Influencing factors of the in-hospital mortality of stroke and acute myocardial infarction: An application of the algebra effectiveness model

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ABSTRACT

Influencing factors of the in-hospital mortality of stroke and acute myocardial infarction: An application of the algebra effectiveness model

Ischemic stroke, hemorrhagic stroke, and acute myocardial infarction (AMI) are diseases that occur during the so-called golden hour. These diseases need timely treatment and quick response to reduce mortality. Although the government has made efforts to improve survival, 30-day in-hospital mortality rates due to stroke and AMI are high.

This study aimed to identify and compare factors that affect 7-day, 30-day, and in-hospital mortality in patients who had a stroke and have AMI who are admitted via the emergency department.

This study used the Korean National Health Insurance claims data from 2002 to 2013. The study sample included 7,693 patients who had an ischemic stroke, 2,828 patients who had a hemorrhagic stroke, and 4,916 patients with AMI who were admitted via the emergency departments of a superior general hospital and general hospital, did not transfer to another hospital or come from another hospital, and were aged ≥20 years. This study was analyzed by using Cox's proportional hazards frailty model.

500 (6.5%) patients were dead of 7,693 patients with ischemic stroke, 569 (20.1%)

patients were dead of 2,828 patients with hemorrhagic stroke, and 399 (8.1%) patients were dead of 4,916 patients with AMI. The analysis of the association between patient characteristics and mortality, clinical factors were associated with 7-day mortality such as age, sex, hypertension, and diabetes in all three diseases. Non-clinical factors such as individual household income and health insurance type were associated with 30-day mortality and in-hospital mortality. In the analysis of the association between treatment characteristics and mortality, performing PCI was associated with reducing adjusted hazard ratio (aHR) for 7-day, 30-day and in-hospital mortality (aHR,0.40; 95% CI,0.29-0.54; aHR, 0.35; 95% CI, 0.23-0.55; aHR, 0.43; 95% CI, 0.27-0.67, respectively) among AMI patients. In patients with AMI and ischemic stroke, the adjusted hazard ratio of patient who utilized intensive care unit service was high for 7-day, 30-day and in-hospital mortality comparing to those who did not utilize intensive care unit service. There was a weekend effect in AMI and ischemic stroke. In patients with hemorrhagic stroke, the risk of mortality for patients who received surgical interventions such as trephination and craniotomy was high than those who received medical interventions such as administration of mannitol and intravenous antihypertensive agents to control intracranial pressure (eg., for 30-day mortality; aHR, 2.42; 95% CI, 1.36-4.32 for patients who received mannitol; aHR, 3.30; 95% CI, 1.80-6.04 for patients who received trephination; aHR, 5.27; 95% CI, 2.49-11.17 for patients who received craniotomy). In the analysis of the association between hospital characteristics and mortality, characteristic of funding source and number of patients per one nurse was associated with reducing risk of mortality for 7-day, 30-day and in-hospital mortality in patients with ischemic stroke. In all three diseases, greater volume was associated with reducing the risk of mortality, and greater transferred rated was associated with increasing the risk of mortality in patients with hemorrhagic stroke.

These findings suggest that focus should be on preventing hypertension in stroke and preventing diabetes in AMI. Health-care providers should make efforts to provide consistent care like that provided on weekdays. Especially health policy makers and health-care providers should seek ways to obtain personal resources that can provide highly technical interventions such as percutaneous coronary intervention (PCI). At the same time, ways that can reflect the real hospital context have been developed to improve the quality of hospital care.

Keywords: stroke, acute myocardial infarction, in-hospital mortality, algebra effectiveness model

Ⅰ. Introduction

1. Background

Cardiovascular and cerebrovascular diseases accounts for a quarter of the total mortality. These diseases were the second and third leading causes of mortality, being responsible for 52.4 and 48.2 deaths per 1,000,000 people in Korea, respectively[1]. Especially stroke is the first leading cause of mortality as single disease in Korea[1], and is the second leading cause of death worldwide[2]. With increases in the aging population and the prevalence of chronic diseases such as hypertension[3-9], diabetes[6-10], and hyperlipidemia[7-9] associated with stroke and acute myocardial infarction (AMI). In addition, many patients remain in a disabled condition after having a stroke and AMI. Consequently, the health-care cost and disease burden have increased in the country. The nationwide total cost for stroke increased from $3.3 billion in 2005 to $3.94 billion in 2010, with a 54.7% increase in the total cost for admission and outpatient visits for stroke between 2005 and 2009 in Korea[11-13].

The health policy makers in Korea are starting to realize the severity of the problems due to cardiovascular and cerebrovascular diseases, and have established medium- and long-term plans for Health Plan 2020 under the goals of reducing the incidence of, mortality in, and disability due to cardiovascular and cerebrovascular diseases[14]. The Korean government is proceeding with the implementation of the project by focusing on primary, secondary, and tertiary prevention[15]. Tertiary prevention includes reinforcing emergent coping skills for cardiac arrest and early stroke, consideration medical care capability such as introduction certification of cardiocerebral center, and constructing infrastructures such as standardizing clinical process and developing insurance benefit criteria.

At the same time, health-care providers and clinical experts have also made efforts to reduce mortality due to these diseases by using the clinical guidelines and critical pathway. AMI and stroke are diseases that occur during the so-called golden hour[16-20]. Time to treatment with tissue plasminogen activator (tPA)[13,21] and decompression of intracranial pressure[22,23] is crucial to outcomes among patients with ischemic stroke and acute myocardial infarction (AMI), and hemorrhagic stroke. According to previous studies, the time to reperfusion in AMI and acute ischemic stroke is in the first hour of AMI and 3 hours of acute ischemic stroke significantly reduce mortality rates. As AMI and stroke are a time-dependent disease, the importance of early hospital arrival and treatment in the emergency department is well known among health-care professionals. The Health Insurance Review and Assessment Service (HIRA) demonstrated pay for performance (P4P) from July 2007 to December 2010 for AMI and stroke for superior general hospitals. Throughout the demonstration program, the HIRA expanded to an official project and evaluated general hospitals, including superior general hospitals in 2011[24]. Despite several advances in AMI and stroke care over the last decade, in-hospital mortality remains common and is linked to disease burden. In case of AMI, despite the decrease in age-sex standardized 30-day mortality due to the efforts of the government and professional experts, from 8.1% in 2007 to 6.4% in 2009, 30-day mortality remained higher, at 5.0% in 2007 and 5.4% in 2009, than the average for other member countries of the Organization for Economic Co-operation and Development (OECD)[25]. By contrast, the achievement for stroke was great. In 2009, the age-sex standardized 30-day mortality was 1.8% in Korea, while the average age-sex standardized 30-day mortality in the OECD countries was 5.2% for ischemic stroke[25]. The age-sex standardized 30-day mortality was 9.9% in Korea and 19.0% for hemorrhagic stroke in the OECD countries[25]. However, the absolute level of 9.9% was still high.

In addition, according to Crossing the Quality Chasm by the Institute of

Medicine, the Institute of Medicine (IOM) identified problems of quality as a systems problem, not as an issue of individual competence or incompetence[26]. The report suggested that health-care quality required an overhaul of existing systems of care at all levels of the system.

2. Objectives

The purpose of this study was to identify and compare hospital characteristics that affect the in-hospital mortality of patients who were admitted via the emergency department because of stroke and AMI.

