UCLA
UCLA Previously Published Works

Title

Chest Pain Center Accreditation Is Associated With Improved In-Hospital Outcomes of Acute Myocardial Infarction Patients in China: Findings From the CCC-ACS Project

Permalink

https://escholarship.org/uc/item/4sb973pw

Journal

Journal of the American Heart Association, 8(21)

ISSN

2047-9980

Authors

Fan, Fangfang
Li, Yuxi
Zhang, Yan
et al.

Publication Date

2019-11-05

DOI

10.1161/jaha.119.013384

Peer reviewed

Chest Pain Center Accreditation Is Associated With Improved In-Hospital Outcomes of Acute Myocardial Infarction Patients in China: Findings From the CCC-ACS Project

Fangfang Fan, MD;* Yuxi Li, MD;* Yan Zhang, MD; Jianping Li, MD; Jing Liu, MD, PhD; Yongchen Hao, PhD; Sidney C. Smith Jr., MD; Gregg C. Fonarow, MD; Kathryn A. Taubert, PhD; Junbo Ge, MD, PhD; Dong Zhao, MD, PhD; Yong Huo, MD; on behalf of the CCC-ACS Investigators[†]

Background—Chest pain center (CPC) accreditation plays an important role in the management of acute myocardial infarction (AMI). However, no evidence shows whether the outcomes of AMI patients are improved with CPC accreditation in China.

Methods and Results—This retrospective analysis is based on a predesigned nationwide registry, CCC-ACS (Improving Care for Cardiovascular Disease in China-Acute Coronary Syndrome). The primary outcome was major adverse cardiovascular events (MACE), including all-cause death, reinfarction, stent thrombosis, stroke, and heart failure. A total of 15 344 AMI patients, from 40 CPC-accredited hospitals, were enrolled, including 7544 admitted before and 7800 after accreditation. In propensity score matching, 6700 patients in each group were matched. The incidence of 7-day MACE (6.7% versus 8.0%; *P*=0.003) and all-cause death (1.1% versus 1.6%; *P*=0.021) was lower after accreditation. In multivariate adjusted mixed-effects Cox proportional hazards models, CPC accreditation was associated with significantly decreased risk of MACE (hazard ratio: 0.78; 95% CI, 0.68–0.91) and all-cause death (hazard ratio: 0.71; 95% CI, 0.51–0.99). The risk of MACE and all-cause death both followed a reverse J-shaped trend: the risk of MACE and all-cause death decreased gradually after achieving CPC accreditation, with minimal risk occurring in the first year, but increased in the second year and after.

Conclusions—Based on a large-scale national registry data set, CPC accreditation was associated with better in-hospital outcomes for AMI patients. However, the benefits seemed to attenuate over time, and reaccreditation may be essential for maintaining AMI care quality and outcomes. (***J Am Heart Assoc***. 2019;8:e013384. DOI: 10.1161/JAHA.119.013384.)

Key Words: accreditation • acute myocardial infarction • chest pain center • China • in-hospital outcomes

S ince 1981, when the concept of the chest pain center (CPC) was introduced, studies have shown that CPC is associated with improving timing of chest pain diagnosis, reperfusion time of ST-segment–elevation myocardial infarction (STEMI) and reduced readmissions and costs.[1–4] Accreditation by the Society of Chest Pain Centers (now known as the American College of Cardiology [ACC] accreditation committee) has further standardized CPCs in the United States, and the ACC accreditation committee has promoted international accreditation standards since 2010.[5–7] Several countries have also established their national CPC accreditation projects, such as the Chest Pain Unit Certification Working Group issued by the German Society of Cardiology.[8–10]

Clinical Perspective

What Is New?

- This is the first study focus on the association of chest pain center accreditation with improved in-hospital major adverse cardiovascular events of acute myocardial infarction patients in China based on a large-scale national registry covering 15 344 patients from 40 hospitals.

What are the Clinical Implications?

- This study demonstrated and confirmed the importance and effectiveness of chest pain center development and accreditation in China.
- Hazards for the risk of outcomes during the in-hospital period as a function of the duration of accreditation followed a reverse J-shaped trend, with the maximum associated effectiveness occurring up until the first year after accreditation, supporting the rationale of the recently established CPC reaccreditation project to ensure a long-lasting effect after initial CPC accreditation.

The incidence and mortality of acute myocardial infarction (AMI) are increasing in China, and the in-hospital mortality of STEMI patients has not improved over the past decade.[11–13] The development of CPCs in China was initiated in 2010, and the headquarters of China Chest Pain Centers, which oversees CPC accreditation, was officially established in July 2016 to coordinate social resources and promote the rapid development of CPCs.[14,15] To date, evidence has not shown whether the outcomes of AMI patients are improved by CPC accreditation in China. The purpose of this study was to evaluate whether patients admitted for AMI after CPC accreditation had better in-hospital outcomes than those admitted before accreditation and to further study the temporal associations of the accreditation process on AMI quality improvement.

Methods

For the concern about intellectual property and patient privacy, the data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure.

Study Design

The CCC-ACS (Improving Care for Cardiovascular Disease in China–Acute Coronary Syndrome) project is a nationwide registry and quality improvement study with an ongoing database focusing on quality of acute coronary syndrome care. Details of the study design and methodology of the CCC-ACS project have been described elsewhere.[16] A standard

procedure was used during data collecting from the patients' medical records, and third-party research associates performed regular quality audits to ensure the accuracy and completeness of research data. Institutional review board approval was granted for this research by the ethics committee of Beijing Anzhen Hospital, Capital Medical University, and no informed consent was required.

Study Population

From November 1, 2014, to June 30, 2017, a total of 63 641 patients diagnosed with acute coronary syndrome from 150 hospitals were registered in the database, among which 19 270 patients from 40 accredited hospitals during this period were included in this study. We excluded 2659 patients who were admitted to 10 hospitals with data only before or after accreditation and 1182 patients diagnosed with unstable angina pectoris. In addition, 85 patients with missing data about key variables for the identification of in-hospital outcomes and candidate factors were excluded. Finally, 15 344 patients were included in the final analyses (Figure 1).

In-Hospital Outcomes

In this study, the primary outcome was major adverse cardiovascular events (MACE), including all-cause death, reinfarction, stent thrombosis, stroke, and heart failure during hospitalization. The secondary outcome was in-hospital all-cause death. Only those incidents that occurred within 7 days
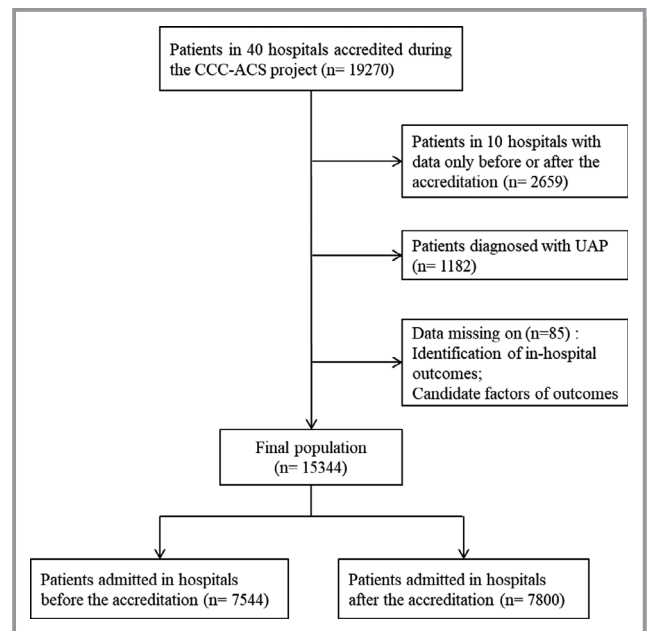

Figure 1. Flow diagram of selection of the study population. CCC-ACS indicates Improving Care for Cardiovascular Disease in China-Acute Coronary Syndrome; UAP, unstable angina pectoris.

of admission were taken into account for the analysis because the main effect of the CPC was reflected a short time after the first medical contact; there will be more censored data because of hospital discharge.

Statistical Analysis

Hospital information, demographic characteristics, medical history, clinical procedures, and 7-day in-hospital outcomes of the participants were compared by hospital status of accreditation (before and after) when each patient was admitted. Continuous variables were shown as mean±SD. Categorical variables were presented as the number (percentage). Differences in various characteristics among the groups were compared using the Student t test and χ^2 test.

The differences of 7-day in-hospital outcomes between the 2 groups were compared in a propensity score–matched population to minimize selection bias from the real world. Patients admitted to hospitals before accreditation were matched at a 1:1 ratio with randomly selected patients admitted to hospitals after accreditation, on the basis of nearest neighbor in terms of Mahalanobis distance with a caliper of 0.02. Propensity score was estimated with a logistic regression model with the variables of age; sex; hospital location (first-line municipality, provincial capital, or prefecture-level city); first medical contact site (no or yes); department arrived (emergency and catheter lab, or outpatient and others); comorbidities including smoking status, diabetes mellitus, hypertension, and dyslipidemia; heart failure history; renal failure history; previous myocardial infarction (MI); previous percutaneous coronary intervention or coronary artery bypass grafting; type of MI; Killip classes; preadmission use of aspirin; preadmission use of $P2Y_{12}$ receptor inhibitors; and preadmission use of statins.

The incidence of 7-day in-hospital outcomes by hospital status of accreditation in the whole study population and in the propensity score–matched subset were compared. Because some variables were not comparable between the 2 groups even after propensity score matching, we used mixed-effects Cox proportional hazards models containing Gaussian random effects, also known as frailty models, to compare the risk by adjusting other confounders in the logistic regression model, considering that this data set contained hospital-level information and the data structure was hierarchical.

Subgroup analyses of 7-day in-hospital outcomes were then performed according to important characteristics, including age (<65 or ≥65 years), sex (male or female), city type (provincial capital or prefecture-level city), first medical contact site (no or yes), department arrived (emergency and catheter lab, or outpatient and others), type of MI (STEMI or non-STEMI), Killip class I (no or yes), previous MI (no or yes), and previous percutaneous coronary intervention or coronary artery bypass grafting (no or yes).

Considering the quality improvement effect of the CCC-ACS project itself along with time, we performed sensitivity analyses in patients admitted to hospitals without accreditations during the project and those contemporarily admitted in hospitals after accreditation. Propensity score was also estimated with a logistic regression model with all of the listed variables included plus the admission date. Cox proportional hazards models were then used to compare the risk of 7-day in-hospital outcomes.

A 2-tailed $P<0.05$ was considered statistically significant in all analyses. R software (http://www.R-project.org) was used for all statistical analyses.

Results

Patient Characteristics

A total of 15 344 patients were enrolled in this study from 40 hospitals, including 7544 admitted before the accreditation and 7800 after accreditation. Baseline characteristics are shown in Table 1. Compared with patients admitted to hospitals when not accredited, those admitted after accreditation were mainly from hospitals in cities of provincial capitals, had the hospital as the first medical facility, and arrived in the emergency department and catheter lab. The postaccreditation group had more patients diagnosed with STEMI and had a higher proportion of patients with Killip class I. Comparing comorbidities, patients in the postaccreditation group were less likely to have hypertension, dyslipidemia, heart failure history, and previous MI but more likely to have previous percutaneous coronary intervention or coronary artery bypass grafting. In addition, there were fewer patients to be treated with statins in the postaccreditation group regarding preadmission medications.

After propensity score matching, postmatching absolute standardized differences were <10% for all covariates. The mirrored histograms before and after matching are shown in Figure S1 to present the propensity score distribution status. A total of 6700 patients in each group were matched. The characteristics of the 2 groups were recompared. In the propensity score–matched population, there were no significant differences of baseline characteristics between the 2 groups except for hypertension comorbidity (Table 1).

