

RESEARCH ARTICLE

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# National trends in hospital length of stay for acute myocardial infarction in China

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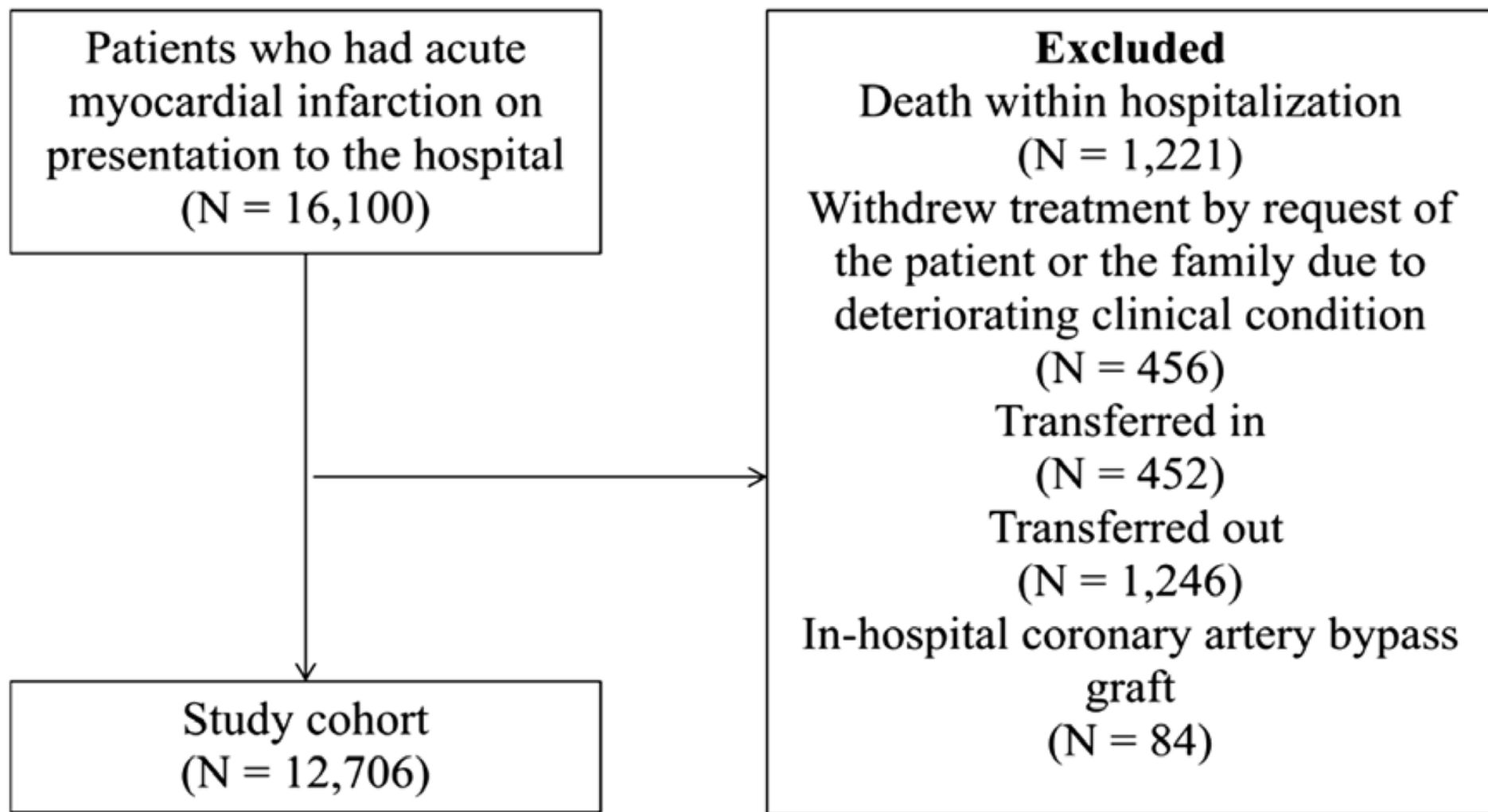
# Abstract

**Background:** China is experiencing increasing burden of acute myocardial infarction (AMI) in the face of limited medical resources. Hospital length of stay (LOS) is an important indicator of resource utilization.

