



Performance on management strategies with Class I Recommendation and A Level of Evidence among hospitalized patients with non–ST-segment elevation acute coronary syndrome in China: Findings from the Improving Care for Cardiovascular Disease in China–Acute Coronary Syndrome (CCC-ACS) project

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Background This study aimed to examine hospital performance on evidence-based management strategies for non–ST-segment elevation acute coronary syndrome (NSTEMI-ACS) and variations across hospitals.

Methods Improving Care for Cardiovascular Disease in China (CCC)-ACS project is an ongoing registry and quality improvement project, with 150 tertiary hospitals recruited across China. We examined hospital performance on nine management strategies (Class I Recommendations with A Level of Evidence) based on established guidelines. We also evaluated the proportion of patients receiving defect-free care, which was defined as the care that included all the required management strategies for which the patient was eligible. The hospital-level variations in the performance were examined.

Results From 2014 to 2018, 28,170 NSTEMI-ACS patients were included. Overall, 16% of patients received defect-free care. Higher-performing metrics were statin at discharge (93%), cardiac troponin measurement (92%), dual antiplatelet therapy (DAPT) within 24 hours (90%), and DAPT at discharge (85%). These were followed by metrics of β -blocker at discharge (69%), angiotensin converting enzyme inhibitor/angiotensin receptor blocker (ACEI/ARB) at discharge (59%), and risk stratification (56%). Lower-performing metrics were smoking cessation counseling (35%) and percutaneous coronary intervention (PCI) within recommended times (33%). The proportion of patients receiving defect-free care substantially varied across hospitals, ranging from 0% to 58% (Median (interquartile range): 12% (7%–21%)). There were large variations across hospitals in performance on risk stratification, smoking cessation counseling, PCI within recommended times, ACEI/ARB at discharge and β -blocker at discharge.

Conclusions About one in six NSTEMI-ACS patients received defect-free care, and the performance varied across hospitals. (Am Heart J 2019;212:80-90.)

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Acute coronary syndrome (ACS) is a severe stage of coronary heart disease that is associated with high mortality¹. Non-ST-segment elevation myocardial infarction (NSTEMI) and unstable angina pectoris (UAP), which are defined as non-ST-segment elevation ACS (NSTEMI-ACS), account for a substantial proportion of ACS hospitalizations^{2,4}. The increasing number of patients hospitalized for NSTEMI-ACS and a larger proportion of patients with NSTEMI-ACS among ACS hospitalizations have been observed in recent years^{1,5}.

Guidelines have been developed for the management of patients with NSTEMI-ACS^{2,4}. There are nine Class I Recommendations with A Level of Evidence in China's guideline for hospitalized NSTEMI-ACS patients. The American Heart Association/American College of Cardiology (AHA/ACC) and European Society of Cardiology (ESC) guidelines have similar recommendations. The nine recommendations are as follows: (1) Cardiac troponin measurement; (2) Risk stratification for patients; (3) Dual antiplatelet therapy (DAPT) (aspirin plus a P2Y₁₂ inhibitor) in the acute phase; (4) Early invasive strategy (<24 hours) for patients at high risk, and invasive strategy (<72 hours) for patients at intermediate risk; (5) DAPT for long-term management of NSTEMI-ACS patients; (6) Angiotensin converting enzyme inhibitor/angiotensin receptor blocker (ACEI/ARB) for long-term management after NSTEMI-ACS for patients with left ventricular ejection fraction (LVEF) ≤40%, hypertension or diabetes; (7) β-blocker for long-term management after NSTEMI-ACS for patients with LVEF ≤40%; (8) Statin therapy for long-term management after NSTEMI-ACS; (9) Smoking cessation. If these evidence-based management strategies are applied to eligible patients with NSTEMI-ACS, the short-term and long-term outcomes of these patients will be improved. Measuring hospital performance on the nine management strategies can reflect the quality of care for hospitalized NSTEMI-ACS patients, and identify the key areas for further quality improvement^{6,7}. Therefore, quality improvement initiatives in the United States, Australia, Brazil, and Sweden, and cooperative registries across countries are using these quality metrics to continuously report and improve quality of care for patients with NSTEMI-ACS⁸⁻¹⁰. In China, several studies have reported gaps between guidelines and care practices for patients with NSTEMI-ACS for certain treatments¹¹⁻¹³. However, few studies have systematically evaluated the overall quality of care for hospitalized patients with NSTEMI-ACS and examined variations in quality of care across hospitals in China.

Improving Care for Cardiovascular Disease in China (CCC) is a collaborative project of the AHA and the Chinese Society of Cardiology (CSC). The objective of CCC-ACS project is to extend the use of evidence-based guidelines and improve patient care for ACS patients¹⁴. Based on CCC-ACS project, this study aimed to examine the overall performance on the nine management strategies with Class I Recommendation and A Level of Evidence for hospitalized NSTEMI-ACS patients and investigate variations in the performance across hospitals in China.