Seven-Day In-Hospital Outcomes

In-hospital outcomes within 7 days of admission were compared according to accreditation status (Table 2). In the whole study population, the incidence of MACE was significantly lower in patients admitted after accreditation compared with those admitted before accreditation (6.4% versus 8.4%; $P<0.001$), mainly due to heart failure. The incidence of all-cause death was

Table 1. Baseline Characteristics of the Study Population

Variable	Unmatched			Propensity Score Matched		
	Before Accreditation	After Accreditation	*P* Value	Before Accreditation	After Accreditation	*P* Value
n	7544	7800		6700	6700	
Age, y	62.48 (12.61)	62.52 (12.52)	0.838	62.36 (12.62)	62.42 (12.67)	0.782
Female sex	1796 (23.8)	1808 (23.2)	0.369	1564 (23.3)	1566 (23.4)	0.984
Hospital location: provincial capital	4554 (60.4)	5122 (65.7)	<0.001	4240 (63.3)	4301 (64.2)	0.281
First medical facility: hospital	3712 (49.2)	4124 (52.9)	<0.001	3367 (50.3)	3366 (50.2)	1.000
Department: Emergency/catheter lab	5278 (70.0)	6046 (77.5)	<0.001	5025 (75.0)	4995 (74.6)	0.564
Type of MI						
STEMI	5296 (70.2)	5659 (72.6)	0.001	4824 (72.0)	4831 (72.1)	0.908
Killip class						
I	5298 (70.2)	5797 (74.3)	<0.001	4835 (72.2)	4879 (72.8)	0.651
II to III	1966 (26.1)	1735 (22.2)		1624 (24.2)	1593 (23.8)	
IV	280 (3.7)	268 (3.4)		241 (3.6)	228 (3.4)	
Comorbidity						
Current smoking	3577 (47.4)	3760 (48.2)	0.335	3213 (48.0)	3198 (47.7)	0.809
Hypertension	4052 (53.7)	3992 (51.2)	0.002	3534 (52.7)	3389 (50.6)	0.013
Dyslipidemia	543 (7.2)	358 (4.6)	<0.001	344 (5.1)	352 (5.3)	0.785
Diabetes mellitus	1694 (22.5)	1733 (22.2)	0.739	1477 (22.0)	1500 (22.4)	0.648
Heart failure history	120 (1.6)	71 (0.9)	<0.001	65 (1.0)	69 (1.0)	0.795
Renal failure history	84 (1.1)	85 (1.1)	0.949	74 (1.1)	70 (1.0)	0.802
Previous MI	575 (7.6)	453 (5.8)	<0.001	395 (5.9)	412 (6.1)	0.561
Previous PCI or CABG	446 (5.9)	519 (6.7)	0.063	391 (5.8)	412 (6.1)	0.467
Preadmission medication						
Aspirin	1288 (17.1)	1259 (16.1)	0.126	1081 (16.1)	1104 (16.5)	0.607
P2Y$_{12}$ receptor inhibitors	935 (12.4)	929 (11.9)	0.372	794 (11.9)	820 (12.2)	0.507
Statins	908 (12.0)	815 (10.4)	0.002	714 (10.7)	738 (11.0)	0.523

Data are expressed as mean±SD or n (%). CABG indicates coronary artery bypass grafting; MI, myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction.

also significantly lower after versus before accreditation (1.1% versus 1.6%; *P*=0.016). Cumulative hazards of MACE and all-cause death were also lower in the postaccreditation group compared with the preaccreditation group (log rank *P*<0.001 and *P*=0.020, respectively; Figure 2A and 2C).

After propensity score matching, the incidence of 7-day in-hospital MACE (6.7% versus 8.0%; *P*=0.003) and all-cause death (1.1% versus 1.6%; *P*=0.021) was still lower in the postaccreditation group (log rank *P*=0.003 and *P*=0.020, respectively; Table 2, Figure 2B and 2D).

In mixed-effects Cox proportional hazards models, CPC accreditation was associated with statistically significantly decreased risk of MACE (hazard ratio [HR]: 0.78; 95% CI, 0.68–0.91; *P*=0.001) and all-cause death (HR: 0.71; 95% CI, 0.51–0.99; *P*=0.042) after multivariate analysis adjusted for possible confounders (Table 3).

Hazards for the risk of outcomes during the in-hospital period by the duration of accreditation in the propensity score–matched population are presented in Figure 3. The risk of MACE and all-cause death for those patients admitted after the accreditation both follow a reverse J-shaped trend: the risk of both MACE and all-cause death decreases gradually with CPC accreditation, with the minimal risk occurring in patients admitted from 6 months to the first year after accreditation, and then risk increases in the second year and after.

Subgroup Analyses

Subgroup analyses for MACE and all-cause death based on baseline information were performed in the propensity score–matched population (Figures S2 and S3). The main results were not significantly changed in most subgroups. No interactions

Table 2. In-Hospital Outcomes Within 7 Days After Hospitalization*

Variable	Unmatched			Propensity Score Matched		
	Before Accreditation	After Accreditation	P Value	Before Accreditation	After Accreditation	P Value
n	7544	7800		6700	6700	
MACE, n (%)	636 (8.4)	498 (6.4)	<0.001	539 (8.0)	448 (6.7)	0.003
All-cause death, n (%)	120 (1.6)	88 (1.1)	0.016	107 (1.6)	75 (1.1)	0.021
Cardiac death, n (%)	114 (1.5)	85 (1.1)	0.025	101 (1.5)	72 (1.1)	0.032
Reinfarction, n (%)	18 (0.2)	11 (0.1)	0.228	14 (0.2)	10 (0.1)	0.540
Stent thrombosis, n (%)	10 (0.1)	7 (0.1)	0.579	9 (0.1)	7 (0.1)	0.802
Stroke, n (%)	12 (0.2)	8 (0.1)	0.456	11 (0.2)	7 (0.1)	0.479
Heart failure, n (%)	547 (7.3)	419 (5.4)	<0.001	459 (6.9)	378 (5.6)	0.004

Data are expressed as n (%). MACE indicates major adverse cardiovascular events.
*Patients may have had >1 outcome in each category but were counted only once for overall events.

were found in most subgroups except for MACE risk by the type of MI (P=0.002 for interaction) and the disease history of previous percutaneous coronary intervention or coronary artery bypass grafting (P=0.049 for interaction); the associated risk of MACE was decreased more significantly after CPC accreditation in patients diagnosed with STEMI (HR: 0.70; 95% CI, 0.58–0.84) compared with those diagnosed with non–STEMI (HR: 0.97; 95% CI, 0.75–1.26).

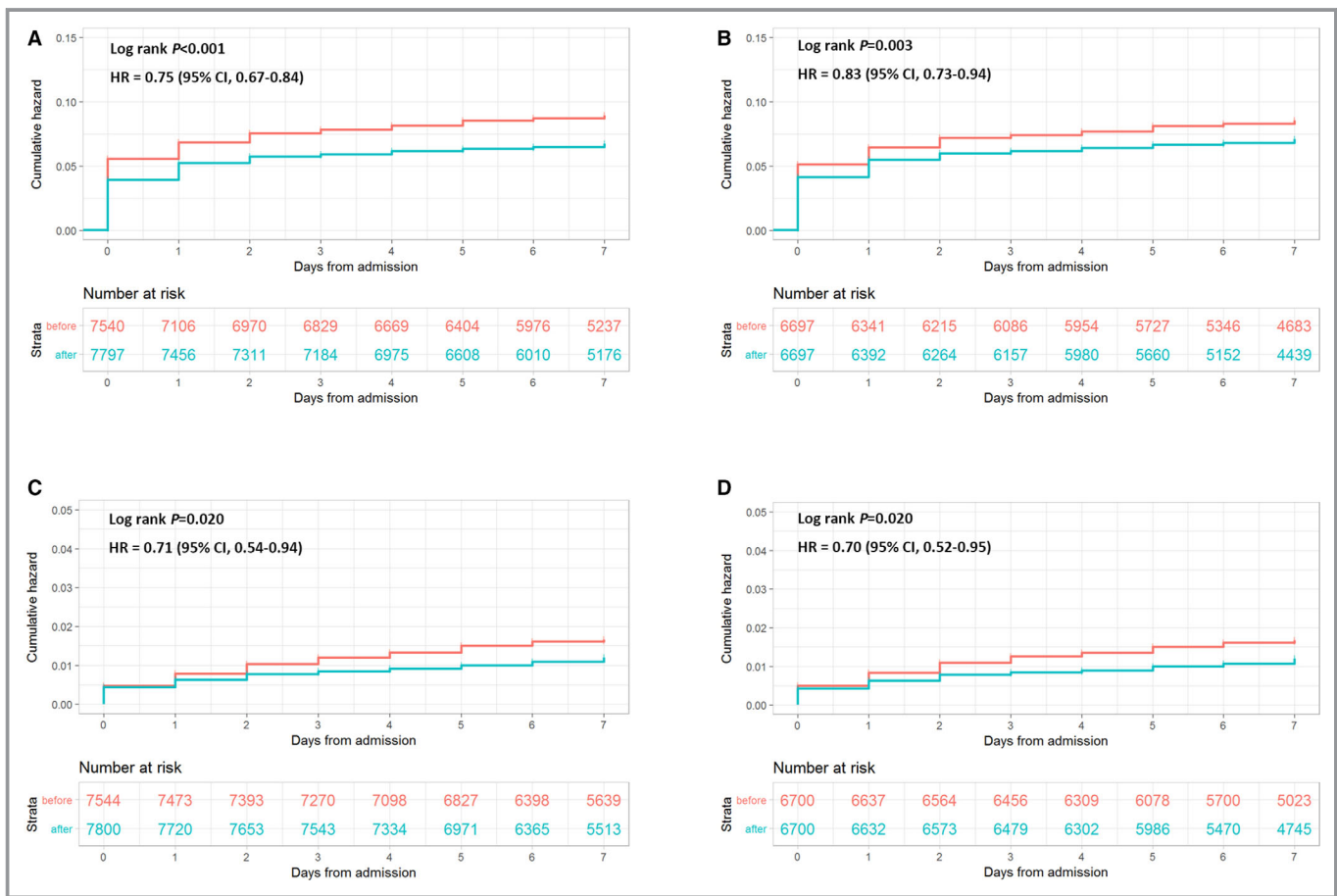**Figure 2.** Cumulative Kaplan–Meier curve estimates of outcomes within 7 days after hospitalization. Data for MACE in the whole study population (**A**) and the propensity score–matched population (**B**). Data for all-cause death in the whole study population (**C**) and the propensity score-matched population (**D**). HR indicates hazard ratio; MACE, major adverse cardiovascular events.

Table 3. Outcomes Within 7 Days After Hospitalization Associated With Accreditation: Unadjusted and Multivariate Adjusted Analyses With and Without Propensity Score Matching

Variable	Unmatched		Propensity Score Matched	
	Before Accreditation	After Accreditation	Before Accreditation	After Accreditation
MACE				
Crude HR (95% CI)	1.00	0.79 (0.68–0.9)	1.00	0.85 (0.74–0.98)
P value		0.001		0.029
Age- and sex-adjusted HR (95% CI)	1.00	0.75 (0.65–0.86)	1.00	0.81 (0.7–0.94)
P value		<0.001		0.006
Multivariate adjusted HR (95% CI)*	1.00	0.77 (0.67–0.88)	1.00	0.78 (0.68–0.91)
P value		<0.001		0.001
All-cause death				
Crude HR (95% CI)	1.00	0.67 (0.49–0.91)	1.00	0.67 (0.48–0.93)
P value		0.011		0.017
Age- and sex-adjusted HR (95% CI)	1.00	0.64 (0.47–0.88)	1.00	0.64 (0.46–0.89)
P value		0.005		0.009
Multivariate-adjusted HR (95% CI)*	1.00	0.69 (0.5–0.95)	1.00	0.71 (0.51–0.99)
P value		0.022		0.042

HR indicates hazard ratio; MACE, major adverse cardiovascular events; MI, myocardial infarction.