**Methods:** We used data from the Retrospective AMI Study within the China Patient-centered Evaluative Assessment of Cardiac Events, a nationally representative sample of patients hospitalized for AMI during 2001, 2006, and 2011. Hospital-level variation in risk-standardized LOS (RS-LOS) for AMI, accounting for differences in case mix and year, was examined with two-level generalized linear mixed models. A generalized estimating equation model was used to evaluate hospital characteristics associated with LOS. Absolute differences in RS-LOS and 95% confidence intervals were reported.

**Results:** The weighted median and mean LOS were 13 and 14.6 days, respectively, in 2001 (n = 1,901), 11 and 12.6 days in 2006 (n = 3,553), and 11 and 11.9 days in 2011 (n = 7,252). There was substantial hospital level variation in RS-LOS across the 160 hospitals, ranging from 9.2 to 18.1 days. Hospitals in the Central regions had on average 1.6 days (p = 0.02) shorter RS-LOS than those in the Eastern regions. All other hospital characteristics relating to capacity for AMI treatment were not associated with LOS.

**Conclusions:** Despite a marked decline over the past decade, the mean LOS for AMI in China in 2011 remained long compared with international standards. Inter-hospital variation is substantial even after adjusting for case mix. Further improvement of AMI care in Chinese hospitals is critical to further shorten LOS and reduce unnecessary hospital variation.



**Figure 1.** Flow diagram of study population.

**Table 1.** Characteristics of patients in tertiles of hospitals with regard to median length of stay

	<b>All hospitals (n = 12706)</b>	<b>High-tertile hospitals (n = 4784)</b>	<b>Middle-tertile hospitals (n = 5105)</b>	<b>Low-tertile hospitals (n = 2817)</b>	<b>P-value</b>
Length of stay, median (IQR)					
2001	13 (8–19)	14 (9–21)	14 (9–18)	11 (7–16)	0.004
2006	11 (7–16)	13 (9–19)	11 (7–15)	8 (5–12)	<.0001
2011	11 (7–15)	14 (9–18)	11 (8–14)	9 (6–12)	<.0001
Year of admission					
2001	1901 (15.0)	773 (16.2)	834 (16.3)	294 (10.4)	
2006	3553 (28.0)	1361 (28.5)	1391 (27.3)	801 (28.4)	
2011	7252 (57.1)	2650 (55.4)	2880 (56.4)	1722 (61.1)	
<b>Socio-demographics</b>					
Age, years					
Mean $\pm$ std	64.4 $\pm$ 12.5	63.8 $\pm$ 12.4	64.5 $\pm$ 12.7	65.1 $\pm$ 12.1	0.2
<55	2905 (22.9)	1176 (24.6)	1172 (23.0)	557 (19.8)	0.07
55-64	3073 (24.2)	1125 (23.5)	1237 (24.2)	711 (25.2)	
65-74	3779 (29.7)	1455 (30.4)	1460 (28.6)	864 (30.7)	
$\geq$ 75	2949 (23.2)	1028 (21.5)	1236 (24.2)	685 (24.3)	
Female	3779 (29.7)	1385 (29.0)	1574 (30.8)	820 (29.1)	0.4
Place of residence					
Urban	3489 (27.5)	1525 (31.9)	1316 (25.8)	648 (23.0)	
Rural	8266 (65.1)	3087 (64.5)	3166 (62.0)	2013 (71.5)	
Unrecorded	951 (7.5)	172 (3.6)	623 (12.2)	156 (5.5)	