Methods

CCC-ACS registry

The CCC-ACS project is an ongoing registry and quality improvement project focusing on the quality of care for hospitalized patients with ACS. The project has been registered at the [clinicaltrials.gov](http://www.clinicaltrials.gov) (URL: <http://www.clinicaltrials.gov>; Unique identifier: NCT02306616). Details regarding the project design and methodology have been published elsewhere¹⁴. In brief, the project was launched in 2014, and the following steps were used to recruit hospitals. Firstly, mainland China was divided into 7 geographical regions (Northern, Northeastern, Eastern, Central, Southern, Southwestern, and Northwestern China). Secondly, in each region, provinces were grouped into four groups according to gross domestic product per capita (low, medium-low, medium-high, and high). Thirdly, in each geographic-economic stratum, 10% of the tertiary hospitals were recruited. Hospitals with ACS case volume more than 20 per month and were willing to participate in the project were recruited. Finally, a total of 150 hospitals were recruited across 30 provinces in China. Details of the hospital sampling frame of CCC-ACS project and participating hospitals are shown in the Supplemental Material. In each hospital, the first 20 to 30 eligible patients with a principal discharge diagnosis of ACS were consecutively recruited and reported to the CCC-ACS project on a monthly basis. Among all the ACS cases, acute myocardial infarction (AMI) cases have reporting priority.

The project used a standard web-based data collection platform to collect data. Trained data abstractors from each hospital were responsible for abstracting data from patients' medical charts using standardized definitions. Information abstracted included patients' characteristics, clinical presentation, diagnosis and risk evaluation, medical history, in-hospital management, discharge medications and in-hospital outcomes.

Multiple strategies were used to ensure the accuracy and completeness of the data. Regular on-site quality audits by third-party clinical research associates were performed to ensure enrollment of consecutive patients. Comparisons of reported data with the original medical records were conducted for 5% of reported cases, which were selected randomly.

Participating hospitals and study population

Between November 1, 2014 and June 30, 2018, 30,216 patients with NSTEMI-ACS from 150 tertiary hospitals were reported to the registry. We excluded 1447 patients because information on cardiac enzyme levels was unavailable. In addition, 26 hospitals were excluded because they reported fewer than 50 cases during the study period (599 patients were excluded). Finally, 28,170 patients with NSTEMI-ACS from 124 hospitals were included in this analysis. Institutional Review Board approval for this study was granted by the Ethics Committee of Beijing

Anzhen Hospital, Capital Medical University. No informed consent was required from individual patients. The CCC-ACS project is a collaborative study of AHA and CSC. The AHA has received fund from Pfizer for quality improvement initiatives through an independent grant for learning and change. The authors are solely responsible for the design and conduct of this study, all the analyses, the drafting and editing of the manuscript.

Definition of NSTEMI-ACS

NSTEMI-ACS was defined according to the guideline for diagnosis and management of patients with NSTEMI-ACS issued by the CSC in 2016⁴. Diagnosis of NSTEMI-ACS is based on chest pain, electrocardiogram, and measurements of biomarkers of myocardial necrosis: troponin I (TnI) or troponin T (TnT). Compared with patients with NSTEMI, those with UAP do not experience myocardial necrosis. The definition of NSTEMI-ACS was consistent with the definition of NSTEMI-ACS in the 2014 AHA/ACC guideline and the 2015 ESC guideline^{2,3}.

The nine management strategies with Class I Recommendation and A Level of Evidence

Performance on the nine management strategies with Class I Recommendation and A Level of Evidence in the CSC guideline for the management of patients with NSTEMI-ACS were evaluated among eligible patients⁴. The 9 management strategies we evaluated were: (1) cardiac troponin measurement; (2) risk stratification; (3) DAPT within 24 hours; (4) percutaneous coronary intervention (PCI) within recommended times for patients with high or intermediate risk (PCI within 24 hours for patients with high risk, and PCI within 72 hours for patients with intermediate risk). (5) DAPT at discharge; (6) ACEI/ARB at discharge; (7) β -blocker at discharge; (8) statin at discharge; and (9) smoking cessation counseling at discharge.

Definition of variables

Risk stratification criteria proposed by the 2015 ESC guideline and 2016 CSC guideline for the management of NSTEMI-ACS was used to classify patients as "very high risk", "high risk", "intermediate risk" and "low risk". Patients were classified as very high risk if they had ≥ 1 of the following conditions: hemodynamic instability or cardiogenic shock, recurrent or ongoing chest pain refractory to medical treatment, life-threatening arrhythmias or cardiac arrest, mechanical complications of myocardial infarction, acute heart failure, and recurrent dynamic ST- or T-wave changes (particularly with intermittent ST elevation). Patients were classified as high risk if they had ≥ 1 of the following conditions: increase or decrease in cardiac troponin compatible with myocardial infarction, dynamic ST- or T-wave changes or global registry of acute coronary events

(GRACE) score ≥ 140 . Patients were classified as intermediate risk if they had ≥ 1 of the following conditions: diabetes mellitus, renal insufficiency, LVEF $< 40\%$ or congestive heart failure, early post-infarction angina, previous PCI, previous coronary artery bypass grafting, or a GRACE risk score > 109 and < 140 . Patients without any of these conditions were defined as low risk.

