ORIGINAL RESEARCH

Geographic Variations in In-Hospital Mortality and Use of Percutaneous Coronary Intervention Following Acute Myocardial Infarction in China: A Nationwide Cross-Sectional Analysis

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Background—Prevalence of acute myocardial infarction (AMI) is increasing in China, and AMI has become a major cause of mortality; however, information is very limited about the nationwide geographic and hospital variation in in-hospital mortality (IHM) and the use of percutaneous coronary intervention (PCI) after AMI.

Methods and Results—From the Nationwide Hospital Discharge Database of China, we identified 242 866 adult admissions with AMI in 2015 from 1055 tertiary hospitals. We used multivariable logistic regressions to analyze the associations between geographic or hospital characteristics with IHM or PCI use. The national IHM rate was 4.71% (95% confidence interval, 4.62–4.79%). There was a greater risk of mortality in the Northeast (odds ratio [OR]: 1.86), West (OR: 1.73), South (OR: 1.32), and North (OR: 1.14) regions than in the East region of China. Non–teaching hospitals (OR: 1.18) and tertiary level B hospitals (OR: 1.06) were associated with higher IHM rates. The national PCI use rate was 45.3% (95% confidence interval, 45.1–45.5%). Compared with the East region of China, PCI use was lower in the Northeast (OR: 0.50), West (OR: 0.64), North (OR: 0.84), and South (OR: 0.88) regions. Non–teaching hospitals (OR: 0.83) and tertiary level B hospitals (OR: 0.55) were also associated with lower usage rates. There was a significant negative correlation between IHM and PCI use ($r=-0.955$), and IHM rates for patients with and without PCI both differed by geographic regions.

Conclusions—There were significant differences in IHM and PCI use among China's tertiary hospitals, linked to both geographic and hospital characteristics. More targeted intervention at national and regional levels is needed to improve access to effective health technologies and, eventually, outcomes following AMI. **(*J Am Heart Assoc*. 2018;7:e008131. DOI: 10.1161/JAHA.117.008131.)**

Key Words: acute myocardial infarction • in-hospital mortality • percutaneous coronary intervention • regional variations

China has experienced a dramatic transition in disease profile from infectious to noncommunicable diseases, accompanied by rapid economic growth over the past few decades.[1,2] Acute myocardial infarction (AMI) is an acute and often fatal form of ischemic heart disease, which is the second leading cause of death; 1 in every 6 deaths is caused by ischemic heart disease.[3] AMI accounts for the majority of deaths from ischemic heart disease. In contrast to the declining trend in AMI in the United States and European countries,[4–10] AMI mortality in China has increased

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Accompanying Tables S1 through S3 are available at http://jaha.ahajournals.org/content/7/8/e008131/DC1/embed/inline-supplementary-material-1.pdf

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Clinical Perspective

What Is New?

- China had significant variations in regional rates of in-hospital mortality, ranging from 3.60% in the North to 6.44% in the Northeast, and in percutaneous coronary intervention use after acute myocardial infarction, ranging from 36.0% in the Northeast to 50.5% in the east.
- The regional rate of in-hospital mortality was significantly linked to percutaneous coronary intervention use, adjusting for other confounders at regional and hospital levels.
- Non–teaching hospitals and tertiary level B hospitals had significantly higher in-hospital mortality rates (5.82% and 5.26%, respectively) and lower percutaneous coronary intervention use (38.1% and 33.0%, respectively), compared with teaching and tertiary level A hospitals.

What Are the Clinical Implications?

- More targeted interventions at national and regional levels in China are needed to improve access and quality of percutaneous coronary intervention use and, in turn, treatment outcomes for acute myocardial infarction.

sharply.[11,12] The number of AMI cases in China is expected to increase from 8 million in 2010 to 23 million in 2030.[13]

During hospitalization in the acute phase, AMI is associated with high in-hospital mortality (IHM).[14–16] The prognosis for AMI varies significantly among patients for many reasons, including diversity in sex, race, age, AMI subtype, comorbidity, and treatment strategy.[14,15,17,18] Percutaneous coronary intervention (PCI) is now an effective treatment for AMI.[19] Studies from the United States and Canada have reported that IHM rates were significantly lower for AMI patients who underwent PCI.[16,20,21]

PCI use has increased significantly in China[12] but varies by region, partly because of inconsistent medical development.[22] Identifying the determinants of IHM and PCI use among AMI patients is likely to be important in developing targeted interventions to improve access to PCI and to reduce AMI mortality.[23] Previous studies, however, used data from a specific region or selected hospitals[24–28] or focused on patients with ST-segment–elevation myocardial infarction (STEMI).[29–34] Given the marked geographic, economic, demographic, and cultural diversity in China, a nationwide investigation using representative samples is needed.

Since 2013, the Center for Health Statistics Information, under the National Health and Family Planning Commission (NHFPC) of China, has collected hospital discharge data. In this study, hospital discharge data from 2015 were used to investigate how geographic and hospital characteristics are linked to IHM and PCI use for AMI inpatients at 1055 tertiary hospitals in China.

Methods

The authors declare that all supporting data are available within the article and its online supplementary files.

Data Source

The nationwide hospital discharge data used in this study were derived from the Nationwide Hospital Discharge Database (NHDD) operated by the Center for Health Statistics Information. The data were audited by NHFPC and double-checked before any further use. According to the front page of Inpatients Medical Records 2012 revision issued by the NHFPC,[35] summarized information about hospitalized patients is collected routinely from all secondary and tertiary hospitals except traditional Chinese medicine hospitals, national hospitals, army hospitals, and hospitals located in Tibet. This information is imported into NHDD every 3 months via a private network interface. The information includes patient demographics (eg, sex, date of birth, home address, marital status, occupation), medical insurance status (eg, Urban Employee Basic Medical Insurance [UEBMI], Urban Resident Basic Medical Insurance, New Rural Cooperative Medical Scheme, socialized medicine, self-pay), source of hospital admission (emergency, clinic, and referral), length of hospital stay, charge per hospital stay, and discharge deposition (eg, discharged under doctor's order, referral under doctor's order, discharged without doctor's order, death), primary and secondary diagnoses (identified using the *International Classification of Diseases, 10th Revision* [*ICD-10*] codes) and procedures (identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] codes). Authors had full access to all data in the study and take responsibility for its integrity and analysis.