**Table 1. Continued**

	<b>All hospitals (n = 12706)</b>	<b>High-tertile hospitals (n = 4784)</b>	<b>Middle-tertile hospitals (n = 5105)</b>	<b>Low-tertile hospitals (n = 2817)</b>	<b>P-value</b>
<b>Cardiac risk factors</b>					
Current smoking	4406 (34.7)	1836 (38.4)	1659 (32.5)	911 (32.3)	0.03
Hypertension	5743 (45.2)	2252 (47.1)	2323 (45.5)	1168 (41.5)	0.3
Diabetes	2095 (16.5)	805 (16.8)	914 (17.9)	376 (13.4)	0.1
<b>Medical histories</b>					
Myocardial infarction	1369 (10.8)	466 (9.7)	639 (12.5)	264 (9.4)	0.008
Percutaneous coronary intervention	248 (2.0)	95 (2.0)	113 (2.2)	40 (1.4)	0.4
CABG	45 (0.4)	21 (0.4)	19 (0.4)	5 (0.2)	0.4
Stroke	1377 (10.8)	517 (10.8)	568 (11.1)	292 (10.4)	0.9
Chronic renal disease	2527 (19.9)	799 (16.7)	1076 (21.1)	652 (23.2)	0.02
Cancer	72 (0.6)	14 (0.5)	21 (0.4)	37 (0.8)	0.1
<b>Presentation features</b>					
Symptom onset to admission					0.5
≤6 hours	4838 (38.1)	1891 (39.5)	1925 (37.7)	1022 (36.3)	
6-12 hours	1290 (10.2)	477 (10.0)	525 (10.3)	288 (10.2)	
12-24 hours	1635 (12.9)	635 (13.3)	626 (12.3)	374 (13.3)	
>24 hours	4943 (38.9)	1781 (37.2)	2029 (39.8)	1133 (40.2)	
STEMI	10888 (85.7)	4190 (87.6)	4293 (84.1)	2405 (85.4)	0.07
Chest pain	11746 (92.4)	4421 (92.4)	4719 (92.4)	2606 (92.5)	0.9
Cardiogenic shock	475 (3.7)	190 (4.0)	175 (3.4)	110 (3.9)	0.6
Cardiac arrest	105 (0.8)	48 (1.0)	39 (0.8)	18 (0.6)	0.3
Pneumonia	1188 (9.4)	416 (8.7)	486 (9.5)	286 (10.2)	0.7
Exacerbated COPD	203 (1.6)	73 (1.5)	76 (1.5)	54 (1.9)	0.6

**Table 1.** Continued

	<b>All hospitals (n = 12706)</b>	<b>High-tertile hospitals (n = 4784)</b>	<b>Middle-tertile hospitals (n = 5105)</b>	<b>Low-tertile hospitals (n = 2817)</b>	<b>P-value</b>
Acute stroke	114 (0.9)	41 (0.9)	43 (0.8)	30 (1.1)	0.6
eGFR, ml/min/1.73 m <sup>2</sup>					
Mean ± std	84.6 ± 38.6	88.7 ± 37.4	82.9 ± 37.5	80.5 ± 42.0	0.008
>90	4210 (33.1)	1848 (38.6)	1630 (31.9)	732 (26.0)	0.0006
60-90	4158 (32.7)	1515 (31.7)	1792 (35.1)	851 (30.2)	
<60	2389 (18.8)	759 (15.9)	1017 (19.9)	613 (21.8)	
Unknown	1949 (15.3)	662 (13.8)	666 (13.1)	621 (22.0)	
Systolic blood pressure >180 mmHg or diastolic blood pressure >110 mmHg	671 (5.3)	227 (4.7)	297 (5.8)	147 (5.2)	0.5
Heart rate > 100 beats/min	1379 (10.9)	493 (10.3)	572 (11.2)	314 (11.2)	0.5
<b>Outliers of outcome</b>					
<1st percentile value (i.e. <2 days)	316 (2.5)	102 (2.1)	101 (2.0)	113 (4.0)	0.001
>99th percentile value (i.e. >42 days)	121 (1.0)	69 (1.4)	44 (0.9)	8 (0.3)	< .0001

IQR: interquartile range; std: standard deviation; CABG: coronary artery bypass graft; STEMI: ST-segment elevation myocardial infarction; COPD: chronic obstructive pulmonary disease; eGFR: estimated glomerular filtration rate.

Numbers in the second to the fifth columns represent count (percentage), unless otherwise specified.