Types of medical insurance were defined according to reimbursement received. Insurance with full reimbursement, basic medical insurance for urban employees, basic medical insurance for urban unemployed residents and commercial insurance were combined as medical insurance with high reimbursement. New rural cooperative medical insurance was defined as medical insurance with medium reimbursement. No medical insurance, special assistance for the poor and other types of medical insurance were defined as medical insurance with low reimbursement. Elevated TnT or TnI were defined as serum TnT or TnI level exceeding the upper limit of the normal range. Elevated creatine kinase MB isoenzyme (CK-MB) was defined as serum CK-MB level exceeding double the upper limit of the normal range. Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mmHg or diastolic blood pressure (DBP) ≥ 90 mmHg on admission, having a history of hypertension or receiving antihypertensive therapy. Diabetes mellitus was defined as fasting blood glucose ≥ 7.0 mmol/L (126 mg/dL) or HbA1c $\geq 6.5\%$, having a history of diabetes mellitus, or receiving glucose-lowering drugs. Elevated low-density lipoprotein cholesterol (LDL-C) levels were defined as serum LDL-C ≥ 1.81 mmol/L (70 mg/dL). Smoking was defined as having smoked cigarettes in the past 1 year. Severe clinical conditions (including heart failure, cardiac arrest, and cardiac shock) were defined as those occurred within 24 hours of the onset of NSTEMI-ACS.

Statistical analysis

The proportion of patients receiving defect-free care was calculated as the total number of eligible patients who received all of the required management strategies, divided by the total number of patients eligible for the management strategies¹⁵. Patient eligibility for a specific management strategy was defined by the guidelines for management of patients with NSTEMI-ACS²⁻⁴. In addition, hospital performance on each individual management strategy was evaluated by calculating the proportion of eligible patients receiving each management strategy. The denominators and numerators for each management strategy were summarized in the Supplemental Material. Variations in the proportion of patients receiving defect-free care and performance on each individual management strategy across hospitals were examined by aggregating the data at the hospital level.

Table 1. Demographics and clinical characteristics of patients with NSTEMI-ACS enrolled from November 2014 to June 2018 (n = 28,170).

Characteristics	Total	NSTEMI	UAP	P *
	(n = 28,170)	(n = 22,096)	(n = 6074)	
Female	8572 (30.4)	6479 (29.3)	2093 (34.5)	<.0001
Age (years) †	65.0 ± 11.9	65.2 ± 12.2	64.3 ± 10.9	<.0001
<50	2978 (10.6)	2451 (11.1)	527 (8.7)	
50–75	18,552 (65.9)	14,183 (64.2)	4369 (71.9)	
≥75	6640 (23.6)	5462 (24.7)	1178 (19.4)	
Length of hospital stay (days) ‡	9.0 (7.0–12.0)	9.0 (7.0–13.0)	8.0 (6.0–11.0)	<.0001
<7	6484 (23.0)	4723 (21.4)	1761 (29.0)	
7–14	16,404 (58.2)	12,873 (58.3)	3531 (58.1)	
≥14	5282 (18.8)	4500 (20.4)	782 (12.9)	
Medical insurance				.0007
High reimbursement	17,225 (61.2)	13,383 (60.6)	3842 (63.2)	
Medium reimbursement	5187 (18.4)	4133 (18.7)	1054 (17.4)	
Low reimbursement	5758 (20.4)	4580 (20.7)	1178 (19.4)	
Systolic blood pressure (mmHg) †	135.3 ± 22.8	134.7 ± 23.3	137.4 ± 20.6	<.0001
Diastolic blood pressure (mmHg) †	78.7 ± 13.7	78.6 ± 14.0	79.0 ± 12.4	.0277
Heart rate (bpm) †	76.6 ± 15.6	77.4 ± 16.2	73.5 ± 12.7	<.0001
Killip class at admission				<.0001
I	19,964 (70.9)	15,416 (69.8)	4548 (74.9)	
II-III	7405 (26.3)	5919 (26.8)	1486 (24.5)	
IV	801 (2.8)	761 (3.4)	40 (0.7)	
Time from symptom onset to hospital admission (hours) †§	18.7(4.7–96.9)	11.5 (4.1–39.8)	73.0(7.8–287.0)	<.0001
Elevated TnT or TnI	20,081 (71.3)	20,081 (90.9)	0 (0)	<.0001
5-fold elevated TnT or TnI	15,481 (55.0)	15,481(70.1)	0 (0)	<.0001
Elevated CK-MB	8495 (30.2)	8495 (38.4)	0 (0)	<.0001
Heart failure at admission	2247 (8.0)	2112 (9.6)	135 (2.2)	<.0001
Cardiac arrest at admission	194 (0.7)	182 (0.8)	12 (0.2)	<.0001
Cardiac shock at admission	334 (1.2)	321 (1.5)	13 (0.2)	<.0001
Diabetes mellitus	12,203 (43.3)	9911 (44.9)	2292 (37.7)	<.0001
Hypertension	20,352 (72.2)	15,899 (72.0)	4453 (73.3)	.0363
Elevated LDL-C	22,687 (80.5)	18,154 (82.2)	4533 (74.6)	<.0001
Previous MI	3396 (12.1)	2676 (12.1)	720 (11.9)	.4962
Previous reperfusion	3845 (13.7)	2650 (12.0)	1195 (19.7)	<.0001
Heart failure history	1008 (3.6)	837 (3.8)	169 (2.8)	.0002
Chronic kidney disease history	769 (2.7)	694 (3.1)	75 (1.2)	<.0001
Cerebrovascular disease history	3052 (10.8)	2507 (11.4)	545 (9.0)	<.0001
Smoking	10,086 (35.8)	8272 (37.4)	1814 (29.9)	<.0001
Grace score †	138.0 ± 37.6	143.0 ± 37.6	116.4 ± 29.1	<.0001
Grace score > 140	11,298 (40.1)	10,233 (46.3)	1065 (17.5)	
Risk stratification at early stage				<.0001
Unavailable risk assessment	377 (1.3)	69 (0.3)	308 (5.1)	
Low risk	1193 (4.2)	207 (0.9)	986 (16.2)	
Intermediate risk	3121 (11.1)	573 (2.6)	2548 (41.9)	
High risk	17,921 (63.6)	16,252 (73.6)	1669 (27.5)	
Very high risk	5558 (19.7)	4995 (22.6)	563 (9.3)	

Abbreviations: NSTEMI-ACS, non-ST-segment elevation acute coronary syndrome; NSTEMI, non-ST-segment elevation myocardial infarction; UAP, unstable angina pectoris; TnT, troponin T; TnI, troponin I; CK-MB, creatine kinase MB; LDL-C, low-density lipoprotein cholesterol; MI, myocardial infarction; GRACE, global registry of acute coronary events.

