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Are Medical Record Front Page Data Suitable for Risk Adjustment in Hospital Performance Measurement: A Risk Model of In-hospital Mortality after Acute Myocardial Infarction

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ABSTRACT

Objectives

To develop a model of in-hospital mortality using MRFP data, and assess its validity in case-mix standardization by comparison with a model developed using the complete medical record data.

Design

A nationally representative retrospective study.

Setting

Representative hospitals in China, covering 161 hospitals in modelling cohort and 156 hospitals in validation cohort.

Participants

Representative patients admitted for AMI. 8370 patients in modelling cohort and 9704 patients in validation cohort.

Primary outcome measures

In-hospital mortality, which was defined explicitly as death that occurred during hospitalization, and the hospital-level risk standardized mortality rate (RSMR)

Results

A total of 14 variables were included in the model predicting in-hospital mortality based on MRFP data, with the AUC of 0.78 among modelling cohort and 0.79 among validation cohort. The median of absolute difference between the hospital RSMR predicted by hierarchical generalized linear models established based on MRFP data and complete medical record data, which was built as ‘reference model’, was 0.08% (10th and 90th percentiles: -

1.8% and 1.6%). In the regression model comparing the RSMR between two models, the slope and intercept of the regression equation is 0.90 and 0.007 in modelling cohort, while 0.85 and 0.010 in validation cohort, which indicated that the evaluation capability from two models were very similar.

Conclusions

The models based on MRFP data showed good discrimination and calibration capability, as well as similar risk prediction effect in comparison with the model based on complete medical record data, which proved that MRFP data could be suitable for risk adjustment in hospital performance measurement.

KEY WORDS

Health informatics, Myocardial infarction, Quality in health care

Strengths and limitations of this study

- The Hospital Quality Monitoring System (HQMS) in China provided a nationwide data source to assess disparities in quality of care.
- However, it is still unclear whether medical record front page (MRFP) data collected in HQMS are suitable to adjust for patient case-mix across hospitals, in the comparison of patient outcomes.
- Based on MRFP and complete medical record data from representative cohorts of patients admitted with AMI from representative hospitals, hierarchical generalized linear models(HGLMs) of in-hospital mortality was established and validated.
- Two methods were used to compare the hospital-level risk standardized mortality rate derived from two HGLMs to explore whether the model based on MRFP data had similar efficiency with that based on complete medical record data
- Although this study was based on nationally representative cohorts with model development and validation using data from different years, external validations that include more diverse hospitals will be needed in the future.

INTRODUCTION

Equal access to high-quality health care is one of the major aims in China's recent public hospital reform[1 2]. To continuously improve quality of care and mitigate its disparities across regions or hospitals, sustainable assessment of hospital performance is firstly required [3 4]. The Ministry of Health (named as "National Health Commission" now) of China established the Hospital Quality Monitoring System (HQMS) in 2011 that currently covers over 1800 tertiary hospitals and 2300 secondary hospitals, to collect key information of all hospitalizations, including patients' diagnosis and outcomes recorded in the medical record front page (MRFP) using a standardized form (Table S1)[5 6]. Although the MRFP lack of detailed information on treatment process such as lab test results or medications, with structured records on diagnosis, procedure and outcome, it could be utilized as a unique nationwide data source of outcome quality assessment (i.e. in-hospital mortality).

Assessing quality of care between hospitals needs to take into account patients' different demographic and clinical characteristics of patients between hospitals, like most of the prior studies have done based on a broad array of information from complete medical record[7-9]. However, it is still unclear whether the MRFP data collected in HQMS are suitable for adjustment for the patient case-mix between hospitals, to achieve the goals similarly.

In China PEACE (Patient-centred Evaluative Assessment of Cardiac Events) - Retrospective study, we built a nationally representative sample of patients hospitalized for acute myocardial infarction (AMI) and extracted high-quality data from their complete medical records (including medical record front pages), which provided an ideal condition to assess disparities in quality of care,[10]. We aim to develop a model of in-hospital mortality

using their MRFP data, then assess its validity in case-mix standardization by comparison with a model developed using the complete medical record data of the same patient cohort.

METHODS

Patient and Public Involvement

No patient involved.

Study design and population

The design of China PEACE-Retrospective AMI study has been published previously [11]. In brief, the study used a stratified two-stage random sampling method to select representative hospitals and patients admitted for AMI nationwide during 2001, 2006, and 2011. In addition, the study also included a more recent sample of patients admitted in 2015 using the same random sampling process. Firstly, five regions (Eastern cities, Central and Western cities, Eastern villages, Central villages, and Western villages) were used for representative hospital selection by simple random sampling method. Secondly, AMI cases (diagnosed as ICD-9 coded 410.xx or ICD-10 coded I21.xx, or key words from discharge diagnosis) were randomly selected from all patients who met the inclusion criteria in each selected hospital by random sampling method. Trained personnel at the national coordinating centres abstracted data from the medical records using standardized data definitions. Data abstraction quality was monitored by randomly audits that ensured that the overall variable accuracy exceeded 98% [11].

The Ethics Committee at the National Center for Cardiovascular Diseases approved the study (2012-377; 2016-769). All collaborating hospitals either accepted central ethics

approval or obtained local ethics approval by their ethics committees. As a retrospective study, written informed consent of patients were not required. It's our goal to share data from the China PEACE studies; however, at this time, we are unable to do so.

In this study, patients from year 2011 were regarded as the modelling cohort, and patients from the year 2015 were regarded as the validation cohort. Patients who transferred out to another hospital were excluded since we could not get their outcomes. A total of 8370 patients from 161 hospitals (96 secondary hospitals and 65 tertiary hospitals) were included as modelling cohort, and another 9704 patients from 156 hospitals (93 secondary hospitals and 63 tertiary hospitals) were included as validation cohort. In addition, if a hospital had less than 10 eligible patients per year, it would be further excluded from the hospital-level analysis. 8269 patients (137 hospitals, 73 secondary hospitals and 64 tertiary hospitals) from modelling cohort and 9583 patients (132 hospitals, 71 secondary hospitals and 61 tertiary hospitals) from validation cohort were included in the further analysis (Figure S1).

Statistical analysis

According to study aim, we need to develop and evaluate a model predicting in-hospital outcome at patient level based on MRFP data from modelling cohort firstly. If the model performed well, then another model used to evaluate hospital quality of care would be built based on prior model. The validation cohort was used to conduct external evaluation of models. Hospital level model would be built based on complete medical record data, which could be considered as 'the best reference'. By comparing the difference and association of the indicators evaluated by the MRFP model and the complete medical record model, we could explore whether the model based on MRFP data had similar efficiency with that based

on complete medical record data. The analysis roadmap was demonstrated in Figure S2.

Candidate predictors and outcome

Patient characteristics were selected as candidate predictors, according to previous AMI predictive models such as GRACE, TIMI, and ACTION-GWTG[7-9 12-17]. For the model based on MRFP data, the candidate predictors included demographic characteristics (gender, age, medical insurance status, ethnicity, marital status), admission department, diagnosis at admission (cardiac arrest) and at discharge (acute ST-segment elevation myocardial infarction [STEMI], infarction position, hypertension, diabetes, dyslipidaemia, cardiogenic shock, heart failure, stroke, renal failure), which was available from MRFP data. For the model based on complete medical record, we additionally include patients' symptoms, vital signs and lab test results at admission.

In-hospital mortality, as the outcome variable in the models, was defined explicitly as death that occurred during hospitalization, which was recorded both on the MRFP and elsewhere such as discharge record. For the accuracy of analysis, we used complete medical record as data source. We did not include patients who withdraw treatment as outcome since we could not get "withdraw" information from MRFP data, though plenty of these patients might die soon after giving up treatment.

Patient-level model development and evaluation

A logistic regression model was built based on MRFP data from the modelling cohort. Area under receiver operating characteristic curve (AUC) and observed rates in deciles determined by model estimating value were used to evaluate the discrimination. Slope and intercept of regression equation between the observed and the predicted mortality was used to evaluate the

calibration ability. To assess the overfitting of the model, we used the coefficients estimated from the logistic model to predict the probability of mortality in the validation cohort, by multiplying coefficients by the observed risk factors variables and summing over for each subject. Then another logistic regression model was built, in which the dependent variable was observed mortality and independent variables were the predicted mortality generated as above. The slope different from 1 and the intercept different from 0 indicated overfitting.

Furthermore, we re-estimated the logistic regression model in the validation cohort used selected predictors above. If the estimated coefficients of new model were similar to prior, the selected predictors were considered to be stable. Discrimination and calibration were also evaluated in the re-established logistic model.

Complete medical record model was developed and validated based on the data from complete medical records, using the same method mentioned above.

Hospital-level model development and comparison

Hierarchical generalized linear models (HGLM) were established among modelling and validation cohort separately, using above selected covariates and hospitals as random effects. HGLM considered the patient clustering in hospitals, and could be used to distinguish the differences of outcome within and between hospitals.

Hospital-level risk standardized mortality rate (RSMR) was used as an indicator to evaluating hospital quality of care in this study. The RSMR of each hospital could be calculated from HGLM as the ratio of predicted and expected mortality of the hospital, multiplied by the unadjusted rate of all hospitals. The expected mortality is the mortality rate of the hospital if patients in each hospital were treated in a “reference” hospital; the predicted

mortality accounted for the characteristics of a hospital (the hospital-level random effects of the model) [8 18].

We use two methods to compare the RSMR derived from the HGLMs based on MRFP and the complete medical record data. (1) Absolute differences of RSMR from two models were calculated, and the distribution of differences was described using mean, median, and maximum. (2) A linear regression model was built, with RSMR from the complete medical record data as the dependent variable and RSMR from the MRFP data as the independent variable. The slope of the model approaching 1 and the intercept approaching 0 indicated that the predicted probabilities from the two models were very similar. All above calculation and comparison would be conducted among the modelling and validation cohort separately.

All statistical inferences were performed on two-tailed test, and $p<0.05$ was considered statistically significant. The statistical software used is SAS 9.4 (SAS Institute Inc., Cary, North Carolina).

RESULTS

Study Population and Characteristics

In the modelling cohort, the average age was 65.4±12.8 years, and 2519 (30.1%) patients were female. About 1/2 of the patients were admitted to cardiovascular department at admission. 65.8% were diagnosed with STEMI, while 46.5%, 19.7% and 10.0% had comorbidities of hypertension, diabetes and dyslipidaemia, respectively. Cardiac shock occurred in 4.8% of the patients, and 0.1% of patients had cardiac arrest before admission (Table 1). A total of 621 patients died during hospitalization, accounting for 7.4% of the

modelling cohort.

Compared with modelling cohort, patients in the validation cohort had a higher proportion of patients with medical insurance and admission in cardiovascular departments ($p<0.001$). Less proportion (49.0%) of patients were diagnosed with STEMI ($p<0.001$), while a greater proportion of patients had hypertension, diabetes, dyslipidaemia, heart failure and renal failure ($p<0.05$) (Table 1). 689 patients died during hospitalization, accounting for 7.1% of the validation cohort, which was not significantly different from the modelling cohort ($p=0.41$).

Development and validation of patient-level model

A total of 14 risk factors were included in the MRFP model based on modelling cohort (Figure 1a). Model discrimination was good, with the AUC of 0.78, and observed mortality rate ranging from 0.83% in the lowest decile of the predicted mortality rate to 26.88% in the highest decile. The slope of the calibration curve was 0.91 and the intercept was -0.007, which showed the good calibration ability of this model (Table 2). The overfitting statistics were within an acceptable range (slope=1.01, intercept=-0.07), indicating that no overfitting exist.

The predictors included above were applied to the validation cohort to reconstruct the model, which showed that the effect direction and size were still similar (Figure 1a). In the validation cohort, the AUC was 0.79, with observed mortality rate ranging from 1.00% to 29.72%, and the slope and intercept of the calibration curve was 0.93 and 0.005 (Table 2).

Using the same method, a complete medical record model was built, in which a total of 13 risk factors were included (Figure 1b). The AUC of the model was 0.79, and observed

mortality rate ranged from 0.51% in the lowest decile to 27.96% in the highest decile. The slope of the calibration curve was 0.94 and the intercept was 0.004 (Table 2). Similar with the MRFP model, the complete medical record model had good discrimination and calibration, as well as relatively stable coefficients when validated among the validation cohort (Figure 1b and Table2).

Development and comparison of hospital-level model

8269 patients (137 hospitals, 73 secondary hospitals and 64 tertiary hospitals) from modelling cohort and 9583 patients (132 hospitals, 71 secondary hospitals and 61 tertiary hospitals) from validation cohort were included in estimating the hospital-level HGLMs.

In the modelling cohort, the median hospital-level RSMR was 7.4% (IQR: 5.2% - 10.1%). The median of absolute difference between the RSMR predicted by the complete medical record data and MRFP data was 0.08% (IQR: -0.67% - 0.53%), and the 10th and 90th percentiles were -1.8% and 1.6%, with no statistical significance (p=0.499). In the validation cohort, the median RSMR was 6.4% (IQR: 4.5% - 10.4%), and the median of absolute difference was 0.05%, with 10th and 90th percentiles of -2.8% and 1.9% (Figure S3). For the regression model comparing the RSMR between the MRFP data and complete medical record data, the slope (intercept) was 0.90 (0.007) in the modelling cohort, while 0.85 (0.010) in the validation cohort (Figure 3). The correlations among secondary hospitals were better than among tertiary hospitals.

DISCUSSION

This study developed patient and hospital level MRFP models of in-hospital mortality of

AMI, and took into account the patient case-mix in the hospital-level disparity analysis. These models based on MRFP data showed good discrimination and calibration capability, as well as similar risk prediction effect in comparison with the model based on complete medical record data, which proved that MRFP data could be suitable for risk adjustment in hospital performance measurement in China.

To our knowledge, the current study extended literatures in several ways. First, this is the first in-hospital mortality risk model based only on MRFP data in China. Currently in China, it is still difficult to obtain detailed complete medical records data nationwide for quality monitoring, due to the fragmentation in development and deployment of Hospital Information Systems and Electronic Medical Record Systems. In the United States which faces similar challenges, several risk models have been developed using concise administrative claims data, and successfully applied as substitute of complete medical record models [8 9]. The key value of this model is to demonstrate how MRFP data from HQMS can serve as a solution for national quality assessment, rather than to identify coefficients of specific risk characteristics.

Second, the methods we chosen for model development specifically to standardize the hospital-level case-mix. We firstly selected an array of patient characteristics that influence their risk profile significantly using backward logistic regression, and confirmed the stability of this array in the validation cohort. Then we established a HGLM using these characteristics, because the HGLM takes into account the correlation of patients admitted in the same hospital to avoided underestimating the standard error of other risk factors,[18 19] which fits the nature that patients clustered within individual hospitals, and has been well-tested in previous studies on hospital-level comparisons[7-9].

Third, model based on MRFP data was robustly validated by not only repeating in validation cohorts, but more importantly comparing with which based on complete medical records data. Even though there is no real golden standard of risk standardization, medical record data enable the most complete characteristics of patients' demographic and clinical profile. The China PEACE Retrospective study provided a unique opportunity to compare the MRFP model against the complete medical record model, because scanning copies of sampled medical records were collected, and detailed information on patient characteristics had been centrally extracted from the front page and all other parts of medical records.

The feasibility of MRFP model has significant policy implications for China, as the government emphasized the importance of hospital performance monitoring [20]. Even though research on quality of care has been growing fast during the past decade, China needs a nationwide health information technology systems covering all healthcare providers, in which the data collection and analysis could be more timely, accurate and sustainable [3 4]. Since the HQMS was established, it has increasingly covered over 1800 (73%) tertiary hospitals and 2300 (26%) secondary hospitals, but the utilization of data remains limited [3]. Our study showed how this existing platform with concise MRFP data can serve as a base for national hospital performance measurement, similar to the United States Centers for Medicare & Medicaid Services' use of administrative claims data [19 20]. Moreover, some challenges should to be addressed. First, the quality of MRFP data across hospitals, particularly the completeness of comorbidity documentation and accuracy of diagnosis coding in diagnosis, needs to be improved [21]. Second, for chronic conditions with low in-hospital mortality rates, data on post-discharge outcomes (e.g. 30-day readmission rates) data need to be obtained

from clinical registries, insurance claims and other sources.

Limitations of the study

There are some limitations in this study. First, weaker correlation in tertiary hospitals between RSMRs generated from the two risk models indicated a relatively poorer performance of current MRFP model applied in tertiary hospitals. However, this could be improved if the model development and disparity assessment were conducted within subgroups of hospitals separately. Second, although this study was based on nationally representative cohorts with model development and validation using data from different years, external validations that include more diverse hospitals will be needed in the future.

Conclusion

In conclusion, the MRFP model of in-hospital mortality supported that HQMS data could act as reasonable substitute for complete medical record data in risk adjustment between hospitals across the nation. The lessons from AMI treatment could serve as a model to nationwide assessment on quality of care in other clinical fields.

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Declaration of conflicting interests

None declared.

Author contributions

XL contributed to the conception or design of the work. CW, DZ and XB contributed to the acquisition of data for the work. CW and XB contributed to the analysis of data for the work. CW, DZ, TZ and XL contributed to the interpretation of data for the work. CW and DZ drafted the manuscript. TZ, YW, ZL, GH and XL critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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TABLES

Table 1. Patients' characteristics from MRFP data and in-hospital mortality in modelling cohort and validation cohort.

	Modelling Cohort (Year 2011) N=8370	Validation Cohort (Year 2015) N=9704	p value
In-hospital mortality	621 (7.4)	687 (7.1)	0.3793
Female	2519 (30.1)	3121 (32.2)	0.0028
Age, mean(SD)	65.4 (12.8)	65.9(12.7)	0.0081
<40	195 (2.3)	213 (2.2)	<0.0001
40-49	910 (10.9)	891 (9.2)	
50-59	1600 (19.1)	1816 (18.7)	
60-69	2090 (25.0)	2674 (27.6)	
70-79	2431 (29.0)	2590 (26.7)	
≥80	1144 (13.7)	1520 (15.7)	
Han	7701 (92.0)	9285 (95.7)	<0.0001
Married	7460 (89.1)	8740 (90.1)	0.0391
Having medical insurance	5126 (61.2)	7507 (77.4)	<0.0001
Admission at cardiology department	4087 (48.8)	6532 (67.3)	<0.0001
Admission Diagnosis			
Cardiac arrest	6 (0.1)	18 (0.2)	0.0362
Discharge Diagnosis			

STEMI	5509 (65.8)	4753 (49.0)	<0.0001
Acute extensive anterior MI	967 (11.6)	769 (7.9)	<0.0001
Acute anterior MI	1504 (18.0)	1310 (13.5)	<0.0001
Acute anterior intermural MI	587 (7.0)	408 (4.2)	<0.0001
Acute inferior MI	2558 (30.6)	2214 (22.8)	<0.0001
Acute lateral MI	359 (4.3)	311 (3.2)	0.0001
Acute posterior MI	699 (8.4)	502 (5.2)	<0.0001
Acute right ventricular infarction	615 (7.3)	418 (4.3)	<0.0001
Hypertension	3894 (46.5)	5080 (52.3)	<0.0001
Diabetes mellitus	1650 (19.7)	2345 (24.2)	<0.0001
Dyslipidemia	836 (10.0)	1434 (14.8)	<0.0001
Cardiac shock	403 (4.8)	510 (5.3)	0.1773
Heart failure	2853 (34.1)	3793 (39.1)	<0.0001
Stroke	655 (7.8)	1389 (14.3)	<0.0001
Renal failure	259 (3.1)	684 (7.0)	<0.0001

*MI: myocardial infarction; STEMI: ST-segment elevation myocardial infarction

Table 2. Performance of the MRFP model and the complete medical record model

Model	N	Discrimination		Calibration
		Area under ROC curve	Predictive Ability* (mean rate of lowest/highest decile)	Calibration Indices (slope, intercept)
MRFP model				
Year 2011(modelling cohort)	8370	0.776	0.83%-26.88%	(0.909,0.007)
Year 2015(validation cohort)	9704	0.794	1.00%-29.72%	(0.933,0.005)
Complete medical record model				
Year 2011(modelling cohort)	8370	0.790	0.51%-27.96%	(0.940,0.004)
Year 2015(validation cohort)	9704	0.798	0.92%-28.69%	(0.927,0.005)

*observed rates in deciles determined by estimated model

ROC: receiver operating characteristic; MRFP: medical record front page.