The detailed objectives of this study were as follows:

(1) To identify patient characteristics that affect 7-day mortality (acute health outcome), 30-day mortality (sub-acute health outcome), and in-hospital mortality (latent health outcome), stratified to diseases.

(2) To identify treatment characteristic that affect 7-day mortality (acute health outcome), 30-day mortality (sub-acute health outcome), and in-hospital mortality (latent health outcome), stratified to diseases.

(3) To identify hospital characteristics that affect 7-day mortality (acute health outcome), 30-day mortality (sub-acute health outcome), and in-hospital mortality (latent health outcome), stratified to diseases.

Ⅱ. Literature Review

1. Definition of Quality of Care

The growing demand for health care, increasing treatment costs, constrained resources, and evidence of variations in clinical practice have increased the interest in measuring and improving the quality of health care in many countries[27]. Quality of care can be defined in various ways depending on perspectives, and how *quality* is to be defined is an important issue. Many definitions are available, and much effort has already been spent on refuting and defending old definitions. Hence, approaches for assessment of quality can be differed according to the definition of quality of care. Each definition of quality of care has not only one meaning, and each one may be defined as a set of properties that must be met to achieve good health outcomes. Quality has been defined as multidimensional attributes[28-33] (Table 1).

The first definition, suggested by Lee & Jones[34], was "good medical care is the kind of medicine practiced and taught by the recognized leaders of the medical profession at a given time or period of social, cultural, and professional development in a community or population group."[35]. According to Myers[28], quality of care includes accessibility, quality, continuity, and efficiency. Donabedian stated that the balance of health benefits and harm is the essential core of the definition of quality and established theory of quality of care[36]. According to Donabedian's theory, quality of care consists of three elements, namely technical aspect, interpersonal aspect, and amenity, and seven attributes, namely efficacy, effectiveness, efficiency, optimality, acceptability, legitimacy, and equity. In its technical aspect, quality of care is the application of science of medicine to solve health problems, in its interpersonal aspect, that is, management of social and psychiatric interactions between patients and physicians. Final, amenity means comfort such as that of the waiting room environment, a clean bed, and meals. The IOM suggested a comprehensive definition of quality as follows: "quality of care is the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge"[37]. IOM explained health-care quality as the following six main concepts: safe, effective, patient-centered, timely, efficient, and equitable[33]. The Joint Commission also identified the following dimensions of clinical performances that could be used to categorize indicators: appropriateness, availability, continuity, effectiveness, efficacy, efficiency, respect and caring, safety, and timeliness[38].

Table 1. Dimensions that used for defining quality of care

Myers, 1969[28]	Vuori, 1982[29]	Maxwell,1984[30]	Donabedian,1990[31]	HSRG, 1992[32]	IOM, 2001[33]	Joint Commission[38]
Accessibility		Accessibility		Accessibility		
					Safe	Safe
				Patient-centeredness	Patient-centeredness	Respect and caring
Effectiveness	Effectiveness	Effectiveness	Effectiveness	Effectiveness	Effectiveness	Effectiveness
	Efficiency	Efficiency	Efficiency	Efficiency	Efficiency	Efficiency
Continuity				Continuity/ co-ordination		Continuity
			Efficacy			Efficacy
		Acceptability	Acceptability			
		Equity	Equity		Equitable	
			Legitimacy			
				Comprehensiveness		
		Relevance				
	Appropriateness					Appropriateness
Quality improvement						
	Scientific technique					
					Timely	Timely
						Availability

2. Conceptual Framework for Approach to Measuring Quality

Until 1980s, basic approach for measuring of quality of care was to use a model of Donabedian in aspects of structure, process, and outcome. According to Donabedian, structure, process and outcome can be indicator of quality of care. However, looking at history of quality assurance, approach for measuring of quality of care changed gradually that quality of care measured in terms of structure in early stage, and measured in aspect of process, and tendency have showed that measuring of quality of care emphasized on outcomes. Measuring structure and process is relative easy but there is a limitation in terms of indirect assessment. In contrast, measuring outcomes as quality of care has an advantage that can directly evaluate an effectiveness of quality of care.

(1) Donabedian's framework

As Avedis Donabedian was a pioneer in the field of health-care quality, his framework became the basis of all other definitions or framework for defining quality of care. Donabedian's view has guided works regarding the elements used to evaluate and compare health-care quality[39]. For good quality of care, technical performance, management of interpersonal relationship, and amenities are needed[36,40]. Technical performance refers to how well current scientific medical knowledge and technology are applied in a given situation[40,41]. Technical performance depends on the knowledge and judgment used in arriving at the appropriate strategies of care and on the skill in implementing the strategies. Interpersonal relationship is also important because of how it can affect technical performance. A clinician who relates well to a patient is better able to elicit from the patient a more complete and accurate medical history[40]. Privacy, confidentiality, informed choice, concern, empathy, honesty, tact, and sensitivity, among others, are virtues expected in interpersonal relationship. The amenities of care are the desirable attributes of the setting within which care is provided. They include convenience, comfort, quiet, and privacy[40]. If these elements and their attributes are met, care can be considered of good quality according to Donabedian's definition.

Donabedian first proposed a systems-based framework of structure, process, and outcome how to evaluate the quality of care (Figure 1)[42]. Structures are usually thought to affect processes, which in turn produce desirable or undesirable outcomes[39]. This three-part approach to quality assessment is possible only because good structure increases the likelihood of a good process, and a good process increases the likelihood of a good outcome[40]. Structure can explain the context and refers to the organizational factors that define the health system under which care is provided[43]. Structure denotes the attributes of the setting in which care occurs. This includes the attributes of material resources such as facilities, equipment, and money of human resources such as the number and qualifications of personnel and organizational structure such as medical staff organization, methods of peer review, and methods of reimbursement[41]. Process denotes what is actually done in giving and receiving care. It includes the patients' activities in seeking care and carrying it out, and the practitioner's activities in making a diagnosis and recommending or implementing treatment. Outcome denotes the effects of care on the health status of patients and populations[40]. It includes mortality, morbidity, and patient's satisfaction. This three-part approach to quality assessment is possible only because good structure increases the likelihood of good process, and good process increases the likelihood of a good outcome[40]. He convinced that the activity of quality assessment is not itself designed to establish the presence of these relationships.