*Adjusted for age, sex, the level of the city where the hospital is located, first medical contact site or not, comorbidities including smoking status, diabetes mellitus, hypertension, dyslipidemia, diabetes mellitus, heart failure history, renal failure history, previous MI, previous percutaneous coronary intervention or coronary artery bypass grafting, type of MI, Killip classes, preadmission use of aspirin, preadmission use of P2Y$_{12}$ receptor inhibitors, and preadmission use of statins.

Sensitivity Analyses

Sensitivity analyses included 36 911 patients admitted to hospitals without accreditations during the project and 8858 patients contemporarily admitted in hospitals after accreditation (Figure S4). After propensity score matching at a 1:1 ratio, postmatching absolute standardized differences were <10% for all covariates except for admission date. The mirrored histograms are shown in Figure S5 to present the propensity score distribution status.

Baseline characteristics between no accreditation and postaccreditation groups before propensity score matching were not significantly different from the main results except those regarding hospital location, type of MI, and history of diabetes mellitus (Table S1). The results for the risk of in-hospital outcomes within 7 days after admission did not significantly change except for the comparison of all-cause death, with a *P* value not significantly different (Tables S2 and S3; Figure S6).

Discussion

Our study found that AMI patients admitted to hospitals with CPC accreditation had better in-hospital outcomes than those admitted to hospitals without accreditation, based on a large-scale national registry data set, even after propensity score matching and using Cox proportional hazards models. To our knowledge, this study is the first to focus on this issue in China. This is especially important because a previous study found no improvement of outcome for STEMI patients from 2001 to 2011.[11] The results of this study confirm the importance and effectiveness of CPC development and accreditation for AMI patients in China.

The most compelling reason for hospitals and programs to obtain accreditations is better patient outcomes, but prior studies focusing on the impact of accreditation were inconclusive. A recent study including >4 million patients aged ≥65 years showed no patient mortality benefit for hospitals with a Joint Commission certification compared with those accredited by another independent accrediting organization.[17] Another recent analysis showed that there might be differences in treatment and mortality for stroke patients according to which organization provided certification.[18] However, regarding AMI patients, previous studies have shown that CPC accreditation was associated with better performance on core measurements,[19] which is the fundamental goal for CPC accreditation.[20–23] These findings suggested that the improvements in care processes with CPC accreditation are further associated with improved short-term outcomes for AMI patients.

Our study found that CPC accreditation was associated with statistically significant risk reduction of MACE and all-
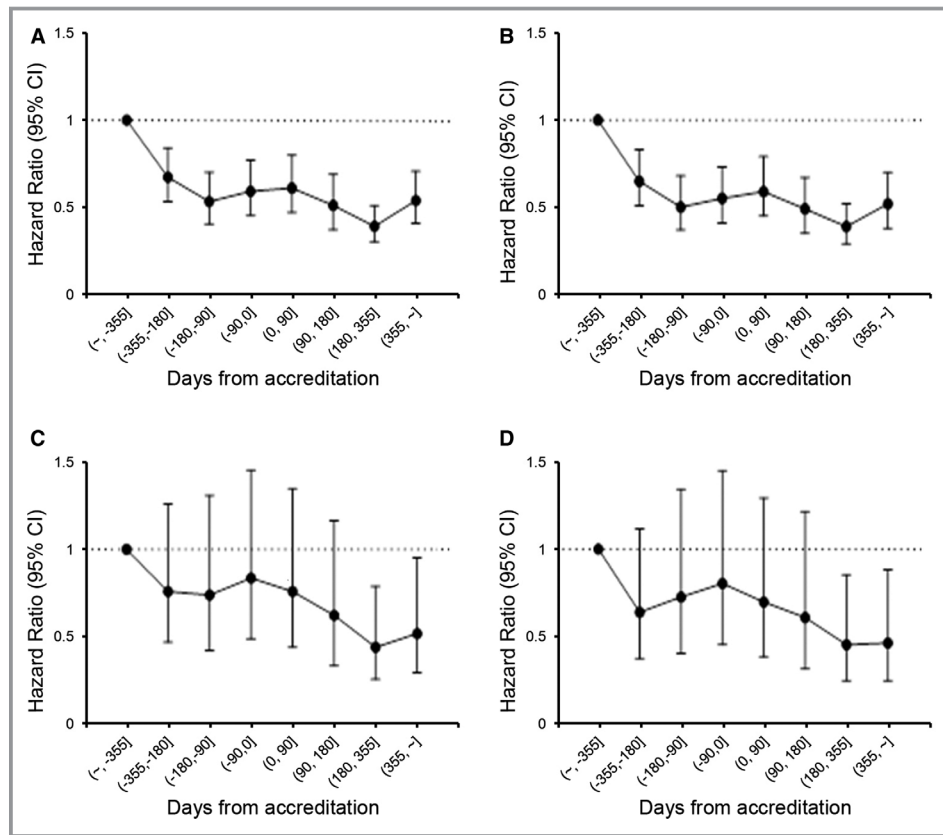
Figure 3. Hazard for the risk of outcomes within 7 days after hospitalization by the duration of accreditation. Data for MACE in the whole study population (**A**) and the propensity score–matched population (**B**). Data for all-cause death in the whole study population (**C**) and the propensity score–matched population (**D**). MACE indicates major adverse cardiovascular events.

cause death after adjustment. Although the main contributor to MACE improvement was heart failure, all-cause mortality was also significantly improved with CPC accreditation, even in Cox proportional hazards models, which means the conclusion was solid. Although the history of CPC accreditation in China is relatively short, this study suggested that there were favorable associations with clinical outcomes. Further implementation and optimization of accreditation standards, focused especially on core measurements for care management of AMI patients, may be warranted.

In 2010, the China Expert Consensus on the Construction of Chest Pain Centers was published and played a crucial role in promoting the development of CPCs at that time.[15] The first CPC in China with the regional collaborative network as its core concept was established in March 2011 in Guangzhou. With the scope of collaboration with resources and promoting the rapid development of CPCs, the China Cardiovascular Association and the Chinese Society of Cardiology collaboratively established the China Chest Pain Center in July 2016. After its establishment, this CPC assumed responsibility for most of the organization, management, and coordination originally undertaken by the China Chest Pain Center

Accreditation Office. More details on the process, benchmarks, requirements, and so forth, according to CPC certification in China are provided in Data S1 for reference.

An important insight from this study is that the hazards for the risk of outcomes during the in-hospital period as a function of the duration of accreditation followed a reverse J-shaped trend, with the maximum associated effectiveness occurring up until the first year after accreditation. This finding supports the rationale of the recently established reaccreditation project, which may promote a long-lasting effect after initial CPC accreditation and help to limit subsequent declines in associated benefits for AMI care and outcomes with CPC accreditation after the first year. In January 2018, considering continuing quality improvement, the headquarters of China CPCs formally established a reaccreditation protocol and standard that demands a 3-year validation period for the initial CPC accreditation. The validation period for the reaccreditation of CPCs will be 5 years, and reaccreditation should be performed every 5 years.

This study had several limitations. First, this was a retrospective observational study; even using propensity score matching, we could not eliminate bias from unobserved

variables. A follow-up study with a more robust design, such as prospective cluster randomization, would be warranted. Second, the difference in outcomes was largely driven by difference in heart failure and all-cause death, which should be taken into consideration in the interpretation of results. Third, hospitals involved in CCC-ACS projects cannot reflect the whole picture of China's hospitals with and without CPC accreditation; furthermore, this study focuses on only AMI rather than all acute chest pain diagnoses and diseases. Last, our analysis was able to focus on only in-hospital outcomes rather than effect of accreditation on long-term outcome improvements, which can be further studied in the future.

Conclusions

Based on a large-scale national registry data set, CPC accreditation was associated with better in-hospital outcomes for AMI patients. However, because there was some attenuation in associated benefits over time, reaccreditation may be essential to maintain the quality of AMI care after initial CPC accreditation.

Acknowledgments

We acknowledge all participating hospitals for their contributions to the CCC-ACS (Improving Care for Cardiovascular Disease in China-Acute Coronary Syndrome) project.

Sources of Funding

Disclosures

None.

References

1. Goodacre S, Nicholl J, Dixon S, Cross E, Angelini K, Arnold J, Revill S, Locker T, Capewell SJ, Quinney D, Campbell S, Morris F. Randomised controlled trial and economic evaluation of a chest pain observation unit compared with routine care. *BMJ*. 2004;328:254.

2. Keller T, Post F, Tzikas S, Schneider A, Arnolds S, Scheiba O, Blankenberg S, Münzel T, Genth-Zotz S. Improved outcome in acute coronary syndrome by establishing a chest pain unit. *Clin Res Cardiol*. 2010;99:149–155.

3. Graff LG, Dallara J, Ross MA, Joseph AJ, Itzcovitz J, Andelman RP, Emerman C, Turbiner S, Espinosa JA, Severance H. Impact on the care of the emergency department chest pain patient from the chest pain evaluation registry (CHEPER) study. *Am J Cardiol*. 1997;80:563–568.

4. Steurer J, Held U, Schmid D, Ruckstuhl J, Bachmann LM. Clinical value of diagnostic instruments for ruling out acute coronary syndrome in patients with chest pain: a systematic review. *Emerg Med J*. 2010;27:896–902.

5. Peacock WF, Kontos MC, Amsterdam E, Cannon CP, Diercks D, Garvey L, Graff L IV, Holmes D, Holmes KS, McCord J, Newby K, Roe M, Dadkhah S, Siler-Fisher A, Ross M. Impact of Society of Cardiovascular Patient Care accreditation on quality: an ACTION Registry®-Get With The Guidelines™ analysis. *Crit Pathw Cardiol*. 2013;12:116–120.

6. Joseph AJ, Cohen AG, Bahr RD. A formal, standardized and evidence-based approach to Chest Pain Center development and process improvement: the Society of Chest Pain Centers and Providers accreditation process. *J Cardiovasc Manag*. 2003;14:11–14.

7. Bahr RD. Milestones in the development of the first chest pain center and development of the new Society of Chest Pain Centers and Providers. *Md Med*. 2001;Spring(Suppl):106–108.

8. Breuckmann F, Burt DR, Melching K, Erbel R, Heusch G, Senges J, Garvey JL. Chest pain centers: a comparison of accreditation programs in Germany and the United States. *Crit Pathw Cardiol*. 2015;14:67–73.

9. Münzel T, Post F. The development of chest pain units in Germany. *Eur Heart J*. 2011;32:657–658.

10. Post F, Gori T, Senges J, Giannitsis E, Katus H, Münzel T. Establishment and progress of the chest pain unit certification process in Germany and the local experiences of Mainz. *Eur Heart J*. 2012;33:682–686.

11. Li J, Li X, Wang Q, Hu S, Wang Y, Masoudi FA, Spertus JA, Krumholz HM, Jiang L; China PEACE Collaborative Group. ST-segment elevation myocardial infarction in China from 2001 to 2011 (the China PEACE-Retrospective Acute Myocardial Infarction Study): a retrospective analysis of hospital data. *Lancet*. 2015;385:441–451.