FIGURE LEGENDS

Figure 1. Odds ratios of MRFP model and complete medical record model based on modelling and validation cohorts.

(a) MRFP model (b) Complete medical record model

MRFP: medical record front page.

Figure 2. Receiver operating characteristic (ROC) curve of MRFP model and complete medical record model based on modelling and validation cohorts.

MRFP: medical record front page.

Figure 3. Correlation of risk standardized mortality rate estimated by MRFP model and complete medical record model.

(a) Modelling cohort (b) Validation cohort

MRFP: medical record front page.

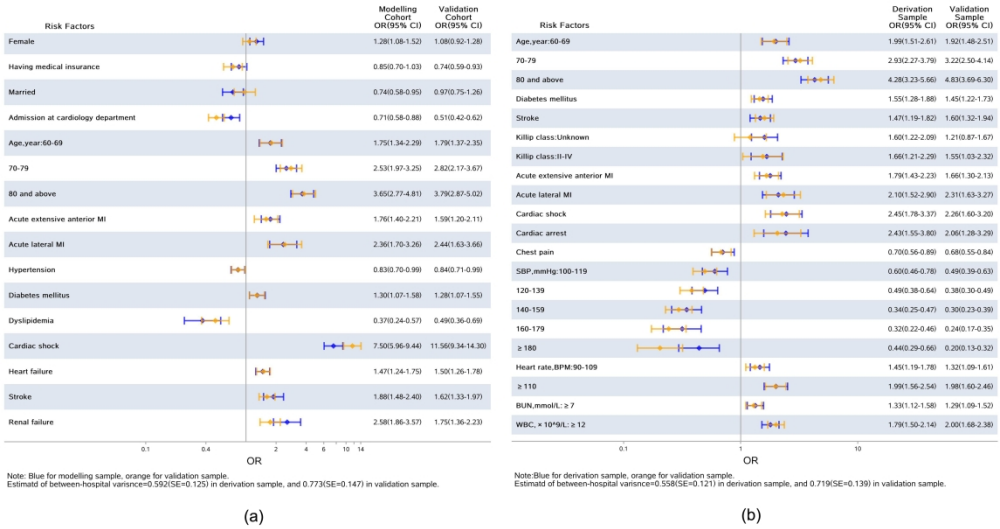


Figure 1. Odds ratios of MRFP model and complete medical record model based on modelling and validation cohorts. (a) MRFP model (b) Complete medical record model MRFP: medical record front page

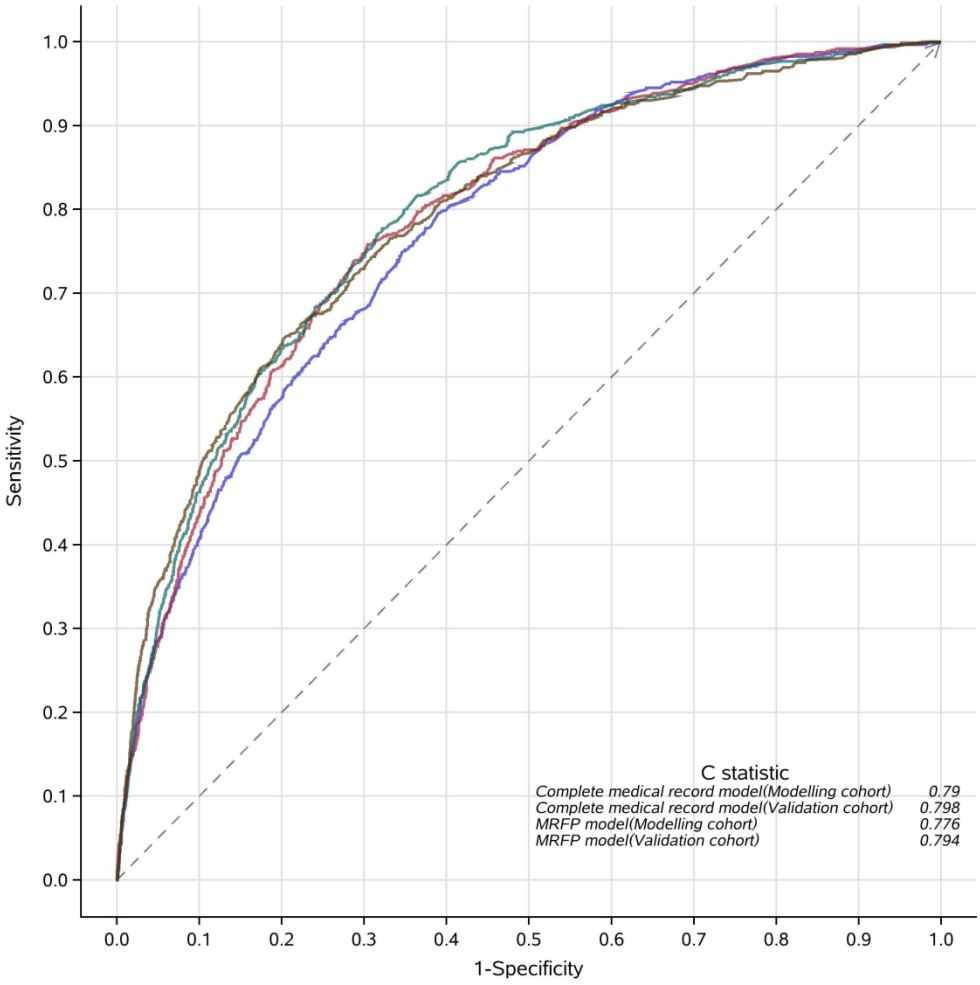


Figure 2. Receiver operating characteristic (ROC) curve of MRFP model and complete medical record model based on modelling and validation cohorts. MRFP: medical record front page.

207x208mm (300 x 300 DPI)

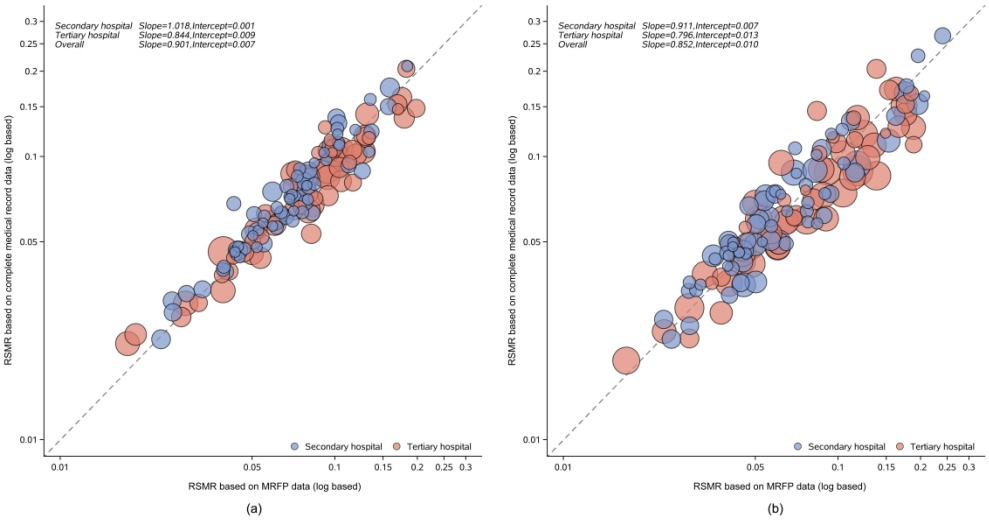
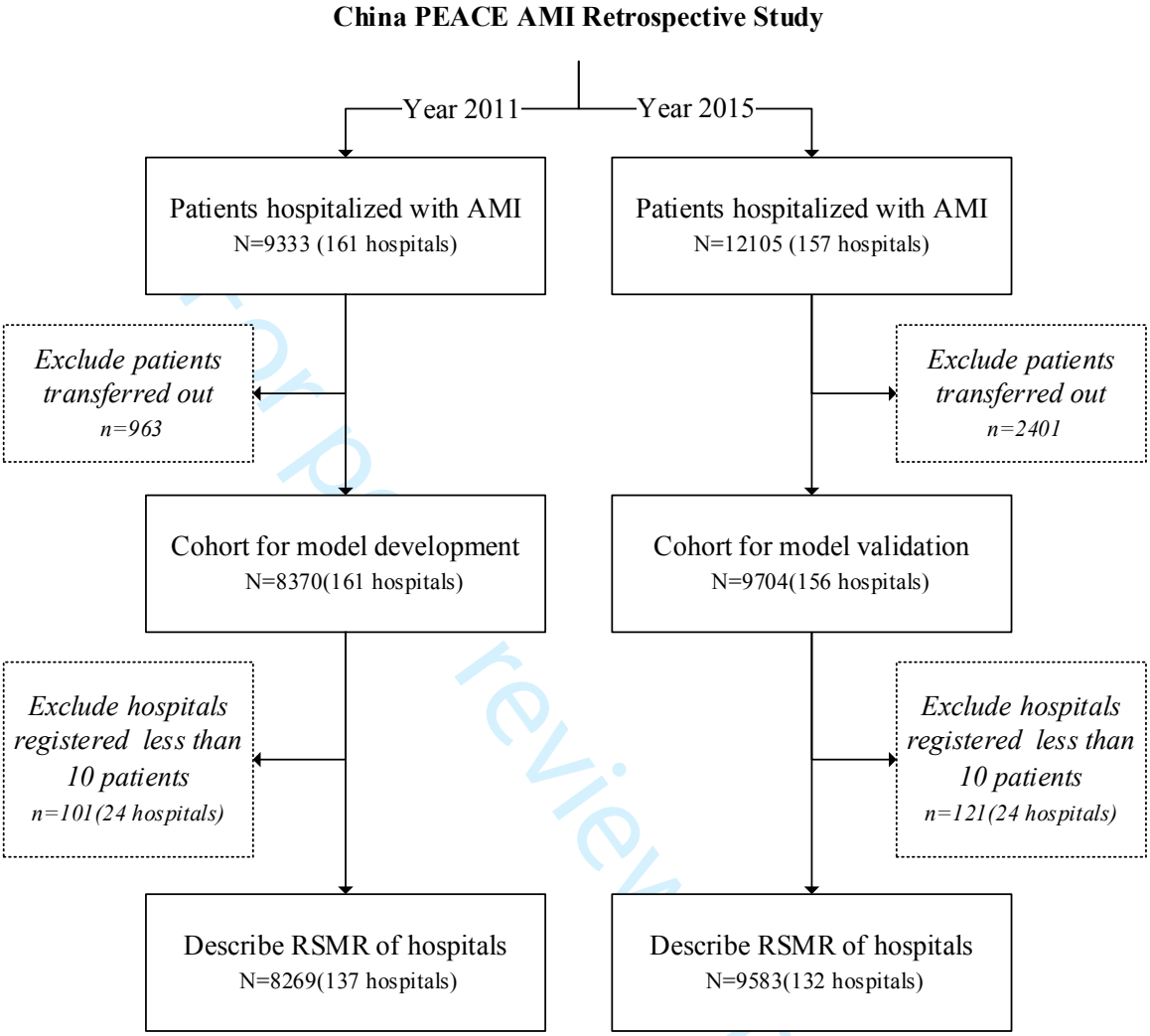


Figure 3. Correlation of risk standardized mortality rate estimated by MRFP model and complete medical record model. (a) Modelling cohort (b) Validation cohort MRFP: medical record front page.

Supplementary materials

Figure S1. Flowchart of patients' exclusion



RSMR: risk standardized mortality rate

Figure S2. Analysis roadmap

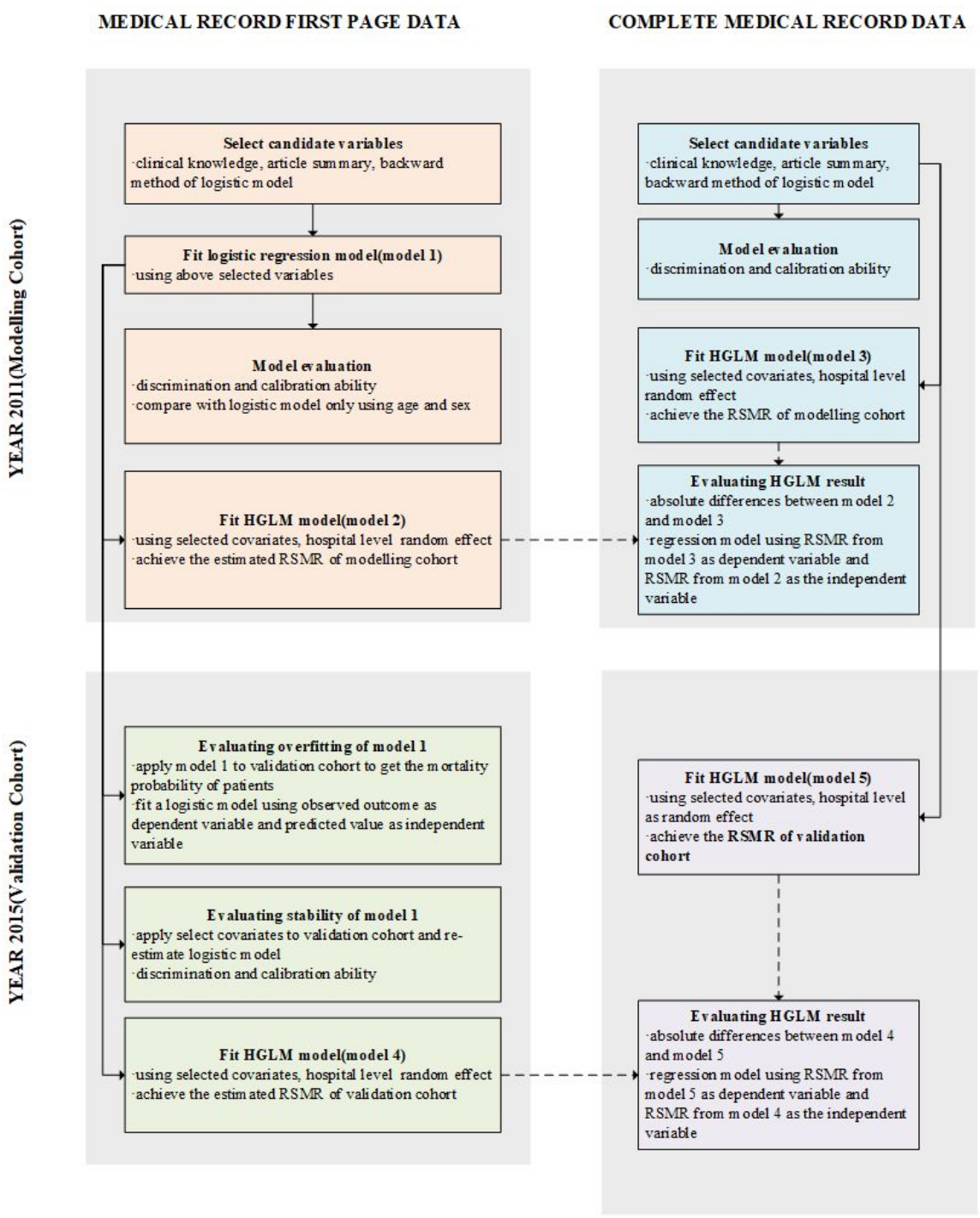
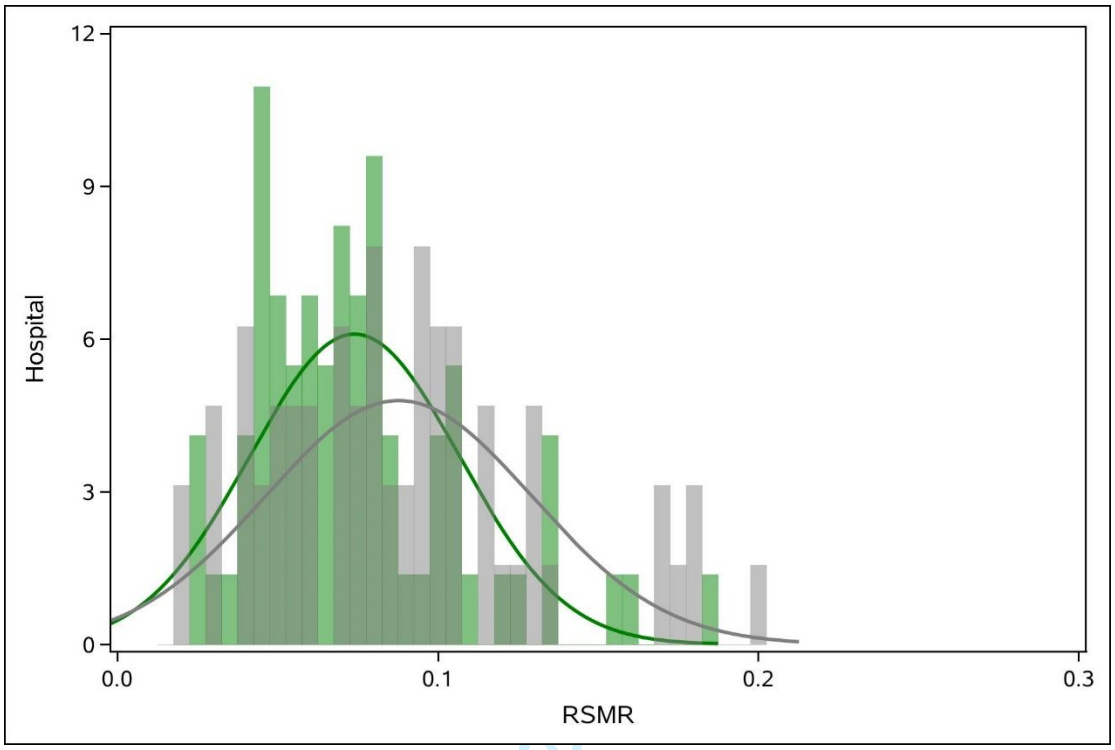
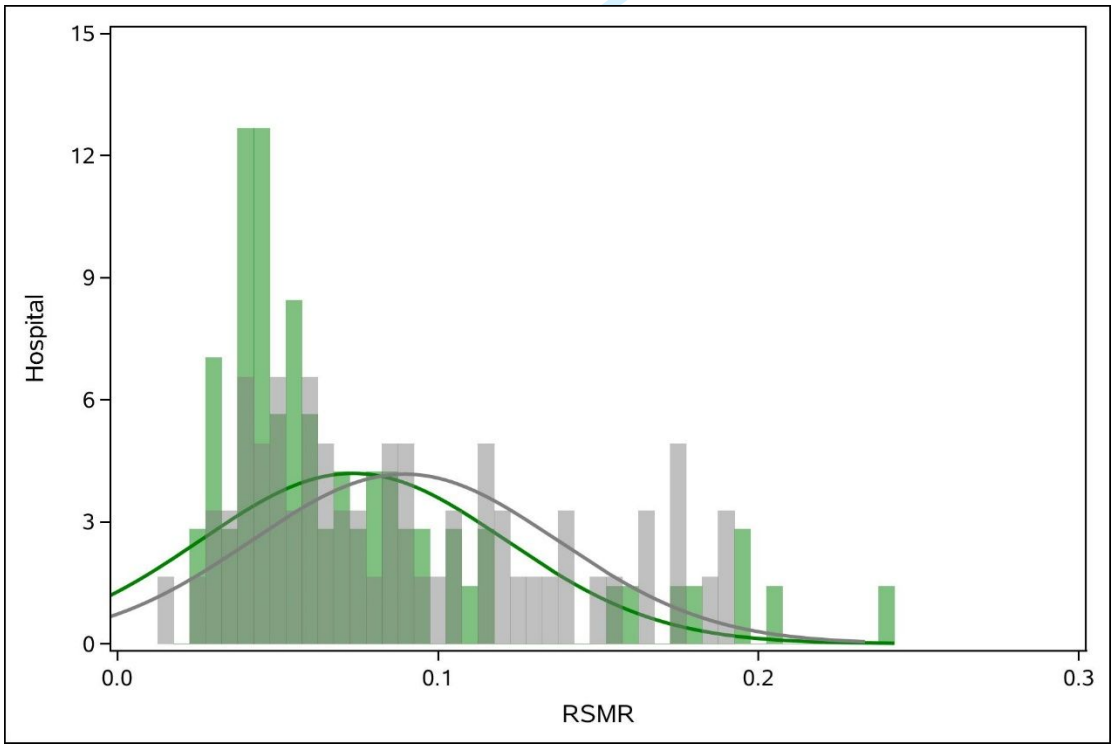


