Case records
Reasons for evaluation	
NA	
Guidelines	
NA	
Ways of reporting	
Percentages and numerator/denominator	

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Figure S1. Organizational Framework and Governance of the CCC-AF Program

NHFPC, National Health and Family Planning Commission of the People's Republic of China;

CHFP, Commission of Health and Family Planning; CSC, Chinese Society of Cardiology; AHA,

American Heart Association