12. Zhou M, Wang H, Zhu J, Chen W, Wang L, Liu S, Li Y, Wang L, Liu Y, Yin P, Liu J, Yu S, Tan F, Barber RM, Coates MM, Dicker D, Fraser M, González-Medina D, Hamavid H, Hao Y, Hu G, Jiang G, Kan H, Lopez AD, Phillips MR, She J, Vos T, Wan X, Xu G, Yan LL, Yu C, Zhao Y, Zheng Y, Zou X, Naghavi M, Wang Y, Murray CJ, Yang G, Liang X. Cause-specific mortality for 240 causes in China during 1990–2013: a systematic subnational analysis for the Global Burden of Disease Study 2013. *Lancet*. 2016;387:251–272.

13. Recent hospitalization trends for acute myocardial infarction in Beijing. *Eur Heart J*. 2016;37:3188–3189.

14. Zhang Y, Huo Y. Early reperfusion strategy for acute myocardial infarction: a need for clinical implementation. *J Zhejiang Univ Sci B*. 2011;12:629–632.

15. Yan Z, Yong H. Current status and future prospects of chest pain center accreditation in China. *China Acad J Electron Publ House*. 2017;9:1–5.

16. Hao Y, Liu J, Liu J, Smith SC Jr, Huo Y, Fonarow GC, Ma C, Ge J, Taubert KA, Morgan L, Guo Y, Zhang Q, Wang W, Zhao D; CCC-ACS Investigators. 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. *Am Heart J*. 2016;179:107–115.

17. Lam MB, Figueroa JF, Feyman Y, Reimold KE, Orav EJ, Jha AK. Association between patient outcomes and accreditation in US hospitals: observational study. *BMJ*. 2018;363:k4011.

18. Man S, Cox M, Patel P, Smith EE, Reeves MJ, Saver JL, Bhatt DL, Xian Y, Schwamm LH, Fonarow GC. Differences in acute ischemic stroke quality of care and outcomes by primary stroke center certification organization. *Stroke*. 2017;48:412–419.

19. Ross MA, Amsterdam E, Peacock WF, Graff L, Fesmire F, Garvey JL, Kelly S, Holmes K, Karunaratne HB, Toth M, Dadkhah S, McCord J. Chest pain center accreditation is associated with better performance of centers for medicare and medicaid services core measures for acute myocardial infarction. *Am J Cardiol*. 2008;102:120–124.

20. Bahr RD, Copeland C, Strong J. Chest pain centers–Part 1. Chest pain centers: past, present and future. *J Cardiovasc Manag*. 2002;13:19–20.

21. Bahr RD, Copeland C, Strong J. Chest pain centers–Part 2. The strategy of the chest pain center. *J Cardiovasc Manag*. 2002;13:21–22.

22. Bahr RD, Copeland C, Strong J. Chest pain centers–Part 3. Evaluation in the hospital ED or chest pain center (CPC). *J Cardiovasc Manag*. 2002;13:23–25.

23. Bahr RD, Copeland C, Strong J. Chest pain centers–Part 4. Executive summary: issues with APC's and observation services. *J Cardiovasc Manag*. 2002;13:26–33.

SUPPLEMENTAL MATERIAL

Appendix S1 Group information: *Hospitals for Phase One (Investigator)*:

Shanxi Cardiovascular Hospital (Bao Li); Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School (Biao Xu, Guangshu Han); Hainan General Hospital (Bin Li); The Second Hospital of Jilin University (Bin Liu); The 2nd Affiliated Hospital of Harbin Medical University (Bo Yu); The Ninth Hospital Affiliated to Shanghai Jiaotong University School of Medicine (Changqian Wang); Henan Provincial People's Hospital (Chuanyu Gao); Shanxi Provincial People's Hospital (Chunlin Lai); Xinqiao Hospital, Third Military Medical University (Cui Bin, Lan Huang); China Meitan General Hospital (Di Wu); The 309th Hospital of Chinese People's Liberation Army (Fakuan Tang, Jun Xiao); Zhongda Hospital, Southeast University (Genshan Ma); The First Affiliated Hospital of Liaoning Medical University (Guizhou Tao); Xinjiang Uygur Autonomous Region People's Hospital (Guoqing Li); Sir Run Run Shaw Hospital, College of Medicine, Zhejiang University (Guosheng Fu); Beijing Friendship Hospital, Capital Medical University (Hongwei Li); The First Affiliated Hospital of Bengbu Medical College (Honhju Wang); General Hospital of TISCO (Huifeng Wang); Dongguan People's Hospital (Jianfeng Ye); Panyu Hospital of Chinese Medicine (Jianhao Li); Peking University First Hospital (Jie Jiang); Sun Yat-sen Memorial Hospital, Sun Yat-sen University (Jingfeng Wang); Guangdong General Hospital (Jiyan Chen); Hospital of Xinjiang Production & Construction Corps (Junming Liu); The Military General Hospital of Beijing PLA (Junxia Li); The First Affiliated Hospital of Guangxi Medical University (Lang Li); Tongren Hospital Affiliated to Shanghai Jiaotong University School of Medicine (Li Jiang); Binzou City Center Hospital (Lijun Meng); The First Affiliated Hospital of Zhengzhou University (Ling Li); Xijing

Hospital (Ling Tao); The Affiliated Hospital of Guizhou Medical University (Lirong Wu); First Affiliated Hospital of the People's Liberation Army General Hospital (Miao Tian); The Second People's Hospital of Yunnan Province (Minghua Han); Haikou People's Hospital (Moshui Chen); Gansu Provincial Hospital (Ping Xie); The First Affiliated Hospital of Henan University of Science and Technology (Pingshuan Dong); Chenzhou First People's Hospital (Qiaoqing Zhong); People's Hospital of Qinghai Province (Rong Chang); Affiliated Hospital of Ningxia Medical University (Shaobin Jia); Beijing Anzhen Hospital, Capital Medical University (Shaoping Nie, Xiaohui Liu); North Jiangsu People's Hospital (Shenghu He); Shanghai Sixth People's Hospital (Shixin Ma); The First Hospital of Handan (Shuanli Xin); Huai'an First People's Hospital (Shuren Ma); The First Affiliated Hospital of Chongqing Medical University (Suxin Luo); Navy General Hospital (Tianchang Li); Zhejiang Provincial Hospital of TCM (Wei Mao); The Third Xiangya Hospital of Central South University (Weihong Jiang); Affiliated Hospital of Qinghai University (Weijun Liu); Teda International Cardiovascular Hospital (Wenhua Lin); The Second Hospital of Hebei Medical University (Xianghua Fu); Changhai Hospital of Shanghai (Xianxian Zhao); The Second Affiliated Hospital to Nanchang University (Xiaoshu Cheng); Hebei General Hospital (Xiaoyong Qi); Inner Mongolia People's Hospital (Xingsheng Zhao); The General Hospital of Shenyang Military Region (Yaling Han); The First Hospital of Jilin University (Yang Zheng); Tianjin Chest Hospital (Yin Liu); Hunan Provincial People's Hospital (Ying Guo); People's Hospital of Yuxi City (Yinglu Hao); The People's Hospital of Guangxi Zhuang Autonomous Region (Yingzhong Lin); The First Teaching Hospital of Xinjiang Medical University (Yitong Ma); Baogang Hospital (Yongdong Li); Tianjin Medical University General Hospital (Yuemin

Sun); The Second Affiliated Hospital of Zhengzhou University (Yulan Zhao); Nanfang Hospital of Southern Medical University (Yuqing Hou); The First Affiliated Hospital to Nanchang University (Zeqi Zheng); The First Affiliated Hospital of Lanzhou University (Zheng Zhang); The Third Hospital of Shijiazhuang (Zhenguo Ji); Wuxi People's Hospital (Zhenyu Yang); Jiangsu Province Hospital (Zhijian Yang); The Second Hospital of Shanxi Medical University (Zhiming Yang); The Affiliated Hospital of Xuzhou Medical College (Zhirong Wang); Southwest Hospital, Third Military Medical University (Zhiyuan Song); The First Affiliated Hospital of Xi'an Jiaotong University (Zuyi Yuan). *Hospitals for Phase Two (Investigator)*: Yangzhou First People's Hospital (Aihua Li); Hospital 463 of Chinese People's Liberation Army (Bosong Yang); The Central Hospital of Mianyang (Caidong Luo); Liaocheng People's Hospital (Chunyan Zhang); Yancheng Third People's Hospital (Chunyang Wu); The Second Xiangya Hospital of Central South University (Daoquan Peng); The Central Hospital of Panzhihua (Dawen Xu); The First Hospital of Qiqihaer City (Gang Xu); The Third the People's Hospital of Bengbu (Gengsheng Sang); The First Hospital of Jiamusi (Guixia Zhang); Zhoushan People's Hospital (Guoxiong Chen); Dalian Municipal Central Hospital (Hailong Lin); Renmin Hospital of Wuhan University (Hong Jiang); Ningxia People's Hospital (Hong Luan); The First People's Hospital of Yunnan Province (Kunhua Hospital) (Hong Zhang); The Central Hospital of Zhoukou (Hualing Liu); Anyang District Hospital (Hui Liu); Sichuan Provincial People's Hospital (Jianhong Tao); Mudanjiang Cardiovascular Disease Hospital (Jianwen Liu); Yichang Central Hospital (Jiawang Ding); Qilu Hospital of Shandong University (Jifu Li); Affiliated Hospital of Jiangsu University (Jinchuan Yan); The First People's Hospital of Nanning City (Jinru Wei); The First Affiliated

Hospital of Fujian Medical University (Jinzi Su); Chengdu Third People's Hospital (Jiong Tang); Yantaishan hospital (Juexin Fan); Qingdao Municipal Hospital (Jun Guan); Zhongshan Hospital Affiliated to Fudan University (Junbo Ge); Longyan First Hospital (Kaihong Chen); Affiliated Hospital of Guangdong Medical College (Keng Wu); Jiangxi Provincial People's Hospital (Lang Ji); Anhui Provincial Hospital (Likun Ma); Xiangtan City Central Hospital (Lilong Tang); The First Hospital of Haerbin City (Lin Wei); Central Hospital Affiliated to Shenyang Medical College (Man Zhang, Kaiming Chen); The Central Hospital of Wuhan (Manhua Chen); Hangzhou First People's Hospital (Ningfu Wang); The Central Hospital of Xuzhou (Peiying Zhang); The Second hospital of Dalian Medical University (Peng Qu); The First Affiliated Hospital of Liaoning University of Traditional Chinese Medicine (Ping Hou); Beijing Tsinghua Changgung Hospital (Ping Zhang); Guizhou Provincial People's Hospital (Qiang Wu); The First Affiliated Hospital of Xiamen University (Qiang Xie); Quanzhou First Hospital (Rong Lin); Wuzhou People's Hospital (Shaowu Ye); The Central Hospital of Jilin (Shuangbin Li); Xiangya Hospital Central South University (Tianlun Yang); Guangzhou Red Cross Hospital (Tongguo Wu); The First Affiliated Hospital of Guangzhou Medical College (Wei Wang); The First Affiliated Hospital of Wenzhou Medical University (Weijian Huang); The Second Affiliated Hospital of Soochow University (Weiting Xu); Wuhan Asia Heart Hospital (Xi Su); The First Affiliated Hospital of Soochow University (Xiangjun Yang); Affiliated Hospital of Yan'an University (Xiaochuan Ma); The First People's Hospital of Jining (Xiaofei Sun); The Central Hospital of Taiyuan (Xiaoping Chen); West China Hospital of Sichuan University (Xiaoping Chen); The Third Affiliated Hospital of Guangzhou Medical College (Ximing Chen); The First

Affiliated Hospital of Wannan Medical College (Xingsheng Tang); Tangdu Hospital of The Fourth Military Medical University (Xue Li); Shanghai East Hospital Affiliated to Tongji University (Xuebo Liu); Xiamen Cardiovascular Disease Hospital (Yan Wang); Zhongnan hospital of Wuhan University (Yanggan Wang); Fujian Provincial Hospital (Yansong Guo); The First Affiliated hospital of Dalian Medical University (Yanzong Yang); The First People's Hospital of Changde (Yi Huang); The First Affiliated Hospital of China Medical University (Yingxian Sun); The Fourth Affiliated Hospital of China Medical University (Yuanzhe Jin); Cangzhou Central Hospital (Zesheng Xu); The Central Hospital of Shaoyang (Zewei Ouyang); The People's Hospital of Liaoning Province (Zhanquan Li); The First Affiliated Hospital of Jiamusi University (Zhaofa He); Tangshan Gongren Hospital (Zheng Ji); Huaibei Miners General Hospital (Zhenqi Su); Linyi People's Hospital (Zhihong Ou).