**Table 2.** In-hospital diagnostic tests, treatments, and procedures received by patients in tertiles of hospitals with regard to median length of stay

	<b>All hospitals (n = 12706)</b>	<b>High-tertile hospitals (n = 4784)</b>	<b>Middle-tertile hospitals (n = 5105)</b>	<b>Low-tertile hospitals (n = 2817)</b>	<b>P-value</b>
Diagnostic tests					
Echocardiogram	6994 (55.0)	2765 (57.8)	2803 (54.9)	1426 (50.6)	0.6
Ejection fraction					
Available	6436 (50.7)	2497 (52.2)	2586 (50.7)	1353 (48.0)	0.8
Mean $\pm$ std	54.0 $\pm$ 11.8	54.6 $\pm$ 11.8	53.9 $\pm$ 11.6	53.3 $\pm$ 12.3	0.5
Biomarkers					0.04
None	1338 (10.5)	393 (8.2)	466 (9.1)	479 (17.0)	
CK only	855 (6.7)	263 (5.5)	399 (7.8)	193 (6.9)	
CK-MB only	4685 (36.9)	2094 (43.8)	1650 (32.3)	941 (33.4)	
Troponin only	395 (3.1)	112 (2.3)	231 (4.5)	52 (1.9)	
CK-MB + Troponin	5433 (42.8)	1922 (40.2)	2359 (46.2)	1152 (40.9)	
Medications within 24 hours of admission					
Aspirin	11209 (88.2)	4191 (87.6)	4591 (89.9)	2427 (86.2)	0.2
Clopidogrel	7418 (58.4)	2739 (57.3)	3104 (60.8)	1575 (55.9)	0.7
GP IIb/IIIa inhibitors	877 (6.9)	306 (6.4)	392 (7.7)	179 (6.4)	0.8
Unfractionated heparin	9753 (76.8)	3740 (78.2)	3840 (75.2)	2173 (77.1)	0.6
Low-molecular-weight heparin	6953 (54.7)	2692 (56.3)	2742 (53.7)	1519 (53.9)	0.8
Beta-blockers	6328 (49.8)	2346 (49.0)	2657 (52.1)	1325 (47.0)	0.4
Nitrates	10677 (84.0)	3989 (83.4)	4325 (84.7)	2363 (83.9)	0.9
Traditional Chinese medicines	7251 (57.1)	2736 (57.2)	2680 (52.5)	1835 (65.1)	0.3



**Table 2.** Continued

	<b>All hospitals (n = 12706)</b>	<b>High-tertile hospitals (n = 4784)</b>	<b>Middle-tertile hospitals (n = 5105)</b>	<b>Low-tertile hospitals (n = 2817)</b>	<b>P-value</b>
Medications during the hospitalization					
Calcium channel blockers	2206 (17.4)	838 (17.5)	893 (17.5)	475 (16.9)	0.9
ACEIs or ARBs	8345 (65.7)	3226 (67.4)	3311 (64.9)	1808 (64.2)	0.7
Any Statins	9833 (77.4)	3683 (77.0)	4058 (79.5)	2092 (74.3)	0.5
Traditional Chinese medicines	8605 (67.7)	3314 (69.3)	3210 (62.9)	2081 (73.9)	0.4
Reperfusion therapies among STEMI					
Primary PCI	1307 (12.0)	506 (12.1)	606 (14.1)	195 (8.1)	0.5
Fibrinolytic therapy	2637 (24.2)	1108 (26.4)	976 (22.7)	553 (23.0)	0.4
Cardiac procedures					
Catheterization	3483 (27.4)	1357 (28.4)	1457 (28.5)	669 (23.8)	0.8
PCI	3013 (23.7)	1165 (24.4)	1284 (25.2)	564 (20.0)	0.7