*P value was calculated by χ^2 test or Fisher exact test for categorical variables, and t test or Mann-Whitney U test for continuous variables.

†Mean ± SD.

‡ Median (interquartile range).

§ Time from symptom onset to hospital admission was presented only for patients that were treated at the index hospital as the first medical contact site.

Patients' demographic and clinical characteristics were summarized using mean ± standard deviation or median (interquartile range (IQR)) for continuous variables and frequencies for categorical variables. For comparisons of continuous variables between groups, unpaired t test or Mann-Whitney U test was performed, while χ^2 test or

Fisher exact test was used for categorical variables. For variables with missing value, the IVEware software version 0.2 (Survey Research Center, University of Michigan, Ann Arbor, MI, USA) was used to impute the missing value with the sequential regression multiple imputation method. Time from symptom onset to

Table 2. Characteristics of the hospitals participating in the CCC-ACS project (n = 124).

Characteristics	n (%)
Location	
North	23 (18.5)
East	40 (32.3)
South	15 (12.1)
Central	13 (10.5)
Northeast	16 (12.9)
Southwest	9 (7.2)
Northwest	8 (6.5)
Bed size*	2000 (1500–2600)
Academic hospital	119 (96.0)
Annual ACS volume*	1200 (651–2300)
Annual PCI volume*	1000 (600–1960)

Abbreviations: ACS, acute coronary syndrome; PCI, percutaneous coronary intervention;

* Median (interquartile range).

admission was not imputed since 33% of the data was missing. Missing rates of each variable and the management of missing data were listed in the Supplemental Material. All analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC). $P < .05$ was considered statistically significant.

Results

Patients' demographics and clinical characteristics

Patients' demographics and clinical characteristics were summarized in Table 1. Among 28,170 NSTEMI-ACS patients from 124 hospitals, 78.4% were NSTEMI and 21.6% were UAP. Female patients account for 30.4% of all the patients. Patients' mean age was 65.0 ± 11.9 years, and the median length of hospital stay was 9 days (IQR, 7–12 days). At admission, 8.0% of the patients had heart failure, 1.2% had cardiac shock and 0.7% had cardiac arrest. Analysis of comorbidities showed that, 43.3% of the patients had diabetes mellitus, 72.2% had hypertension, and 80.5% had elevated LDL-C. A total of 19.7% of the patients were classified as very high risk and 63.6% as high risk. Differences in demographics and clinical characteristics were observed between patients with NSTEMI and UAP (Table 1).

Characteristics of hospitals participating in the CCC-ACS project

A total of 96.0% of the hospitals were academic hospitals. The median (IQR) of hospital annual ACS volume was 1200 (651–2300) (Table 2).

Hospital performance on the nine management strategies with Class I Recommendation and A Level of Evidence

The eligibility on all of the management strategies was available for 24,956 patients. Overall, 16% (3880/24,956) of the patients received defect-free care. The proportion

Table 3. Proportion of patients receiving defect-free care according to patients' characteristics and characteristics of the hospitals caring for the patients (n = 24,956)*.

Characteristics	Proportion of patients receiving defect-free care	P^{\dagger}
Patients' characteristics		
NSTEMI-ACS types		
NSTEMI	3040 (15.5)	.7415
UAP	840 (15.7)	
Age (years)		
<50	367 (14.0)	<.0001
50–75	2431 (14.9)	
≥ 75	1082 (18.1)	
Sex		
Female	1347 (17.5)	<.0001
Male	2533 (14.7)	
Medical insurance		
High reimbursement	2499 (16.3)	<.0001
Medium reimbursement	710 (15.3)	
Low reimbursement	671 (13.4)	
Risk stratification at early stage		
Low risk	224 (18.8)	<.0001
Moderate risk	358 (14.1)	
High risk	1764 (11.5)	
Very high risk	1477 (26.6)	
Hospital characteristics		
Location		
North	568 (10.7)	<.0001
East	1377 (17.0)	
South	524 (17.4)	
Central	539 (19.6)	
Northeast	489 (16.8)	
Southwest	250 (15.5)	
Northwest	133 (10.5)	
Academic hospital		
Yes	3795 (15.7)	<.0001
No	17 (3.5)	
Bed size		
≤ 2000	2163 (16.5)	<.0001
>2000	1717 (14.5)	
Annual ACS volume		
≤ 1000	2073 (17.4)	<.0001
>1000	1807 (13.9)	
Annual PCI volume		
≤ 1000	2220 (18.3)	<.0001
>1000	1660 (12.9)	

Abbreviations: NSTEMI-ACS, non-ST-segment elevation acute coronary syndrome; NSTEMI, non-ST-segment elevation myocardial infarction; UAP, unstable angina pectoris; PCI, percutaneous coronary intervention;