Figure S3. Distribution of risk standardized mortality rate of study hospitals estimated by MRFP model. (a) Modelling cohort (b) Validation cohort



(a)



(b)

Table S1. Data elements required in the HQMS system

No.	Data element	Field name	Data type	Length	Required	Remarks
1	Hospital ID	P900	Character	22	Yes	
2	Hospital name	P6891	Character	80	Yes	
3	Medical Insurance Number	P686	Character	50		
4	Health-card number	P800	Character	50		
5	Method of healthcare payment	P1	Character	1	Yes	
6	Admission times	P2	Number	3	Yes	
7	Medical record number	P3	Character	20	Yes	
8	Name	P4	Character	40		
9	Gender	P5	Character	1	Yes	
10	Birth date	P6	Date			yyyy-mm-dd
11	Age	P7	Number	3		Unit (year)
12	Marital status	P8	Character	1	Yes	
13	Occupation	P9	Character	2		
14	Birthplace (province)	P101	Character	30		
15	Birthplace (city)	P102	Character	30		
16	Birthplace (county)	P103	Character	30		
17	Ethnicity	P11	Character	20		
18	Nationality	P12	Character	40		
19	Social ID	P13	Character	18		
20	Residence	P801	Character	200		
21	Residential phone number	P802	Character	40		
22	Postcode of residence	P803	Character	6		
23	Name and address of employer	P14	Character	200		
24	Phone number	P15	Character	40		
25	Postcode of employer address	P16	Character	6		
26	“Hukou” address	P17	Character	200		
27	Postcode of "Hukou" address	P171	Character	6		
28	Name of the contact	P18	Character	20		
29	Relationship with the patient	P19	Character	40		
30	Address of the contact	P20	Character	200		
31	Admission path	P804	Character	1		
32	Phone number of the contact	P21	Character	30		
33	Admission date	P22	Date, time		Yes	yyyy-mm-dd HH:mm:ss
34	Department of admission	P23	Character	6	Yes	
35	Ward of admission	P231	Character	30		
36	Department of patient being transferred to	P24	Character	6		
37	Discharge date	P25	Date, time		Yes	yyyy-mm-dd HH:mm:ss
38	Department of discharge	P26	Character	6	Yes	

39	Ward of discharge	P261	Character	30		
40	Length of hospitalization	P27	Number	6	Yes	
41	Diagnosis code of out-patient/emergency department	P28	Character	20		Diagnosis code: ICD10
42	Diagnosis of out-patient/emergency department	P281	Character	100	Yes	
43	Admission status	P29	Character	1		
44	Admission diagnosis code	P30	Character	30		Diagnosis code: ICD10
45	Admission diagnosis	P301	Character	100		
46	Date of diagnosis being confirmed	P31	Date			yyyy-mm-dd
47	Code of main diagnosis	P321	Character	20	Yes	Diagnosis code: ICD10. If there's no appropriate one, fill in "NA"
48	Primary diagnosis	P322	Character	100	Yes	
49	Primary diagnosis: admission status	P805	Character	1		
50	Primary diagnosis: discharge status	P323	Character	1		
51	Code of other diagnosis 1	P324	Character	20		Diagnosis code: ICD10
52	Other diagnosis 1	P325	Character	100		
53	Other diagnosis 1: admission status	P806	Character	1		
54	Other diagnosis 1: discharge status	P326	Character	1		
55	Code of Other diagnosis 2	P327	Character	20		Diagnosis code: ICD10
56	Other diagnosis 2	P328	Character	100		
57	Other diagnosis 2: admission status	P807	Character	1		
58	Other diagnosis 2: discharge status	P329	Character	1		
59	Code of Other diagnosis 3	P3291	Character	20		Diagnosis code: ICD10
60	Other diagnosis 3	P3292	Character	100		
61	Other diagnosis 3: admission status	P808	Character	1		
62	Other diagnosis 3: discharge status	P3293	Character	1		
63	Code of Other diagnosis 4	P3294	Character	20		Diagnosis code: ICD10
64	Other diagnosis 4	P3295	Character	100		
65	Other diagnosis 4: admission status	P809	Character	1		
66	Other diagnosis 4: discharge status	P3296	Character	1		

67	Code of Other diagnosis 5	P3297	Character	20		Diagnosis code: ICD10
68	Other diagnosis 5	P3298	Character	100		
69	Other diagnosis 5: admission status	P810	Character	1		
70	Other diagnosis 5: discharge status	P3299	Character	1		
71	Code of Other diagnosis 6	P3281	Character	20		Diagnosis code: ICD10
72	Other diagnosis 6	P3282	Character	100		
73	Other diagnosis 6: admission status	P811	Character	1		
74	Other diagnosis6: discharge status	P3283	Character	1		
75	Code of Other diagnosis 7	P3284	Character	20		Diagnosis code: ICD10
76	Other diagnosis 7	P3285	Character	100		
77	Other diagnosis 7: admission status	P812	Character	1		
78	Other diagnosis 7: discharge status	P3286	Character	1		
79	Code of Other diagnosis 8	P3287	Character	20		Diagnosis code: ICD10
80	Other diagnosis 8	P3288	Character	100		
81	Other diagnosis 8: admission status	P813	Character	1		
82	Other diagnosis 8: discharge status	P3289	Character	1		
83	Code of Other diagnosis 9	P3271	Character	20		Diagnosis code: ICD10
84	Other diagnosis 9	P3272	Character	100		
85	Other diagnosis 9: admission status	P814	Character	1		
86	Other diagnosis 9: discharge status	P3273	Character	1		
87	Code of Other diagnosis 10	P3274	Character	20		Diagnosis code: ICD10
88	Other diagnosis 10	P3275	Character	100		
89	Other diagnosis 10: admission status	P815	Character	1		
90	Other diagnosis 10: discharge status	P3276	Character	1		
91	Frequency of in-hospital infection	P689	Number	5		
92	Code of pathological diagnosis 1	P351	Character	20		Diagnosis code: ICD10
93	Pathological diagnosis 1	P352	Character	100		
94	Pathological number 1	P816	Character	50		

95	Code of pathological diagnosis 2	P353	Character	20		Diagnosis code: ICD10
96	Pathological diagnosis 2	P354	Character	100		
97	Pathological number 2	P817	Character	50		
98	Code of pathological diagnosis 3	P355	Character	20		Diagnosis code: ICD10
99	Pathological diagnosis 3	P356	Character	100		
100	Pathological number 3	P818	Character	50		
101	External factors' code of trauma and poisoning 1	P361	Character	20		Diagnosis code: ICD10
102	External factors of trauma and poisoning 1	P362	Character	100		
103	External factors' code of trauma and poisoning 2	P363	Character	20		Diagnosis code: ICD10
104	External factors of trauma and poisoning 2	P364	Character	100		
105	External factors' code of trauma and poisoning 3	P365	Character	20		Diagnosis code: ICD10
106	External factors of trauma and poisoning 3	P366	Character	100		
107	Allergen	P371	Collection	Multi-choice		
108	Allergic drug	P372	Character	100		
109	HBsAg	P38	Character	1		
110	HCV-Ab	P39	Character	1		
111	HIV-Ab	P40	Character	1		
112	Coincidence between out-patient and discharge diagnosis	P411	Character	1		
113	Coincidence between admitting and discharge diagnosis	P412	Character	1		
114	Coincidence between pre- and post-operation diagnosis	P413	Character	1		
115	Coincidence between clinical and pathological diagnosis	P414	Character	1		
116	Coincidence between radial and pathological diagnosis	P415	Character	3		
117	Rescue times	P421	Number	3		
118	Succeeding rescue times	P422	Number	1		
119	Strongest evidence of diagnosis	P687	Character	1		
120	Differentiation degree	P688	Character	40		
121	Chief	P431	Character	40		
122	(Associate) chief physician	P432	Character	40		
123	Attending physician	P433	Character	40		

124	Resident	P434	Character	40		
125	Primary nurse	P819	Character	40		
126	Refresher physician	P435	Character	40		
127	Postgraduate intern	P436	Character	40		
128	Intern	P437	Character	40		
129	Coder	P438	Character	40		
130	Medical record quality	P44	Character	1		
131	Quality-control physician	P45	Character	40		
132	Quality-control primary nurse	P46	Character	40		
133	Quality-control date	P47	Date			yyyy-mm-dd
134	Operation / Procedure code 1	P490	Character	20		Diagnosis code: ICD10
135	Operation / Procedure date 1	P491	Date, time		Obliged if operation code isn't empty	yyyy-mm-dd HH:mm:ss
136	Operation / Procedure level 1	P820	Character	1		
137	Operation / Procedure name 1	P492	Character	100	Obliged if operation code isn't empty	
138	Operation / Procedure part 1	P493	Character	4		
139	Operation / Procedure duration 1	P494	Number	5		Unit (hour)
140	Surgeon 1	P495	Character	40		
141	First assistant 1	P496	Character	40		
142	Second assistant 1	P497	Character	40		
143	Anaesthesia 1	P498	Character	6		
144	Anaesthesia class 1	P4981	Character	1		
145	Wound healing ratings 1	P499	Character	2		
146	Anaesthesiologist 1	P4910	Character	40		
147	Operation / Procedure code 2	P4911	Character	20		Diagnosis code: ICD10
148	Operation / Procedure date 2	P4912	Date, time			yyyy-mm-dd HH:mm:ss
149	Operation / Procedure level 2	P821	Character	1		
150	Operation / Procedure name 2	P4913	Character	100		
151	Operation / Procedure part 2	P4914	Character	4		
152	Operation / Procedure duration 2	P4915	Number	5		Unit (hour)
153	Surgeon 2	P4916	Character	40		
154	First assistant 2	P4917	Character	40		
155	Second assistant 2	P4918	Character	40		
156	Anaesthesia 2	P4919	Character	6		
157	Anaesthesia class 2	P4982	Character	1		
158	Wound healing ratings 2	P4920	Character	2		

159	Anaesthesiologist 2	P4921	Character	40		
160	Operation / Procedure code 3	P4922	Character	20		Diagnosis code: ICD10
161	Operation / Procedure date 3	P4923	Date, time			yyyy-mm-dd HH:mm:ss
162	Operation / Procedure level 3	P822	Character	1		
163	Operation / Procedure name 3	P4924	Character	100		
164	Operation / Procedure part 3	P4925	Character	4		
165	Operation / Procedure duration 3	P4526	Number	5		Unit (hour)
166	Surgeon 3	P4527	Character	40		
167	First assistant 3	P4528	Character	40		
168	Second assistant 3	P4529	Character	40		
169	Anaesthesia 3	P4530	Character	6		
170	Anaesthesia class 3	P4983	Character	1		
171	Wound healing ratings 3	P4531	Character	2		
172	Anaesthesiologist 3	P4532	Character	40		
173	Operation / Procedure code 4	P4533	Character	20		Diagnosis code: ICD10
174	Operation / Procedure date 4	P4534	Date, time			yyyy-mm-dd HH:mm:ss
175	Operation / Procedure level 4	P823	Character	1		
176	Operation / Procedure name 4	P4535	Character	100		
177	Operation / Procedure part 4	P4536	Character	4		
178	Operation / Procedure duration 4	P4537	Number	5		Unit (hour)
179	Surgeon 4	P4538	Character	40		
180	First assistant 4	P4539	Character	40		
181	Second assistant 4	P4540	Character	40		
182	Anaesthesia 4	P4541	Character	6		
183	Anaesthesia class 4	P4542	Character	1		
184	Wound healing ratings 4	P4543	Character	2		
185	Anaesthesiologist 4	P4544	Character	40		
186	Operation / Procedure code 5	P4545	Date, time	20		Diagnosis code: ICD10
187	Operation / Procedure date 5	P4546	Character			yyyy-mm-dd HH:mm:ss
188	Operation / Procedure level 5	P824	Character	1		
189	Operation / Procedure name 5	P4546	Character	100		
190	Operation / Procedure part 5	P4547	Character	4		
191	Operation / Procedure duration 5	P4548	Number	5		Unit (hour)
192	Surgeon 5	P4549	Character	40		
193	First assistant 5	P4550	Character	40		
194	Second assistant 5	P4551	Character	40		
195	Anaesthesia 5	P4552	Character	6		
196	Anaesthesia class 5	P4985	Character	1		
197	Wound healing ratings 5	P4553	Character	2		
198	Anaesthesiologist 5	P4554	Character	40		

199	Operation / Procedure code 6	P45002	Character	20		Diagnosis code: ICD10
200	Operation / Procedure date 6	P45003	Date, time			yyyy-mm-dd HH:mm:ss
201	Operation / Procedure level 6	P825	Character	1		
202	Operation / Procedure name 6	P45004	Character	100		
203	Operation / Procedure part 6	P45005	Character	4		
204	Operation / Procedure duration 6	P45006	Number	5		Unit (hour)
205	Surgeon 6	P45007	Character	40		
206	First assistant 6	P45008	Character	40		
207	Second assistant 6	P45009	Character	40		
208	Anaesthesia 6	P45010	Character	6		
209	Anaesthesia class 6	P45011	Character	1		
210	Wound healing ratings 6	P45012	Character	2		
211	Anaesthesiologist 6	P45013	Character	40		
212	Operation / Procedure code 7	P45014	Character	20		Diagnosis code: ICD10
213	Operation / Procedure date 7	P45015	Date, time			yyyy-mm-dd HH:mm:ss
214	Operation / Procedure level 7	P826	Character	1		
215	Operation / Procedure name 7	P45016	Character	100		
216	Operation / Procedure part 7	P45017	Number	4		
217	Operation / Procedure duration 7	P45018	Character	5		Unit (hour)
218	Surgeon 7	P45019	Character	40		
219	First assistant 7	P45020	Character	40		
220	Second assistant 7	P45021	Character	40		
221	Anaesthesia 7	P45022	Character	6		
222	Anaesthesia class 7	P45023	Character	1		
223	Wound healing ratings 7	P45024	Character	2		
224	Anaesthesiologist 7	P45025	Character	40		
225	Operation / Procedure code 8	P45026	Character	20		Diagnosis code: ICD10
226	Operation / Procedure date 8	P45027	Date, time			yyyy-mm-dd HH:mm:ss
227	Operation / Procedure level 8	P827	Character	1		
228	Operation / Procedure name 8	P45028	Character	100		
229	Operation / Procedure part 8	P45029	Character	4		
230	Operation / Procedure duration 8	P45030	Number	5		Unit (hour)
231	Surgeon 8	P45031	Character	40		
232	First assistant 8	P45032	Character	40		
233	Second assistant 8	P45033	Character	40		
234	Anaesthesia 8	P45034	Character	6		
235	Anaesthesia class 8	P45035	Character	1		
236	Wound healing ratings 8	P45036	Character	2		
237	Anaesthesiologist 8	P45037	Character	40		
238	Operation / Procedure code 9	P45038	Character	20		Diagnosis code: ICD10

239	Operation / Procedure date 9	P45039	Date, time			yyyy-mm-dd HH:mm:ss
240	Operation / Procedure level 9	P828	Character	1		
241	Operation / Procedure name 9	P45040	Character	100		
242	Operation / Procedure part 9	P45041	Character	4		
243	Operation / Procedure duration 9	P45042	Number	5		Unit (hour)
244	Surgeon 9	P45043	Character	40		
245	First assistant 9	P45044	Character	40		
246	Second assistant 9	P45045	Character	40		
247	Anaesthesia 9	P45046	Character	6		
248	Anaesthesia class 9	P45047	Character	1		
249	Wound healing ratings 9	P45048	Character	2		
250	Anaesthesiologist 9	P45049	Character	40		
251	Operation / Procedure code 10	P45050	Character	20		Diagnosis code: ICD10
252	Operation / Procedure date 10	P45051	Date, time			yyyy-mm-dd HH:mm:ss
253	Operation / Procedure level 10	P829	Character	1		
254	Operation / Procedure name 10	P45052	Character	100		
255	Operation / Procedure part 10	P45053	Character	4		
256	Operation / Procedure duration 10	P45054	Number	5		Unit (hour)
257	Surgeon 10	P45055	Character	40		
258	First assistant 10	P45056	Character	40		
259	Second assistant 10	P45057	Character	40		
260	Anaesthesia 10	P45058	Character	6		
261	Anaesthesia class 10	P45059	Character	1		
262	Wound healing ratings 10	P45060	Character	2		
263	Anaesthesiologist 10	P45061	Character	40		
264	Length of critical care	P561	Number	6		Unit (day)
265	Length of Grade 1 nursing	P562	Number	6		Unit (day)
266	Length of Grade 2 nursing	P563	Number	6		Unit (day)
267	Length of Grade 3 nursing	P564	Number	6		Unit (day)
268	Intensive care unit 1	P6911	Character	4		
269	Entrance date and time 1	P6912	Date			yyyy-mm-dd
270	Exit date and time 1	P6913	Date			yyyy-mm-dd
271	Intensive care unit 2	P6914	Character	4		
272	Entrance date and time 2	P6915	Date			yyyy-mm-dd
273	Exit date and time 2	P6916	Date			yyyy-mm-dd
274	Intensive care unit 3	P6917	Character	4		
275	Entrance date and time 3	P6918	Date			yyyy-mm-dd
276	Exit date and time 3	P6919	Date			yyyy-mm-dd
277	Intensive care unit 4	P6920	Character	4		
278	Entrance date and time 4	P6921	Date			yyyy-mm-dd
279	Exit date and time 4	P6922	Date			yyyy-mm-dd