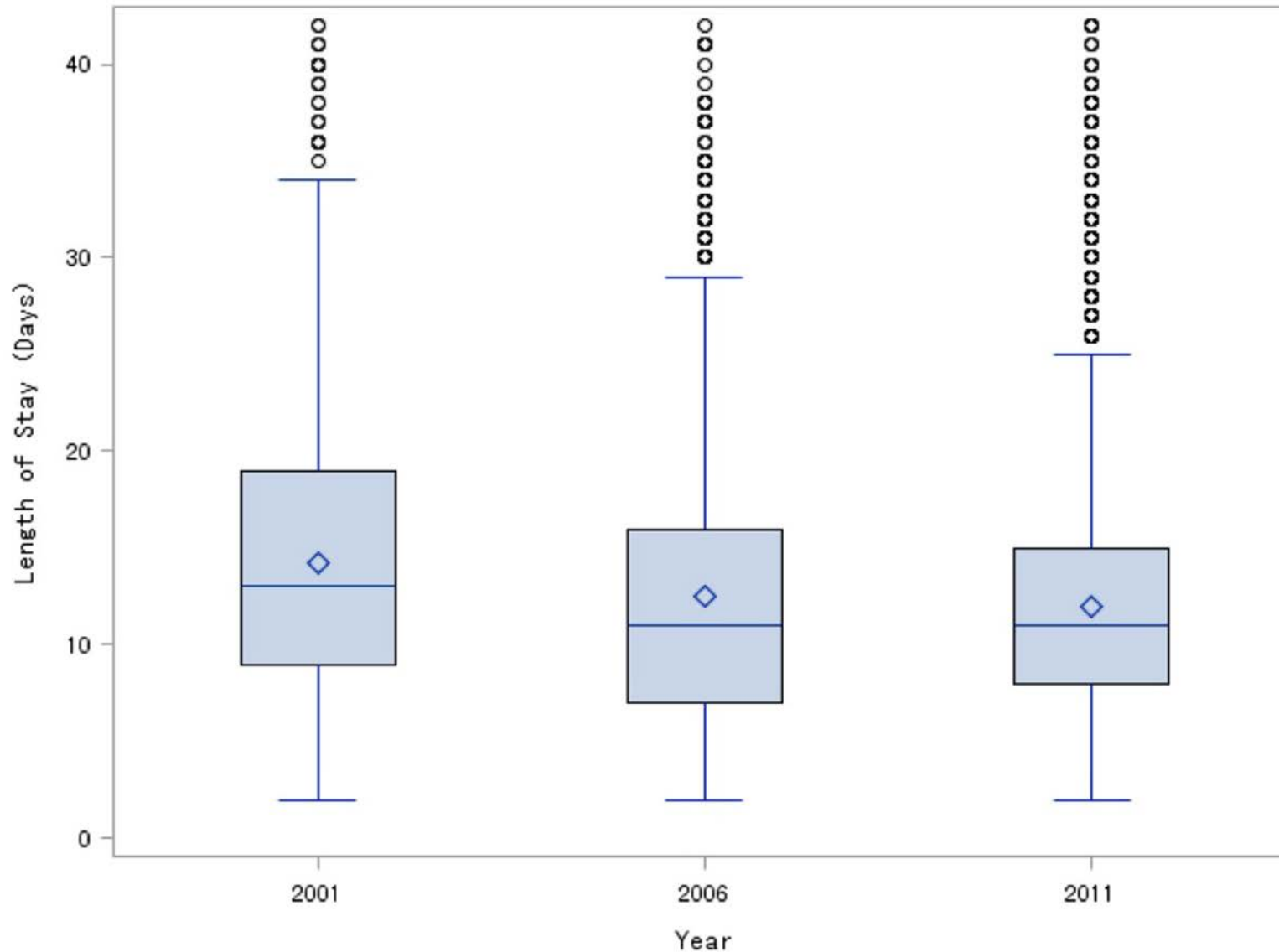
CK: creatine kinase; CK-MB: creatine kinase MB fraction; ACEI: angiotensin converting enzyme inhibitor; ARB: angiotensin receptor blocker; STEMI: ST-segment elevation myocardial infarction; PCI: Percutaneous coronary intervention.

Numbers in the second to the fifth columns represent count (percentage), unless otherwise specified.