Study Design and Population

Because very few secondary hospitals are able to perform PCI, only data from tertiary hospitals were used in the study. We exported data from all 243 222 hospitalizations discharged in 2015 with a primary diagnosis of AMI (identified using *ICD-10* codes I21 and I22[37,38]; 97.5% of all hospital discharges with AMI according to the official statistics reported by NHFPC[36]). To restrict our study to a typical adult AMI population, we excluded 50 hospitalizations involving those aged <18 years. We also excluded 287 records with missing sex information and 19 records with length of stay of 0 day (which may not reflect a diagnosis of AMI) or ≥180 days. The final study sample included 242 866 distinct hospitalization episodes.

Outcomes

The primary outcome of interest was IHM, defined as the in-hospital case-fatality rate for patients hospitalized with AMI.

The death information was obtained from the discharge deposition field. The secondary outcome was the use of PCI, identified using *ICD-9-CM* codes 00.66, 36.03 to 04, 36.06 to 07, and 36.09 in any of the primary and secondary procedural fields.[39]

Patient and Hospital Characteristics

Patient demographic characteristics included sex, age (grouped into 18–44, 45–59, 60–69, 70–79, and ≥80 years), and medical insurance status. AMI was categorized into 2 subtypes by existing ST-segment elevation: STEMI, identified by *ICD-10* codes I21.0 to 3, I21.9, I22.0 to 1, and I22.8 to 9; and non-STEMI (NSTEMI), identified by *ICD-10* codes I21.4 and I22.2.[40] We also calculated each patient's Charlson Comorbidity Index (CCI)[41] using the adaptation to predict in-hospital or short-term mortality.[42–45] This comorbidity index is based on the presence or absence of 17 different conditions during the primary (index) hospitalization, including disorders such as renal disease, liver disease, pulmonary disease, diabetes mellitus, peripheral arterial disease, and cancer. Clinical conditions included in the CCI system were identified using *ICD-10* codes in any secondary diagnosis field.[46] Myocardial infarction was excluded from our CCI system. Weight of 1, 2, 3, or 6 was assigned to each Charlson comorbidity, and the weighted sum of all Charlson comorbidities was calculated as the CCI score. The higher the CCI score, the greater the severity of the comorbidity. A CCI of 0 was assigned to indicate the absence of any Charlson comorbidity.

Hospital characteristics included hospital level (tertiary level A and B) and teaching status (teaching and nonteaching), obtained from the hospitals' official websites. We also identified hospital location. There are 6 administrative regions in mainland China: North, Northeast, East, South, Southwest, and Northwest. The study populations were very small in the Southwest and Northwest regions, so the 2 regions were merged into 1 region named *West*. The country was thus divided into 5 geographic regions in the study.

Statistical Analyses

Statistical analyses used IBM SPSS Statistics 23.0 (IBM Corp). Patient and hospital characteristics were reported as means with standard deviations or frequencies with percentages and compared among geographic regions using 1-way ANOVA for scale variables, the Pearson χ^2 test for nominal variables, and the Kruskal–Wallis test for ordinal variables. $P<0.05$ was considered statistically significant.

Factors potentially affecting IHM, including patient characteristics (age, sex, medical insurance status, AMI subtype, and CCI score) and hospital characteristics (geographic region, hospital level, and teaching status), were first examined alone using univariable logistic regressions. To explore associations between geographic regions and IHM, we used multivariable logistic regression analysis, controlling for patient and hospital characteristics. We also examined the associations between geographic regions and PCI use with similar analyses. Crude and adjusted odds ratios with 95% confidence intervals were used to report the results of univariable and multivariable logistic regression analyses. The relationship between IHM rate and PCI use by geographic region was analyzed using linear regression analysis, and the partial correlation coefficient of IHM rate and PCI use was calculated when adjusting for other confounders.

Results

Baseline Patient Characteristics

We identified a total of 242 866 hospital discharge records for adult patients with a primary diagnosis of AMI from 1055 tertiary hospitals (616 and 439 tertiary level A and B hospitals, and 793 and 262 teaching and non–teaching hospitals, respectively) across China during the study period, yielding an average of 230.2 discharges per hospital. There were differences in regional proportions of the total hospital discharge figures and numbers of average discharge per hospital in each region (Figure 1 and Table S1).

The mean±SD age of the 242 866 AMI patients was 64.2±13.0 years, and patients in the East were the youngest on average. A predominance of male inpatients and STEMI patients was seen in all 5 regions. More than half (range: 55.6–68.2%) of the patients in all 5 regions had UEBMI or New Rural Cooperative Medical Scheme as their primary medical insurance. The patients in the East and South were more likely to pay out of pocket compared with their counterparts in other regions. There were similar distributions of severity of comorbidities in the North, East and West, and patients in the South and Northeast were more likely to have severe and mild comorbidities, respectively. There was significant variation in the proportion of discharges from tertiary level A hospitals (range: 77.2–87.8%) and teaching hospitals (79.6–89.1%) across geographic regions (both $P<0.001$; Table 1).

IHM of AMI Inpatients

A total of 11 429 patients with AMI died during hospitalization. The observed national IHM rate was 4.71% (95% confidence interval, 4.62–4.79%), but the IHM rate differed significantly by geographic region, hospital level, and teaching status (all $P<0.001$). IHM rates for tertiary level A hospitals were lower than for tertiary level B hospitals in most regions

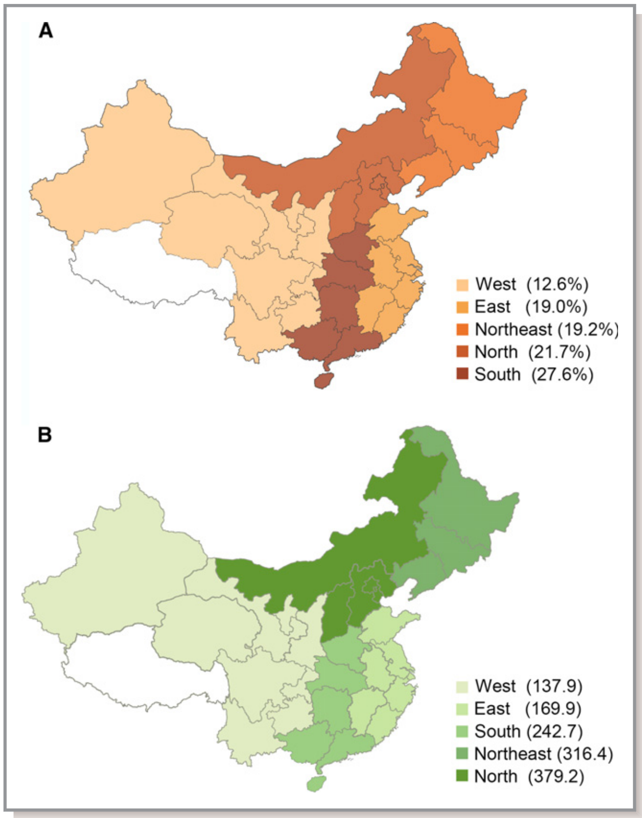

Figure 1. Regional variation in hospital discharge following acute myocardial infarction. A, Proportion of the total discharges for the hospitals located in each of the 5 regions. B, Average number of discharges per hospital in each of the 5 regions are shown in the brackets. No discharge data were available for Tibet (white area) during the study period.

except the East (3.88% versus 3.30%, P=0.010). IHM rates were higher in non–teaching hospitals than teaching hospitals in each region (Figure 2).