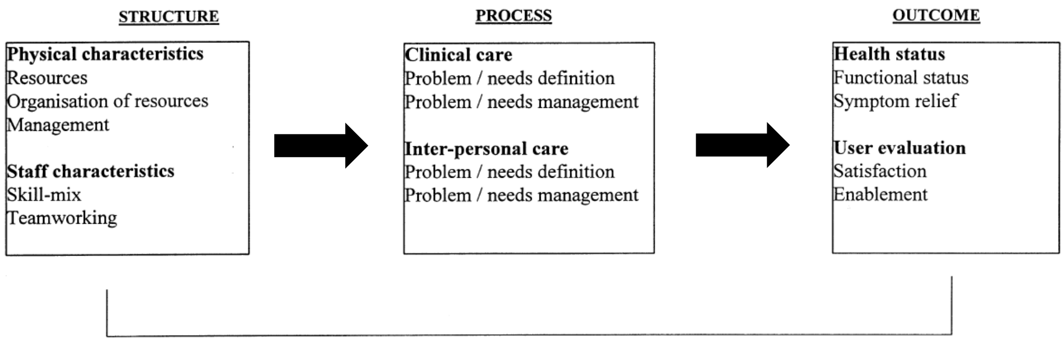


Figure 1. Donabedian's conceptual framework for measuring quality of care[42]

(2) Algebra Effectiveness

Donabedian's classic framework delineated three dimensions as follows: structure, process, and outcome[43]. The three dimensions are intertwined, but their relative utility depends on context[44]. Outcomes that are not linked to specific medical practices provide little guidance for developing quality-improvement strategies[45]. Furthermore, comparing outcomes across groups frequently requires adjustment for patient risk and the recognition that some patients are sicker than others[46]. For these reasons, Lisa Iezzoni provides a conceptual model of the summation of patient factors, treatment effects, and random events that produce health outcomes[46,47]. This conceptual model is referred to as the "Algebra Effectiveness"[47]. This model is based on the viewpoint that in-hospital patient outcome is caused by the sum of three components. To assess hospital net quality, factors such as patient factors are removed that could affect health outcome. This concept is a risk adjustment. Lisa Iezzoni mathematized these concepts (Formula 1) and developed a risk-adjustment framework (Figure 2)[47]. In the framework, treatment effectiveness includes both treatment and organization characteristics. The treatment costs for patients with more severe illnesses or more health-related risks are higher, and these patients do less well than their healthier counterparts. The characteristics of persons treated with different clinical interventions, providers, or health plans vary. These differences have consequences. The purpose of risk adjustment aims to account for differences in intrinsic health risks that patients bring to their health-care encounters. Therefore, according to the "Algebra of Effectiveness" conceptual framework, to identify the association between hospital characteristics and health outcome, patient's risk factors should be found well based on accurate data.

$$\text{Outcomes} = f(\text{intrinsic patient-related risk factors, treatment effectiveness, quality of care, random chance}) \quad \text{----------} \quad \text{(Formula1)}$$

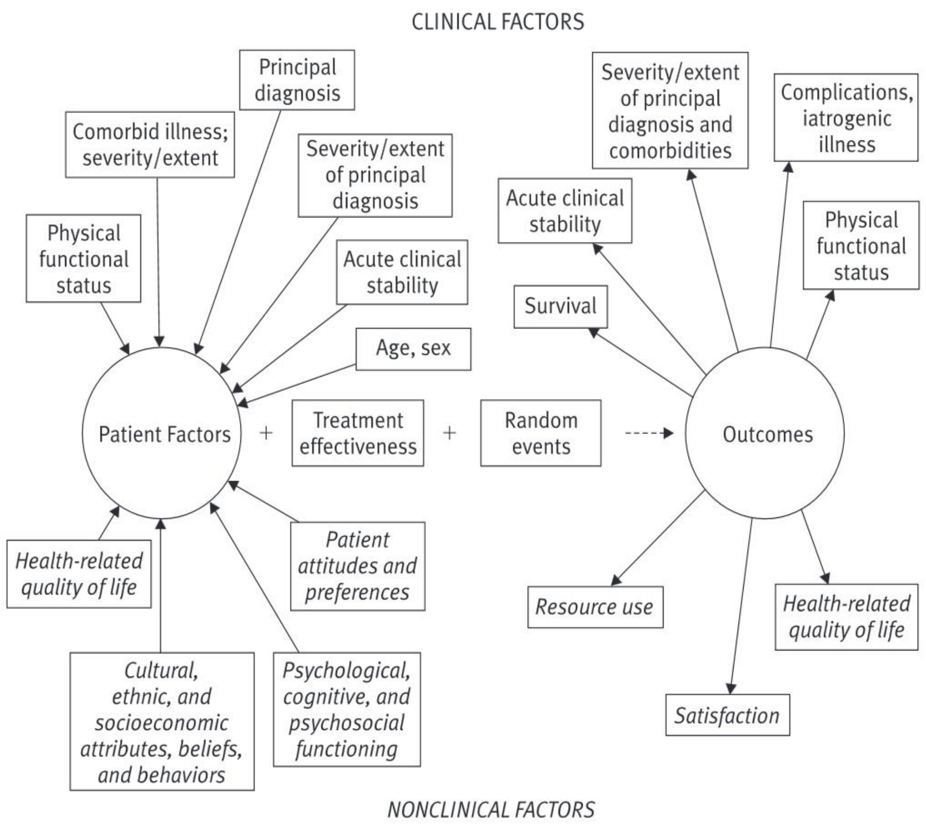


Figure 2. Algebra Effectiveness model[47]

3. Variations in Health Outcome

The Agency for Healthcare Research and Quality (AHRQ) classified quality problems according to four concepts as follows: overuse, underuse, misuse, and variation. According to each defined concept by AHRQ, overuse leads to unnecessary services, which add costs, and to complications that undermine the health of patients[48]. Overuse can lead to circumstances in which its potential for harm exceeds the possible benefits. Underuse is failure to provide a needed service, which can lead to additional complications, higher costs, and premature deaths. Misuse implies that errors in health-care delivery lead to missed or delayed diagnosis, higher costs, and unnecessary injuries and deaths. Variation is the difference between an observed event and a standard or norm[49]. In this study, we are willing to focus on variations of health outcomes caused by hospital characteristics.

Without this standard, or best practice, measurement of variation offers little beyond a description of the observations, with minimal, if any, understanding of what they mean. Variation can be either random or assignable[49]. According to Wheeler[50], random variation is a physical attribute of the event or process, addressing the laws of probability, that cannot be traced to a root cause. He called this “background noise” or “expected variation.” Common-cause variation appears as random variation in all measures from health-care processes. Assignable variation arises from a single or small set of causes that are not part of the event or process and can therefore be traced, identified, and implemented or eliminated[51].

Variation can explain to divide into four dimensions: process variation, outcome variation, performance variation, and variation in medical care[52]. Process variation is the difference in procedure throughout an organization. To reduce process variation, health-care providers may use clinical guidelines and critical pathway. The purpose of use is to standardize process. Outcome variation is the difference in the results of any single process. Performance variation is the difference between any given result and the optimal or ideal result[53]. To identify and compare a performance variation, optimal or ideal result should be defined, or threshold, best practice, and standard should be followed.

Variations in health care can occur due to various reasons. Mant J. explained causes of variation according to the following four major categories: (1) differences in the type of patient as confounded by patient characteristics; (2) differences in measurement as ascertainment and definition of cases, outcome, and risk factors; (3) chance as random variation, influenced by the number of cases and frequency with which outcome occurs; and (4) differences in quality of care as use of proven interventions[54]. In addition, the King's Fund suggested a map of causes of variation after recognizing that variations represent evidence of inappropriate care (Figure 3)[55]. Figure 3 presents the complexities and interactions of possible causes. The variation can be caused by various paths as follows: data inaccuracy, demand, supply, and random variation. The sources of demand variation included general practitioner decisions, patient decisions, morbidity, commissioning priorities, and determinants of illness. Clinical decisions, government policy, resource availability, private provision (payment), service configuration, prevailing custom, and clinical guidelines could be resources of supply variation.