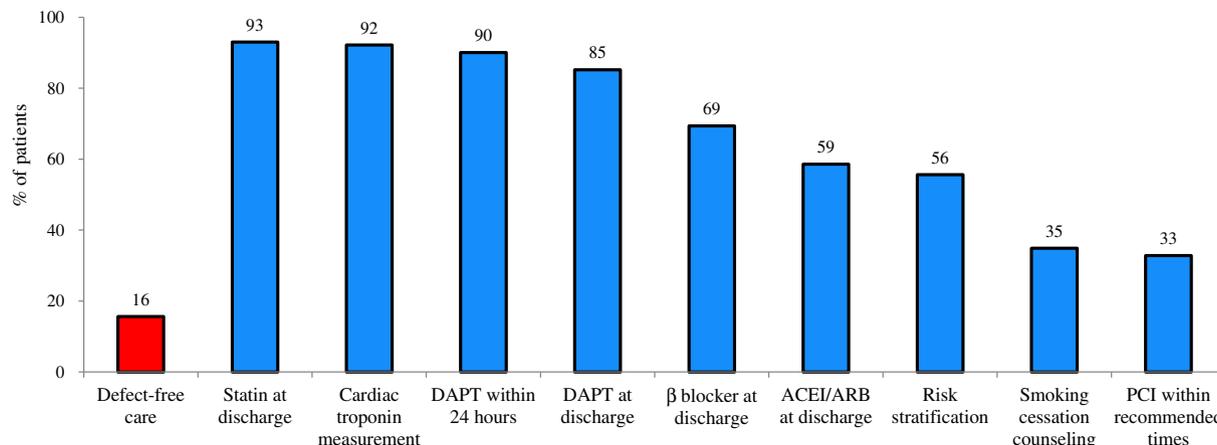
*Only patients with information on eligibility of all the management strategies were included.

$\dagger P$ value was calculated by χ^2 test or Fisher exact test.

of patients receiving defect-free care varied according to patients' characteristics and characteristics of the hospitals caring for the patients (Table 3).

When evaluated separately, there was substantial difference in hospital performance on the nine management strategies (Figure 1). Metrics with higher performance were statin at discharge (93%), cardiac troponin measurement (92%), DAPT within 24 hours (90%), and DAPT at discharge

Figure 1



Proportion of eligible patients receiving defect-free care and each individual management strategy with Class I Recommendation and A Level of Evidence. Abbreviations: DAPT, dual antiplatelet therapy (aspirin plus a P2Y₁₂ inhibitor); ACEI/ARB, angiotensin converting enzyme inhibitor/angiotensin receptor blocker; PCI, percutaneous coronary intervention.

(85%). These were followed by β-blocker at discharge (69%), ACEI/ARB at discharge (59%), and risk stratification (56%). Metrics with lower performance were smoking cessation counseling at discharge (35%) and PCI within recommended times (33%). A detailed analysis of information on invasive management showed that 67.9% of the patients with intermediate risk and 69.2% of patients with high risk received PCI. Among those who received PCI, 57.5% of patients with intermediate risk received PCI within 72 hours, and 30.1% with high risk received PCI within 24 hours.

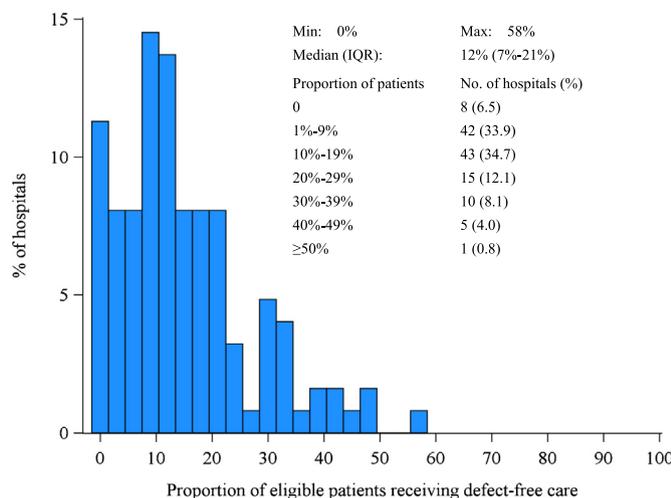
Hospital-level variations in the performance

The proportion of patients receiving defect-free care varied across hospitals, ranging from 0% to 58% (Median (IQR): 12% (7%-21%)). In 6.5% of the hospitals, no patients received defect-free care. In 33.9% of the hospitals, less than 10% of the patients received defect-free care, and in only one hospital, more than 50% of the patients received defect-free care (Figure 2).

Figure 3 shows the hospital-level variations in the proportion of patients receiving each management strategy. The proportion of patients receiving risk stratification and smoking cessation counseling at discharge varied substantially across hospitals. Risk stratification was performed on no patients in 4.0% of the hospitals, less than 50% of the patients in 41.9% of the hospitals, more than 50% of the patients in 53.2% of the hospitals, and all the patients in only 1 hospital. Smoking cessation counseling was delivered to no patients in 13.0% of the hospitals, less than 50% of the patients in 54.0% of the hospitals, and more than 80% of the patients in 15.3% of the hospitals.