Data S1. Details on the process, benchmarks, requirements according to the CPC accreditation in China

The accreditation standard system of CPC in China

1. CPC Accreditation Standard: China Chest Pain Center Accreditation Standard was released in 2013, including a standard version and a basic version for different hospitals. The standard version is suitable for the annual pPCI operation volume ≥200 cases and guarantee 7x24 hours for emergency PCI operation. The main target of the basic version is for those hospitals do not meet the requirements of the standard version, but the number of patients with acute myocardial infarction who are admitted/referred to ≥ 30 cases per year. The two sets of standards effectively cover the needs of the construction of CPCs in China. With the continuous accumulation of accreditation work experience, the actual situation of medical institutions in different regions of the country has been comprehensively revised. The standard has been revised several times during the period. The current standard version has been updated to the fifth edition, and the basic version has been updated to the second in version.

2. Re-accreditation standard: In order to continuously supervise and manage the certified units, the accreditation standard clearly requires that the CPC should be valid for 3 years after the first accreditation, and each CPC needs to be re-accredited before the expiration date. In January 2018, the China Chest Pain Center Accreditation Working Committee issued the "China Chest Pain Center Re-accreditation Standard (Standard Edition)". With the approval of the first batch of primary CPCs at the end of 2016, the re-accreditation standards for basic CPCs will be drafted and announced by the end of 2019.

3. Construction standards: In order to further clarify the basic requirements for the construction of a CPC, assist the hospital to conduct self-assessment, and encourage more medical institutions to join the CPC construction team. In September 2016, the China Chest Pain Center Accreditation Work Committee drafted, revised and released "standards for the construction of chest pain centers".

4. Group standards: In order to actively respond to the call for reforming of the national

standardization system, effectively promote the implementation of the policies of the National Health and Health Commission, and provide a solid foundation for the future CPC network in China, in August 2018, "China Cardiopulmonary Resuscitation and Cardiac Defibrillation Group Standards and China Chest Pain Center Construction and Evaluation Group Standards", which was prepared by the Rescue Association, the Chinese Nursing Association, the China Cardiovascular Health Alliance, and the Cardiovascular Health (Suzhou Industrial Park) Institute, was officially released and published on the national group standard information platform (standard numbers T/CADERM2001-2018 and T/CADERM2002-2018).

Construction and review process of CPC in China

Medical institutions at all levels actively responded to the policy requirements of the government, promote the construction of CPCs, and provide patients with higher quality medical services. They need to go through three stages before the accreditation, namely self-construction stage, the review phase and the continuous quality improvement phase.

1. Self-construction: The establishment of a CPC committee should led by the dean or the deputy medical dean of the medical institution, covering all the heads of medical and technical departments related to acute chest pain treatment, and also setting up medical directors, administrative directors, and liaisons. The person in charge of the position, conduct self-assessment, and in accordance with the requirements of the published accreditation standards (standard or basic version), by participating in relevant construction training sessions or watching the operation experience of the demonstration base, set up corresponding points in the main roads and major treatment points. The identification/guidance, optimize the relevant treatment process, unify the hospital clock, sign a joint treatment agreement with the pre-hospital emergency and network hospital, classify the whole staff treatment training in the hospital and the community, and faithfully record all except traumatic chest pain.

2. Review phase: Data on treatment of patients with acute chest pain and training related raw materials, and continuous optimization of the treatment process based on phased data analysis, when the CPCs actually running for at least 6 months (providing no less than 6 months of data

to assess the quality of operation) and self-assessment after basically meeting the requirements of the accreditation standard, at the specified time in the inter-node, the application for accreditation is issued to the China Chest Pain Center Accreditation Working Committee and the Chest Pain Center Headquarters. The whole year is divided into 4 batches of accreditation stages. After receiving the accreditation application from the medical institution, the headquarters first checks the accreditation qualification (including the consultation). Whether the quantity meets the requirements of the corresponding standard, whether the construction materials are complete, whether the case record meets the requirements of 6 months, whether the key treatment indicators are up to standard, etc.), the unit that passed the examination is handed over to the corresponding regional accreditation office for detailed review of each accreditation clause, and the unsatisfied clause proposed rectification opinions. After the unit was rectified, the office re-evaluated and recommended to enter the provincial pre-examination list of the provincial chest pain center. The provincial alliance assigned the provincial pre-inspection experts to the hospital for field visits, and conducted the operation of the chest pain center of the applicant unit. After the actual evaluation and suggestions for improvement, the provincial alliance comprehensively gives the results of the batch pre-inspection after passing the pre-inspection or rectification. Units that pass the pre-inspection of the provincial alliance will accept random and anonymous online materials and data reviews from three non-provincial national verification experts. Applicants who pass the expert online review will enter the unannounced visit and on-site verification stage. The unannounced visit is an expert commissioned by the headquarters to investigate the hospital's identification guidelines without the knowledge of the accreditation unit, and observe the applicant's actual acute chest pain patients or hire volunteers to simulate the patient's diagnosis and treatment. The diagnosis process and assessment of whether each link is standardized, and the corresponding score. The on-site inspection was carried out by three non-provincial experts and an office staff member to the applicant to evaluate the construction materials of the chest pain center, the authenticity of the data and the training effect of the whole staff, and to give a rating. All the online evaluations, unannounced visits and on-site inspections and scores of the applicants entering

the unannounced visit/site verification stage will be reported by the office at the plenary session of the China Chest Pain Center Accreditation Working Committee and will be voted by secret ballot on the overall situation of the members present. More than half of the votes will be passed, otherwise they will need to be revisited and/or checked again. The units that have passed the voting will elect to issue the bronze medals that have passed the accreditation.

3. Continuous quality improvement: Continuous improvement is the standard operation of the CPC, ensuring the essence of providing high-efficiency treatment. For certified CPCs, accreditation standards should continue to be optimized, enhanced training and extensive publicity and education, and accurate data management to further improve the efficiency and level of treatment for acute chest pain-related diseases. The China Chest Pain Center Accreditation Working Committee has separately formulated the "China Chest Pain Center Quality Control Indicators and Assessment Methods" (Standard Edition and Basic Edition, now updated to the second edition) and "China Chest Pain Center Re-accreditation Standards" (first edition) promote continuous improvement of accreditation through the unit. Specifically, the quality control center will monitor and evaluate the operation quality of each chest pain center every month. The regional reaccreditation office will conduct an overall assessment of the operation of the chest pain center within three years after accreditation.

Quality control system of China CPC

"Without scale, there is no benefit, no quality, no life". In keeping with this aim, while promoting the rapid growth of the number of CPCs, the Accreditation Work Committee and the Chest Pain Center Headquarter continue to promote and improve quality control methods.

1. Establish a data platform for chest pain center data and provide it to all chest pain centers for free. The patient type collected by the data reporting platform covers all patients with acute chest pain except traumatic chest pain. The collected fields focus on the treatment time node and key medical behavior record, providing data support for accreditation, quality control and reaccreditation assessment. Current data reporting platform In the process of upgrading, it is mainly updated from two angles. The first is the classification of data fields.

The existing fields are summarized into the basic information of the patient, the basic information of the disease and the information of the specialist diagnosis and treatment, for the future and the center of atrial fibrillation and heart failure. The integration of data platforms such as rehabilitation centers has paved the way for the formation of a big data center for cardiovascular diseases, which has become an important support for government decision-making and the development of the industry. Second, the positioning of database roles, providing basic library of accreditation quality control and scientific research to meet different positioning. The work needs of the medical institutions have made the chest pain center database truly an assistant to departmental patient management and to promote medical quality improvement.

2. Promote the development of data collection information, improve reporting efficiency and data quality. Develop existing real-time filing and data uploading applets, apps or automatic collection technology with existing Internet technologies, to reduce the workload of data manual reporting, reduce error rate, improve data quality and report efficiency, and provide reliable quality control.

3. Establish a data quality control platform for the chest pain center to provide a grasp for the provincial/local alliance to promote quality control. The establishment of the quality control platform will summarize and analyze the data reported by the CPCs of each unit, and present them in a visualized form to express the continuous quality improvement of each CPC. The index ranking has become an important starting point for the provincial/municipal chest pain center alliance to carry out quality control work.

4. Establish a normalized quality control system to promote the continuous improvement of the quality of the chest pain center. The normalized quality control system includes: issuing quality control indicators and assessment methods for chest pain centers, developing quality control platforms, formulating quality control reports for health care committees, provincial/municipal chest pain center alliances, hospitals, etc.. The system is commended and criticized at the annual Chest Pain Center Quality Control Conference. Thereby establishing a four-level quality control system for hospital internal quality control, municipal-level alliance

quality control, provincial-level alliance quality control and national quality control. In the future, with the support of the National Health and Health Commission, the quality control effect of the chest pain center can provide data support for the grade hospitals or key disciplines, and can also provide reference for the cost settlement of the medical insurance bureaus at all levels.

Table S1.   Baseline Characteristics of the Study Population in Sensitivity Analyses.

Variables	Unmatched			Propensity score-matched		
	no accreditation	after accreditation	p value	no accreditation	after accreditation	p value
n	36911	8858		8719	8719	
Age, years	62.66 (12.66)	62.48 (12.44)	0.211	62.36 (12.50)	62.46 (12.45)	0.597
Sex: Female	8862 (24.0)	2100 (23.7)	0.559	2015 (23.1)	2069 (23.7)	0.343
Hospital location			<0.001			0.305
First-line municipality	5715 (15.5)	0 (0.0)				
Provincial capital	15297 (41.4)	2798 (31.6)		5985 (68.6)	5921 (67.9)	
Prefecture-level city	15899 (43.1)	6060 (68.4)		2734 (31.4)	2798 (32.1)	
Hospital: First medical facility	19223 (52.1)	4844 (54.7)	<0.001	4790 (54.9)	4745 (54.4)	0.503
Department: Emergency/Cath lab	24039 (65.1)	6797 (76.7)	<0.001	6507 (74.6)	6660 (76.4)	0.007
Type of MI						
STEMI	26620 (72.1)	6303 (71.2)	0.072	6104 (70.0)	6207 (71.2)	0.090
Killip class			<0.001			0.975
Class I	25828 (70.0)	6584 (74.3)		6444 (73.9)	6457 (74.1)	
Class II-III	9394 (25.5)	1970 (22.2)		1971 (22.6)	1959 (22.5)	
Class IV	1689 (4.6)	304 (3.4)		304 (3.5)	303 (3.5)	
Comorbidity						
Current smoking	16183 (43.8)	4193 (47.3)	<0.001	4099 (47.0)	4103 (47.1)	0.964
Hypertension	19013 (51.5)	4495 (50.7)	0.715	4461 (51.2)	4422 (50.7)	0.565
Dyslipidemia	2922 (7.9)	427 (4.8)	0.200	463 (5.3)	426 (4.9)	0.215
Diabetes mellitus	7999 (21.7)	1936 (21.9)	<0.001	1880 (21.6)	1903 (21.8)	0.686

Heart failure history	762 (2.1)	85 (1.0)	<0.001	103 (1.2)	85 (1.0)	0.213
Renal failure history	701 (1.9)	93 (1.0)	<0.001	101 (1.2)	92 (1.1)	0.563
Previous MI	2650 (7.2)	512 (5.8)	<0.001	507 (5.8)	505 (5.8)	0.974
Previous PCI or CABG	2298 (6.2)	584 (6.6)	0.210	576 (6.6)	567 (6.5)	0.807
Pre-admission of medication						
Aspirin	8214 (22.3)	1467 (16.6)	<0.001	1466 (16.8)	1455 (16.7)	0.839
$P2Y_{12}$ receptor inhibitors	6176 (16.7)	1105 (12.5)	<0.001	1100 (12.6)	1099 (12.6)	1.000
Statins	5737 (15.5)	1008 (11.4)	<0.001	1028 (11.8)	1000 (11.5)	0.524

Data are expressed as means ± SD, or n (%). Abbreviations: CABG, coronary artery bypass graft; Cath, Catheter; MI, myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST elevation myocardial infarction.