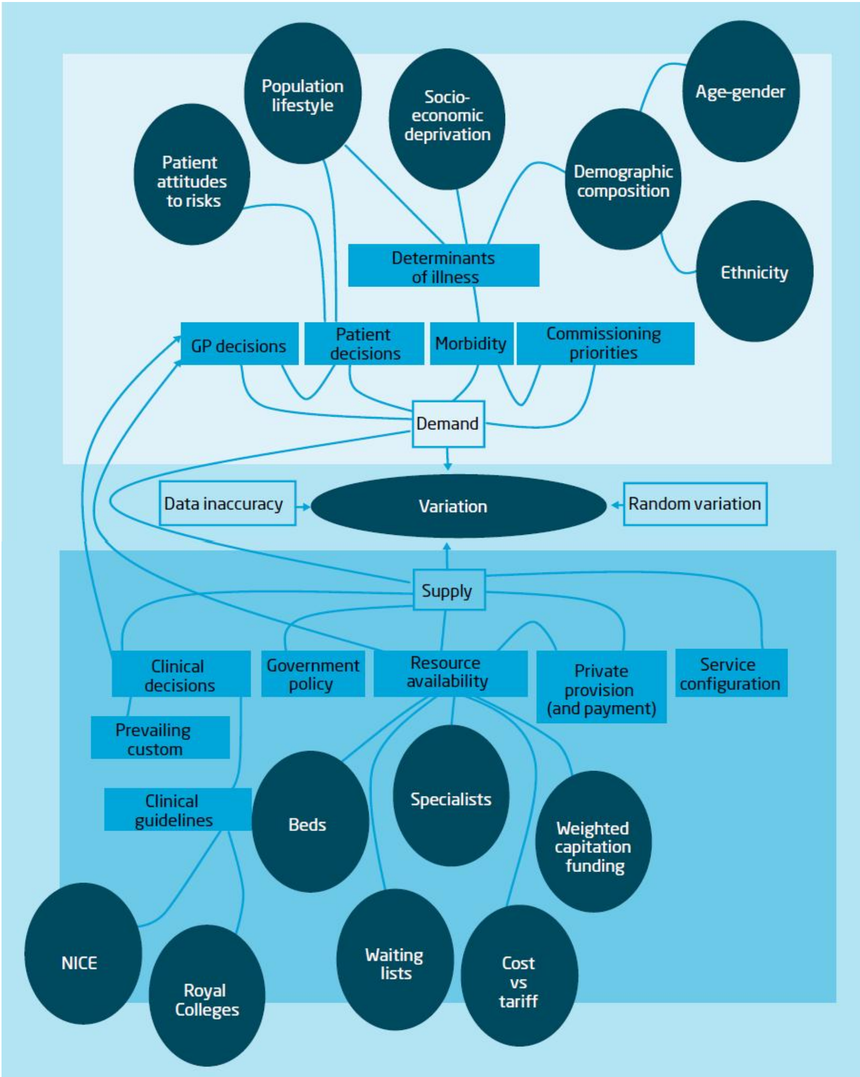


Figure 3. Mapping causes of variation[55]

4. Review Previous Studies

In Donabedian's framework, process is the clinical service provided to a patient. Organizational processes are the activities undertaken by an organization in pursuit of its objectives. Structure-outcome was by far the most common paring, in previous studies. Differences in predictor and outcome variable pairing become apparent when distinguished by the organizational level of analysis. Hospital-level studies are predominantly focused on structure-outcome relationships, particularly the relationship of volume, staffing, and ownership on mortality. Similarly, unit-level studies favor structure-outcome pairings; however, these studies have favored the relationship between staffing and medical errors. Team/subunit analyses are predominantly focused on process-outcome relationships. The most common predictor variables at the team/subunit level were cultural features of the team/subunit (e.g., commitment to/support of total quality management), communication, and collaboration.

By contrast, structure-process and process-outcome pairings have fewer non-significant findings and more robust effects across the levels of analysis. The structure-process pairing has the most robust, positive relationship across all levels of analysis. Considerable variation exists in the way process variables are measured, even within the same level of analysis. Reviewed articles focused predominantly on quality deficiencies, and all study relationships used mortality or adverse events as an outcome. The most variation is observed in the adverse events category, but even methods of measuring mortality varied across studies, ranging from crude mortality rates to case-mix adjusted, excess mortality rates.

Table 2. Summary of previous studies

Study	Data	Research design	Structure-Process-Outcome	Outcome variables	Organizational Variable of Interest	Main Finding	Relationship with Quality
Aiken et al.[56] (2000)	Magnet hospitals for Medicare Patients from HCFA	Cross-sectional	Structure-outcome	Mortality	Magnet hospital designation	lowered mortality rate among Medicare patients	Positive
Aiken et al.[57] (2002)	Hospitals survey data	Cross-sectional	Structure-outcome	Adverse events	Average patient/med-surgical nurse ratio	adequate nurse staffing and organizational/managerial support for nursing are key to improving the quality of patient care	Positive
AI-Haider & Wan[58] (1991)	Hospital data from HCFA	Cross-sectional	Structure-outcome	Mortality	Size	the effect of hospital size and specialization on mortality was a spurious.	No association
	The American Hospital Association file				Specialization		No association
	the Area Resources File				Service intensity	a positive association existed between service intensity and hospital mortality	Positive
	case-mix index for study hospitals				For-profit status	a slightly higher mortality rate in for-profit hospitals than in not-for-profit hospitals	Negative

Table 2. Summary of previous studies *(Continued)*

Study	Data	Research design	Structure-Process-Outcome	Outcome variables	Organizational Variable of Interest	Main Finding	Relationship with Quality
Alexander JA et al.[59] (2006)	Hospital QI practices from survey of all 6150 US hospitals	Cross-sectional	Process-Outcome	Adverse events	Intensity of use of statistical and process measurement	appropriate organizational infrastructure and financial support are significantly associated with greater scope and intensity of hospital-level QI implementation.	Positive
Bach et al.[60] (2001)	Surveillance, epidemiology, and ends results (SEER) Cancer registries	Longitudinal	Structure-outcome	Mortality	Hospital volume	patients who undergo resection for lung cancer at hospitals that perform large numbers of such procedures are likely to survive longer than patients who have such surgery at hospitals with a low volume.	Positive
Basu, Friedman, & Burstin[61] (2004)	Hospital discharge data from HCUP, AHRQ	Cross-sectional, quantitative	Structure-outcome	Adverse events	Size Teaching hospital Urban hospital	HMO enrollment was associated with fewer preventable admissions than marker admissions, compared to fee-for-service	No association Negative No association
Berner et al.[62] (2003)	Patients enrolled a tranditional Health Care Quality Imrpovement Program	Group-randomized controlled trial	Structure-process	Quality improvement	Quality improvement program with opinion leader	The influence of physician opinion leaders was unequivocally positive for only of five quality indicators.	Positive

Table 2. Summary of previous studies *(Continued)*

Study	Data	Research design	Structure-Process-Outcome	Outcome variables	Organizational Variable of Interest	Main Finding	Relationship with Quality
Birbeck, Zingmond, Cui, & Vickrey[63] (2006)	Adminstrative discharge databases from all acute, non-federal hospital in California	Cross-sectional, quantitative	Structure-outcome	Mortality	Dedicated stroke unit Adoption of stroke guidelines Stroke specialist on staff	Dedicated, multispecialty stroke services are underutilized despite their association with reduced stroke mortality at bot academic and non-academic hospitals.	Positive No association No association
Byrne et al.[64] (2004)	Facility-level data from Veterans Health Affairs	Longitudinal, quantitative	Structure-outcome	Adverse events	Presence of service line structure Duration of service line structure	Health care organizations are implementing innovative organizational structures in hopes of improving quality of care and reducing resource utilization	Negative Negative
Grossbart[65] (2006)	Data from premier Hospital Quality Initiative Demonstration Project Participants	Longitudinal, quantitative	Structure-outcome	Quality improvement	Participation in pay-for performance program	the findings show that participation in the pay-for-performance initiative had a significant impact on the rate and magnitude of performance improvement	Positive