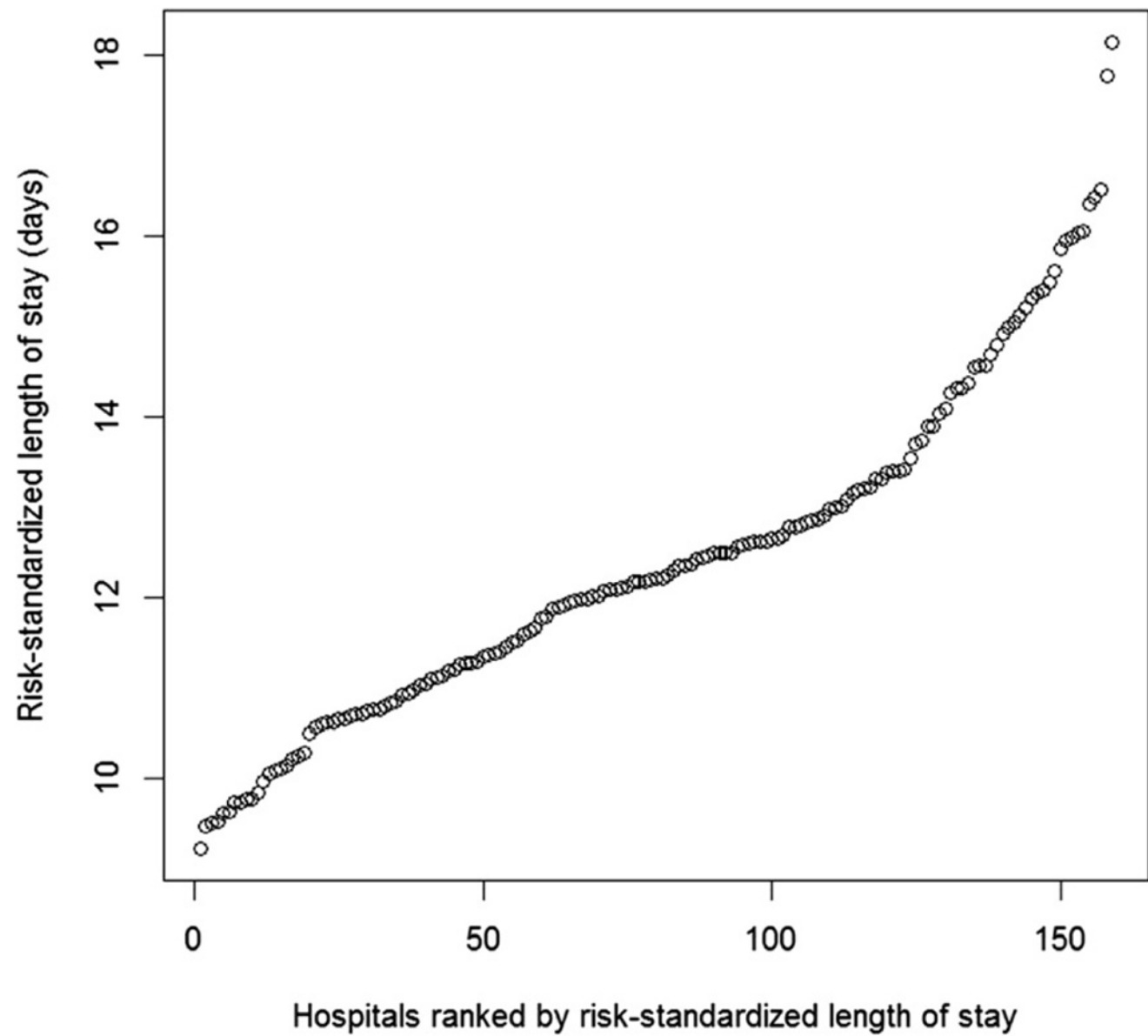
**Table 3.** In-hospital outcomes of patients in tertiles of hospitals with regard to median length of stay