280	Intensive care unit 5	P6923	Character	4		
281	Entrance date and time 5	P6924	Date			yyyy-mm-dd
282	Exit date and time 5	P6925	Date			yyyy-mm-dd
283	Autopsy	P57	Character	1		
284	First case of operation, treatment, examination and diagnosis	P58	Character	1		
285	Type of the patients with operation	P581	Collection	Multi-choice		
286	Follow-up	P60	Character	1		
287	Follow-up time (week)	P611	Number	2		
288	Follow-up time (month)	P612	Number	2		
289	Follow-up time (year)	P613	Number	2		
290	Teach Case	P59	Character	1		
291	Blood type (ABO)	P62	Character	1	Yes	
292	Blood type (Rh)	P63	Character	1	Yes	
293	Transfusion reaction	P64	Character	1		
294	Erythrocyte	P651	Number	6		Unit (U)
295	Platelet	P652	Number	6		Unit (bag)
296	Plasma	P653	Number	6		Unit (ml)
297	Whole blood	P654	Number	6		Unit (ml)
298	Autologous recovery	P655	Number	6		Unit (ml)
299	Others	P656	Number	6		Unit (ml)
300	Age (less than 1 years old)	P66	Number	4,2		Unit (month), two decimal places
301	New-born weight 1	P681	Number	6		Unit (gram)
302	New-born weight 2	P682	Number	6		Unit (gram)
303	New-born weight 3	P683	Number	6		Unit (gram)
304	New-born weight 4	P684	Number	6		Unit (gram)
305	New-born weight 5	P685	Number	6		Unit (gram)
306	New-born weight at admission	P67	Number	6		Unit (gram)
307	Pre-admitting (coma duration of cranial injury patients, hour)	P731	Number	6		Unit (hour)
308	Pre-admitting (coma duration of cranial injury patients, minute)	P732	Number	2		Unit (min)
309	Post-admitting (coma duration of cranial injury patients, hour)	P733	Number	6		Unit (hour)
310	Post-admitting coma duration of cranial injury patients, minute)	P734	Number	2		Unit (min)
311	Duration of ventilator application	P72	Number	6		Unit (hour)

312	Readmission Plan within 31 days after discharge	P830	Character	1		
313	Readmission aims	P831	Character	100		
314	Method of discharge	P741	Character	1		
315	Hospital from which the patient is transferred	P742	Character	100		
316	Community service association/county hospital from which the patient is transferred	P743	Character	100		
317	Gross charge	P782	Number	10,2	Yes	Two decimal places
318	Out-of-pocket money	P751	Number	10,2		Two decimal places
319	Cost for general medical care	P752	Number	10,2		Two decimal places
320	Cost for treatment	P754	Number	10,2		Two decimal places
321	Cost for nursing care	P755	Number	10,2		Two decimal places
322	Cost for other integrated medical services	P756	Number	10,2		Two decimal places
323	Cost for pathological diagnosis	P757	Number	10,2		Two decimal places
324	Cost for lab text	P758	Number	10,2		Two decimal places
325	Cost for imaging test	P759	Number	10,2		Two decimal places
326	Cost for clinical diagnosis items	P760	Number	10,2		Two decimal places
327	Cost for nonoperation therapy	P761	Number	10,2		Two decimal places
328	Cost for clinical physical treatment	P762	Number	10,2		Two decimal places
329	Operation-treatment cost	P763	Number	10,2		Two decimal places
330	Anaesthesia cost	P764	Number	10,2		Two decimal places
331	Operation cost	P765	Number	10,2		Two decimal places
332	Rehabilitation cost	P767	Number	10,2		Two decimal places
333	Cost for traditional Chinese medicine	P768	Number	10,2		Two decimal places
334	Cost for western medicine	P769	Number	10,2		Two decimal places
335	Cost for Antibiotics	P770	Number	10,2		Two decimal places
336	Cost for traditional Chinese medicine	P771	Number	10,2		Two decimal places
337	Cost for Herbs	P772	Number	10,2		Two decimal places
338	Cost for whole blood transfusion	P773	Number	10,2		Two decimal places
339	Cost for blood transfusion	P774	Number	10,2		Two decimal places
340	Cost for globin transfusion	P775	Number	10,2		Two decimal places
341	Cost for clotting factor transfusion	P776	Number	10,2		Two decimal places
342	Cost for cytokine transfusion	P777	Number	10,2		Two decimal places

343	Cost for disposable medical material in examination	P778	Number	10,2		Two decimal places
344	Cost for disposable medical material in treatment	P779	Number	10,2		Two decimal places
345	Cost for disposable medical material in operation	P780	Number	10,2		Two decimal places
346	Other cost	P781	Number	10,2		Two decimal places

Appendix A. China PEACE-Retrospective AMI Study Site Investigators by Hospital

Aba Tibetan and Qiang Autonomous Prefecture People's Hospital, ShipingWeng, ShuyingXie; Affiliated Hospital of Guiyang Medical College, Lirong Wu, Jiulin Chen; Affiliated Hospital of Hainan Medical College, Tianfa Li, Jun Wang; Affiliated Zhongshan Hospital of Dalian University, Qin Yu, Xiaofei Li; Alxa League Central Hospital, Zhong Li, ShiguoHao, Yuzhen Zhang, Xuemei Wu; Baiquan County People's Hospital, Yachen Zhang, Zhifeng Liu; Biyang People's Hospital, Zhongxin Wang, HaoJia; Bortala Mongol Autonomous Prefecture People's Hospital, Bayin Bate, BadengQiqige; Changda Hospital Of Anshan, Xiang Jin, Ting Cai; Chengwu County People's Hospital, Fengqin Liu, Dayong Xu; Chenxi County People's Hospital, Xuejin He, Shui Yang; Chongren County People's Hospital, Chun Yuan, Jiping Wang; County People's Hospital of Jinning, LihuaGu, Lin Li, Shijiao Chen; Dalian Municipal Central Hospital, YongchaoZhi, Lili Sun; Dao County People's Hospital, Shengcheng Zhou, Lingjiao Jin; Daofu County People's Hospital, Yong Leng, Liangchuan Zhang, Tianyun Deng; Dingyuan County People's Hospital of Anhui Province, Yuanjin Wang, Wenhua Zhang, Xinmin Ma; Dongyang People's Hospital, Weimin Li, Liang Lu, Xuan Ge; Dulong and Nu Autonomous County People's Hospital of Gongshan, Xiaoping Wu, Yanming He; Dunhua City Hospital of Jilin Province, FanjuMeng, Jia Li; Fenghuang County People's Hospital, Dexi Liao, Guangyong Liu, Wen Qin; Fengshan County People's Hospital, Wen Long, Xiangwen Chen; Fourth Hospital of Baotou City, Baohong Zhang, Yonghou Yin, Bin Tian; Fourth People's Hospital of Zigong City, Yong Yi, Chaoyong Wu; Fugu County People's Hospital of Shaanxi Province, Baoqi Liu, Zhihui Zhao, Haiming Li; Fujian Provincial Hospital, YansongGuo, Xinjing Chen; Fuling Center Hospital of Chongqing City, Liquan Xiang, Lin Ning; Gannan County People's Hospital, Mei Chen, Xin Jin, Guiling Li; General Hospital of the Yangtze River Shipping, Xiuqi Li, Xing'an Wu; Gongcheng Yao Autonomous County People's Hospital, Congjun Tan, Mingfang Feng, Meili Wang; Guangchang County People's Hospital, Liangfa Wen, Xiang Fu, QunxingXie; Guilin People's Hospital, Wei Zhang, Yanni Zhuang, Hua Lu;Guiping People's Hospital, Jiaqian Lu, Yu Huang; Haerbin 242 Hospital, Yin Zhou, Qiuling Hu; Haiyan People's Hospital, Chunhui Xiao, Xiaoli Hu; Heling Ge Er County People's Hospital, Yongshuan Wu, Qiuli Wang; Helong Municipal People's Hospital, Youlin Xu, Xuefei Yu; Henan Provincial People's Hospital, Chuanyu Gao, Jianhong Zhang, You Zhang; Heze Municipal Hospital, WentangNiu, Xiaolei Ma, Yong Wang; HGKY Group Company General Hospital, Xiaowen Pan, Yanlong Liu; Hua Xin HospitalFirst Hospital of Tsinghua University, Lifu Miao, Yanping Yin, Zhiying Zhang; Huairen People's Hospital, Shutang Feng; Huayin People's Hospital, Aiping Wang, Jiangli Zhang, Feipeng Li; Huaying People's Hospital , Hong Wang; Hunchun Hospital, Lijun Yu, Xinxin Zhao; Huizhou Municipal Central Hospital, Yuansheng Shen, Zhiming Li, Lizhen He; Hunan Province Mawangdui Hospital, ZhiyiRong, Wei Luo; Ji'an Municipal Central People's hospital, Xueqiao Wang; Jianghua Yao Autonomous County

People's Hospital, Rongjun Wan, Jianglin Tang, Guanghan Wu; Jiangsu Haimen People's Hospital, Jie Wu, Bin Xu; Jiangxi Provincial People's Hospital, Qing Huang, Xiaohe Wu; Jiangzi County People's Hospital, Sang Ge, Pian Pu, PingcuoDuoji; Jilin Province People's Hospital, Hui Dai, Yuming Du, Wei Guo; Jilin Integrated Traditional Chinese & Western Medicine Hospital, Jilin Province, Jianping Shi; Jinghai County Hospital, Peihua Zhao, Jingsheng Sun; Jingxi County People's Hospital, Hongxiang Li, Wen Liang; Jingxing County Hospital, Zhiwen Dong, Zhenhai Zhao; Jingzhou Central Hospital, Xin Li, Qin Xu; Jiuquan City People's Hospital, Yaofeng Yuan, Zhirong Li; Jixi People's Hospital of The Jixi Municipal People's Hospital Medical Group, Jinbo Gao; Jize County Hospital, Qiu'eGuo; Kangbao County People's Hospital, Ruiqing Zhao, Guangjun Song; Keshiketengqi Hospital of Chifeng City, Lize Wang, Haiyun Song; Lanping Bai and Pumi Autonomous County People's Hospital, Jinwen He, Jinming He; Laoting County Hospital, Keyong Shang, Changjiang Liu, Kuituan Xi; Liaoyang Central Hospital, Rihui Liu, Peng Guo; Liaoyuan Central Hospital, ChaoyangGuo, Xiangjun Liu, Rujun Zhao, Zeyong Yu; Lindian County Hospital, Wenzhou Li, Xudong Jing, Huanling Wang; Linxiang People's Hospital, Xiyuan Zhao, Chao Zhang, Long Chen; Liujiang County People's Hospital, Meifa Wei, Yan Liu, Shengde Chen; Longyan First Hospital, Kaihong Chen, Yong Fang, Ying Liao; Luancheng County Hospital, Junli Wang, Tianyu Liu, Suzhe Cheng; Lucheng People's Hospital, Yunke Zhou, XiaoxiaNiu, Huifang Cao; Luchuan County People's Hospital, Zebin Feng, Min Feng; Luxi County People's Hospital, FeilongDuan, Haiming Yi; Luyi County People's Hospital, Yuanxun Xu, AnranGuo; Macheng People's Hospital, Xianshun Zhou, HongzhuanCai, Peng Zheng; Mengcheng First People's Hospital, GaofengGuo; MenglianLahudaiwa autonomous counties People's Hospital, Xiang Li; Min County People's Hospital, MinwuBao, Yuhong Liu; Nanjing First Hospital, Shaoliang Chen, HaiboJia, Hongjuan Peng; Nan'an Hospital, Duanping Dai, Shaoxiong Hong; Nantong Third People's Hospital, Song Chen, Dongya Zhang, Ying Wang; Nanyang Central Hospital, Yudong Li, Jianbu Gao, Shouzhong Yang; Ningwu County People's Hospital, Junhu An; Peking University People's Hospital, Chenyang Shen, Yunfeng Liu; Peking University Shenzhen Hospital, Chun Wu, Huan Qu, Saiyong Chen; People's Hospital of Jingyu, Yuhui Lin, Dehai Jiao; People's Hospital of Yueqing City, Manhong Wang, Qiu Wang; Pianguan County People's Hospital, YingliangXue, Ruijun Zhang; Puding County People's Hospital, Cheng Yuan, Lei Wu; Qinghai Red Cross Hospital, Jianqing Zhang, Chunmei Wei, Yanmei Shen; Qinshui County People's Hospital, Hehua Zhang, Hongmei Pan, Yong Gao; Qinyang People's Hospital, Xiaowen Ma, Yanli Liang, Tianbiao Wang; Queshan County People's Hospital, Daguo Zhao; Quzhou People's Hospital, XiaomingTu, Zhenyan Gao; Rongjiang County People's Hospital, Fangning Wang, Qiang Yang; Rudong County People's Hospital, Xiaoping Kang, Jianbin Fang, Dongmei Liu; Ruyang County People's Hospital, Chengning Shen, Mengfei Li; Shangluo Central Hospital, Yingmin Guan, Wenfeng Wang, Ting Xiao; ShangqiuChangzheng People's Hospital, Qian Wang; Shaoyang County People's Hospital, Fengyun Jiang, Kaiyou Wu; Shengsi People's

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Are Medical Record Front Page Data Suitable for Risk Adjustment in Hospital Performance Measurement: Development and Validation of a Risk Model of In-hospital Mortality after Acute Myocardial Infarction

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Are Medical Record Front Page Data Suitable for Risk Adjustment in Hospital Performance Measurement: Development and Validation of a Risk Model of In-hospital Mortality after Acute Myocardial Infarction

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ABSTRACT

Objectives

To develop a model of in-hospital mortality using MRFP data, and assess its validity in case-mix standardization by comparison with a model developed using the complete medical record data.

Design

A nationally representative retrospective study.

Setting

Representative hospitals in China, covering 161 hospitals in modelling cohort and 156 hospitals in validation cohort.

Participants

Representative patients admitted for AMI. 8370 patients in modelling cohort and 9704 patients in validation cohort.

Primary outcome measures

In-hospital mortality, which was defined explicitly as death that occurred during hospitalization, and the hospital-level risk standardized mortality rate (RSMR)

Results

A total of 14 variables were included in the model predicting in-hospital mortality based on MRFP data, with the AUC of 0.78 among modelling cohort and 0.79 among validation cohort. The median of absolute difference between the hospital RSMR predicted by hierarchical generalized linear models established based on MRFP data and complete medical record data, which was built as ‘reference model’, was 0.08% (10th and 90th percentiles: -

1.8% and 1.6%). In the regression model comparing the RSMR between two models, the slope and intercept of the regression equation is 0.90 and 0.007 in modelling cohort, while 0.85 and 0.010 in validation cohort, which indicated that the evaluation capability from two models were very similar.

Conclusions

The models based on MRFP data showed good discrimination and calibration capability, as well as similar risk prediction effect in comparison with the model based on complete medical record data, which proved that MRFP data could be suitable for risk adjustment in hospital performance measurement.

KEY WORDS

Health informatics, Myocardial infarction, Quality in health care

Strengths and limitations of this study

- The analysis was based on a nationally representative cohort of hospitals in China, from which random samples of patients admitted with AMI was drawn to represent the heterogeneity in outcome of care.
- We used hierarchical generalized linear models that fully consider the patient clustering in hospitals, and is able to distinguish the differences within and between hospitals, which suits the purpose to adjust for case-mix in hospital performance comparison.
- We validated the finding that concise data extracted from medical record front page are good enough to reflect patients' risk profile, using the data from a closer year.
- External validations that include more diverse hospitals and among other diseases will be needed in the future.

INTRODUCTION

Equal access to high-quality health care is one of the major aims in China's recent public hospital reform[1 2]. To continuously improve quality of care and mitigate its disparities across regions or hospitals, sustainable monitoring of hospital performance, particularly patient outcomes, is firstly required [3 4]. The Ministry of Health (named as "National Health Commission" now) of China established the Hospital Quality Monitoring System (HQMS) in 2011, to collect key information of all hospitalizations, including patients' diagnosis and outcomes recorded in the medical record front page (MRFP) using a standardized form (Table S1)[5 6]. Although the MRFP lack of detailed information on treatment process such as lab test results or medications, with structured records on diagnosis, procedure and outcome, it could be utilized as a unique nationwide data source of outcome quality assessment (i.e. in-hospital mortality).

Assessing quality of care between hospitals needs to take into account patients' different demographic and clinical characteristics of patients between hospitals, like most of the prior studies have done based on a broad array of information from complete medical record[7-9]. However, it is still unclear whether the MRFP data collected in HQMS can act as good surrogates for complete medical record model in estimation of risk-standardized mortality.

In China PEACE (Patient-centred Evaluative Assessment of Cardiac Events) - Retrospective study, we built a nationally representative sample of patients hospitalized for acute myocardial infarction (AMI) and extracted high-quality data from their complete medical records (including medical record front pages), which provided an ideal condition to assess disparities in quality of care,[10]. We aim to develop a model of in-hospital mortality

using their MRFP data, then assess its effect in case-mix standardization by comparing with a model developed using the complete medical record data of the same patient cohort.

METHODS

Patient and Public Involvement

No patient involved.

Study design and population

The design of China PEACE-Retrospective AMI study has been published previously [11]. In brief, the study used a stratified two-stage random sampling method to select representative hospitals and patients admitted for AMI nationwide during 2001, 2006, and 2011. In addition, the study also included a more recent sample of patients admitted in 2015 using the same random sampling process. Firstly, five regions (Eastern cities, Central and Western cities, Eastern villages, Central villages, and Western villages) were used for representative hospital selection by simple random sampling method. Secondly, AMI cases (diagnosed as ICD-9 coded 410.xx or ICD-10 coded I21.xx, or key words from discharge diagnosis) were randomly selected from all patients who met the inclusion criteria in each selected hospital by random sampling method. Trained personnel at the national coordinating centres abstracted data from the medical records using standardized data definitions. Data abstraction quality was monitored by randomly audits that ensured that the overall variable accuracy exceeded 98% [11].