After adjusting for demographics, CCIs, AMI subtypes, and hospital characteristics, we found a significantly higher IHM risk in the Northeast, West, South, and North than the East. Hospital level and teaching status were also associated with IHM when controlling for demographics, comorbidities, AMI subtypes, and hospital locations. Other significant risk factors were older age, female sex, higher CCI, STEMI, and UEBMI as the main medical insurance (Table 2 and Table S2).

PCI Use Among AMI Inpatients

A total of 110 074 PCIs were performed in the 5 regions. The nationwide PCI rate was 45.3% (95% confidence interval, 45.1–45.5%) and differed significantly by geographic region, hospital level, and teaching status (all with P<0.001). After adjusting for patient and hospital characteristics, significantly higher PCI use was found in the East than in the other regions. Hospital level and teaching status were also associated with PCI use for AMI patients after adjusting for demographics, comorbidities, AMI subtypes, and hospital locations (Table 3). In addition to geographic region and hospital characteristics, baseline patient characteristics were significantly associated with the use of PCI among AMI patients (Table 3 and Table S3).

Association Between IHM and PCI Use

The overall IHM rate was significantly lower for AMI patients who received PCI than for those who did not (1.34% versus 7.50%, P<0.001), and both IHM rates varied significantly among the regions, with the lowest rates (0.86% and 6.14%) in the North and the highest (2.11% and 8.87%) in the Northeast (Figure 3). There was a significant negative correlation between IHM and PCI use at the regional level (r=−0.955, P=0.012; Figure 4).

We reevaluated the relationship between the IHM rate and PCI use by adjusting for several hospital and regional characteristics that might contribute to the relationship. The IHM rate had a significant negative correlation with the proportion of both teaching hospitals (r=−0.952, P=0.012) and tertiary level A hospitals (r=−0.918, P=0.028) at the regional level, whereas other confounders, such as average discharge per tertiary level A hospital, average discharge per teaching hospital, the proportion of male patients and patients with STEMI, average age, and CCI, had no significant relationship with IHM. The relationship between the IHM rate and PCI use improved slightly after adjustment (correlation coefficient improved from −0.955 to −0.979, P=0.699).

Discussion

To the best of our knowledge, this study is the first to investigate regional variations in AMI outcomes using real-world hospital discharge data in China. The results of the study may be helpful in promoting the appropriate use of PCI and reducing unnecessary variations in treatment for AMI patients. A large national hospital discharge database (NHDD) was used to study AMI mortality and PCI use in the hospital setting. The structure, contents, and coverage of this database are quite similar to those of the Nationwide Inpatient Sample database sponsored by the US Healthcare Cost and Utilization Project, which has been widely used in >3000 observational studies on hospitalization characteristics.[47] Few studies, however, have used NHDD data. We drew on this data source for a large observational study of AMI in China, with data collected from 1055 tertiary hospitals. Our findings include significant regional

Table 1. Patient Demographics and Hospital Characteristics for 242 866 Patients With AMI

		Geographic Region					
	Overall (n=242 866)	North (n=52 709)	Northeast (n=46 513)	East (n=46 047)	South (n=66 976)	West (n=30 621)	*P* Value
Patient demographics							
Age, y, mean (SD)	64.2 (13.0)	62.8 (12.9)	65.0 (12.8)	66.0 (13.0)	63.7 (13.1)	64.1 (12.9)	<0.001
Age, y, n (%)							<0.001
18–44	17 269 (7.1)	4418 (8.4)	2697 (5.8)	2648 (5.8)	5259 (7.9)	2247 (7.3)	
45–59	68 881 (28.4)	16 639 (31.6)	13 053 (28.1)	11 356 (24.7)	19 337 (28.9)	8496 (27.7)	
60–69	67 571 (27.8)	15 085 (28.6)	12 679 (27.3)	12 583 (27.3)	18 720 (28)	8504 (27.8)	
70–79	57 465 (23.7)	10 847 (20.6)	11 392 (24.5)	11 889 (25.8)	15 506 (23.2)	7831 (25.6)	
≥80	31 680 (13.0)	5720 (10.9)	6692 (14.4)	7571 (16.4)	8154 (12.2)	3543 (11.6)	
Sex, n (%)							<0.001
Male	172 971 (71.2)	37 835 (71.8)	30 064 (64.6)	32 984 (71.6)	49 475 (73.9)	22 613 (73.8)	
Female	69 895 (28.8)	14 874 (28.2)	16 449 (35.4)	13 063 (28.4)	17 501 (26.1)	8008 (26.2)	
AMI subtype, n (%)							<0.001
NSTEMI	56 888 (23.4)	16 663 (31.6)	10 082 (21.7)	9072 (19.7)	14 698 (21.9)	6373 (20.8)	
STEMI	185 978 (76.6)	36 046 (68.4)	36 431 (78.3)	36 975 (80.3)	52 278 (78.1)	24 248 (79.2)	
CCI, mean (SD)	1.21 (1.25)	1.26 (1.33)	0.93 (1.17)	1.14 (1.13)	1.40 (1.27)	1.21 (1.23)	<0.001
CCI, n (%)							<0.001
0	79 219 (32.6)	17 221 (32.7)	21 584 (46.4)	14 706 (31.9)	15 806 (23.6)	9902 (32.3)	
1	86 966 (35.8)	18 053 (34.3)	13 806 (29.7)	17 856 (38.8)	26 247 (39.2)	11 004 (35.9)	
2	45 772 (18.8)	9872 (18.7)	6711 (14.4)	8752 (19.0)	14 574 (21.8)	5863 (19.1)	
3	17 918 (7.4)	4170 (7.9)	2584 (5.6)	2958 (6.4)	5996 (9.0)	2210 (7.2)	
4	7810 (3.2)	1854 (3.5)	1149 (2.5)	1176 (2.6)	2643 (3.9)	988 (3.2)	
≥5	5181 (2.1)	1539 (2.9)	679 (1.5)	599 (1.3)	1710 (2.6)	654 (2.1)	
Medical insurance status, n (%)							<0.001
UEBMI	89 832 (37.0)	22 287 (42.3)	19 338 (41.6)	18 100 (39.3)	19 231 (28.7)	10 876 (35.5)	
URBMI	30 143 (12.4)	2871 (5.4)	5332 (11.5)	6898 (15.0)	10 341 (15.4)	4701 (15.4)	
NRCMS	55 994 (23.1)	13 634 (25.9)	7717 (16.6)	9727 (21.1)	18 012 (26.9)	6904 (22.5)	
Socialized medicine	7591 (3.1)	2994 (5.7)	1840 (4.0)	299 (0.6)	2258 (3.4)	200 (0.7)	
Self-pay	33 935 (14.0)	6731 (12.8)	4138 (8.9)	8021 (17.4)	11 529 (17.2)	3516 (11.5)	
Other	25 371 (10.4)	4192 (8.0)	8148 (17.5)	3002 (6.5)	5605 (8.4)	4424 (14.4)	
Hospital characteristics							
Level, n (%)							<0.001
Tertiary level A	198 692 (81.8)	43 690 (82.9)	40 832 (87.8)	37 114 (80.6)	51 678 (77.2)	25 378 (82.9)	
Tertiary level B	44 174 (18.2)	9019 (17.1)	5681 (12.2)	8933 (19.4)	15 298 (22.8)	5243 (17.1)	
Teaching status, n (%)							<0.001
Teaching	204 833 (84.3)	46 533 (88.3)	37 017 (79.6)	41 032 (89.1)	55 181 (82.4)	25 070 (81.9)	
Non–teaching	38 033 (15.7)	6176 (11.7)	9496 (20.4)	5015 (10.9)	11 795 (17.6)	5551 (18.1)	