The proportion of patients receiving PCI within recommended times, ACEI/ARB at discharge, and β-blocker at discharge also showed large variability across hospitals. In hospitals with good performance, these three management strategies were applied to more than 80%, even 100% of the patients. However, in hospitals with lower performance, these management strategies were applied to few or none of the patients. The distribution of hospital performance on metric of PCI within recommended times was left-skewed. No patients underwent PCI within recommended times in 2.4% of the hospitals, and less than 50% of the patients underwent PCI within recommended times in 83.7% of the hospitals. In terms of the variations in proportion of high risk patients receiving PCI within 24 hours, no patients received PCI within 24 hours in 7.4% of the hospitals, and less than 50% of the patients received PCI within 24 hours in 81.1% of the hospitals (Figure 4). There were also variations in the proportion of intermediate risk patients receiving PCI within 72 hours. No patients received PCI within 72 hours in one hospital, and less than 50% of the patients received PCI within 72 hours in 27.5% of the hospitals (Figure 5). For ACEI/ARB at discharge and β-blocker at discharge, the distribution of hospital performance was right-skewed. More than 50% of the patients received ACEI/ARB at discharge in 67.0% of the hospitals, and more than 50% of the patients received β-blockers at discharge in 84.0% of the hospitals.

Other metrics including cardiac troponin measurement, DAPT within 24 hours, DAPT at discharge, and statin at discharge showed less variability across hospitals. However, there were still some hospitals with low performance on these four management strategies.

Figure 2

Distribution of the proportion of eligible patients receiving defect-free care across hospitals (n = 124).

Discussion

To our best knowledge, this was the first study that systematically examined the overall quality of care as well as hospital-level variations in quality of care for hospitalized patients with NSTEMI-ACS based on a nationally representative sample from tertiary hospitals in China.

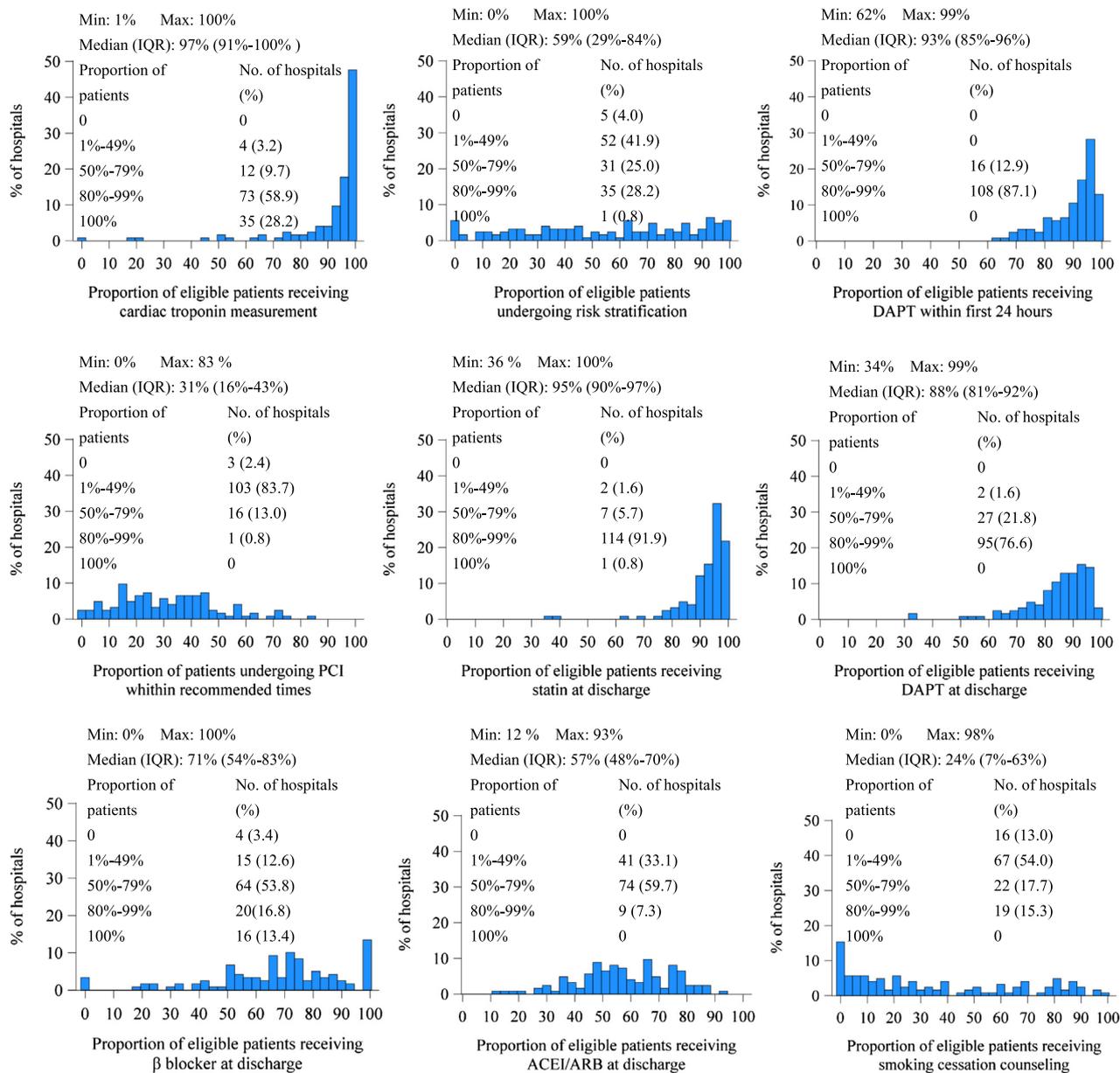
First, we found that one in six patients hospitalized with NSTEMI-ACS received defect-free high-quality care, which suggested that the evidence-based guidelines have not been adequately implemented in the daily clinical practice for patients with NSTEMI-ACS in China. All the hospitals in our study were tertiary hospitals, performance might be even worse in community hospitals or non-academic centers. Thus the striking underuse of evidence-based management strategies highlighted the urgent need for quality improvement efforts in China. The next step would be the identification of the reasons for the underuse. Our data have shown that patients' characteristics may be one consideration of the care providers, and affect the delivery of guideline-recommended management strategies. In addition, the delivery of defect-free care also differed by hospital characteristics. A qualitative research of the care providers from Clinical Pathways for Acute Coronary Syndromes in China (CPACS) has provided further insights. The study found several system barriers to the implementation of evidence-based care including lack of leadership support, variations in capacity and resources of hospitals, fears of patient disputes, and out-of-pocket expenses¹⁶. Further studies are needed to identify the reasons for the underuse of evidence-based management strategies.