Table 2. Summary of previous studies *(Continued)*

Study	Data	Research design	Structure -Process- Outcome	Outcome variables	Organizational Variable of Interest	Main Finding	Relationship with Quality
Kovner & Gergen[66] (1998)	Survey data from US community hospitals	Cross-sectional, quantitative	Structure-outcome	Adverse events	RN FTEs	Inverse relationships between nurse staffing and these adverse events	Positive
Mark, Harless, McCue, & Xu[67] (2004)	Secondary data from the American Hospital Association	Longitudinal, quantitative	Structure-outcome	Adverse events Mortality	Change in RN FTE Change in LPN FTE Change in non-nurse FTE	The findings provide limited support for the prevailing notion that improving registered nurse (RN) staffing unconditionally improves quality of care	Positive No association No association
Poon et al.[68] (2004)	Survey of senior managers from 26 hospitals	Cross-sectional, quantitative	Process-process	Quality improvement	Leadership Physician champions Leveraging house staff/hospitalists	Outside the hospital, financial incentives and public pressures encouraged computerized physician order entry (CPOE).	Positive Positive Positive
Tu et al.[69] (2004)	Telephone interview from 29 acute hospitals in Connecticut	Cross-sectional, quantitative	structure-process	Quality improvement	Development and use of evidence-based clinical pathway Use of physician champions Use of multidisciplinary teams	Hospitals applying all four social influence QI strategies showed a greater-than-average increase in delivery of antibiotics within 8 hours of patients' hospital arrival	Positive Positive Positive

Ⅲ. Study Methods

1. Framework of Study

This study suggested two models about an approach for measuring of quality of care. This study used an algebra effectiveness model as approach to measure hospital performance. Unlike Donabedian's model in terms of structure, process and outcome model that three aspects can be one of quality indicators and patient's factors are treated as Antecedent factors, the algebra effectiveness model was to more emphasize the outcome rather than structure and process. So that patient's risk adjustment is important in algebra effectiveness model. The aim of this study was identify the factors that affect mortality summation of patient characteristics and treatment characteristics including variations. Therefore, to evaluate the factors, this study was determined that algebra effectiveness model was fitted for this study's purpose. By using the study design framework (Figure 4), this study aimed to identify patient, treatment, and hospital factors that affect mortality as outcomes for each condition. First, in this study, the study population for each condition was determined, and the clinical factors were distinguished from the non-clinical factors among the patient factors. In case of treatment effectiveness, treatment characteristics were treated as clinical factors and hospital characteristics were treated as non-clinical factors. Despite of the same health outcome such as 7-day mortality, this study examined how the factors such as patient, treatment, and hospital factors affected 7-day mortality differently according to each condition. In addition, despite the same condition such ischemic stroke, this study determined how each factor affected mortality differently according to 7-day mortality (acute health outcome), 30-day mortality (subacute health outcome), and in-hospital mortality (latent health outcome).

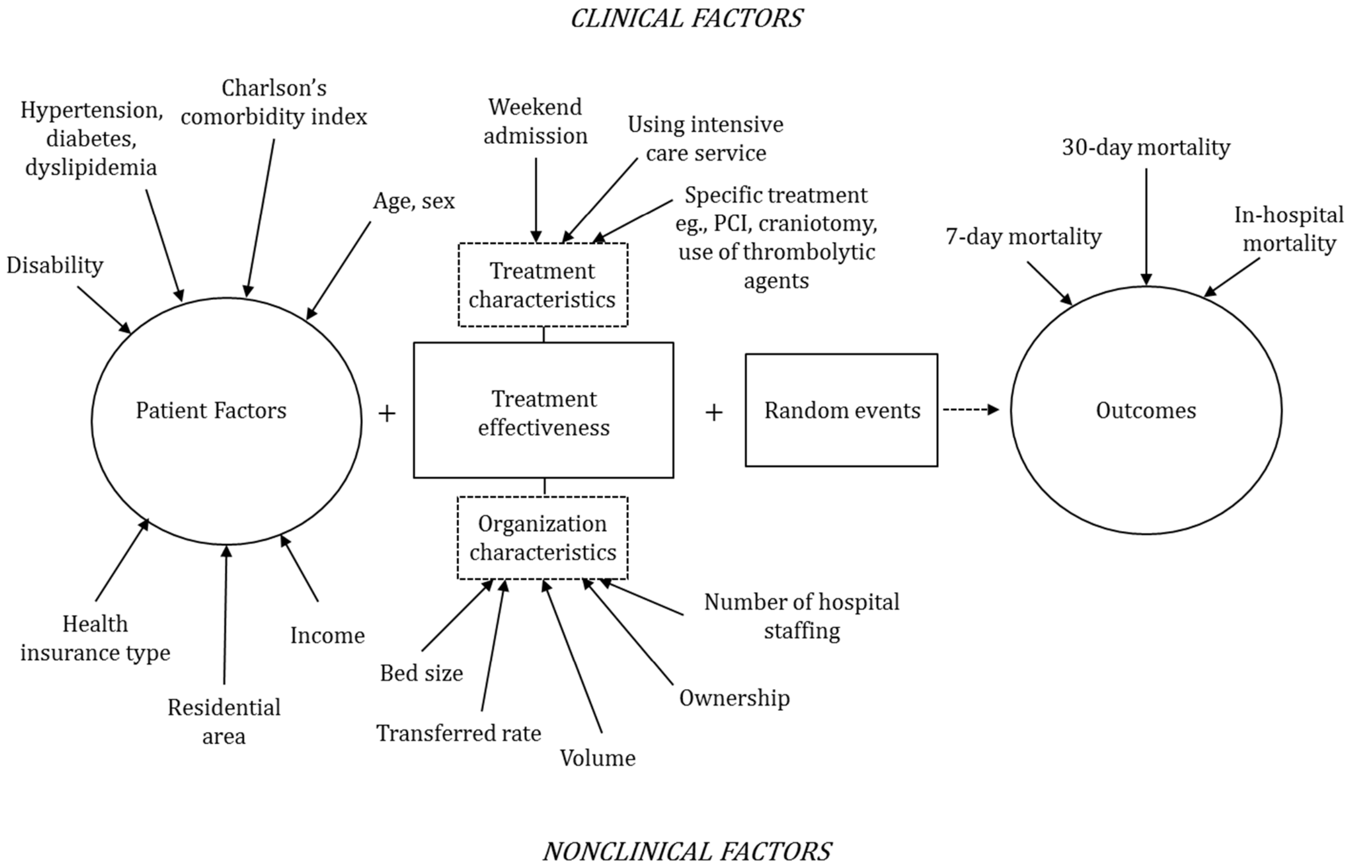


Figure 4. Framework of this study

2. Data Source

The dataset was obtained from the Korean National Health Insurance (KNHI) claims database from 2002 to 2013. The National Health Insurance Corporation collects cohort data representative of the country's population. These data include information on 10,250,340 patients. These subjects represent a stratified random sample selected according to age, sex, region, health insurance type, income quintile, and individual total medical costs based on the year 2002. The database includes information on reimbursement for each medical service, including basic patient information, an identifier for the clinic or hospital, a disease code, costs incurred, results of health screening, personal/family history, health behaviors, and information related to death. These data are publicly available for research purposes. Ethical approval for this study was granted by the institutional review board of the Graduate School of Public Health, Yonsei University (2-1040939-AB-N-01-2016-402).