The Ethics Committee at the National Center for Cardiovascular Diseases approved the study (2012-377; 2016-769). All collaborating hospitals either accepted central ethics

approval or obtained local ethics approval by their ethics committees. As a retrospective study, written informed consent of patients were not required.

In this study, patients from year 2011 were regarded as the modelling cohort, and patients from the year 2015 were regarded as the validation cohort. Patients who transferred out to another hospital were excluded since we could not get their outcomes. A total of 8370 patients from 161 hospitals (96 secondary hospitals and 65 tertiary hospitals) were included as modelling cohort, and another 9704 patients from 156 hospitals (93 secondary hospitals and 63 tertiary hospitals) were included as validation cohort. In addition, if a hospital had less than 10 eligible patients per year, it would be further excluded from the hospital-level analysis. 8269 patients (137 hospitals, 73 secondary hospitals and 64 tertiary hospitals) from modelling cohort and 9583 patients (132 hospitals, 71 secondary hospitals and 61 tertiary hospitals) from validation cohort were included in the further analysis (Figure S1).

Statistical analysis

According to study aim, we need to develop and evaluate a model predicting in-hospital outcome at patient level based on MRFP data from modelling cohort firstly. If the model performed well, then another model used to evaluate hospital quality of care would be built based on prior model. The validation cohort was used to conduct external evaluation of models. Hospital level model would be built based on complete medical record data, which could be considered as 'the best reference'. By comparing the difference and association of the indicators evaluated by the MRFP model and the complete medical record model, we could explore whether the model based on MRFP data had similar efficiency with that based on complete medical record data. The analysis roadmap was demonstrated in Figure 1.

Candidate predictors and outcome

Patient characteristics were selected as candidate predictors, according to previous AMI predictive models such as GRACE, TIMI, and ACTION-GWTG[7-9 12-17]. For the model based on MRFP data, the candidate predictors included demographic characteristics (gender, age, medical insurance status, ethnicity, marital status), admission department, diagnosis at admission (cardiac arrest) and at discharge (acute ST-segment elevation myocardial infarction [STEMI], infarction position, hypertension, diabetes, dyslipidaemia, cardiogenic shock, heart failure, stroke, renal failure), which was available from MRFP data. For the model based on complete medical record, we additionally include patients' symptoms, vital signs and lab test results at admission.

In-hospital mortality, as the outcome variable in the models, was defined explicitly as death that occurred during hospitalization, which was recorded both on the MRFP and elsewhere such as discharge record. For the accuracy of analysis, we used complete medical record as data source. We did not include patients who withdraw treatment as outcome since we could not get "withdraw" information from MRFP data, though plenty of these patients might die soon after giving up treatment.

Patient-level model development and evaluation

A logistic regression model was built based on MRFP data from the modelling cohort. Area under receiver operating characteristic curve (AUC) and observed rates in deciles determined by model estimating value were used to evaluate the discrimination. Slope and intercept of regression equation between the observed and the predicted mortality was used to evaluate the calibration ability. To assess the overfitting of the model, we used the coefficients estimated

from the logistic model to predict the probability of mortality in the validation cohort, by multiplying coefficients by the observed risk factors variables and summing over for each subject. Then another logistic regression model was built, in which the dependent variable was observed mortality and independent variables were the predicted mortality generated as above. The slope different from 1 and the intercept different from 0 indicated overfitting.

Furthermore, we re-estimated the logistic regression model in the validation cohort used selected predictors above. If the estimated coefficients of new model were similar to prior, the selected predictors were considered to be stable. Discrimination and calibration were also evaluated in the re-established logistic model.

Complete medical record model was developed and validated based on the data from complete medical records, using the same method mentioned above. Additionally, we compared the performance of our complete medical record model and MRFP model with the GRACE in-hospital mortality model[7] among development and validation cohorts, by calculating the difference of AUC and the Integrated discrimination improvement(IDI) (Appendix A).

Hospital-level model development and comparison

Hierarchical generalized linear models (HGLM) were established among modelling and validation cohort separately, using above selected covariates and hospitals as random effects. HGLM considered the patient clustering in hospitals, and could be used to distinguish the differences of outcome within and between hospitals.

Hospital-level risk standardized mortality rate (RSMR) was used as an indicator to evaluating hospital quality of care in this study. The RSMR of each hospital could be

calculated from HGLM as the ratio of predicted and expected mortality of the hospital, multiplied by the unadjusted rate of all hospitals. The expected mortality is the mortality rate of the hospital if patients in each hospital were treated in a "reference" hospital; the predicted mortality accounted for the characteristics of a hospital (the hospital-level random effects of the model) [8 18].

We use two methods to compare the RSMR derived from the HGLMs based on MRFP and the complete medical record data. (1) Absolute differences of RSMR from two models were calculated, and the distribution of differences was described using mean, median, and maximum. (2) A linear regression model was built, with RSMR from the complete medical record data as the dependent variable and RSMR from the MRFP data as the independent variable. The slope of the model approaching 1 and the intercept approaching 0 indicated that the predicted probabilities from the two models were very similar. All above calculation and comparison would be conducted among the modelling and validation cohort separately.

All statistical inferences were performed on two-tailed test, and $p<0.05$ was considered statistically significant. The statistical software used is SAS 9.4 (SAS Institute Inc., Cary, North Carolina).

RESULTS

Study Population and Characteristics

In the modelling cohort, the average age was 65.4±12.8 years, and 2519 (30.1%) patients were female. About 1/2 of the patients were admitted to cardiovascular department at admission. 65.8% were diagnosed with STEMI, while 46.5%, 19.7% and 10.0% had

comorbidities of hypertension, diabetes and dyslipidaemia, respectively. Cardiogenic shock occurred in 4.8% of the patients, and 0.1% of patients had cardiac arrest before admission (Table 1). A total of 621 patients died during hospitalization, accounting for 7.4% of the modelling cohort.

Compared with modelling cohort, patients in the validation cohort had a higher proportion of patients with medical insurance and admission in cardiovascular departments ($p<0.001$). Less proportion (49.0%) of patients were diagnosed with STEMI ($p<0.001$), while a greater proportion of patients had hypertension, diabetes, dyslipidaemia, heart failure and renal failure ($p<0.05$) (Table 1). 689 patients died during hospitalization, accounting for 7.1% of the validation cohort, which was not significantly different from the modelling cohort ($p=0.41$).

Development and validation of patient-level model

A total of 14 risk factors were included in the MRFP model based on modelling cohort (Figure 2a). Model discrimination was good, with the AUC of 0.78, and observed mortality rate ranging from 0.83% in the lowest decile of the predicted mortality rate to 26.88% in the highest decile. The slope of the calibration curve was 0.91 and the intercept was -0.007, which showed the good calibration ability of this model (Table 2). The overfitting statistics were within an acceptable range (slope=1.01, intercept=-0.07), indicating that no overfitting exist.

The predictors included above were applied to the validation cohort to reconstruct the model, which showed that the effect direction and size were still similar (Figure 2a). In the validation cohort, the AUC was 0.79, with observed mortality rate ranging from 1.00% to

29.72%, and the slope and intercept of the calibration curve was 0.93 and 0.005 (Figure S2 and Table 2).

Using the same method, a complete medical record model was built, in which a total of 13 risk factors were included (Figure 2b). The AUC of the model was 0.79, and observed mortality rate ranged from 0.51% in the lowest decile to 27.96% in the highest decile. The slope of the calibration curve was 0.94 and the intercept was 0.004 (Figure S2 and Table 2). Similar with the MRFP model, the complete medical record model had good discrimination and calibration, as well as relatively stable coefficients when validated among the validation cohort (Figure 2b, Figure S2 and Table2). Additional analysis showed that both our two patient risk prediction model had better AUC (all p value<0.001) and positive IDI among development and validation cohorts compared with the GRACE prediction model (Appendix A).

Development and comparison of hospital-level model

8269 patients (137 hospitals, 73 secondary hospitals and 64 tertiary hospitals) from modelling cohort and 9583 patients (132 hospitals, 71 secondary hospitals and 61 tertiary hospitals) from validation cohort were included in estimating the hospital-level HGLMs.

In the modelling cohort, the median hospital-level RSMR was 7.4% (IQR: 5.2% - 10.1%). The median of absolute difference between the RSMR predicted by the complete medical record data and MRFP data was 0.08% (IQR: -0.67% - 0.53%), and the 10th and 90th percentiles were -1.8% and 1.6%, with no statistical significance (p=0.499). In the validation cohort, the median RSMR was 6.4% (IQR: 4.5% - 10.4%), and the median of absolute difference was 0.05%, with 10th and 90th percentiles of -2.8% and 1.9% (Figure S3). For the

regression model comparing the RSMR between the MRFP data and complete medical record data, the slope (intercept) was 0.90 (0.007) in the modelling cohort, while 0.85 (0.010) in the validation cohort (Figure 3). The correlations among secondary hospitals were better than among tertiary hospitals.

DISCUSSION

This study developed patient and hospital level MRFP models of in-hospital mortality of AMI, and took into account the patient case-mix in the hospital-level disparity analysis. These models based on MRFP data showed good discrimination and calibration capability, as well as similar risk prediction effect in comparison with the model based on complete medical record data, which proved that MRFP data could be suitable for risk adjustment in hospital performance measurement in China.

To our knowledge, the current study extended literatures in several ways. First, this is the first in-hospital mortality risk model based only on MRFP data in China. Currently in China, it is still difficult to obtain detailed complete medical records data nationwide for quality monitoring, due to the fragmentation in development and deployment of Hospital Information Systems and Electronic Medical Record Systems. In the United States which faces similar challenges, several risk models have been developed using concise administrative claims data, and successfully applied as substitute of complete medical record models [8 9]. The key value of this model is to demonstrate how MRFP data from HQMS can serve as a solution for national quality assessment, rather than to identify coefficients of specific risk characteristics.

Second, the methods we chosen for model development specifically to standardize the

hospital-level case-mix. We firstly selected an array of patient characteristics that influence their risk profile significantly using backward logistic regression, and confirmed the stability of this array in the validation cohort. Then we established a HGLM using these characteristics, because the HGLM takes into account the correlation of patients admitted in the same hospital to avoided underestimating the standard error of other risk factors,[18 19] which fits the nature that patients clustered within individual hospitals, and has been well-tested in previous studies on hospital-level comparisons[7-9].

Third, model based on MRFP data was robustly validated by not only repeating in validation cohorts, but more importantly comparing with which based on complete medical records data. Even though there is no real golden standard of risk standardization, medical record data enable the most complete characteristics of patients' demographic and clinical profile. The China PEACE Retrospective study provided a unique opportunity to compare the MRFP model against the complete medical record model, because scanning copies of sampled medical records were collected, and detailed information on patient characteristics had been centrally extracted from the front page and all other parts of medical records.

The feasibility of MRFP model has significant policy implications for China, as the government emphasized the importance of hospital performance monitoring [20]. China needs a nationwide data platform, which supports timely, accurate and sustainable outcome measurement, since the outcomes of care such as mortality provide a global assessment of quality and have the most relevance to patients. However, outcome measurement is challenging, because of variation among hospitals in patients' risk profile, meanwhile extracting data from electronic medical records is infeasible in most hospitals. Our study

firstly proved that concise medical record front page data that are available in the HQMS can sufficiently reflect patients' risk profile, which makes it suitable to generating risk-standardized mortality rates at hospital-level. Thus, this existing platform covering 1800 (73%) tertiary hospitals and 2300 (26%) secondary hospitals can serve as a base for national hospital performance measurement, similar to the United States Centers for Medicare & Medicaid Services' use of administrative claims data [19 20]. Moreover, some challenges should to be addressed. First, the quality of MRFP data across hospitals, particularly the completeness of comorbidity documentation and accuracy of diagnosis coding in diagnosis, needs to be improved [21]. Second, for chronic conditions with low in-hospital mortality rates, data on post-discharge outcomes (e.g. 30-day readmission rates) data need to be obtained from clinical registries, insurance claims and other sources.

Limitations of the study

There are some limitations in this study. First, weaker correlation in tertiary hospitals between RSMRs generated from the two risk models indicated a relatively poorer performance of current MRFP model applied in tertiary hospitals. However, this could be improved if the model development and disparity assessment were conducted within subgroups of hospitals separately. Second, although this study was based on nationally representative cohorts with model development and validation using data from different years, external validations that include more diverse hospitals will be needed in the future.

Conclusion

In conclusion, the MRFP model of in-hospital mortality supported that HQMS data could act as reasonable substitute for complete medical record data in risk adjustment between

hospitals across the nation. The lessons from AMI treatment could serve as a model to nationwide assessment on quality of care in other clinical fields.

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Declaration of conflicting interests

None declared.

Author contributions

XL contributed to the conception or design of the work. CW, DZ and XB contributed to the acquisition of data for the work. CW and XB contributed to the analysis of data for the work. CW, DZ, TZ and XL contributed to the interpretation of data for the work. CW and DZ drafted the manuscript. TZ, YW, ZL, GH and XL critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

Data availability

No additional data available

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TABLES

Table 1. Patients' characteristics from MRFP data and in-hospital mortality in modelling cohort and validation cohort.

	Modelling Cohort (Year 2011) N=8370	Validation Cohort (Year 2015) N=9704	p value
In-hospital mortality	621 (7.4)	687 (7.1)	0.3793
Female	2519 (30.1)	3121 (32.2)	0.0028
Age, mean(SD)	65.4 (12.8)	65.9(12.7)	0.0081
<40	195 (2.3)	213 (2.2)	<0.0001
40-49	910 (10.9)	891 (9.2)	
50-59	1600 (19.1)	1816 (18.7)	
60-69	2090 (25.0)	2674 (27.6)	
70-79	2431 (29.0)	2590 (26.7)	
≥80	1144 (13.7)	1520 (15.7)	
Han	7701 (92.0)	9285 (95.7)	<0.0001
Married	7460 (89.1)	8740 (90.1)	0.0391
Having medical insurance	5126 (61.2)	7507 (77.4)	<0.0001
Admission at cardiology department	4087 (48.8)	6532 (67.3)	<0.0001
Admission Diagnosis			
Cardiac arrest	6 (0.1)	18 (0.2)	0.0362
Discharge Diagnosis			

STEMI	5509 (65.8)	4753 (49.0)	<0.0001
Acute extensive anterior MI	967 (11.6)	769 (7.9)	<0.0001
Acute anterior MI	1504 (18.0)	1310 (13.5)	<0.0001
Acute anterior intermural MI	587 (7.0)	408 (4.2)	<0.0001
Acute inferior MI	2558 (30.6)	2214 (22.8)	<0.0001
Acute lateral MI	359 (4.3)	311 (3.2)	0.0001
Acute posterior MI	699 (8.4)	502 (5.2)	<0.0001
Acute right ventricular infarction	615 (7.3)	418 (4.3)	<0.0001
Hypertension	3894 (46.5)	5080 (52.3)	<0.0001
Diabetes mellitus	1650 (19.7)	2345 (24.2)	<0.0001
Dyslipidemia	836 (10.0)	1434 (14.8)	<0.0001
Cardiogenic shock	403 (4.8)	510 (5.3)	0.1773
Heart failure	2853 (34.1)	3793 (39.1)	<0.0001
Stroke	655 (7.8)	1389 (14.3)	<0.0001
Renal failure	259 (3.1)	684 (7.0)	<0.0001

*MI: myocardial infarction; STEMI: ST-segment elevation myocardial infarction

Table 2. Performance of the MRFP model and the complete medical record model

Model	N	Discrimination		Calibration
		Area under ROC curve	Predictive Ability* (mean rate of lowest/highest decile)	Calibration Indices (slope, intercept)
MRFP model				
Year 2011(modelling cohort)	8370	0.776	0.83%-26.88%	(0.909,0.007)
Year 2015(validation cohort)	9704	0.794	1.00%-29.72%	(0.933,0.005)
Complete medical record model				
Year 2011(modelling cohort)	8370	0.790	0.51%-27.96%	(0.940,0.004)
Year 2015(validation cohort)	9704	0.798	0.92%-28.69%	(0.927,0.005)

*observed rates in deciles determined by estimated model

ROC: receiver operating characteristic; MRFP: medical record front page.

FIGURE LEGENDS

Figure 1. Analysis roadmap

Figure 2. Odds ratios of MRFP model and complete medical record model based on modelling and validation cohorts.

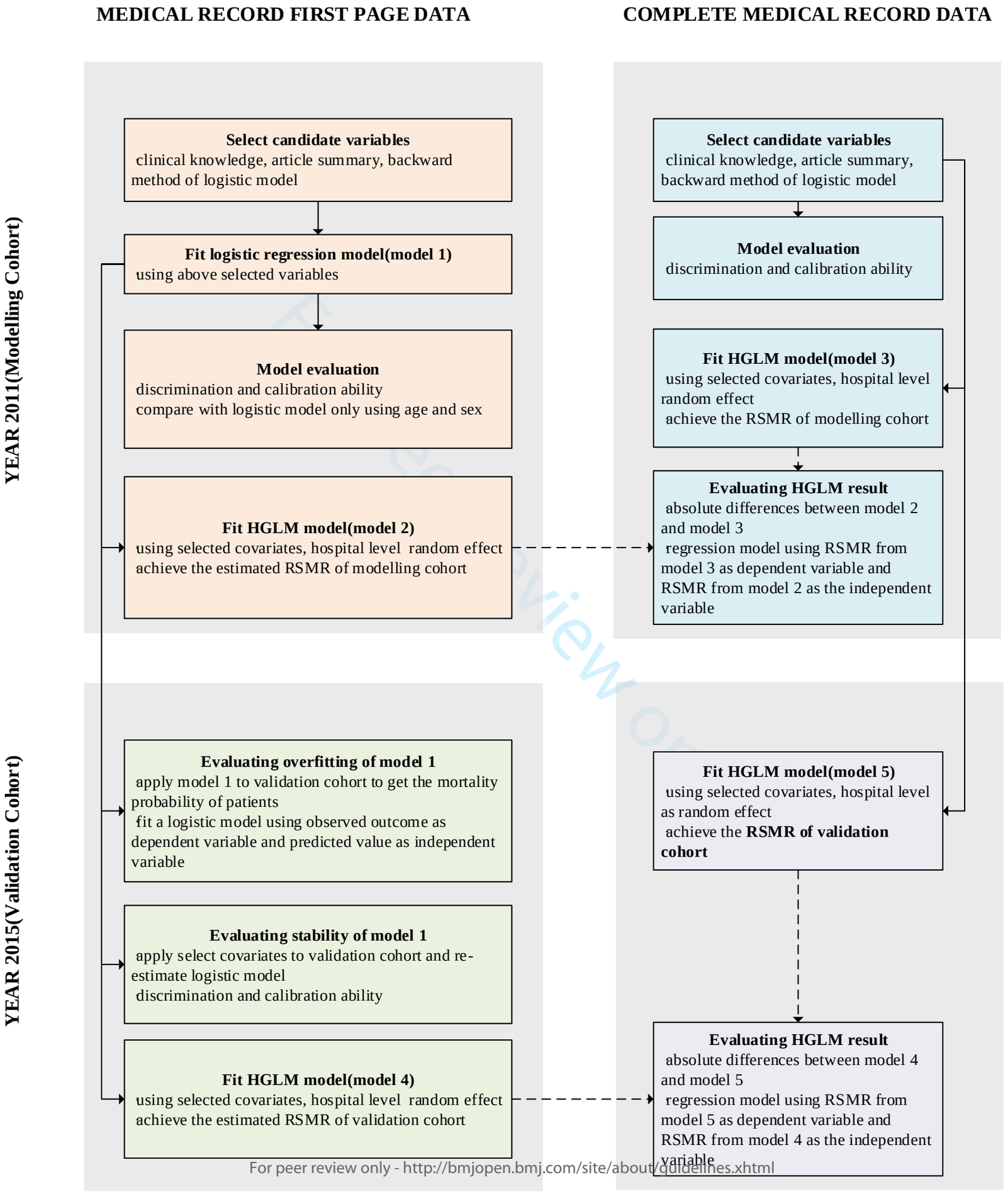
(a) MRFP model (b) Complete medical record model