AMI indicates acute myocardial infarction; CCI, Charlson Comorbidity Index; NRCMS, New Rural Cooperative Medical System; NSTEMI, non–ST-segment–elevation myocardial infarction; STEMI, ST-segment–elevation myocardial infarction; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance.

variations in IHM and PCI use among AMI patients admitted to tertiary hospitals and in IHM among AMI patients who received PCI. These findings not only demonstrate the utility of NHDD but also provide real-world evidence to drive policy on promoting PCI use in particular regions in China to reduce IHM after AMI.

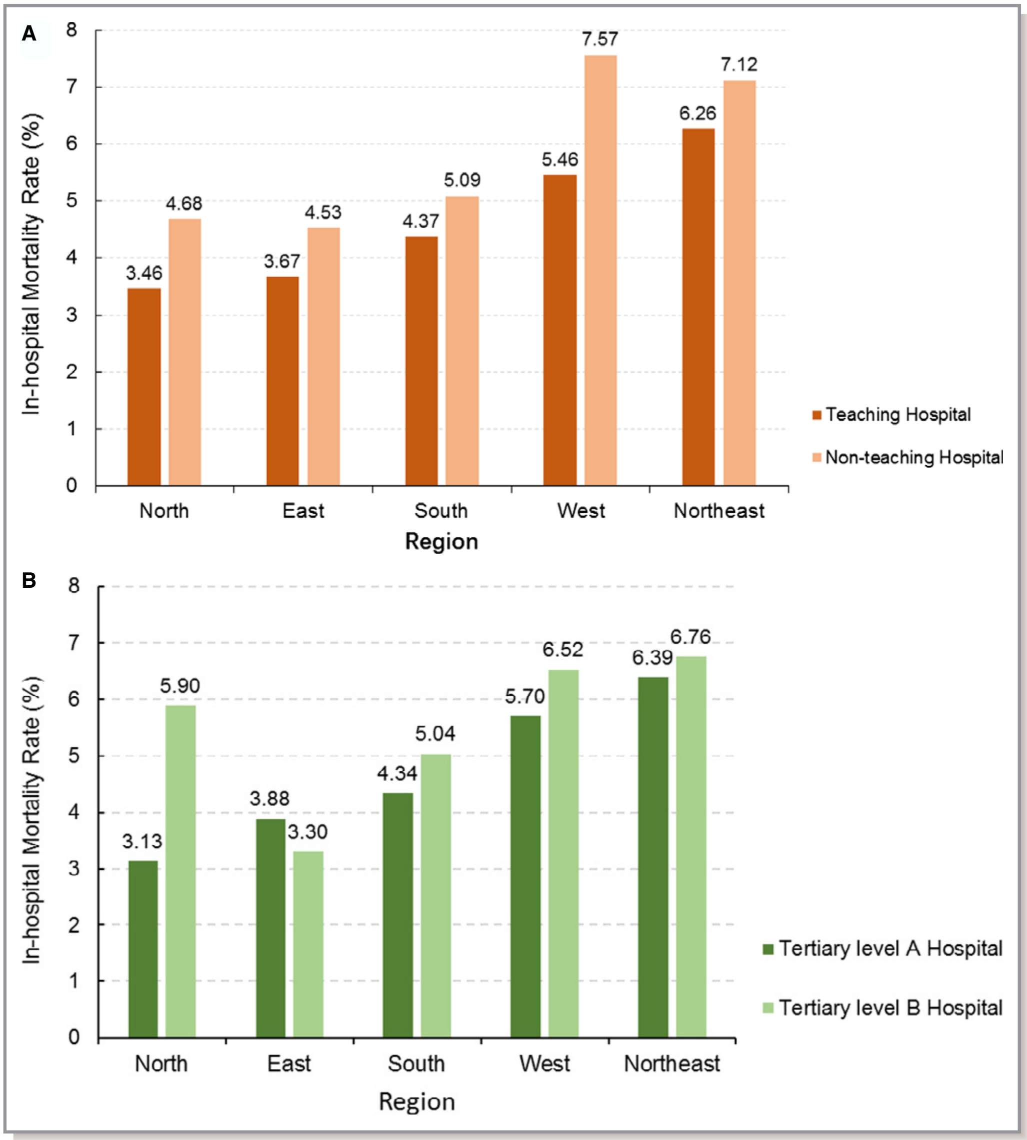

Figure 2. Regional variation in in-hospital mortality following acute myocardial infarction. In-hospital mortality rates among the 5 geographic regions by (A) hospital teaching status and (B) hospital level.

Previous studies have reported varied findings for AMI patients in the United States, European, and Asian countries. In-hospital and 30-day mortality rates for AMI patients in these studies ranged from 4.54% to 10.1% and from 6% to 16.1%, respectively.[6,8,15,48–51] Even within China, region-, province-, and hospital-level IHM rates vary in studies using sampled data.[24,52] These differences in AMI patients' outcomes suggest an urgent need for timely, nationwide statistics for AMI in China to assist policy makers. In our study, which used routinely collected discharge data for AMI patients, the national IHM rate was 4.71%, with the lowest rate in the North (3.60%) and the highest in the Northeast (6.44%).