3. Study Sample

The total number of individuals admitted to acute care hospitals, including superior general hospitals and general hospitals, via the emergency department without dropping by other health-care institutions due to ischemic stroke, hemorrhagic stroke, and AMI. The Korean health-care delivery system is classified into 3 steps base on fee-for-services as the reimbursement mechanism as follows: clinics function as primary care institutions, hospitals function as secondary care institutions, and general hospitals function as tertiary care institutions. The exclusion criteria were necessary to ensure study population homogeneity and were selected because clinics were likely to receive only low-risk or a limited number of patients, and patients who were transferred to superior hospitals. In case of transferring patients, each hospital's net quality or performance cannot be measured, and time to treatment was delayed. To determine real stroke and AMI patients, patients with stroke and AMI as a principal or secondary diagnosis were identified by searching for codes of the *International Classification of Diseases, 10th Revision* (*ICD-10*); medication information; and clinical test information. According to the assessment report for AMI and stroke quality, in cases of ischemic stroke and AMI, the administration rates of anticoagulants and antiplatelet agents within 48 hours and aspirin within

24 hours are both almost close to 100%. In the case of AMI, almost all patients with suspected AMI received tests for cardiac enzymes such as creatine kinase MB fraction (CK-MB), troponins T and I, and myoglobin. In the case of hemorrhagic stroke, approximately 90% of these patients received intravenous antihypertensive drugs according to the guideline for hemorrhagic stroke. Otherwise, patients received mannitol to control their conditions or craniotomy to decrease intracranial pressure as intervention. To identify patients who had a real stroke and AMI, these factors were used.

To determine patients who had an ischemic stroke, the following criteria should be met: 1) patients who were admitted via the emergency department because of ischemic stroke classified as I63 (cerebral infarction) and G45 (transient cerebral ischemic attacks and related syndrome) of the *ICD-10* codes, 2) patients who received anticoagulants and antiplatelet agents, 3) patients admitted to the general hospital and superior hospital without transferring to another hospital, and 4) patients aged >20 years. The total number of individuals who were admitted via the emergency department because of ischemic stroke were 14,127. Of these patients, 4,642 did not receive anticoagulants and antiplatelet agents and 1,792 were excluded, including the 1,135 patients transferred to another hospital, 642 patients who used long-term facilities, hospitals and clinics;

and 15 patients aged <20 years. The final study sample with ischemic stroke included 7,693 participants (Figure 5).

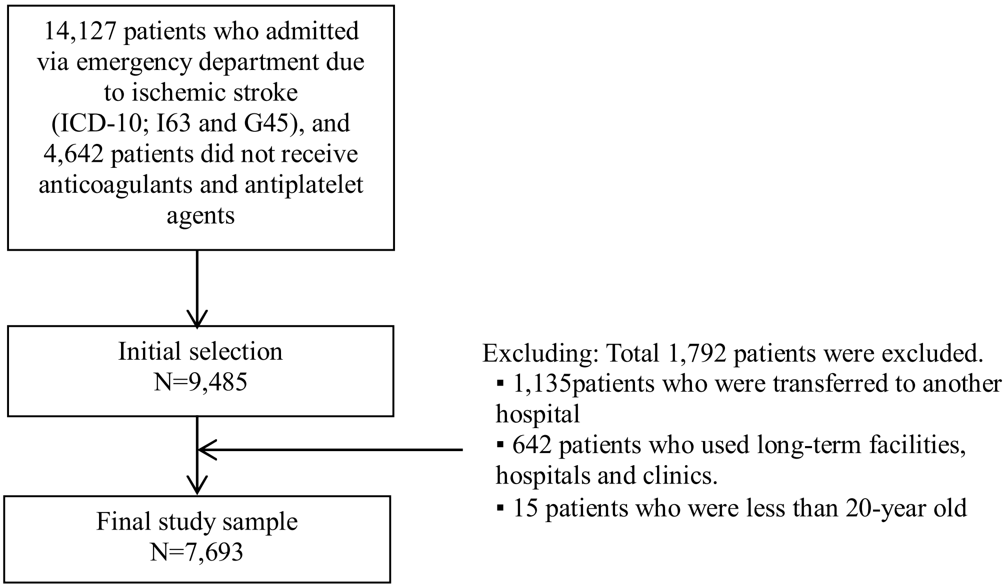


Figure 5. Flowchart of study sample who were ischemic stroke

To determine hemorrhagic stroke, the following criteria should be met: 1) patients admitted via the emergency department because of hemorrhagic stroke classified as I60 (subarachnoid hemorrhage), I61 (intracerebral hemorrhage), and I62 (other non-traumatic intracranial hemorrhage) of the *ICD-10* codes; 2) patients who received intravenous antihypertensive agents, mannitol, or craniotomy; 3) patients who used general hospitals and superior hospitals without transferring to another hospital; and 4) patients aged >20 years (Figure 6). The total number of individuals who were admitted via the emergency department due to AMI was 4,405. Of these patients, 743 did not receive intravenous antihypertensive agents, mannitol, or craniotomy. Then, 834 patients were excluded, among whom 701 were transferred to another hospital; 98 used long-term facilities, hospitals and clinics; and 35 were <20 years of age.