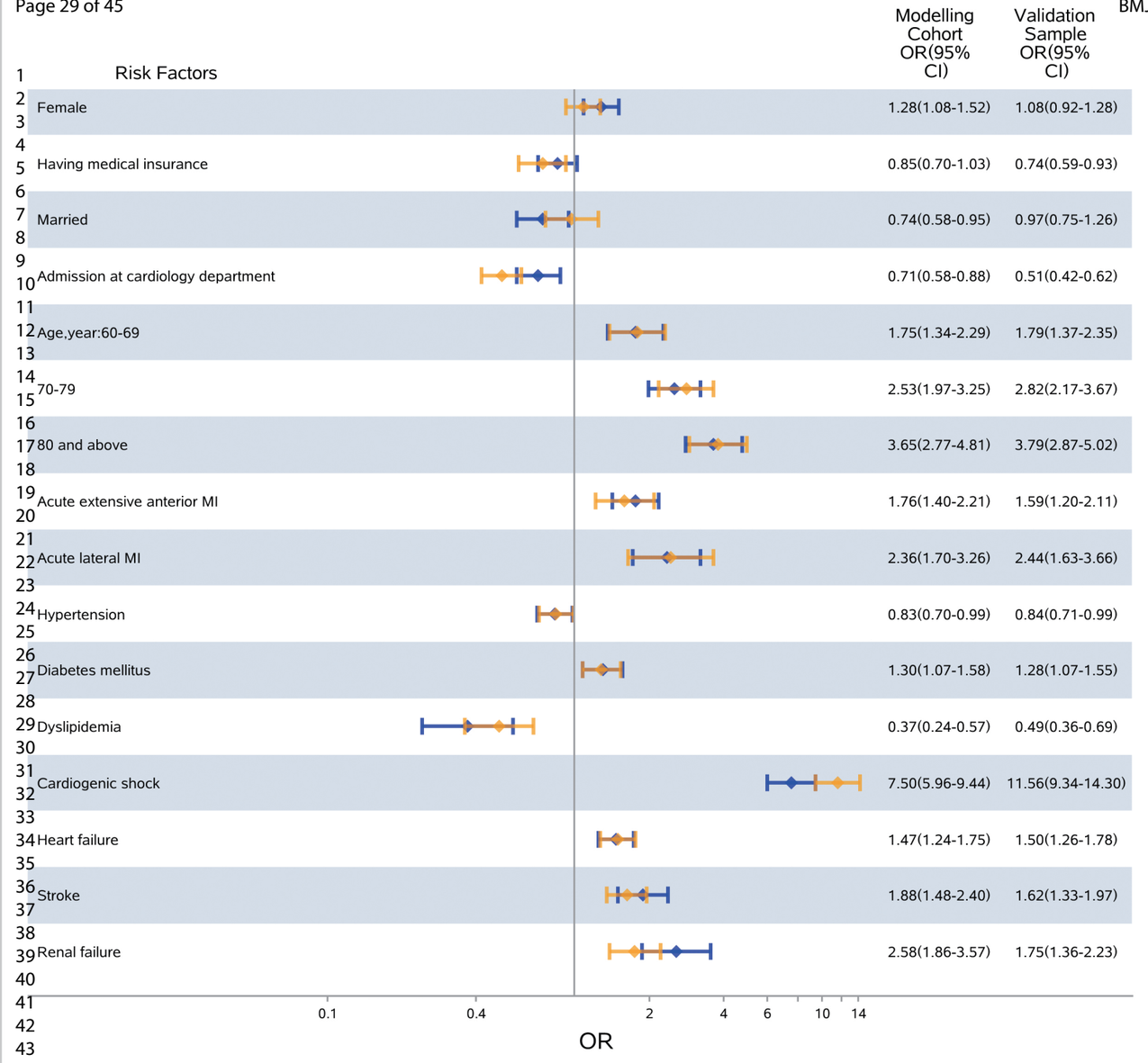
MRFP: medical record front page.

Figure 3. Correlation of risk standardized mortality rate estimated by MRFP model and complete medical record model.

(a) Modelling cohort (b) Validation cohort

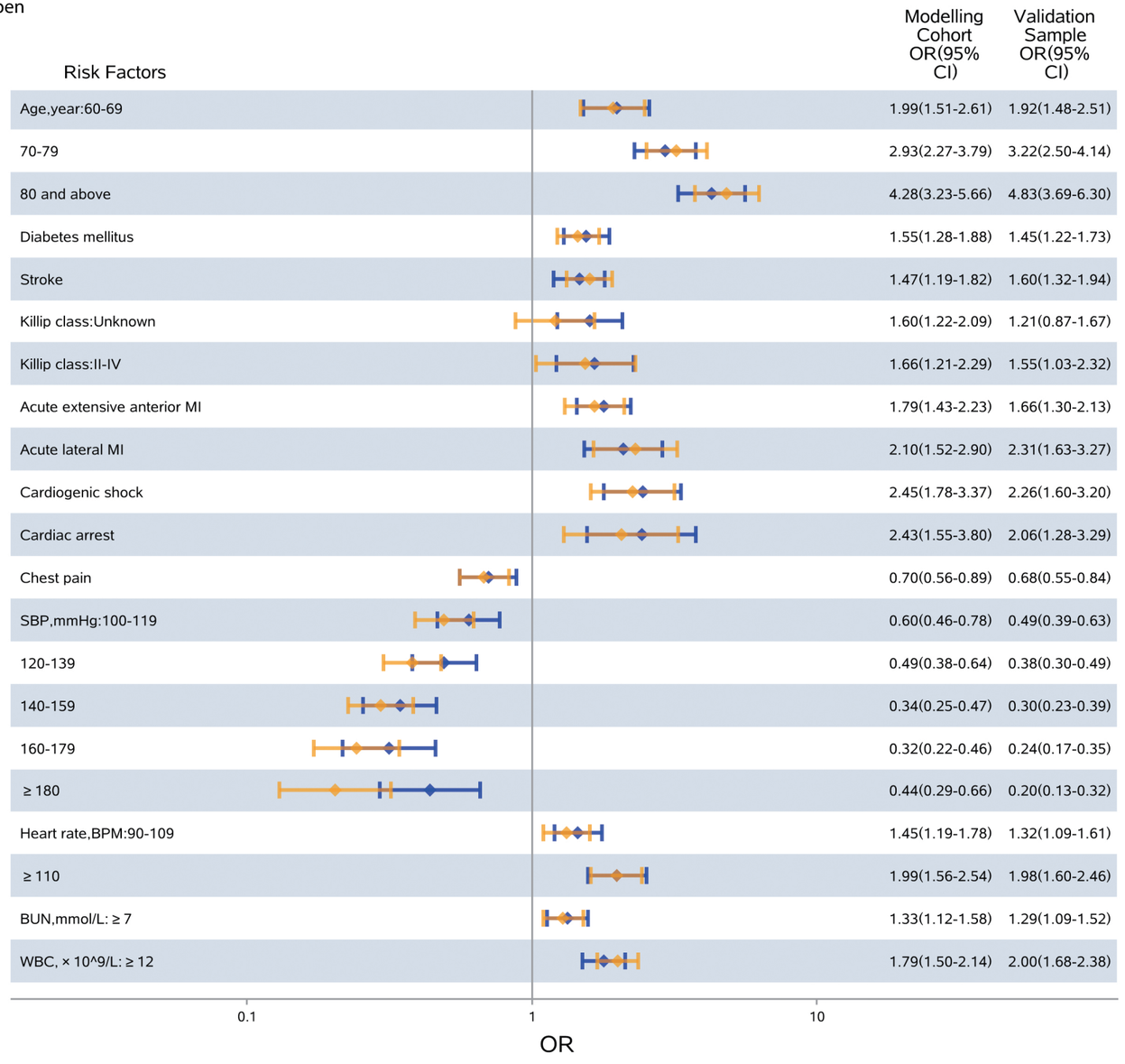
MRFP: medical record front page.





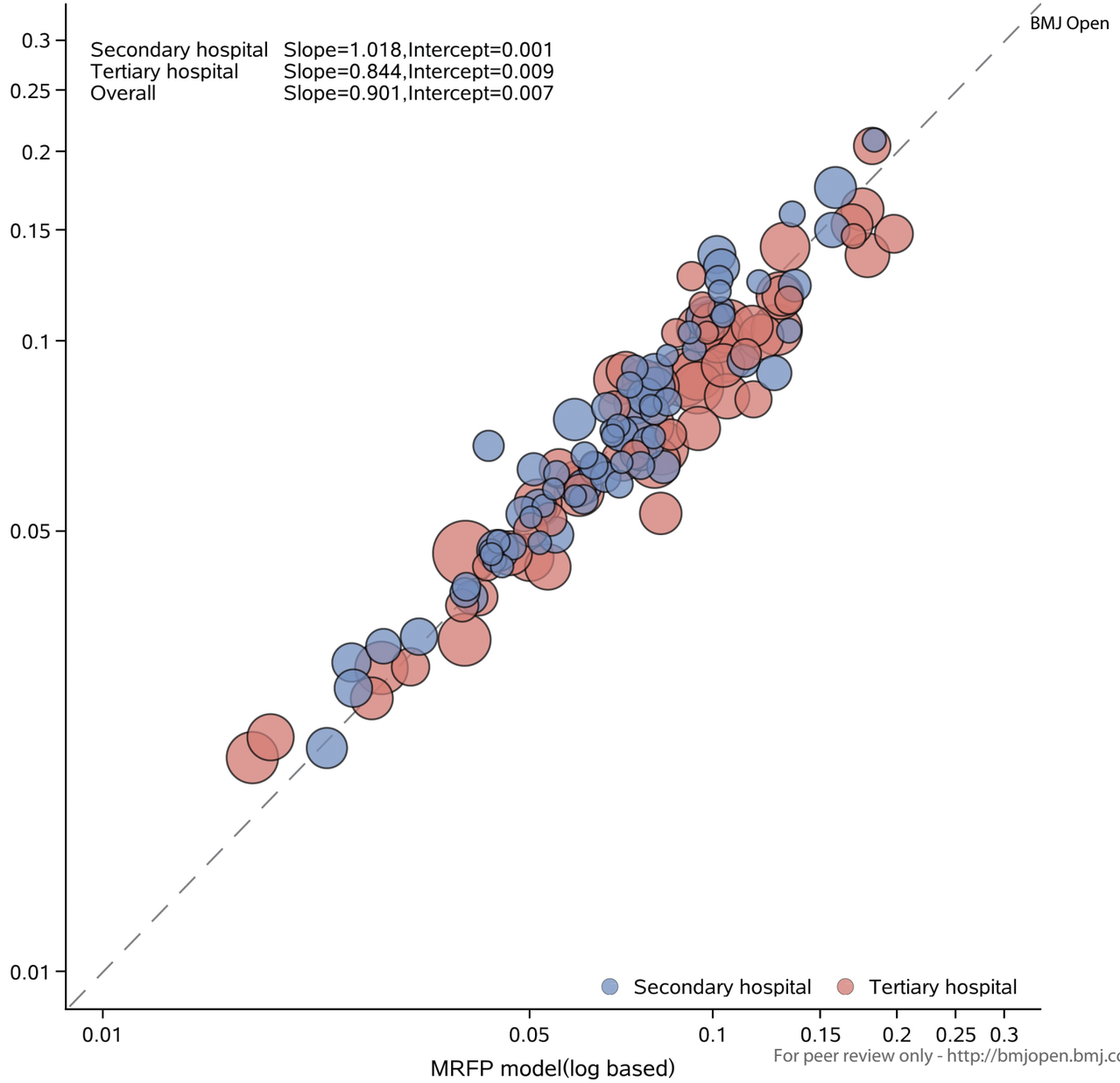
Note: Blue for modelling sample, orange for validation sample.
Estimatd of between-hospital variance=0.592(SE=0.125) in derivation sample, and 0.773(SE=0.147) in validation sample.

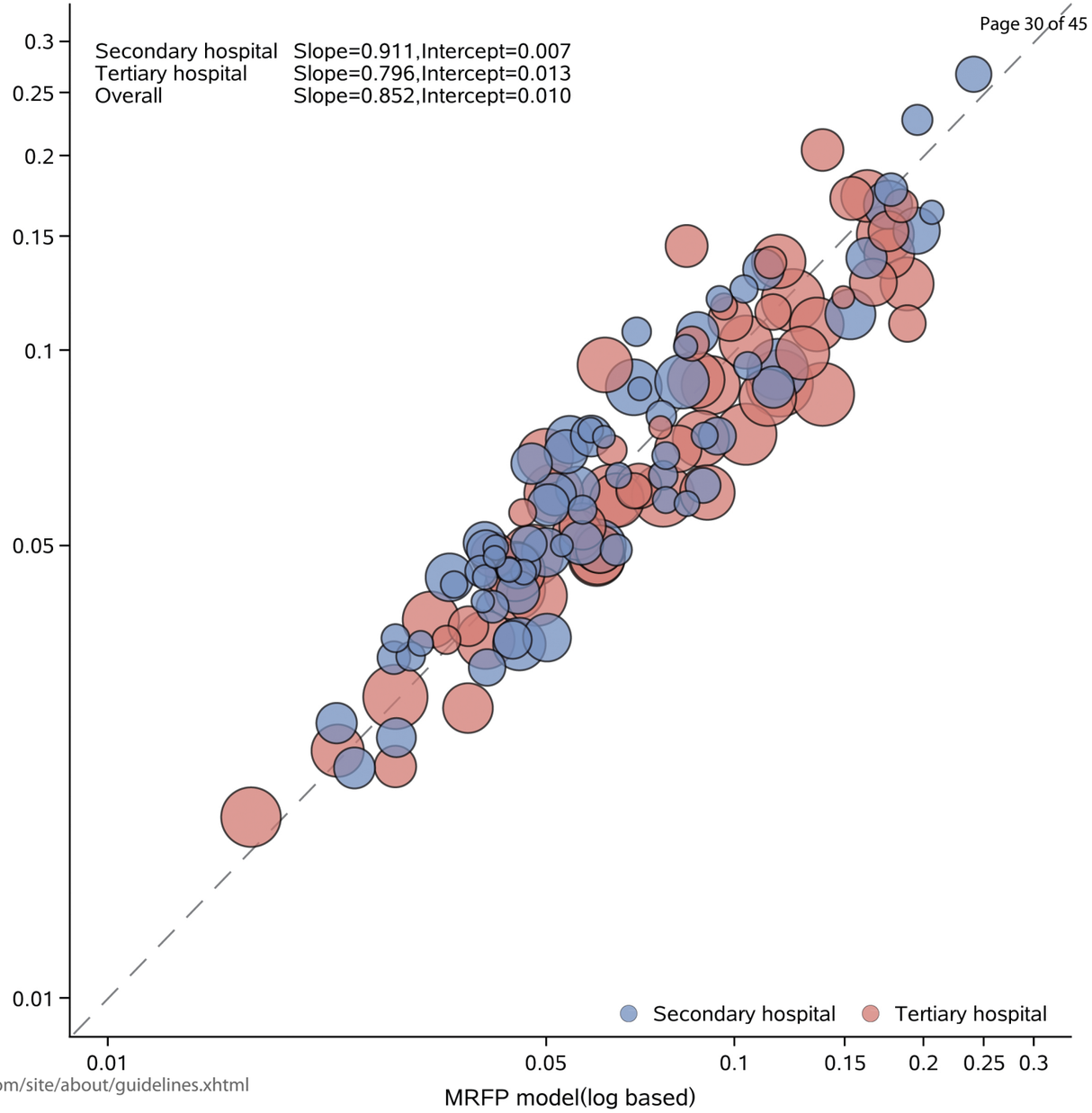
(a)



Note:Blue for derivation sample, orange for validation sample.
Estimatd of between-hospital variance=0.558(SE=0.121) in derivation sample, and 0.719(SE=0.139) in validation sample.