In China, tertiary hospitals are usually comprehensive or general hospitals at the city, province, or national level, with numbers of beds between 500 and 4000. These hospitals provide specialized medical and health services to the surrounding areas. Based on the institute size and medical management, technology, and quality, they are further subdivided into levels A and B. Tertiary level A or teaching hospitals have more resources to support early recognition and accurate diagnosis of and targeted therapy for AMI. It has previously been reported that both AMI patients and patients with other diseases experienced higher mortality in non–teaching hospitals than in teaching hospitals in the United States.[53,54] In this study population, the proportion of patients hospitalized in tertiary level A hospitals and teaching hospitals was higher in the North and East, and the IHM rate was lower. This suggested that the regional differences in the number of patients admitted to tertiary level A and/or teaching hospitals could be linked to the regional differences in IHM rates. Hospital teaching status

Table 2. Factors Associated With In-Hospital Mortality for Patients With AMI

Factor	In-Hospital Mortality Rate, % (95% CI)	Univariable Analysis		Multivariable Analysis		
		OR	95% CI	OR	95% CI	*P* Value
Region						
East	3.77 (3.60–3.95)	1		1		
North	3.60 (3.44–3.76)	0.96	0.89–1.02	1.14	1.06–1.22	<0.001
Northeast	6.44 (6.22–6.67)	1.76	1.66–1.87	1.86	1.74–1.98	<0.001
South	4.50 (4.34–4.66)	1.20	1.13–1.28	1.32	1.24–1.40	<0.001
West	5.84 (5.58–6.11)	1.58	1.48–1.70	1.73	1.62–1.86	<0.001
Hospital level						
Tertiary level A	4.58 (4.49–4.67)	1		1		
Tertiary level B	5.26 (5.05–5.47)	1.16	1.10–1.21	1.06	1.01–1.11	0.024
Hospital teaching status						
Teaching	4.50 (4.41–4.59)	1		1		
Non–teaching	5.82 (5.59–6.06)	1.31	1.25–1.37	1.18	1.12–1.24	<0.001
Sex						
Male	3.92 (3.83–4.01)	1		1		
Female	6.65 (6.47–6.84)	1.74	1.68–1.81	1.27	1.21–1.32	<0.001
Age, y						
18–44	1.42 (1.25–1.61)	1		1		
45–59	1.82 (1.72–1.92)	1.28	1.12–1.47	1.23	1.07–1.41	0.004
60–69	3.37 (3.24–3.51)	2.42	2.12–2.76	2.18	1.90–2.49	<0.001
70–79	6.78 (6.58–6.99)	5.04	4.42–5.73	4.10	3.59–4.67	<0.001
≥80	11.84 (11.49–12.20)	9.29	8.16–10.59	7.20	6.30–8.22	<0.001
AMI subtype						
NSTEMI	3.59 (3.44–3.75)	1		1		
STEMI	5.05 (4.95–5.15)	1.43	1.36–1.50	1.96	1.86–2.06	<0.001
CCI						
0	3.18 (3.06–3.30)	1		1		
1	4.03 (3.90–4.16)	1.28	1.22–1.35	1.27	1.20–1.34	<0.001
2	5.30 (5.10–5.51)	1.71	1.61–1.81	1.50	1.42–1.59	<0.001
3	7.79 (7.40–8.19)	2.58	2.41–2.76	2.05	1.91–2.19	<0.001
4	10.64 (9.96–11.35)	3.63	3.34–3.94	2.72	2.49–2.96	<0.001
≥5	14.50 (13.55–15.49)	5.17	4.74–5.64	3.87	3.53–4.24	<0.001
Medical insurance status						
UEBMI	5.92 (5.77–6.08)	1		1		
URBMI	4.88 (4.64–5.13)	0.82	0.77–0.86	0.77	0.73–0.82	<0.001
NRCMS	2.60 (2.47–2.74)	0.42	0.40–0.45	0.50	0.47–0.53	<0.001
Socialized medicine	5.12 (4.63–5.64)	0.86	0.77–0.95	0.86	0.77–0.96	0.006
Self-pay	4.36 (4.15–4.58)	0.72	0.68–0.77	0.94	0.89–1.00	0.066
Other	5.20 (4.93–5.48)	0.87	0.82–0.93	0.85	0.80–0.91	<0.001

AMI indicates acute myocardial infarction; CCI, Charlson Comorbidity Index; CI, confidence interval; NRCMS, New Rural Cooperative Medical System; NSTEMI, non–ST-segment–elevation myocardial infarction; OR, odds ratio; STEMI, ST-segment–elevation myocardial infarction; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance.

Table 3. Factors Associated With PCI Use for Patients With AMI

Factor	PCI Utilization Rate, % (95% CI)	Univariable Analysis		Multivariable Analysis		
		OR	95% CI	OR	95% CI	*P* Value
Region						
East	50.5 (50.0–51.0)	1		1		
North	48.1 (47.7–48.5)	0.91	0.89–0.93	0.84	0.82–0.86	<0.001
Northeast	36.0 (35.6–36.4)	0.55	0.54–0.57	0.50	0.49–0.51	<0.001
South	47.8 (47.4–48.2)	0.90	0.88–0.92	0.88	0.86–0.90	<0.001
West	41.6 (41.0–42.2)	0.70	0.68–0.72	0.64	0.62–0.66	<0.001
Hospital level						
Tertiary level A	48.1 (47.9–48.3)	1		1		
Tertiary level B	33.0 (32.6–33.4)	0.53	0.52–0.54	0.55	0.54–0.56	<0.001
Hospital teaching status						
Teaching	46.7 (46.5–46.9)	1		1		
Non–teaching	38.1 (37.6–38.6)	0.70	0.69–0.72	0.83	0.81–0.86	<0.001
Sex						
Male	49.6 (49.4–49.8)	1		1		
Female	34.7 (34.3–35.1)	0.54	0.53–0.55	0.75	0.74–0.77	<0.001
Age, y						
18–44	57.4 (56.7–58.1)	1		1		
45–59	56.6 (56.2–57.0)	0.97	0.94–1.00	1.03	1.00–1.07	0.058
60–69	50.6 (50.2–51.0)	0.76	0.73–0.78	0.87	0.84–0.90	<0.001
70–79	36.3 (35.9–36.7)	0.42	0.41–0.44	0.51	0.49–0.53	<0.001
≥80	19.2 (18.8–19.6)	0.18	0.17–0.18	0.22	0.21–0.23	<0.001
AMI subtype						
NSTEMI	37.2 (36.8–37.6)	1		1		
STEMI	47.8 (47.6–48.0)	1.55	1.52–1.58	1.43	1.40–1.46	<0.001
CCI						
0	47.3 (47.0–47.6)	1		1		
1	49.1 (48.8–49.4)	1.08	1.06–1.10	1.11	1.09–1.13	<0.001
2	43.7 (43.2–44.2)	0.87	0.85–0.89	0.96	0.94–0.99	0.002
3	36.3 (35.6–37.0)	0.64	0.62–0.66	0.79	0.76–0.82	<0.001
4	29.2 (28.2–30.2)	0.46	0.44–0.49	0.61	0.58–0.65	<0.001
≥5	21.6 (20.5–22.7)	0.31	0.29–0.33	0.42	0.39–0.45	<0.001
Medical insurance status						
UEBMI	46.6 (46.3–46.9)	1		1		
URBMI	44.2 (43.6–44.8)	0.91	0.89–0.93	0.91	0.89–0.94	<0.001
NRCMS	43.0 (42.6–43.4)	0.87	0.85–0.89	0.74	0.73–0.76	<0.001
Socialized medicine	47.7 (46.6–48.8)	1.05	1.00–1.10	1.02	0.97–1.08	0.376
Self-pay	49.3 (48.8–49.8)	1.12	1.09–1.14	0.88	0.86–0.90	<0.001
Other	41.1 (40.5–41.7)	0.80	0.78–0.82	0.79	0.77–0.82	<0.001