Table S2.   In-hospital Outcomes* within 7 days after Hospitalization in Sensitivity Analyses.

Variables	Unmatched			Propensity score-matched		
	no accreditation	after accreditation	p value	no accreditation	after accreditation	p value
n	36911	8858		8719	8719	
MACE, n(%)	4376 (11.9)	542 (6.1)	<0.001	810 (9.3)	534 (6.1)	<0.001
All-cause death, n(%)	621 (1.7)	107 (1.2)	0.002	121 (1.4)	106 (1.2)	0.350
Cardiac death, n(%)	591 (1.6)	104 (1.2)	0.004	114 (1.3)	103 (1.2)	0.495
Re-infarction, n(%)	88 (0.2)	15 (0.2)	0.268	24 (0.3)	15 (0.2)	0.200
Stent thrombosis, n(%)	50 (0.1)	8 (0.1)	0.365	7 (0.1)	8 (0.1)	1.000
Stroke, n(%)	112 (0.3)	9 (0.1)	0.001	26 (0.3)	9 (0.1)	0.007
Heart failure, n(%)	3907 (10.6)	440 (5.0)	<0.001	696 (8.0)	433 (5.0)	<0.001

Data are expressed as n (%). Abbreviations: MACE, major adverse cardiovascular events.

*Patients may have had more than 1 outcome in each category but counted only once for overall events.

Table S3. Independent Predictors of MACE in Propensity Score-matched Population in Sensitivity Analyses.

Variables	Unmatched		Propensity score-matched	
	Before accreditation	After accreditation	Before accreditation	After accreditation
MACE				
Crude HR (95% CI)	1.00	0.50(0.46,0.55)	1.00	0.65(0.58,0.73)
p value		<0.001		<0.001
Age and sex adjusted HR (95% CI)	1.00	0.50(0.46,0.55)	1.00	0.64(0.58,0.72)
p value		<0.001		<0.001
Multivariate adjusted HR	1.00	0.57(0.52,0.62)	1.00	0.64(0.58,0.72)
p value		<0.001		<0.001
All-cause death				
Crude HR (95% CI)	1.00	0.72(0.59,0.89)	1.00	0.88(0.68,1.15)
p value		0.002		0.350
Age and sex adjusted HR (95% CI)	1.00	0.73(0.60,0.90)	1.00	0.87(0.67,1.14)
p value		0.003		0.314
Multivariate adjusted HR (95% CI)[*]	1.00	0.73(0.59,0.90)	1.00	0.87(0.67,1.13)
p value		0.003		0.289

Abbreviations: CABG, coronary artery bypass graft; CI, confidence interval; HR, hazard ratio; MACE, major adverse cardiovascular events; MI, myocardial infarction; PCI, percutaneous coronary intervention.

[*] Adjusted for age, sex, the level of the city where the hospital is located, first medical contact site or not, comorbidities including smoking status, diabetes mellitus, hypertension, dyslipidemia, diabetes mellitus, heart failure history, renal failure history, previous MI, previous PCI or CABG, type of MI, Killip classes, pre-admission use of aspirin, pre-admission use of P2Y12 receptor inhibitors, and pre-admission use of statins.

Figure S1. Mirrored Histogram before (A) and after (B) propensity score matching. X axis is the number of patients in each group. Y axis is the propensity score. The red bar presents the before accreditation group and the blue bar for the after accreditation group.

A
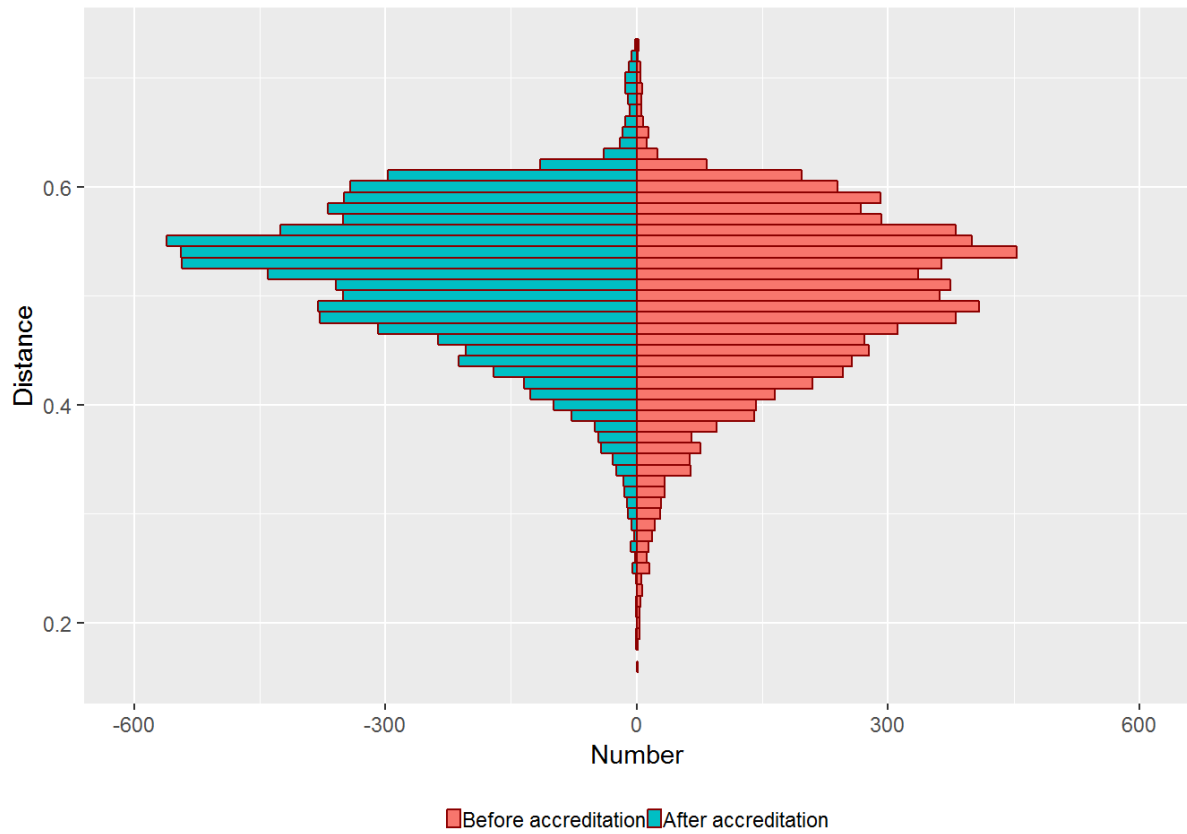
B
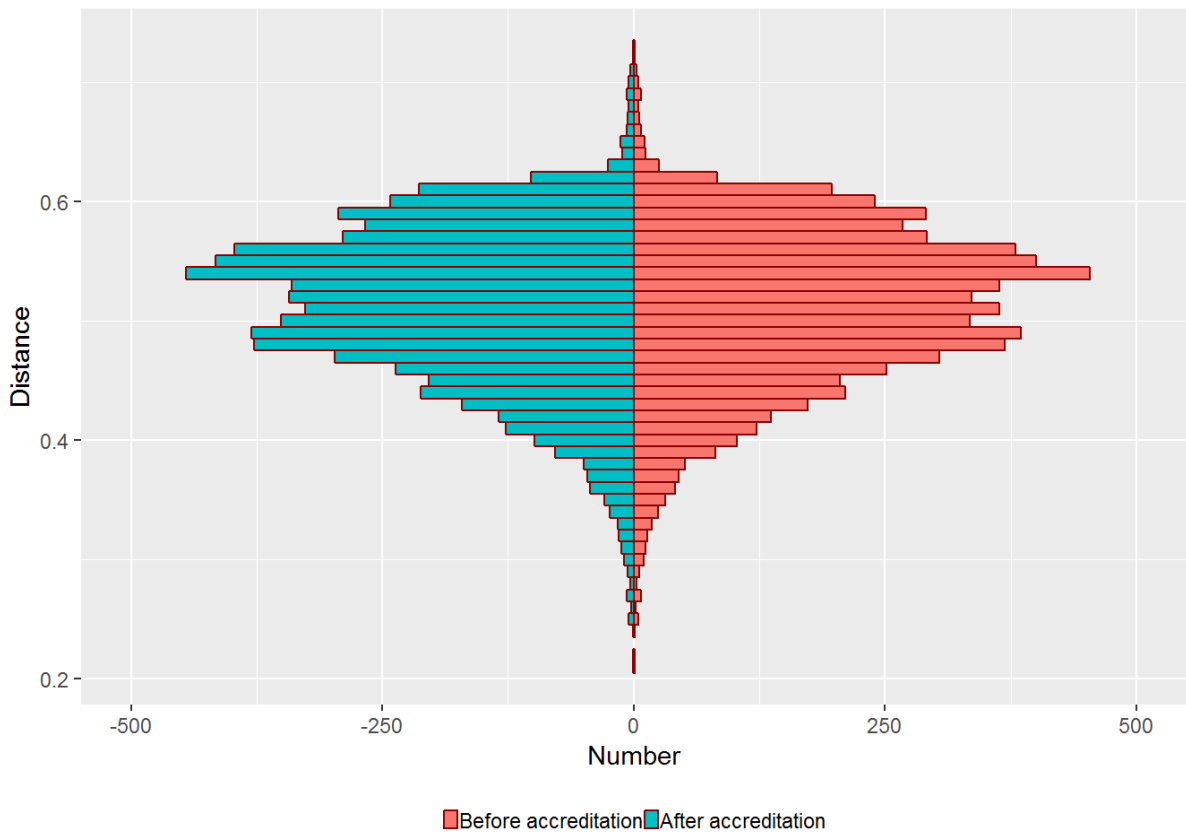
Figure S2.   Subgroup analyses for MACE in the propensity score–matched population. Abbreviations: CABG, coronary artery bypass graft; Cath, Catheter; CI, confidence interval; MACE, major adverse cardiovascular events; MI, myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST elevation myocardial infarction.