Second, three management strategies (statin at discharge, DAPT within 24 hours, and DAPT at discharge)

showed good overall performance, as more than 80% of eligible patients received each management strategy. The performance was similar to that of hospitals in the study of Long-term Follow-up of Anti-thrombotic Management Patterns in Acute Coronary Syndrome Patients, which enrolled hospitals from 20 countries across Europe and Latin America¹⁷. In the present study, the overall performance on cardiac troponin measurement was nearly optimal (92%). Some hospitals in China were still using CK-MB to detect myocardial injury. This may somewhat contribute to the underuse of cardiac troponin.

The application of management strategies including β -blocker at discharge, ACEI/ARB at discharge, risk stratification, smoking cessation counseling and PCI within recommended times was far from optimal. Findings from the study of CPACS revealed that among patients who were not prescribed β -blockers and ACEI/ARB at discharge, the reason of "Not indicated by the clinicians" was documented for 34.7% and 9.4% of the patients, respectively¹². Risk stratification for patients with NSTEMI-ACS guides the selection of treatment strategies (ischemia-guided strategy or early invasive strategy). However, about half of the patients in our study did not undergo risk stratification, which implied that the management of these patients was not based on their risk. In terms of management strategy of smoking cessation counseling at discharge, a meta-analysis of cohort studies has demonstrated that smoking cessation after AMI was associated with nearly 50% reduction in mortality compared with patients who continued to smoke¹⁸. Another study found that patients who continued to smoke after ACS had an 80% risk of lower survival, whereas those who quit smoking had comparable

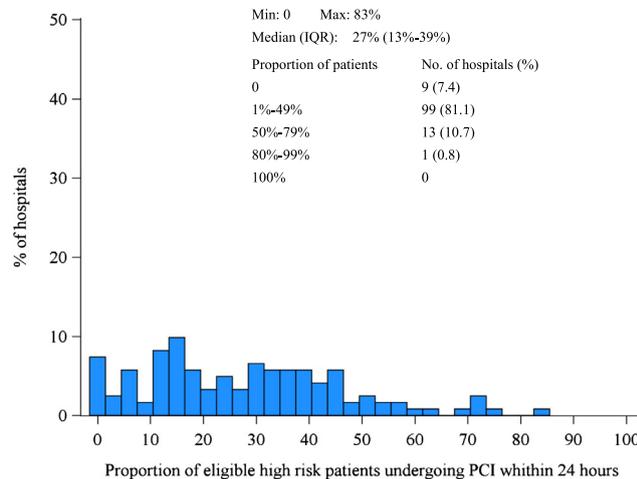
Figure 3



Distribution of the proportion of eligible patients receiving individual management strategies (Class I Recommendation and A Level of Evidence) across hospitals. Abbreviations: DAPT, dual antiplatelet therapy (aspirin plus a P2Y₁₂ inhibitor); ACEI/ARB, angiotensin converting enzyme inhibitor/angiotensin receptor blocker; PCI, percutaneous coronary intervention; IQR, interquartile range.

survival with non-smokers¹⁹. The benefits of smoking cessation are evident. Besides, smoking cessation counseling is a low-cost intervention that is easy to apply. Therefore, more efforts should be made to improve the rate of smoking cessation counseling. Analysis of the management strategy “PCI within recommended times” showed about 70% of

NSTE-ACS patients with high or intermediate risk underwent PCI, but only one third received PCI within recommended times. Although the use of invasive procedure in China has been increased in recent years²⁰, there remains room for improvement in the timeliness of PCI for patients with NSTE-ACS, especially for patients with high risk. The reasons for

Figure 4

Distribution of the proportion of eligible patients with high risk receiving PCI within 24 hours across hospitals (n = 122)*. *Only hospitals with more than 10 patients with documented time from hospital admission to PCI were included. Abbreviations: PCI, percutaneous coronary intervention; IQR, interquartile range.

the delay in PCI were unknown, but a previous qualitative study provided some insights. The study interviewed directors and doctors of the cardiology department and found factors related to delays in PCI included limited and overburdened catheterization facilities, financial burden, and patient-related factors¹⁶.