AMI indicates acute myocardial infarction; CCI, Charlson Comorbidity Index; CI, confidence interval; NRCMS, New Rural Cooperative Medical System; NSTEMI, non–ST-segment–elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-segment–elevation myocardial infarction; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance.

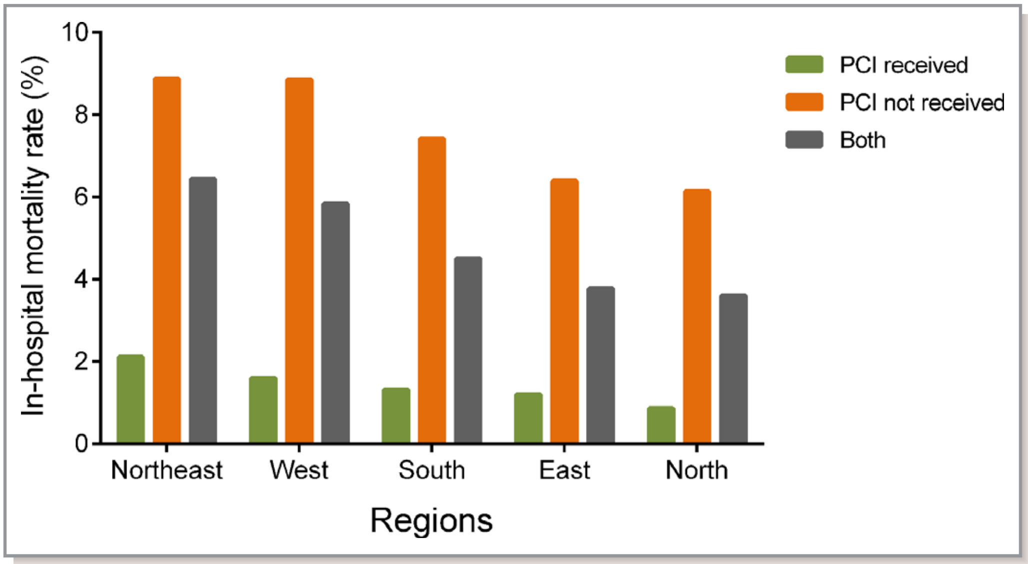

Figure 3. In-hospital mortality rates following acute myocardial infarction among the 5 geographic regions by percutaneous coronary intervention (PCI) use.

had a stronger association than hospital level with the regional differences in IHM rate (crude odds ratio: 1.31 versus 1.16; adjusted odds ratio: 1.18 versus 1.06).

Clinical research and epidemiological surveys have shown that patients with STEMI have higher mortality rates. In our study, the overall IHM rate for STEMI patients was higher than for NSTEMI patients, similar to the result of another study on Chinese AMI patients.[55] Overall, 76.6% of AMI patients had an ST-segment elevation, and the proportions varied by geographic region from 68.4% to 80.3%. IHM rates for STEMI patients also varied by region, from 3.76% to 6.87%. Previous studies on limited regions showed that 5.4% to 6.7% of STEMI patients died within 7 days of admission in China.[31–34] These regional variations in proportion and IHM rate for STEMI patients may contribute to the regional disparities in overall IHM rates. Another important reason for the regional variations in IHM rate may be sex. Our study, like others,[18,56,57] reported higher AMI hospital mortality in women than in men. The higher proportion of female patients in some regions may thus be connected to the higher overall IHM rates in those regions. Other potential reasons for regional variations in IHM rate may include differences in patient characteristics, such as the severity of common comorbidities, age, and medical insurance status.

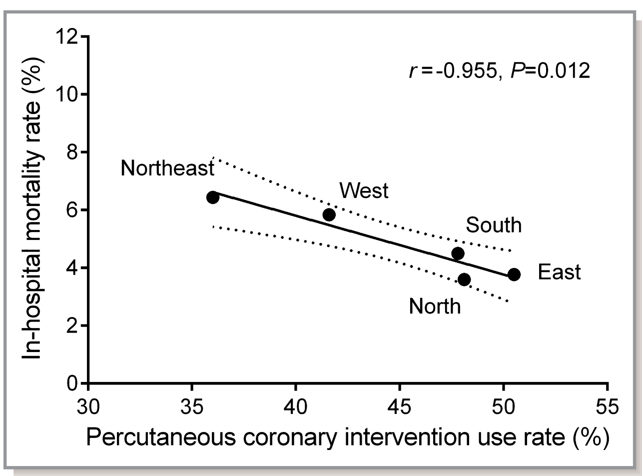

Figure 4. Regional in-hospital mortality rates with percutaneous coronary intervention use following acute myocardial infarction. The solid line is fitted using linear regression analysis and the dotted lines show the 95% confidence band of the fit line.