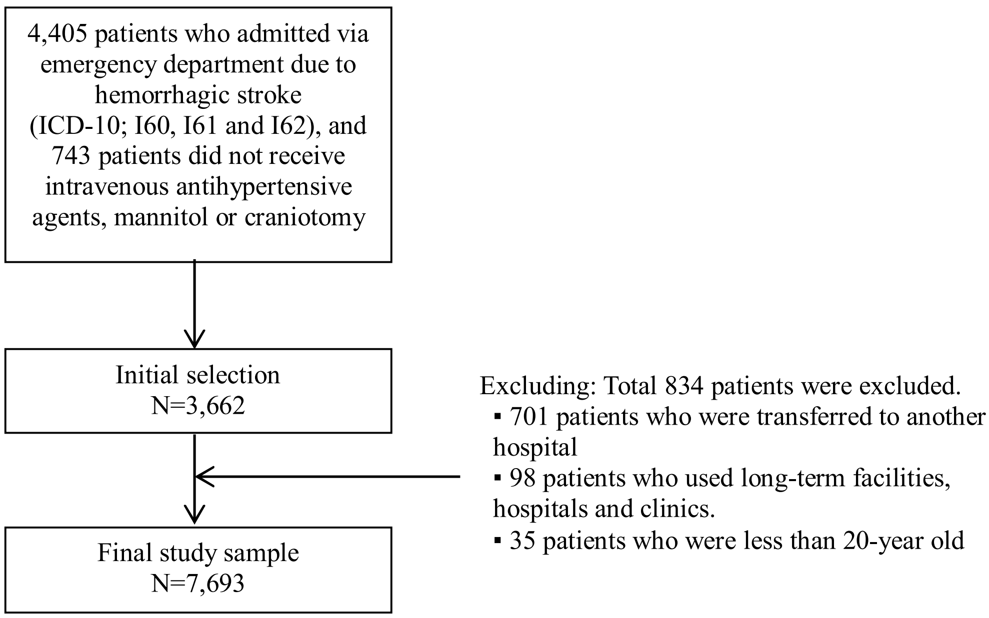


Figure 6. Flowchart of study sample who were hemorrhagic stroke

To identify acute myocardial patients, the following criteria should be met: 1) patients admitted via the emergency department because of AMI classified as I21 (AMI), I22 (subsequent myocardial infarction), and I25.2 (old myocardial infarction) of the *ICD-10* codes; 2) patients who received aspirin; 3) patients who underwent a cardiac enzyme test such as those for CK-MB, troponins T and I, and myoglobin; 4) patients who used general hospital and superior hospital without transferring to another hospital; and 5) patients aged >20 years (Figure 7). The total number of individuals admitted via the emergency department because of AMI was 6,575. Of these patients, 614 did not receive aspirin and 1,045 were excluded, among whom 400 did not receive a clinical cardiac enzyme test; 514 were transferred to another hospital; 122 used long-term facilities, hospitals, and clinics; and 9 were aged <20 years.

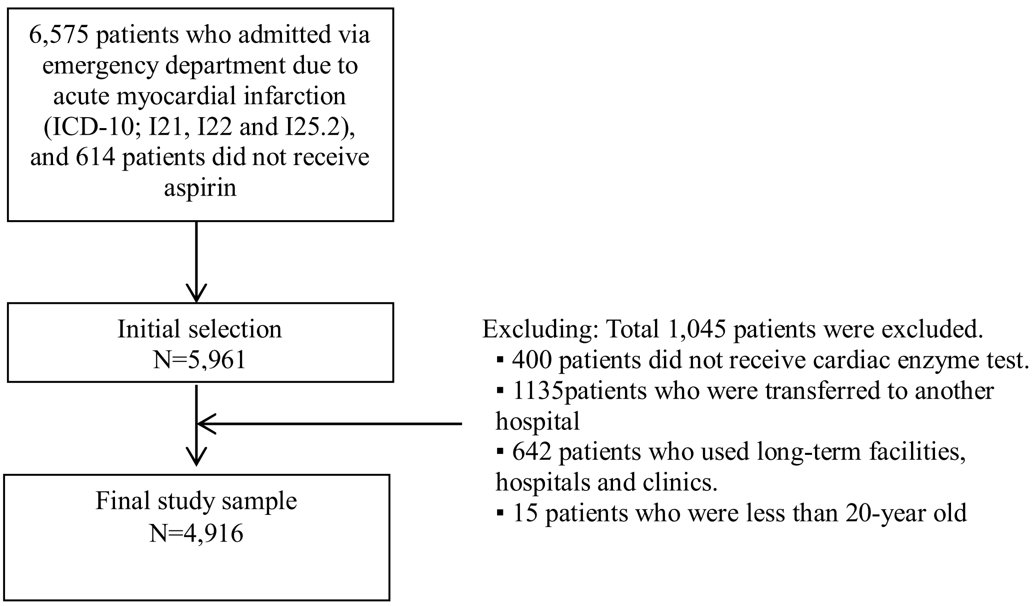


Figure 7. Flowchart of study sample who were acute myocardial infarction

4. Variables

(1) Dependent variables

The dependent variable in the present study was mortality upon in-hospital admission, and at 7 and 30 days after admission. Death was assumed to be the outcome of interest. Death was determined by linking inpatient records with death certificate records from the national death registry. The death certificate records indicated only the month and year of death; we had to determine whether the patient was dead at discharge. We defined in-hospital, 7-day, and 30-day mortalities as follows: First, we matched the discharge and death dates. If the discharge data month/year was the same as the death date, we determined if the patients acquired discharge medication or used any medical services after the discharge date. If they did not, we included them as cases as mortalities.

(2) Independent variables

Patient, treatment, and hospital characteristics were classified as covariates. Patient characteristics included age; sex; health insurance type (national health insurance or medical aid); income level; residential area (metropolitan/urban/rural); Charlson comorbidity index (CCI $\leq$ 1, 2, 3, or $\geq$4);

arrival route (by emergency team/others); disability status (none/mild/severe); presence or absence of hypertension/hypertensive complications, diabetic complications, and hyperlipidemia; and admission on a weekend or weekday. Treatment characteristics included administration of an intervention such as embolization, balloon, or stent (yes/no); administration of intravenous thrombolytic agents in case of ischemic diseases; use of intensive care unit service (yes/no); and administration of surgical procedures (yes/no) in case of hemorrhagic stroke. Hospital characteristics included ownership (public/educational/private), total number of patients admitted via the emergency department because of a corresponding condition per year (quintiles 1–5), proportion of transferred patients to another hospital (<5/5–9/10–14/15–19/≥20), number of beds (quintiles 1–5), patient-to-physician ratio (2.5:1/ 3.5:1/ 5.5:1/ 8.5:1/ >8.5:1), patient-to-nurse ratio (2.0:1/ 2.5:1/ 3.0:1/ 3.5:1/ 4.0:1/ 4.5:1/ >6.0:1), and hospital function (superior general hospital/general hospital). Only the comorbidity component of the CCI was calculated from entry of cohort to before occurrence of interested conditions. In addition, when we calculated CCI, we extracted diabetes scores. The weekend effect was investigated by determining whether patients were admitted via the emergency department on a Saturday or Sunday. In addition, patients who were admitted on an official national holiday were regarded as weekend admissions. Table 3 shows the variables that used in this study.

Table 3. Definitions of main variables in this study

Variables	Definitions
Outcome variable	
In-hospital mortality	Patient was dead at discharge after admission. 1) matched the discharge date month/year and death date month/year and then determining whether two date was the same or not. 2) if that was the same, identifying whether discharge medication or utilization any medical services existed or not.
Independent variables	
Patient characteristics	
Age	Classified as 5 categories: 20-39 year-old patients were included as one group, the others divided into 4 categories according to 10 age-intervals in adults who were more than 20 year-old.
Health Insurance type	National health insurance, and medical aid
Individual household income	Used health insurance premium as proxy for individual household income. Low, 0-30 percentile; Middle, 31-70 percentile; high, 71-100 percentile
Residential area	Used a zip-code where patients lived. Metropolitan (Seoul, Incheon, Daejeon, Daegu, Ulsan, Busan, and Kwangju) City (were included that zip-code was "Dong") Rural (were included that zip-code was "Up and Myun").
Charlson comorbidity index	Classified as 4 categories; $\leq$1, 2, 3, or $\geq$4. To calculate CCI, this study extracted age score and diabetes, hypertension and dyslipidemia.
Disabled status	Severe included patients with 1 or 2 disabled grade Mild included patients with disabled grade of 3-6 None included patients without disabled grade