Third, there was large variability across hospitals in the proportion of patients receiving defect-free care as well as performance on five individual management strategies (risk stratification, smoking cessation counseling at discharge, PCI within recommended times, ACEI/ARB at discharge, and β -blocker at discharge). The heterogeneity of care across hospitals will result in the inequity in receiving evidence-based care for patients with NSTEMI-ACS presenting at different hospitals. Previous studies have shown that every 10% increase in composite opportunity-based adherence to guidelines in a hospital was associated with a 10% decrease in adjusted in-hospital mortality among patients²¹. This suggested that the inequity in receiving evidence-based care may be associated with variations in clinical outcomes.

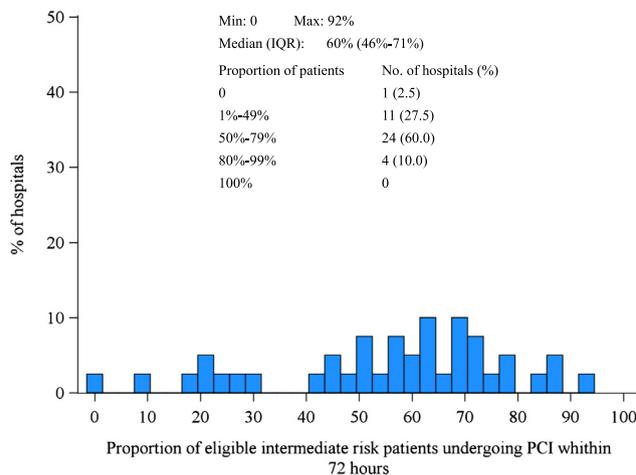
As for the 5 individual management strategies with large variability across hospitals, the performance in hospitals with good performance was similar to that of hospitals participating in the Get With The Guidelines-Coronary Artery Disease (GWTG-CAD) program²². Variability across hospitals in China showed the potential for quality improvement, and the finding was inspiring as it implied that the goal of delivering evidence-based care to all the patients was achievable, at least for some management strategies. Further studies are needed to identify the factors that are unique to hospitals with good performance, and effective hospital-level interventions

will play important roles in improving the use of evidence-based management strategies in hospitals with low performance.

Management strategies such as DAPT within 24 hours, cardiac troponin measurement, DAPT at discharge, and statin at discharge, were delivered to more than 80% of the patients and showed small variability across hospitals. However, a few of hospitals with low performance on these management strategies worth noting. Qualitative research may be helpful in identifying the reasons for the underuse of these strategies in such hospitals.

In recent years, China's government has made great efforts to explore the appropriate models for quality report and improvement in China. In 2009, the National Health Commission of the People's Republic of China initiated a pilot study of clinical pathways for several diseases and procedures (including PCI for NSTEMI-ACS) in 50 tertiary hospitals²³. In 2016, clinical pathways for 1010 diseases and procedures (including AMI) have been developed and extended to all the hospitals. The implementation of clinical pathway in the management of diseases was linked to the hospital performance evaluation, which stimulated the health care providers to deliver guideline-directed care. Findings from CPACS study revealed that the pathway implementation was associated with improved secondary prevention treatments for patients with ACS in China²⁴. Another attempt was the single disease quality control in tertiary hospitals initiated in 2009. AMI was included in the first batch of the diseases²⁵. These efforts showed the national support for quality improvement. Successful experience from other quality improvement initiatives such as GWTG-CAD program, and the European Quality Improvement Program for

Figure 5



Distribution of the proportion of eligible patients with intermediate risk receiving PCI within 72 hours across hospitals (n = 40)*. *Only hospitals with more than 10 patients with documented time from hospital admission to PCI were included. Abbreviations: PCI, percutaneous coronary intervention; IQR, interquartile range.

Acute Coronary Syndromes (EQUIP-ACS), have shown that quality improvement requires a system that can systematically and continuously monitor and feedback the quality of care using established quality metrics, and multiple measures targeting the problems should be taken to improve the quality of care^{26,27}. China's quality improvement effort might begin with the establishment of a quality improvement system, and a comprehensive investigation into the barriers of delivering evidence-based care is needed to guide further quality improvement. The CCC project used multifaceted strategies including monthly feedback of quality report, regional workshops, webinars, hospital recognition and experience sharing to improve quality of care for ACS patients. Hopefully, the project will provide important experience to inform quality improvement initiatives in China.

The study should be interpreted in the context of several limitations. First, the proportion of patients receiving defect-free care was calculated as the total number of eligible patients who received all the required management strategies, divided by the total number of patients eligible for the management strategies. Any inappropriate use of the management strategies was not evaluated. Second, all the hospitals in our study were tertiary hospitals, and there were substantial differences between hospitals at different levels in China. Therefore, the findings cannot be generalized to all the hospitals in China.

Conclusions

About one in six patients with NSTEMI-ACS in China received defect-free high-quality care, and the perfor-

mance varied across hospitals. Our findings highlight the urgent need for quality improvement initiatives in China. Further studies are needed to clarify the reasons for the underuse of these recommended management strategies and establish effective strategies to improve the use of evidence-based guidelines as well as decrease variations across hospitals. The present findings may serve as the baseline quality of care for patients with NSTEMI-ACS in China, continuous report and improvement of quality of care is expected through the implementation of CCC-ACS project.

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Disclosures

Dr. Gregg C. Fonarow reports consulting for Bayer, Janssen, and Novartis. Dr. Dong Zhao reports attending consulting sessions by Bayer, Pfizer, and Boehringer-Ingelheim.

Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ahj.2019.02.012>.

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