	<b>All hospitals (n = 12706)</b>	<b>High-tertile hospitals (n = 4784)</b>	<b>Middle-tertile hospitals (n = 5105)</b>	<b>Low-tertile hospitals (n = 2817)</b>	<b>P-value</b>
Recurrent myocardial infarction	67 (0.5)	25 (0.5)	25 (0.5)	17 (0.6)	0.8
Cardiac arrest	124 (1.0)	55 (1.2)	47 (0.9)	22 (0.8)	0.3
Cardiogenic shock	154 (1.2)	63 (1.3)	60 (1.2)	31 (1.1)	0.7
New-onset heart failure	1656 (13.0)	612 (12.8)	688 (13.5)	356 (12.6)	0.9
Recurrent angina	2120 (16.7)	883 (18.5)	702 (13.8)	535 (19.0)	0.08
Atrial fibrillation	310 (2.4)	127 (2.7)	104 (2.0)	79 (2.8)	0.2
Stroke	63 (0.5)	29 (0.6)	22 (0.4)	12 (0.4)	0.4
Bleeding	769 (6.1)	321 (6.7)	314 (6.2)	134 (4.8)	0.2
Acute renal failure	66 (0.5)	26 (0.5)	31 (0.6)	9 (0.3)	0.4
Ventricular tachycardia or fibrillation	426 (3.4)	175 (3.7)	163 (3.2)	88 (3.1)	0.7
Infection	1397 (11.0)	601 (12.6)	551 (10.8)	245 (8.7)	0.04

Numbers in the second to the fifth columns represent count (percentage), unless otherwise specified.



**Figure 2.** Year-trend Whisker plot of length of stay. Diamond inside the box: mean; line inside the box: median; bottom and top edges of the box: interquartile range (IQR); bottom and top edges of the whiskers:  $1.5 \times \text{IQR}$ ; points beyond the whiskers: outliers.



**Figure 3.** Risk-standardized length of stay across all hospitals.

**Table 4.** Hospital characteristics associated with year-specific risk-standardized length of stay.

Hospital characteristics	N (%)			Difference in risk-standardized length of stay and 95% confidence intervals (in days)	P-value
	2001 (n = 130)	2006 (n = 152)	2011 (n = 158)		
Geographic region					
Eastern	55 (42.3)	60 (39.5)	63 (39.9)	0 (ref)	
Central	41 (31.5)	48 (31.6)	48 (30.4)	-1.6 (-2.9, -0.2)	0.02
Western	34 (26.2)	44 (29.0)	47 (29.8)	0.3 (-1.1, 1.6)	0.7
Tertiary (vs. secondary)	56 (43.1)	64 (42.1)	65 (41.1)	0.5 (-0.7, 1.7)	0.4
Affiliated/teaching status					
Neither affiliated nor teaching	37 (28.5)	42 (27.6)	42 (26.6)	0 (ref)	
Teaching but not affiliated	48 (36.9)	53 (34.9)	54 (34.2)	0.2 (-1.0, 1.3)	0.8
Both teaching and affiliated	45 (34.6)	57 (37.5)	62 (39.2)	-0.4 (-2.1, 1.2)	0.6
Annual AMI patients volume					
≤10	58 (44.6)	39 (25.7)	17 (10.8)	0 (ref)	
11-30	37 (28.5)	43 (28.3)	29 (18.4)	0.1 (-0.9, 1.2)	0.8
31-80	25 (19.2)	35 (23.0)	52 (32.9)	0.6 (-0.7, 1.8)	0.4
>80	10 (7.7)	35 (23.0)	60 (38.0)	0.8 (-0.6, 2.2)	0.3
Cardiac catheterization (vs. not)	33 (25.4)	58 (38.2)	74 (46.8)	0 (-0.5, 0.5)	0.9
Independent cardiology department (vs. not)	28 (21.5)	58 (38.2)	78 (49.4)	-0.3 (-0.7, 0.2)	0.2
Capacity to test biomarkers					
None	24 (18.5)	11 (7.2)	2 (1.3)	0 (ref)	
CK only	29 (22.3)	9 (5.9)	2 (1.3)	0.1 (-1.1, 1.3)	0.9
CK-MB	44 (33.9)	44 (29.0)	27 (17.1)	0.2 (-0.8, 1.2)	0.7
Troponin	33 (25.4)	88 (57.9)	127 (80.4)	0.4 (-0.6, 1.5)	0.4

CK: creatine kinase; CK-MB: creatine kinase MB fraction.

# Conclusions

- Although decreasing in the past decade, hospital LOS for patients with AMI in China is still long relative to most countries in the world.
- There is much inter-hospital variation in LOS for AMI hospitalizations.
- In the context of the growing number of AMI hospitalizations in China, it is critical to rationally shorten LOS, reduce variations in practice among hospitals, and ultimately improve the efficiency of Chinese medical resource utilization.