We also found regional variations in PCI use for AMI patients. Previous studies have focused mainly on the differences in PCI use among STEMI patients.[31–33] In our study, total PCI use rates varied by region (from 36.0% in the Northeast to 50.5% in the East), with similar regional variations for both NSTEMI and STEMI patients. High-level and teaching hospitals often have the resources and support necessary to perform advanced procedures and provide a high level of care to patients.[58] A recent report also showed that the proportion of hospitals with access to PCI varied by hospital level in China,[59] and this study also found that the majority of PCIs were undertaken at tertiary level A and teaching hospitals. Another important factor influencing the regional difference in PCI use may thus be differences in hospital characteristics across regions. Early revascularization and reperfusion are the most effective treatment strategies for AMI patients, so these findings suggest that it is necessary and urgent to improve access to PCI across all regions and facilities associated with lower PCI use (eg, non–teaching hospitals or tertiary level B hospitals) in China. In addition to the hospital characteristics, PCI use may be related to medical insurance coverage. The PCI use rate (43.0%) of AMI patients having the New Rural Cooperative Medical Scheme, one of the 3 main medical insurance systems, was lower than that of patients who had Urban Resident Basic Medical Insurance and UEBMI (44.2% and 46.6%, respectively). The reimbursement ratio of stent consumables from the New Rural Cooperative Medical Scheme was lower than that from Urban Resident Basic Medical Insurance or UEBMI and may lead to somewhat suppressed demand for PCI.

Several studies have shown that an increase in the use and volume of PCI was linked with a decrease in mortality and other adverse outcomes.[16,20,21,53,54] In this study, we observed a negative relationship between the regional rates of IHM and PCI use consistent with previous studies, even after adjusting for some confounders at regional and hospital levels; however, it is difficult to conclude a causal relation due to the unmeasured confounding factors. Hospitals with lower IHM rates are not necessarily hospitals with better care. There are large variations across China in both outcomes and use of PCI for AMI patients. The quasiexperimental methods that better address unmeasured confounding would be useful to argue for potentially causal relationships. Furthermore, investigations showed that the Northeast and West regions had not only higher overall IHM rates with lower overall PCI use but also higher IHM rates for AMI patients who received PCI than other regions. This finding has significant health policy implications for improving the quality of PCI in those regions, such as timely diagnosis and treatment for emergency AMI patients, qualification and skills of interventional physicians, and knowledge sharing on PCI technology across geographic regions.

Limitations

Our study had some limitations. First, although we controlled for multiple confounding factors, we cannot eliminate the possibility of unmeasured or unknown confounders affecting rates of IHM and PCI use for AMI patients. Second, different combinations of *ICD-10* or *ICD-9-CM* codes were used to identify a disease or procedure in previous studies, such as our combination of I21 and I22[25,37,38,50] and I21 alone[24,60,61] for AMI and our combination of 00.66, 36.03 to 04, 36.06 to 07, and 36.09[39] or several different combinations of 00.66, 36.01 to 02, 36.05 to 07, and 36.09[16,25,51,53] for PCI. These choices may affect the identification of AMI, STEMI or NSTEMI, and Charlson comorbidities, as well as PCI use. Third, given the nature of an administrative database, the NHDD lacks clinical information for AMI patients, such as ECG abnormalities and arrhythmia, which can be important in the diagnosis and classification of AMI.[61,62] Consequently, some of our classifications may be incorrect, which would alter the results. In addition, some information about the exact time, such as when patients arrived at the hospital and had the first medical contact, were also unavailable but were important for doctors to choose the most appropriate treatment (eg, primary PCI or thrombolytic therapy) for STEMI patients. Fourth, in this study, we found that the PCI rate (37.2%) for NSTEMI patients was lower than that for STEMI patients (47.8%), which may be due in part to the fact that NSTEMI patients may not have a stenosis suited to PCI. It is of interest to report PCI rates among cardiac catheterization. Unfortunately, the use of cardiac catheterization information was unavailable in our current data set, which is a limitation of this study. Based on our review of relevant literature, a survey of a nationally representative sample in China reported that 82.4% (2551/3094) of AMI patients with a cardiac catheterization underwent PCI.[63] Fifth, some severely ill patients may have stopped treatment and been discharged alive from hospitals because they wanted to die at home or could not afford to remain at the hospital. The survival status of these patients was uncertain and could result in an underestimate of the IHM rate.

Conclusions

In this large nationwide study of hospitalized patients, we observed significant disparities in IHM and PCI use for AMI patients admitted to tertiary hospitals across China. These disparities were linked to geographic locations and hospital characteristics. More work at the provincial, regional, and national levels is needed to develop targeted interventions to reduce disparities and unnecessary variations, to improve access to effective health technology, to enhance the overall quality of AMI treatment and care, and eventually to improve AMI outcomes.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. Information about hospitals and hospital discharges for the 1 055 tertiary hospitals among the five geographic regions in China.

Hospital characteristics		Geographic region					Subtotal
		North	Northeast	East	South	West	
Level							
Tertiary level-A	No. (%) of HD within region	43 690 (82.9)	40 832 (87.8)	37 077 (80.5)	51 678 (77.2)	25 378 (82.9)	198 655 (81.8)
	No. (%) of hospital within region	87 (62.6)	82 (55.8)	161 (59.4)	162 (58.7)	124 (55.9)	616 (58.4)
	Discharge per hospital	502.2	498.0	230.3	319.0	204.7	322.5
Tertiary level-B	No. (%) of HD within region	9 019 (17.1)	5 681 (12.2)	8 970 (19.5)	15 298 (22.8)	5 243 (17.1)	44 211 (18.2)
	No. (%) of hospital within region	52 (37.4)	65 (44.2)	110 (40.6)	114 (41.3)	98 (44.1)	439 (41.6)
	Discharge per hospital	173.4	87.4	81.5	134.2	53.5	100.7
Teaching status							
Teaching	No. (%) of HD within region	46 927 (89.0)	37 017 (79.6)	41 064 (89.2)	55 091 (82.3)	25 579 (83.5)	205 678 (84.7)
	No. (%) of hospital within region	111 (79.9)	87 (59.2)	222 (81.9)	221 (80.1)	152 (68.5)	793 (75.2)
	Discharge per hospital	422.8	425.5	185.0	249.3	168.3	259.4
Non-teaching	No. (%) of HD within region	5 782 (11.0)	9 496 (20.4)	4 983 (10.8)	11 885 (17.7)	5 042 (16.5)	37 188 (15.3)
	No. (%) of hospital within region	28 (20.1)	60 (40.8)	49 (19.1)	55 (19.9)	70 (31.5)	262 (24.8)
	Discharge per hospital	206.5	158.3	101.7	216.1	72.0	141.9
Total							
	No. of HD within region	52 709	46 513	46 047	66 976	30 621	242 866
	No. of hospital within region	139	147	271	276	222	1 055
	Discharge per hospital	379.2	316.4	169.9	242.7	137.9	230.2

HD, hospital discharge.