(b)





Supplementary materials

Table S1. Data elements required in the HQMS system

No.	Data element	Field name	Data type	Length	Required	Remarks
1	Hospital ID	P900	Character	22	Yes	
2	Hospital name	P6891	Character	80	Yes	
3	Medical Insurance Number	P686	Character	50		
4	Health-card number	P800	Character	50		
5	Method of healthcare payment	P1	Character	1	Yes	
6	Admission times	P2	Number	3	Yes	
7	Medical record number	P3	Character	20	Yes	
8	Name	P4	Character	40		
9	Gender	P5	Character	1	Yes	
10	Birth date	P6	Date			yyyy-mm-dd
11	Age	P7	Number	3		Unit (year)
12	Marital status	P8	Character	1	Yes	
13	Occupation	P9	Character	2		
14	Birthplace (province)	P101	Character	30		
15	Birthplace (city)	P102	Character	30		
16	Birthplace (county)	P103	Character	30		
17	Ethnicity	P11	Character	20		
18	Nationality	P12	Character	40		
19	Social ID	P13	Character	18		
20	Residence	P801	Character	200		
21	Residential phone number	P802	Character	40		
22	Postcode of residence	P803	Character	6		
23	Name and address of employer	P14	Character	200		
24	Phone number	P15	Character	40		
25	Postcode of employer address	P16	Character	6		
26	“Hukou” address	P17	Character	200		
27	Postcode of "Hukou" address	P171	Character	6		
28	Name of the contact	P18	Character	20		
29	Relationship with the patient	P19	Character	40		
30	Address of the contact	P20	Character	200		
31	Admission path	P804	Character	1		
32	Phone number of the contact	P21	Character	30		
33	Admission date	P22	Date, time		Yes	yyyy-mm-dd HH:mm:ss
34	Department of admission	P23	Character	6	Yes	
35	Ward of admission	P231	Character	30		
36	Department of patient being transferred to	P24	Character	6		
37	Discharge date	P25	Date, time		Yes	yyyy-mm-dd HH:mm:ss
38	Department of discharge	P26	Character	6	Yes	

39	Ward of discharge	P261	Character	30		
40	Length of hospitalization	P27	Number	6	Yes	
41	Diagnosis code of out-patient/emergency department	P28	Character	20		Diagnosis code: ICD10
42	Diagnosis of out-patient/emergency department	P281	Character	100	Yes	
43	Admission status	P29	Character	1		
44	Admission diagnosis code	P30	Character	30		Diagnosis code: ICD10
45	Admission diagnosis	P301	Character	100		
46	Date of diagnosis being confirmed	P31	Date			yyyy-mm-dd
47	Code of main diagnosis	P321	Character	20	Yes	Diagnosis code: ICD10. If there's no appropriate one, fill in "NA"
48	Primary diagnosis	P322	Character	100	Yes	
49	Primary diagnosis: admission status	P805	Character	1		
50	Primary diagnosis: discharge status	P323	Character	1		
51	Code of other diagnosis 1	P324	Character	20		Diagnosis code: ICD10
52	Other diagnosis 1	P325	Character	100		
53	Other diagnosis 1: admission status	P806	Character	1		
54	Other diagnosis 1: discharge status	P326	Character	1		
55	Code of Other diagnosis 2	P327	Character	20		Diagnosis code: ICD10
56	Other diagnosis 2	P328	Character	100		
57	Other diagnosis 2: admission status	P807	Character	1		
58	Other diagnosis 2: discharge status	P329	Character	1		
59	Code of Other diagnosis 3	P3291	Character	20		Diagnosis code: ICD10
60	Other diagnosis 3	P3292	Character	100		
61	Other diagnosis 3: admission status	P808	Character	1		
62	Other diagnosis 3: discharge status	P3293	Character	1		
63	Code of Other diagnosis 4	P3294	Character	20		Diagnosis code: ICD10
64	Other diagnosis 4	P3295	Character	100		
65	Other diagnosis 4: admission status	P809	Character	1		
66	Other diagnosis 4: discharge status	P3296	Character	1		

67	Code of Other diagnosis 5	P3297	Character	20		Diagnosis code: ICD10
68	Other diagnosis 5	P3298	Character	100		
69	Other diagnosis 5: admission status	P810	Character	1		
70	Other diagnosis 5: discharge status	P3299	Character	1		
71	Code of Other diagnosis 6	P3281	Character	20		Diagnosis code: ICD10
72	Other diagnosis 6	P3282	Character	100		
73	Other diagnosis 6: admission status	P811	Character	1		
74	Other diagnosis6: discharge status	P3283	Character	1		
75	Code of Other diagnosis 7	P3284	Character	20		Diagnosis code: ICD10
76	Other diagnosis 7	P3285	Character	100		
77	Other diagnosis 7: admission status	P812	Character	1		
78	Other diagnosis 7: discharge status	P3286	Character	1		
79	Code of Other diagnosis 8	P3287	Character	20		Diagnosis code: ICD10
80	Other diagnosis 8	P3288	Character	100		
81	Other diagnosis 8: admission status	P813	Character	1		
82	Other diagnosis 8: discharge status	P3289	Character	1		
83	Code of Other diagnosis 9	P3271	Character	20		Diagnosis code: ICD10
84	Other diagnosis 9	P3272	Character	100		
85	Other diagnosis 9: admission status	P814	Character	1		
86	Other diagnosis 9: discharge status	P3273	Character	1		
87	Code of Other diagnosis 10	P3274	Character	20		Diagnosis code: ICD10
88	Other diagnosis 10	P3275	Character	100		
89	Other diagnosis 10: admission status	P815	Character	1		
90	Other diagnosis 10: discharge status	P3276	Character	1		
91	Frequency of in-hospital infection	P689	Number	5		
92	Code of pathological diagnosis 1	P351	Character	20		Diagnosis code: ICD10
93	Pathological diagnosis 1	P352	Character	100		
94	Pathological number 1	P816	Character	50		

95	Code of pathological diagnosis 2	P353	Character	20		Diagnosis code: ICD10
96	Pathological diagnosis 2	P354	Character	100		
97	Pathological number 2	P817	Character	50		
98	Code of pathological diagnosis 3	P355	Character	20		Diagnosis code: ICD10
99	Pathological diagnosis 3	P356	Character	100		
100	Pathological number 3	P818	Character	50		
101	External factors' code of trauma and poisoning 1	P361	Character	20		Diagnosis code: ICD10
102	External factors of trauma and poisoning 1	P362	Character	100		
103	External factors' code of trauma and poisoning 2	P363	Character	20		Diagnosis code: ICD10
104	External factors of trauma and poisoning 2	P364	Character	100		
105	External factors' code of trauma and poisoning 3	P365	Character	20		Diagnosis code: ICD10
106	External factors of trauma and poisoning 3	P366	Character	100		
107	Allergen	P371	Collection	Multi-choice		
108	Allergic drug	P372	Character	100		
109	HBsAg	P38	Character	1		
110	HCV-Ab	P39	Character	1		
111	HIV-Ab	P40	Character	1		
112	Coincidence between out-patient and discharge diagnosis	P411	Character	1		
113	Coincidence between admitting and discharge diagnosis	P412	Character	1		
114	Coincidence between pre- and post-operation diagnosis	P413	Character	1		
115	Coincidence between clinical and pathological diagnosis	P414	Character	1		
116	Coincidence between radial and pathological diagnosis	P415	Character	3		
117	Rescue times	P421	Number	3		
118	Succeeding rescue times	P422	Number	1		
119	Strongest evidence of diagnosis	P687	Character	1		
120	Differentiation degree	P688	Character	40		
121	Chief	P431	Character	40		
122	(Associate) chief physician	P432	Character	40		
123	Attending physician	P433	Character	40		

124	Resident	P434	Character	40		
125	Primary nurse	P819	Character	40		
126	Refresher physician	P435	Character	40		
127	Postgraduate intern	P436	Character	40		
128	Intern	P437	Character	40		
129	Coder	P438	Character	40		
130	Medical record quality	P44	Character	1		
131	Quality-control physician	P45	Character	40		
132	Quality-control primary nurse	P46	Character	40		
133	Quality-control date	P47	Date			yyyy-mm-dd
134	Operation / Procedure code 1	P490	Character	20		Diagnosis code: ICD10
135	Operation / Procedure date 1	P491	Date, time		Obliged if operation code isn't empty	yyyy-mm-dd HH:mm:ss
136	Operation / Procedure level 1	P820	Character	1		
137	Operation / Procedure name 1	P492	Character	100	Obliged if operation code isn't empty	
138	Operation / Procedure part 1	P493	Character	4		
139	Operation / Procedure duration 1	P494	Number	5		Unit (hour)
140	Surgeon 1	P495	Character	40		
141	First assistant 1	P496	Character	40		
142	Second assistant 1	P497	Character	40		
143	Anaesthesia 1	P498	Character	6		
144	Anaesthesia class 1	P4981	Character	1		
145	Wound healing ratings 1	P499	Character	2		
146	Anaesthesiologist 1	P4910	Character	40		
147	Operation / Procedure code 2	P4911	Character	20		Diagnosis code: ICD10
148	Operation / Procedure date 2	P4912	Date, time			yyyy-mm-dd HH:mm:ss
149	Operation / Procedure level 2	P821	Character	1		
150	Operation / Procedure name 2	P4913	Character	100		
151	Operation / Procedure part 2	P4914	Character	4		
152	Operation / Procedure duration 2	P4915	Number	5		Unit (hour)
153	Surgeon 2	P4916	Character	40		
154	First assistant 2	P4917	Character	40		
155	Second assistant 2	P4918	Character	40		
156	Anaesthesia 2	P4919	Character	6		
157	Anaesthesia class 2	P4982	Character	1		
158	Wound healing ratings 2	P4920	Character	2		

159	Anaesthesiologist 2	P4921	Character	40		
160	Operation / Procedure code 3	P4922	Character	20		Diagnosis code: ICD10
161	Operation / Procedure date 3	P4923	Date, time			yyyy-mm-dd HH:mm:ss
162	Operation / Procedure level 3	P822	Character	1		
163	Operation / Procedure name 3	P4924	Character	100		
164	Operation / Procedure part 3	P4925	Character	4		
165	Operation / Procedure duration 3	P4526	Number	5		Unit (hour)
166	Surgeon 3	P4527	Character	40		
167	First assistant 3	P4528	Character	40		
168	Second assistant 3	P4529	Character	40		
169	Anaesthesia 3	P4530	Character	6		
170	Anaesthesia class 3	P4983	Character	1		
171	Wound healing ratings 3	P4531	Character	2		
172	Anaesthesiologist 3	P4532	Character	40		
173	Operation / Procedure code 4	P4533	Character	20		Diagnosis code: ICD10
174	Operation / Procedure date 4	P4534	Date, time			yyyy-mm-dd HH:mm:ss
175	Operation / Procedure level 4	P823	Character	1		
176	Operation / Procedure name 4	P4535	Character	100		
177	Operation / Procedure part 4	P4536	Character	4		
178	Operation / Procedure duration 4	P4537	Number	5		Unit (hour)
179	Surgeon 4	P4538	Character	40		
180	First assistant 4	P4539	Character	40		
181	Second assistant 4	P4540	Character	40		
182	Anaesthesia 4	P4541	Character	6		
183	Anaesthesia class 4	P4542	Character	1		
184	Wound healing ratings 4	P4543	Character	2		
185	Anaesthesiologist 4	P4544	Character	40		
186	Operation / Procedure code 5	P4545	Date, time	20		Diagnosis code: ICD10
187	Operation / Procedure date 5	P4546	Character			yyyy-mm-dd HH:mm:ss
188	Operation / Procedure level 5	P824	Character	1		
189	Operation / Procedure name 5	P4546	Character	100		
190	Operation / Procedure part 5	P4547	Character	4		
191	Operation / Procedure duration 5	P4548	Number	5		Unit (hour)
192	Surgeon 5	P4549	Character	40		
193	First assistant 5	P4550	Character	40		
194	Second assistant 5	P4551	Character	40		
195	Anaesthesia 5	P4552	Character	6		
196	Anaesthesia class 5	P4985	Character	1		
197	Wound healing ratings 5	P4553	Character	2		
198	Anaesthesiologist 5	P4554	Character	40		

199	Operation / Procedure code 6	P45002	Character	20		Diagnosis code: ICD10
200	Operation / Procedure date 6	P45003	Date, time			yyyy-mm-dd HH:mm:ss
201	Operation / Procedure level 6	P825	Character	1		
202	Operation / Procedure name 6	P45004	Character	100		
203	Operation / Procedure part 6	P45005	Character	4		
204	Operation / Procedure duration 6	P45006	Number	5		Unit (hour)
205	Surgeon 6	P45007	Character	40		
206	First assistant 6	P45008	Character	40		
207	Second assistant 6	P45009	Character	40		
208	Anaesthesia 6	P45010	Character	6		
209	Anaesthesia class 6	P45011	Character	1		
210	Wound healing ratings 6	P45012	Character	2		
211	Anaesthesiologist 6	P45013	Character	40		
212	Operation / Procedure code 7	P45014	Character	20		Diagnosis code: ICD10
213	Operation / Procedure date 7	P45015	Date, time			yyyy-mm-dd HH:mm:ss
214	Operation / Procedure level 7	P826	Character	1		
215	Operation / Procedure name 7	P45016	Character	100		
216	Operation / Procedure part 7	P45017	Number	4		
217	Operation / Procedure duration 7	P45018	Character	5		Unit (hour)
218	Surgeon 7	P45019	Character	40		
219	First assistant 7	P45020	Character	40		
220	Second assistant 7	P45021	Character	40		
221	Anaesthesia 7	P45022	Character	6		
222	Anaesthesia class 7	P45023	Character	1		
223	Wound healing ratings 7	P45024	Character	2		
224	Anaesthesiologist 7	P45025	Character	40		
225	Operation / Procedure code 8	P45026	Character	20		Diagnosis code: ICD10
226	Operation / Procedure date 8	P45027	Date, time			yyyy-mm-dd HH:mm:ss
227	Operation / Procedure level 8	P827	Character	1		
228	Operation / Procedure name 8	P45028	Character	100		
229	Operation / Procedure part 8	P45029	Character	4		
230	Operation / Procedure duration 8	P45030	Number	5		Unit (hour)
231	Surgeon 8	P45031	Character	40		
232	First assistant 8	P45032	Character	40		
233	Second assistant 8	P45033	Character	40		
234	Anaesthesia 8	P45034	Character	6		
235	Anaesthesia class 8	P45035	Character	1		
236	Wound healing ratings 8	P45036	Character	2		
237	Anaesthesiologist 8	P45037	Character	40		
238	Operation / Procedure code 9	P45038	Character	20		Diagnosis code: ICD10

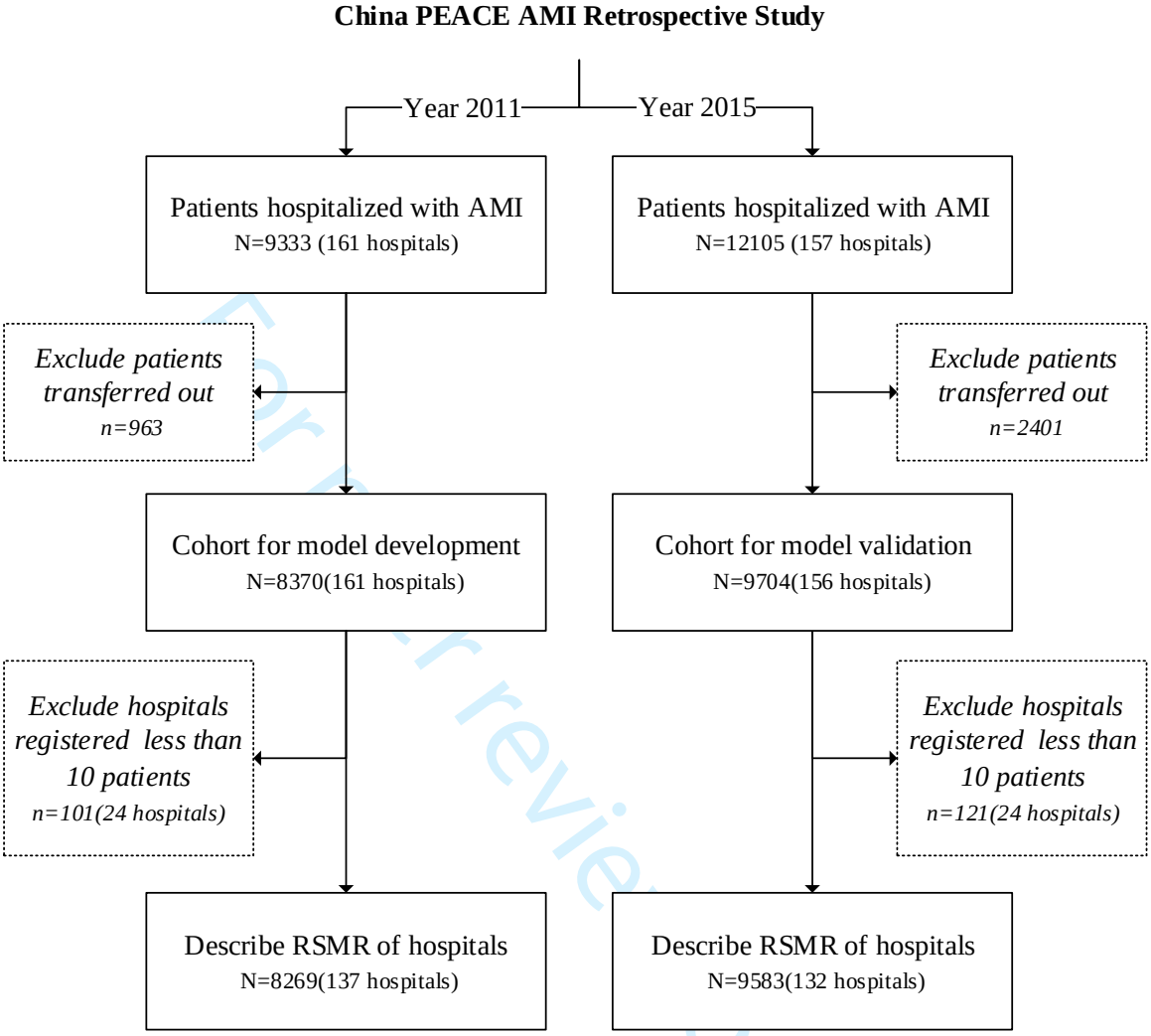
239	Operation / Procedure date 9	P45039	Date, time			yyyy-mm-dd HH:mm:ss
240	Operation / Procedure level 9	P828	Character	1		
241	Operation / Procedure name 9	P45040	Character	100		
242	Operation / Procedure part 9	P45041	Character	4		
243	Operation / Procedure duration 9	P45042	Number	5		Unit (hour)
244	Surgeon 9	P45043	Character	40		
245	First assistant 9	P45044	Character	40		
246	Second assistant 9	P45045	Character	40		
247	Anaesthesia 9	P45046	Character	6		
248	Anaesthesia class 9	P45047	Character	1		
249	Wound healing ratings 9	P45048	Character	2		
250	Anaesthesiologist 9	P45049	Character	40		
251	Operation / Procedure code 10	P45050	Character	20		Diagnosis code: ICD10
252	Operation / Procedure date 10	P45051	Date, time			yyyy-mm-dd HH:mm:ss
253	Operation / Procedure level 10	P829	Character	1		
254	Operation / Procedure name 10	P45052	Character	100		
255	Operation / Procedure part 10	P45053	Character	4		
256	Operation / Procedure duration 10	P45054	Number	5		Unit (hour)
257	Surgeon 10	P45055	Character	40		
258	First assistant 10	P45056	Character	40		
259	Second assistant 10	P45057	Character	40		
260	Anaesthesia 10	P45058	Character	6		
261	Anaesthesia class 10	P45059	Character	1		
262	Wound healing ratings 10	P45060	Character	2		
263	Anaesthesiologist 10	P45061	Character	40		
264	Length of critical care	P561	Number	6		Unit (day)
265	Length of Grade 1 nursing	P562	Number	6		Unit (day)
266	Length of Grade 2 nursing	P563	Number	6		Unit (day)
267	Length of Grade 3 nursing	P564	Number	6		Unit (day)
268	Intensive care unit 1	P6911	Character	4		
269	Entrance date and time 1	P6912	Date			yyyy-mm-dd
270	Exit date and time 1	P6913	Date			yyyy-mm-dd
271	Intensive care unit 2	P6914	Character	4		
272	Entrance date and time 2	P6915	Date			yyyy-mm-dd
273	Exit date and time 2	P6916	Date			yyyy-mm-dd
274	Intensive care unit 3	P6917	Character	4		
275	Entrance date and time 3	P6918	Date			yyyy-mm-dd
276	Exit date and time 3	P6919	Date			yyyy-mm-dd
277	Intensive care unit 4	P6920	Character	4		
278	Entrance date and time 4	P6921	Date			yyyy-mm-dd
279	Exit date and time 4	P6922	Date			yyyy-mm-dd