| Subgroups	No. of Patients	Before	After		Hazard Ratio (95%CI)	p value	p for interaction
Overall	13400	539 (8.0)	448 (6.7)		0.78(0.68,0.91)	0.001	
Age							
<65 year	7457	177 (4.8)	152 (4.1)		0.80(0.61,1.04)	0.980	0.780
≥65 year	5943	362 (12.2)	296 (10.0)		0.79(0.67,0.95)	0.036	
Sex							
Male	10270	342 (6.7)	298 (5.8)		0.80(0.66,0.95)	0.069	0.780
Female	3130	197 (12.6)	150 (9.6)		0.76(0.59,0.97)	0.250	
City							
Prefecture-level city	4859	274 (11.1)	179 (7.5)		0.69(0.55,0.86)	0.037	0.200
Provincial capital	8541	265 (6.2)	269 (6.3)		0.85(0.70,1.03)	0.150	
First medical contact site							
No	6667	276 (8.3)	227 (6.8)		0.74(0.60,0.91)	0.100	0.110
Yes	6733	263 (7.8)	221 (6.6)		0.84(0.68,1.03)	0.220	
Department arrived							
Outpatient, others	3380	141 (8.4)	101 (5.9)		0.79(0.57,1.09)	0.160	0.850
Emergency, cath lab	10020	398 (7.9)	347 (6.9)		0.80(0.67,0.94)	0.110	
Type of MI							
STEMI	3745	166 (8.8)	160 (8.6)		0.70(0.58,0.84)	0.140	0.002
NSTEMI	9655	373 (7.7)	288 (6.0)		0.97(0.75,1.26)	0.064	
Killip class I							
No	9714	239 (4.9)	194 (4.0)		0.74(0.60,0.92)	0.500	0.850
Yes	3686	300 (16.1)	254 (13.9)		0.80(0.65,0.97)	0.009	
Previous MI							
No	12593	496 (7.9)	402 (6.4)		0.77(0.67,0.9)	0.053	0.560
Yes	807	43 (10.9)	46 (11.2)		1.07(0.63,1.84)	0.830	
Previous PCI or CABG							
No	12597	509 (8.1)	407 (6.5)		0.76(0.65,0.88)	0.018	0.049
Yes	803	30 (7.7)	41 (10.0)		1.16(0.68,2.00)	0.390	

0   0.5   1   1.5   2   2.5

Figure S3. Subgroup analyses for all-cause death in the propensity score–matched population. Abbreviations: CABG, coronary artery bypass graft; Cath, Catheter; CI, confidence interval; MACE, major adverse cardiovascular events; MI, myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST elevation myocardial infarction.
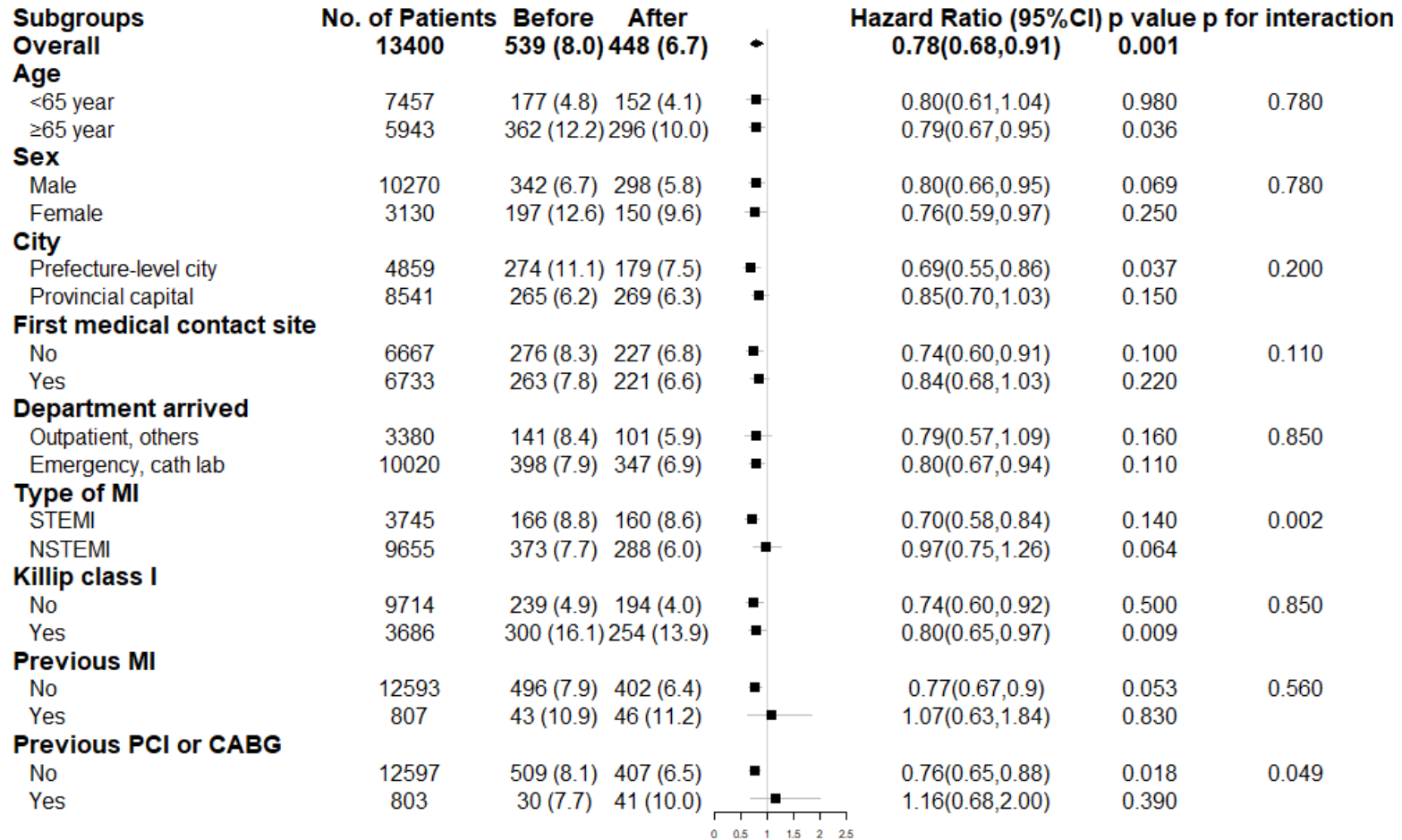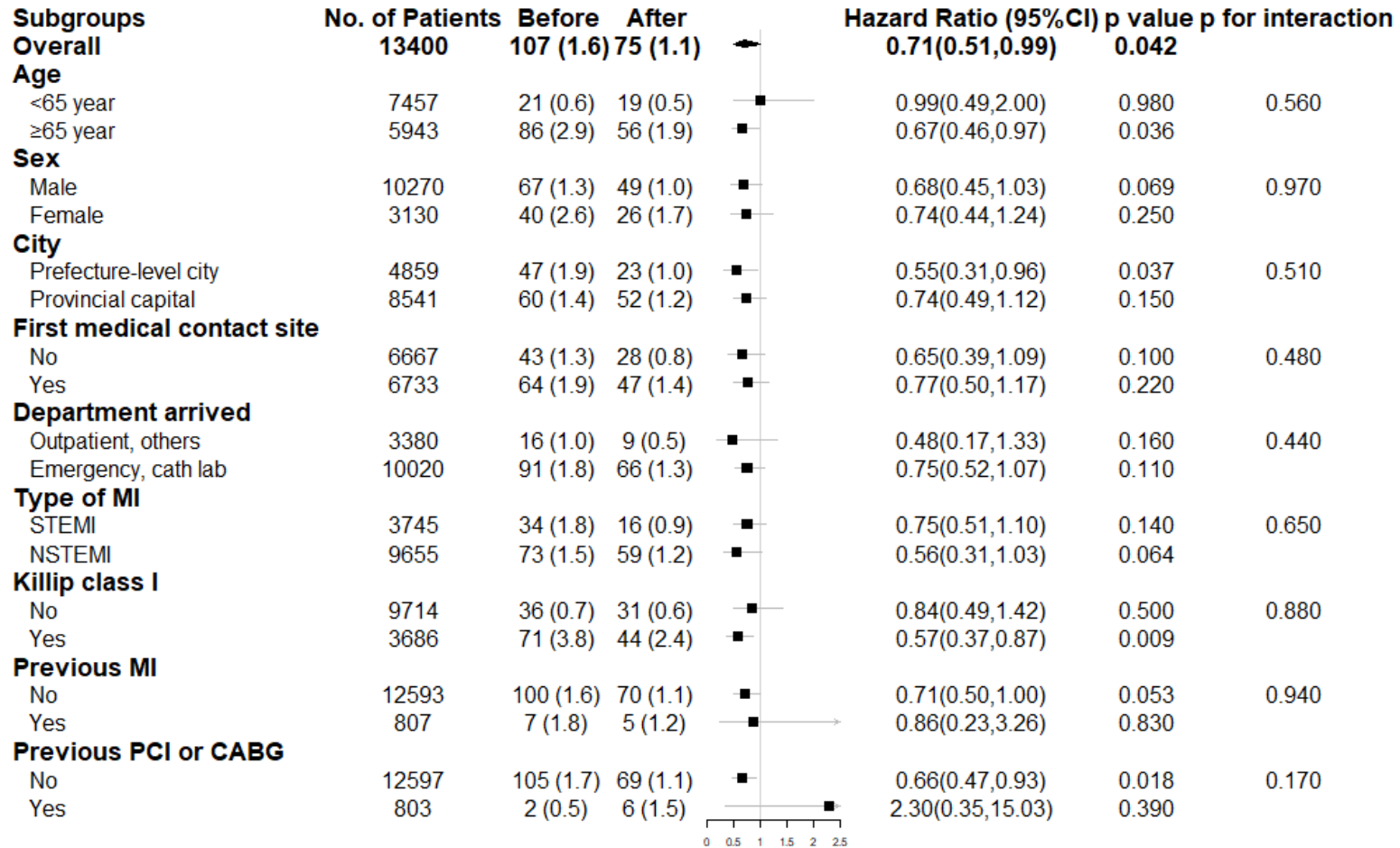
Subgroups	No. of Patients	Before	After		Hazard Ratio (95%CI)	p value	p for interaction
Overall	13400	107 (1.6)	75 (1.1)		0.71(0.51,0.99)	0.042	
Age							
<65 year	7457	21 (0.6)	19 (0.5)		0.99(0.49,2.00)	0.980	0.560
≥65 year	5943	86 (2.9)	56 (1.9)		0.67(0.46,0.97)	0.036	
Sex							
Male	10270	67 (1.3)	49 (1.0)		0.68(0.45,1.03)	0.069	0.970
Female	3130	40 (2.6)	26 (1.7)		0.74(0.44,1.24)	0.250	
City							
Prefecture-level city	4859	47 (1.9)	23 (1.0)		0.55(0.31,0.96)	0.037	0.510
Provincial capital	8541	60 (1.4)	52 (1.2)		0.74(0.49,1.12)	0.150	
First medical contact site							
No	6667	43 (1.3)	28 (0.8)		0.65(0.39,1.09)	0.100	0.480
Yes	6733	64 (1.9)	47 (1.4)		0.77(0.50,1.17)	0.220	
Department arrived							
Outpatient, others	3380	16 (1.0)	9 (0.5)		0.48(0.17,1.33)	0.160	0.440
Emergency, cath lab	10020	91 (1.8)	66 (1.3)		0.75(0.52,1.07)	0.110	
Type of MI							
STEMI	3745	34 (1.8)	16 (0.9)		0.75(0.51,1.10)	0.140	0.650
NSTEMI	9655	73 (1.5)	59 (1.2)		0.56(0.31,1.03)	0.064	
Killip class I							
No	9714	36 (0.7)	31 (0.6)		0.84(0.49,1.42)	0.500	0.880
Yes	3686	71 (3.8)	44 (2.4)		0.57(0.37,0.87)	0.009	
Previous MI							
No	12593	100 (1.6)	70 (1.1)		0.71(0.50,1.00)	0.053	0.940
Yes	807	7 (1.8)	5 (1.2)		0.86(0.23,3.26)	0.830	
Previous PCI or CABG							
No	12597	105 (1.7)	69 (1.1)		0.66(0.47,0.93)	0.018	0.170
Yes	803	2 (0.5)	6 (1.5)		2.30(0.35,15.03)	0.390	