Table S2. In-hospital mortality for patients with acute myocardial infraction by patient and hospital characteristics among the five geographic regions in China.

	Overall (n = 242 866)	Geographic region					*P* value
		North (n = 52 709)	Northeast (n = 46 513)	East (n = 46 047)	South (n = 66 976)	West (n = 30 621)	
Total	4.71	3.60	6.44	3.77	4.50	5.84	<0.001
Patient demographics							
Age, %							
18-44 y	1.42	0.63	2.04	1.06	1.58	2.31	<0.001
45-59 y	1.82	1.19	2.43	1.37	1.91	2.52	<0.001
60-69 y	3.37	2.45	4.71	2.65	3.29	4.30	<0.001
70-79 y	6.78	5.63	9.35	4.77	6.59	8.08	<0.001
≥80 y	11.84	12.12	14.36	8.59	11.33	14.76	<0.001
Sex, %							
Male	3.92	2.83	5.39	3.15	3.85	5.07	<0.001
Female	6.65	5.56	8.36	5.33	6.32	8.02	<0.001
AMI subtype, %							
NSTEMI	3.59	3.26	4.89	2.44	3.33	4.69	<0.001
STEMI	5.05	3.76	6.87	4.09	4.83	6.14	<0.001
CCI score, %							
0	3.18	1.77	3.73	2.99	3.66	3.91	<0.001
1	4.03	2.61	6.65	3.19	3.67	5.31	<0.001
2	5.30	4.02	9.33	4.30	4.55	6.23	<0.001
3	7.79	6.31	14.09	5.68	6.59	9.32	<0.001
4	10.64	11.70	13.14	9.10	8.10	14.37	<0.001
≥5	14.50	15.92	19.15	12.35	11.58	15.90	<0.001
Medical insurance status, %							
UEBMI	5.92	4.50	7.12	4.80	6.58	7.38	<0.001
URBMI	4.88	5.61	7.67	3.75	4.07	4.68	<0.001
NRCMS	2.60	2.01	4.25	1.70	2.35	3.84	<0.001
Socialized medicine	5.12	3.87	4.78	14.38	5.05	14.00	<0.001
Self-pay	4.36	2.97	6.33	3.03	5.13	5.23	<0.001
Other	5.20	3.44	6.53	5.20	3.55	6.51	<0.001

(Continued)

	Overall (n = 242 866)	Geographic region					P value
		North (n = 52 709)	Northeast (n = 46 513)	East (n = 46 047)	South (n = 66 976)	West (n = 30 621)	
Hospital characteristics							
Level, %							
Tertiary level-A	4.58	3.13	6.39	3.88	4.34	5.70	<0.001
Tertiary level-B	5.26	5.90	6.76	3.30	5.04	6.52	<0.001
Teaching status, %							
Teaching	4.50	3.46	6.26	3.67	4.37	5.46	<0.001
Non-teaching	5.82	4.68	7.12	4.53	5.09	7.57	<0.001

UEBMI, urban employee basic medical insurance; URBMI, urban resident basic medical insurance; NRCMS, new rural cooperative medical system; AMI, acute myocardial infraction; STEMI, ST-segment elevation myocardial infraction; NSTEMI, non-ST-segment elevation myocardial infraction; CCI, Charlson comorbidity index.

Table S3. Utilization of percutaneous coronary intervention for patients with acute myocardial infraction by patient and hospital characteristics among the five geographic regions in China.

	Overall (n = 242 866)	**Geographic region**					***P* value**
		North (n = 52 709)	**Northeast (n = 46 513)**	**East (n = 46 047)**	**South (n = 66 976)**	**West (n = 30 621)**	
Total	45.3	48.1	36.0	50.5	47.8	41.6	<0.001
Patient demographics							
Age, %							
18-44 y	57.4	61.9	50.9	58.7	59.6	50.0	<0.001
45-59 y	56.6	60.1	47.3	62.2	59.1	51.2	<0.001
60-69 y	50.6	51.9	42.5	58.2	51.9	46.0	<0.001
70-79 y	36.3	35.7	26.3	44.5	38.6	34.6	<0.001
≥80 y	19.2	16.0	11.9	26.5	21.1	18.1	<0.001
Sex, %							
Male	49.6	52.3	40.4	54.8	51.9	44.9	<0.001
Female	34.7	37.4	27.8	39.6	36.2	32.1	<0.001
AMI subtype, %							
NSTEMI	37.2	37.7	32.3	40.8	38.5	35.1	<0.001
STEMI	47.8	52.9	37.0	52.9	50.4	43.3	<0.001
CCI score, %							
0	47.3	52.3	39.6	55.8	46.6	43.6	<0.001
1	49.1	53.4	38.7	52.4	51.6	44.0	<0.001
2	43.7	44.5	30.2	46.7	48.3	41.4	<0.001
3	36.3	35.8	22.2	37.6	43.1	33.8	<0.001
4	29.2	27.3	15.0	29.1	37.8	26.7	<0.001
≥5	21.6	19.3	11.5	24.0	26.9	21.1	<0.001
Medical insurance status, %							
UEBMI	46.6	47.7	34.4	54.4	50.5	45.8	<0.001
URBMI	44.2	40.6	34.5	43.0	50.6	45.1	<0.001
NRCMS	43.0	46.4	43.4	45.5	41.1	37.8	<0.001
Socialized medicine	47.7	57.6	48.8	42.5	36.7	22.5	<0.001
Self-pay	49.3	51.2	41.0	52.7	51.7	40.0	<0.001
Other	41.1	49.4	28.2	55.0	50.8	35.4	<0.001

(Continued)

	Overall (n = 242 866)	Geographic region					*P* value
		North (n = 52 709)	Northeast (n = 46 513)	East (n = 46 047)	South (n = 66 976)	West (n = 30 621)	
Hospital characteristics							
Level, %							
Tertiary level-A	48.1	50.5	39.0	53.8	50.4	45.2	<0.001
Tertiary level-B	33.0	36.3	14.1	36.9	38.8	24.0	<0.001
Teaching status, %							
Teaching	46.7	49.0	38.9	51.2	48.1	43.3	<0.001
Non-teaching	38.1	41.4	24.7	45.0	46.1	33.9	<0.001

UEBMI, urban employee basic medical insurance; URBMI, urban resident basic medical insurance; NRCMS, new rural cooperative medical system; AMI, acute myocardial infraction; STEMI, ST-segment elevation myocardial infraction; NSTEMI, non-ST-segment elevation myocardial infraction; CCI, Charlson comorbidity index.