280	Intensive care unit 5	P6923	Character	4		
281	Entrance date and time 5	P6924	Date			yyyy-mm-dd
282	Exit date and time 5	P6925	Date			yyyy-mm-dd
283	Autopsy	P57	Character	1		
284	First case of operation, treatment, examination and diagnosis	P58	Character	1		
285	Type of the patients with operation	P581	Collection	Multi-choice		
286	Follow-up	P60	Character	1		
287	Follow-up time (week)	P611	Number	2		
288	Follow-up time (month)	P612	Number	2		
289	Follow-up time (year)	P613	Number	2		
290	Teach Case	P59	Character	1		
291	Blood type (ABO)	P62	Character	1	Yes	
292	Blood type (Rh)	P63	Character	1	Yes	
293	Transfusion reaction	P64	Character	1		
294	Erythrocyte	P651	Number	6		Unit (U)
295	Platelet	P652	Number	6		Unit (bag)
296	Plasma	P653	Number	6		Unit (ml)
297	Whole blood	P654	Number	6		Unit (ml)
298	Autologous recovery	P655	Number	6		Unit (ml)
299	Others	P656	Number	6		Unit (ml)
300	Age (less than 1 years old)	P66	Number	4,2		Unit (month), two decimal places
301	New-born weight 1	P681	Number	6		Unit (gram)
302	New-born weight 2	P682	Number	6		Unit (gram)
303	New-born weight 3	P683	Number	6		Unit (gram)
304	New-born weight 4	P684	Number	6		Unit (gram)
305	New-born weight 5	P685	Number	6		Unit (gram)
306	New-born weight at admission	P67	Number	6		Unit (gram)
307	Pre-admitting (coma duration of cranial injury patients, hour)	P731	Number	6		Unit (hour)
308	Pre-admitting (coma duration of cranial injury patients, minute)	P732	Number	2		Unit (min)
309	Post-admitting (coma duration of cranial injury patients, hour)	P733	Number	6		Unit (hour)
310	Post-admitting coma duration of cranial injury patients, minute)	P734	Number	2		Unit (min)
311	Duration of ventilator application	P72	Number	6		Unit (hour)

312	Readmission Plan within 31 days after discharge	P830	Character	1		
313	Readmission aims	P831	Character	100		
314	Method of discharge	P741	Character	1		
315	Hospital from which the patient is transferred	P742	Character	100		
316	Community service association/county hospital from which the patient is transferred	P743	Character	100		
317	Gross charge	P782	Number	10,2	Yes	Two decimal places
318	Out-of-pocket money	P751	Number	10,2		Two decimal places
319	Cost for general medical care	P752	Number	10,2		Two decimal places
320	Cost for treatment	P754	Number	10,2		Two decimal places
321	Cost for nursing care	P755	Number	10,2		Two decimal places
322	Cost for other integrated medical services	P756	Number	10,2		Two decimal places
323	Cost for pathological diagnosis	P757	Number	10,2		Two decimal places
324	Cost for lab text	P758	Number	10,2		Two decimal places
325	Cost for imaging test	P759	Number	10,2		Two decimal places
326	Cost for clinical diagnosis items	P760	Number	10,2		Two decimal places
327	Cost for nonoperation therapy	P761	Number	10,2		Two decimal places
328	Cost for clinical physical treatment	P762	Number	10,2		Two decimal places
329	Operation-treatment cost	P763	Number	10,2		Two decimal places
330	Anaesthesia cost	P764	Number	10,2		Two decimal places
331	Operation cost	P765	Number	10,2		Two decimal places
332	Rehabilitation cost	P767	Number	10,2		Two decimal places
333	Cost for traditional Chinese medicine	P768	Number	10,2		Two decimal places
334	Cost for western medicine	P769	Number	10,2		Two decimal places
335	Cost for Antibiotics	P770	Number	10,2		Two decimal places
336	Cost for traditional Chinese medicine	P771	Number	10,2		Two decimal places
337	Cost for Herbs	P772	Number	10,2		Two decimal places
338	Cost for whole blood transfusion	P773	Number	10,2		Two decimal places
339	Cost for blood transfusion	P774	Number	10,2		Two decimal places
340	Cost for globin transfusion	P775	Number	10,2		Two decimal places
341	Cost for clotting factor transfusion	P776	Number	10,2		Two decimal places
342	Cost for cytokine transfusion	P777	Number	10,2		Two decimal places

343	Cost for disposable medical material in examination	P778	Number	10,2		Two decimal places
344	Cost for disposable medical material in treatment	P779	Number	10,2		Two decimal places
345	Cost for disposable medical material in operation	P780	Number	10,2		Two decimal places
346	Other cost	P781	Number	10,2		Two decimal places

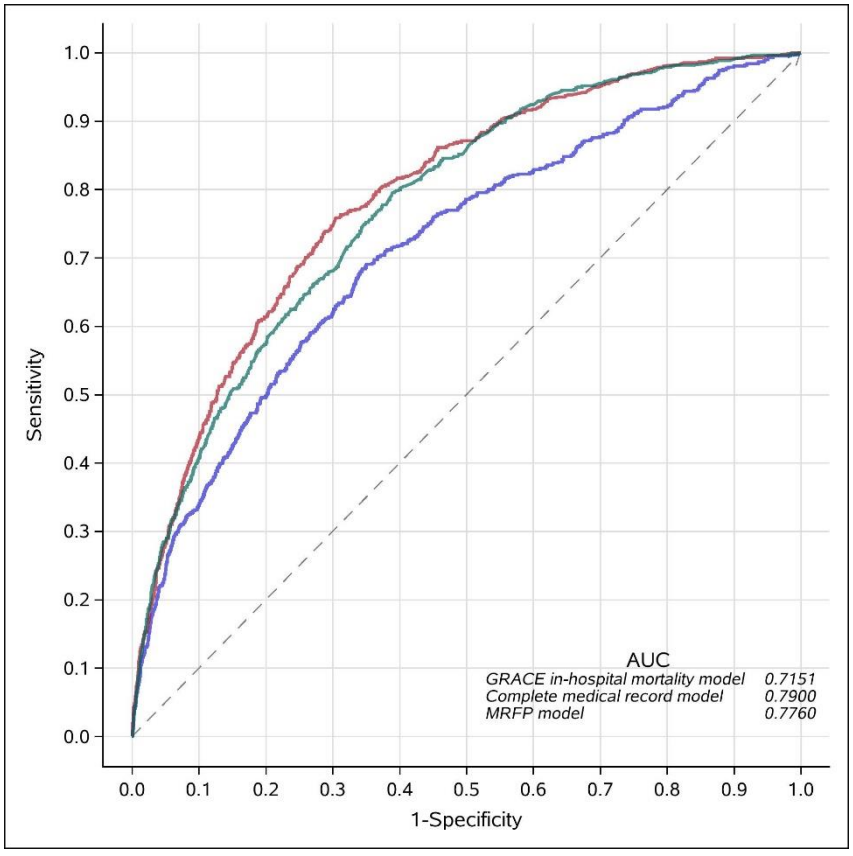
Figure S1. Flowchart of patients' exclusion



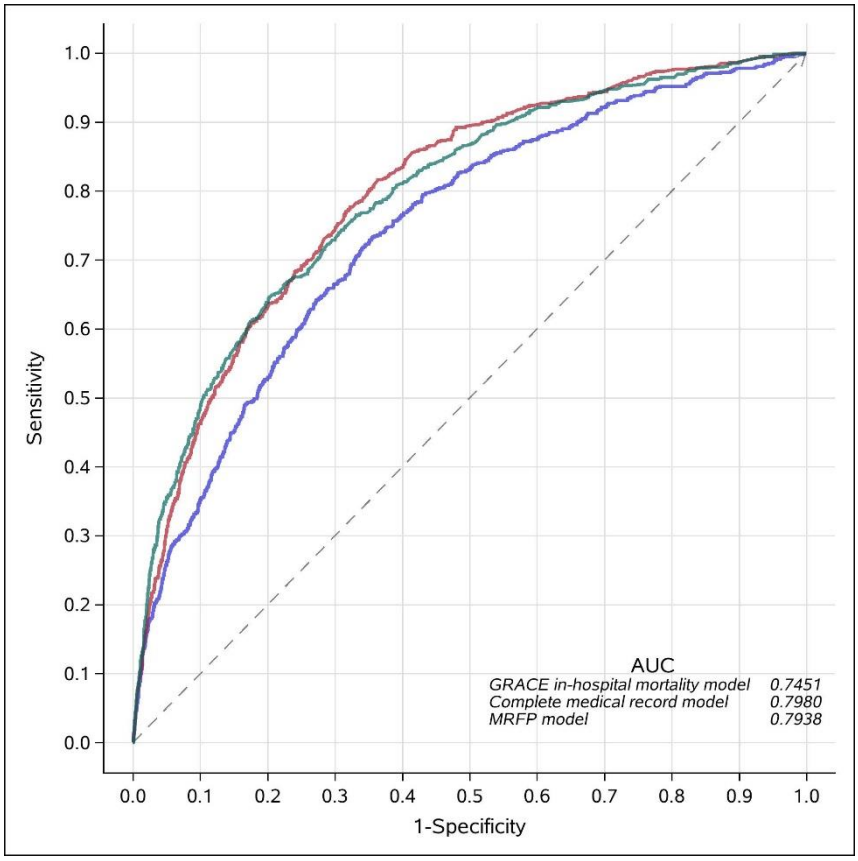
RSMR: risk standardized mortality rate

Appendix A. Comparison of established risk-perdition model with the GRACE ACS in-hospital mortality model

We calculated the predicted probability of in-hospital death among our development and validation cohorts by 3 models (GRACE ACS model, our complete medical record model and medical record front page model), separately. Then we calculated the AUC of each model and test the statistical difference between GRACE and our models. Integrated discrimination improvement(IDI) was also calculated to evaluated the overall improvement of out models compared with GRACE. Results showed that compared with GRACE ACS model, both our two patient risk prediction model had better AUC (all p value<0.001, see bellowing Figure) and positive IDI among development and validation cohorts. In detail, the IDI of medical record front page model compared with GRACE model was 0.010 (0.003,0.017) in development cohort, and 0.028 (0.021,0.036) in validation cohort.



(a)



(b)

Figure. ROC of 3 models among development(a) and validation(b) cohort.

Figure S2. Receiver operating characteristic (ROC) curve of MRFP model and complete medical record model based on modelling and validation cohorts.

MRFP: medical record front page.

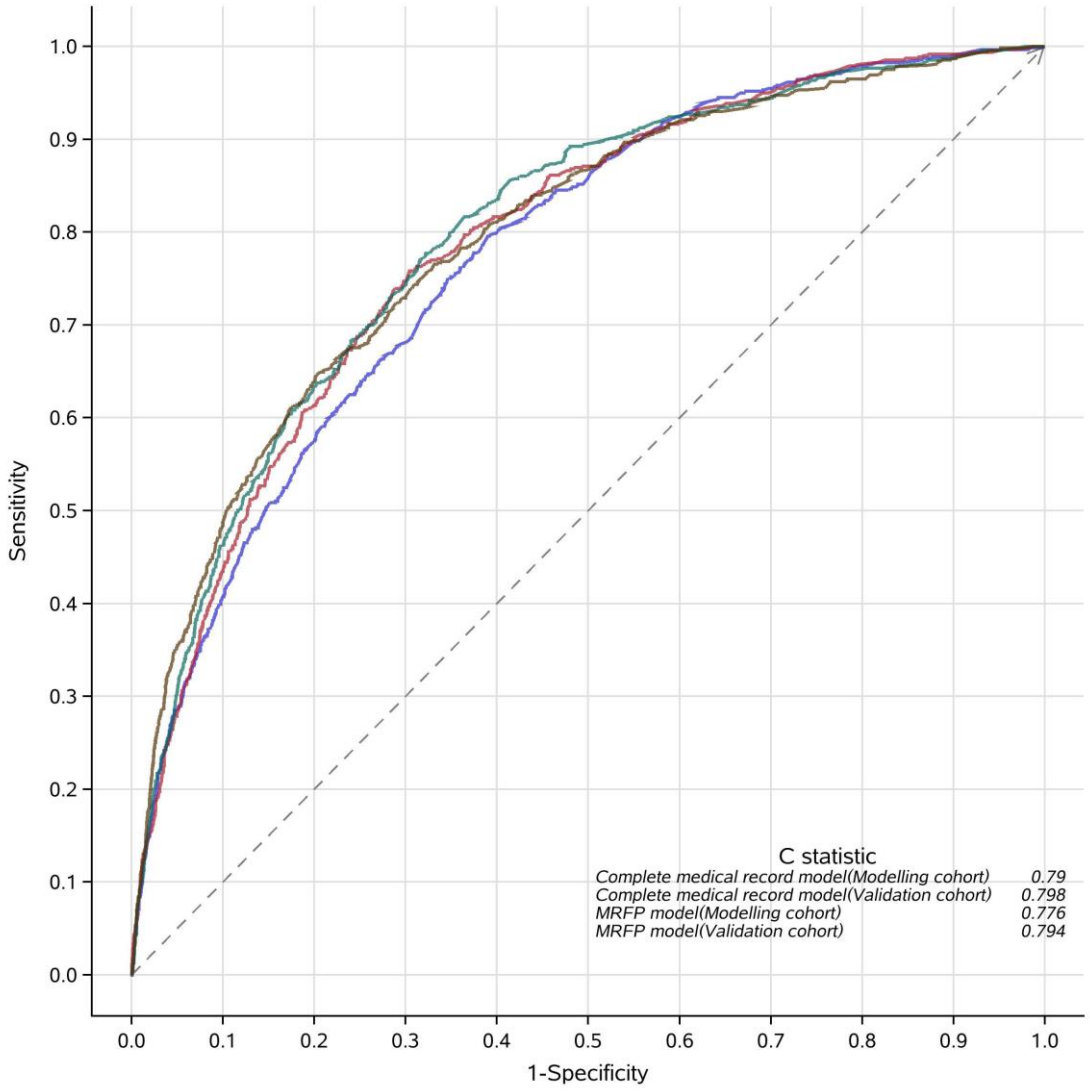
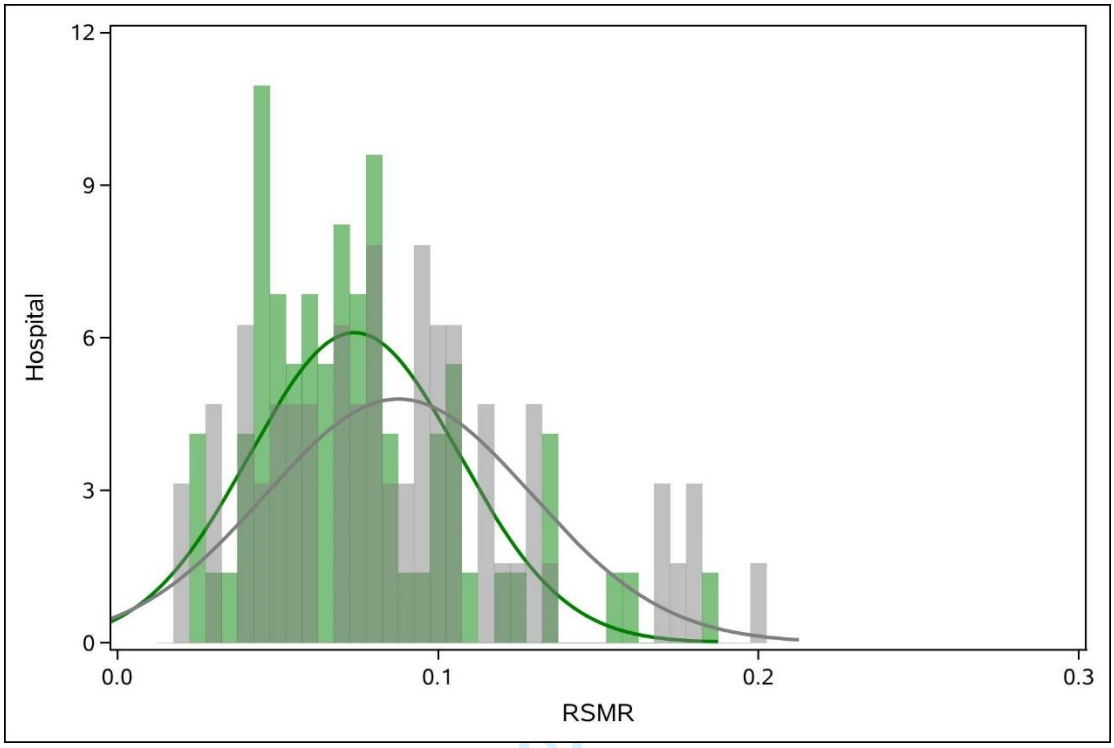
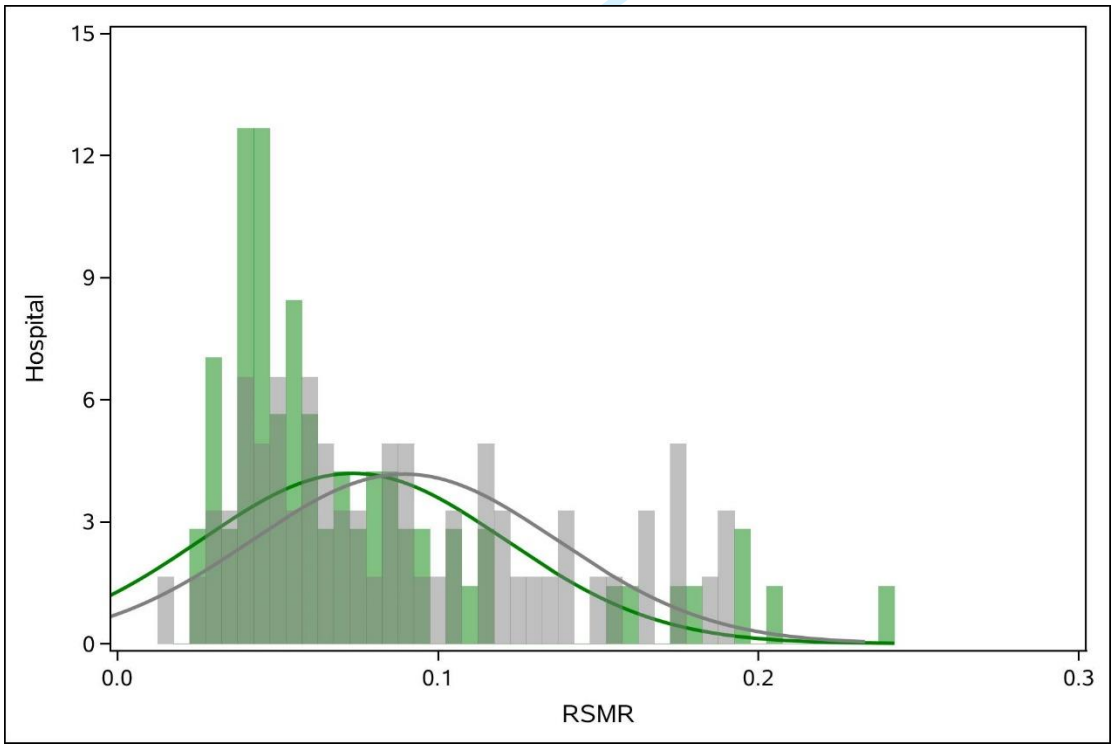


Figure S3. Distribution of risk standardized mortality rate of study hospitals estimated by MRFP model. (a) Modelling cohort (b) Validation cohort



(a)



(b)