0 0.5 1 1.5 2 2.5

Figure S4. Flow Diagram of Selection of the Study Population in Sensitivity Analyses.
Abbreviations: CCC-ACS: Improving Care for Cardiovascular Disease in China-Acute Coronary Syndrome; UAP: Unstable Angina Pectoris.
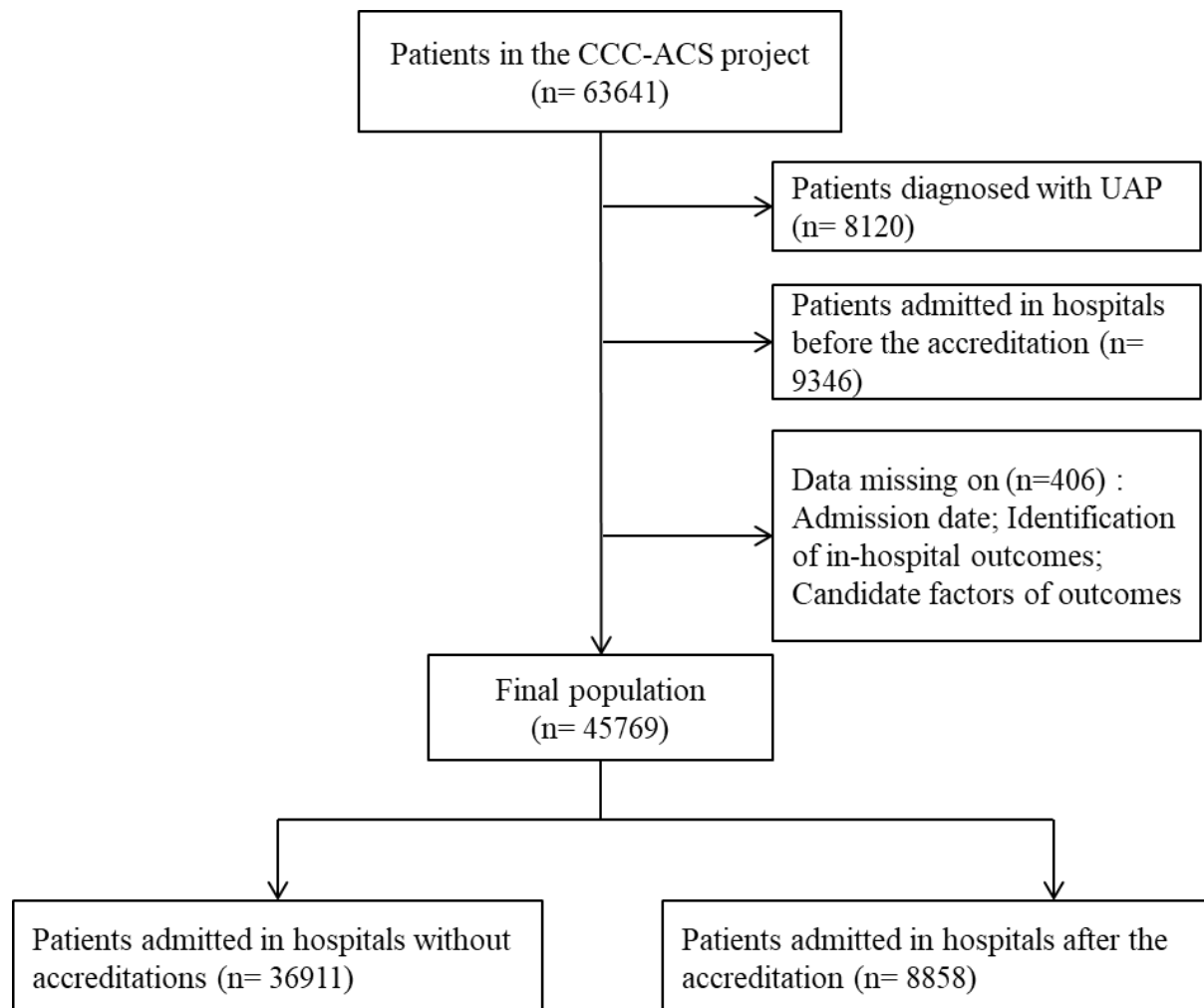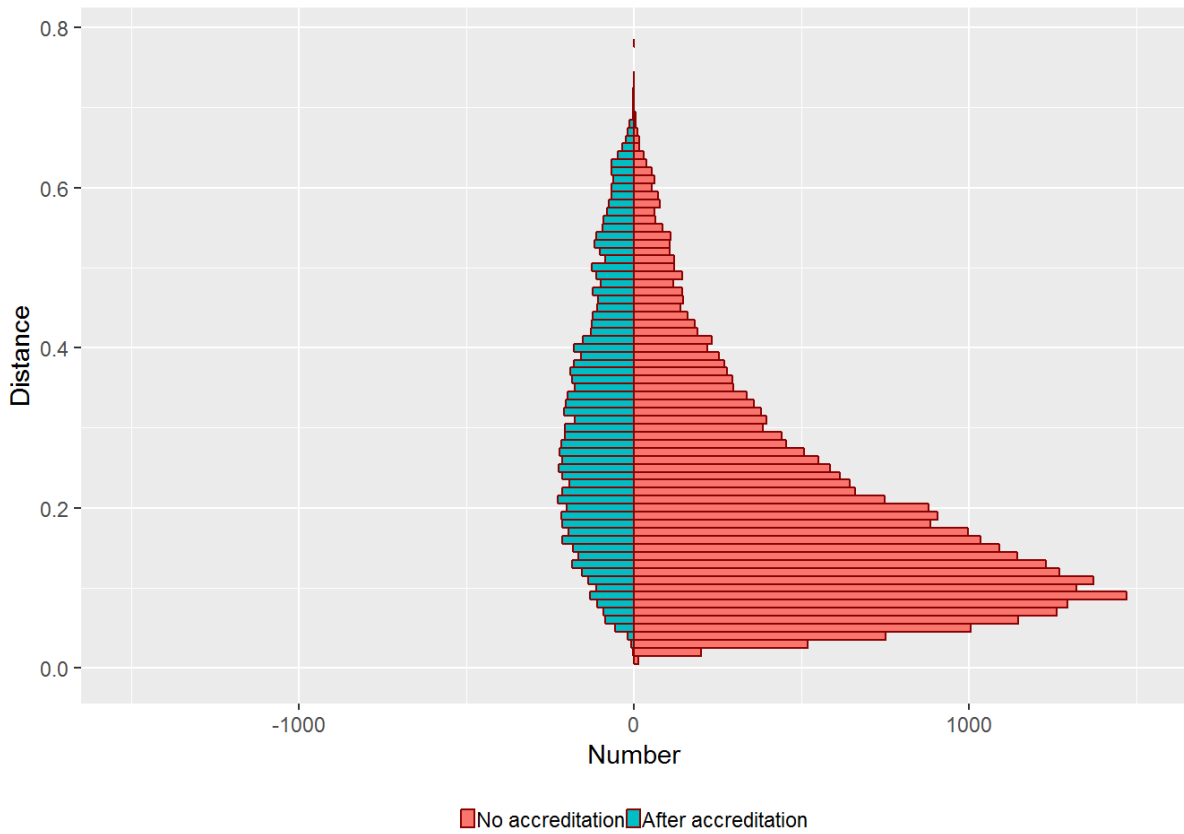
Figure S5. Mirrored Histogram before (A) and after (B) propensity score matching in Sensitivity Analyses. X axis is the number of patients in each group. Y axis is the propensity score. The red bar presents the no accreditation group and the blue bar for the after accreditation group.
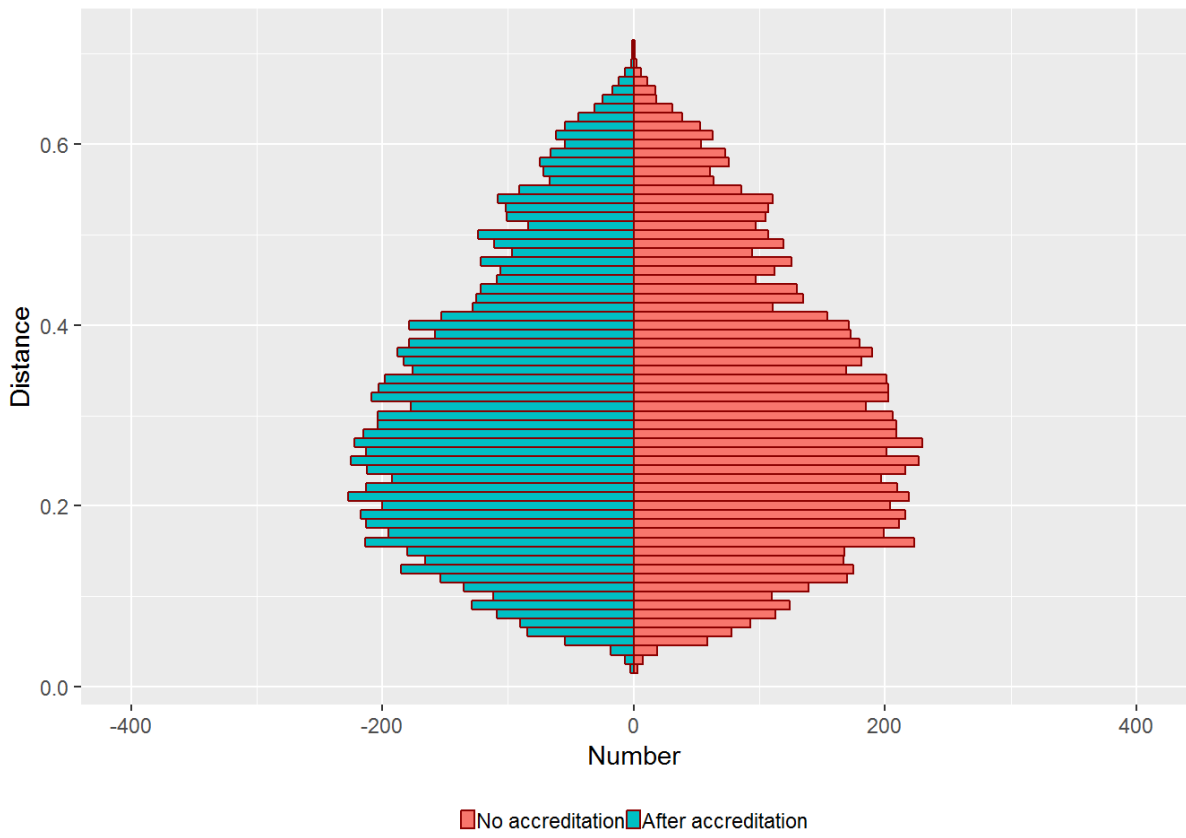
A

B

Figure S6.   Cumulative Kaplan-Meier Curve Estimates of Outcomes within 7 days after Hospitalization in Sensitivity Analyses. Abbreviations: CI, confidence interval; HR, hazard ratio; MACE, major adverse cardiovascular events. Panel A and B show data for MACE in the whole study population and the propensity score-matched population respectively. Panel C and D show data for all-cause death in the whole study population and the propensity score-matched population respectively.