Table 3. Definitions of main variables in this study *(Continued)*

Variables	Definitions
Patient characteristics	
Hypertension	Defined using ICD-10 code from outpatient and inpatient claims data before occurring of stroke and AMI attack Without hypertensive complication included following ICD-10 codes: I10.x With hypertensive complication included following ICD-10 codes: I11.x, I12.x, and I13.x No: without above mentioning codes.
diabetes	Defined using ICD-10 code from outpatient and inpatient claims data before occurring of stroke and AMI attack No: without E10.x-E14.x as ICDd-10 codes Without diabetic complication included following ICD-10 codes: E1x.0, E1x.1 E1x.6, E1x.8, and E1x.9 With diabetic complication included following ICD-10 codes: E1x.2, E1x.3, E1x.4, E1x.5, and E1x.7
dyslipidemia	Defined using ICD-10 code from outpatient and inpatient claims data before occurring of stroke and AMI attack Yes: with E78 of ICD-10 code No: without E78 of ICD-10 code
Treatment Characteristics	
Intensive care unit service	Defined using service billing information from claims data based on fee-for-service. This study used yearly health insurance benefit cost as reference from Health Insurance Review & Assessment Service.
Intravenous thrombolytic agents *Intravenous antihypertensive agents* *Use of Mannitol*	Defined using drug billing information relevant intravenous thrombolytic agents from claims data based on fee-for-service. Intravenous thrombolytic agents were selected according to stroke and AMI guideline from each Association.
Weekend admission	This study treated Saturday, Sunday and national official holidays as weekend.
Percutaneous coronary/cerebrovascular intervention	was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

Table 3. Definitions of main variables in this study *(Continued)*

Variables	**Definitions**
Treatment characteristics	
Trephination *Craniotomy*	Trephination was included the following burr hole or trephination including for exploration, subdural or epidural, intracerebral, and others. Craniotomy was included the following craniotomy or craniectomy including for exploration, decompression, excision of cranial lesion.
Hospital characteristics	
Characteristics of foundation	Classified 3 categories; Public: foundation was based on national, public, special, religious, social welfare, juridical, corporation, and company. School: educational university including national university Private: medical corporation and private
volume	Calculated yearly total patients who admitted via emergency department due to stroke and AMI and then classified 5 categories according to quintile.
Transferred rate	Divided yearly total transferred patients by yearly total patients who admitted via emergency due to stroke and AMI, and then classified 5 categories according to quintile.
The number of beds per one doctor	Divided total bed sizes into the total number of doctors.
Ratio of beds per one nurse	Defined using service billing information from claims data based on fee-for-service. This study used yearly health insurance benefit cost as reference from Health Insurance Review & Assessment Service.

5. Statistical Analysis

Descriptive statistics were computed for all variables as follows: Frequencies and percentages of categorical variables were determined by using the chi-square test. The cumulative incidence for each dependent was estimated by using the Kaplan-Meier product limit method with log-rank tests. To investigate the association between patient/treatment/hospital characteristics and mortality, we performed a survival analysis by using Cox's proportional hazards frailty model, which included random effects to account for covariate hierarchy. This approach used a random effect to test for a hospital effect. This random effect can be thought of as a "frailty," which increases a hospital's susceptibility to a short survival time when it is large and decreases this susceptibility when it is small. We determined the mortality variance and p-values among the hospitals. The variance and p values were 0.126 and 0.050 for ischemic stroke, 0.081 and 0.04 for AMI, and 0.109 and 0.021 for hemorrhagic stroke, respectively.

The equation $\lambda\ (t|\mathbf{x}) = z\lambda 0(t)\exp(\mathbf{x}\beta)$ describes the frailty model, where $\mathbf{x}$ is the covariate matrix, β is the fixed effect vector, and Z is a random variable representing an unknown random effect related to each hospital, with unit mean and variance ξ. These random effects act multiplicatively on the baseline hazard, and large ξ values reflect a great degree of heterogeneity among hospitals. For model distribution purposes, we assumed that the frailties were distributed according to a gamma distribution. One attractive feature of the gamma distribution is that it is mathematically tractable.

In addition, we performed a multilevel logistic regression analysis to investigate the model fitness to identify powerful factors that affect mortality according to acute, subacute, and latent health outcomes. All the statistical analyses were performed by using SAS 9.4 (SAS institute, Inc., Cary, NC, USA).

Ⅳ. Results

1. General Description

(1) Patient Characteristics

Table 4 shows how the three diseases differ in distribution and the general characteristics used in this study. The proportion of individuals who had a hemorrhagic stroke (≥70) was lower than that of patients who had an ischemic stroke and AMI (30.2%, 49.0%, and 41.4%, respectively). Regarding sex, the proportion of males was highest among those with AMI, followed by ischemic and hemorrhagic stroke (63.0%, 54.0%, and 49.6%, respectively). The distribution of patients with high income levels was as follows: 43.5%, 34.6%, and 27.5% for ischemic stroke, AMI, and hemorrhagic stroke, respectively. The distribution of CCI of ≥4 was similar between ischemic stroke and AMI, and lowest for hemorrhagic stroke (38.3%, 34.3%, and 26.7%, respectively). The proportions of patients without hypertension were 27.7%, 29.4%, and 43.6% among those who had an ischemic stroke, AMI, and hemorrhagic stroke, respectively. For diabetes mellitus, the proportions of patients without diabetes were 57.3%, 57.6%, and

74.0% among those who had an ischemic stroke, AMI, and hemorrhagic stroke, respectively.

(2) Treatment Characteristics

Table 5 shows the proportion of treatments stratified according to the disease treated. The proportion of patients admitted to the intensive care unit was highest among those who had a hemorrhagic stroke, followed by those who had an AMI and ischemic stroke (79.2%, 58.8%, and 13.0%, respectively). For ischemic stroke and AMI, which have common characteristic as ischemic diseases, the distribution of administration of intravenous thrombolytic agents was 11.5% for ischemic stroke and 4.1% for ischemic stroke. The distribution of performing of percutaneous coronary/cerebrovascular intervention was 2.1% for ischemic stroke and 47.4% for AMI. The proportions of patients who underwent craniotomy and those who received mannitol were 3.4% and 83.1%, respectively, for hemorrhagic stroke. The distribution of patients who were admitted on a weekend was as follows: 28.6%, 26.7%, and 29.0% for ischemic stroke, AMI, and hemorrhagic stroke.

Table 4. Patient characteristics who admitted via emergency department, stratified by disease

Patient Characteristics, n(%)	**Ischemic Stroke** (N=7,693)		**Hemorrhagic Stroke** (N=2,828)		**Acute Myocardial Infarction** (N=4,916)	
Age						
20-39	173	(2.3)	200	(7.1)	140	(2.9)
40-49	504	(6.6)	482	(17.0)	534	(10.9)
50-59	1,178	(15.3)	634	(22.4)	938	(19.1)
60-69	2,067	(26.9)	657	(23.2)	1,268	(25.8)
≥70	3,771	(49.0)	855	(30.2)	2,036	(41.4)
Sex						
Male	4,155	(54.0)	1,403	(49.6)	3,097	(63.0)
Female	3,538	(46.0)	1,425	(50.4)	1,819	(37.0)
Health insurance type						
National health insurance	7,350	(95.5)	2,659	(94.0)	4,739	(96.4)
Medical aid	343	(4.5)	169	(6.0)	177	(3.6)
Individual household income						
Low	1,876	(24.4)	575	(20.3)	853	(17.4)
Middle	2,468	(32.1)	1,476	(52.2)	2,361	(48.0)
High	3,349	(43.5)	777	(27.5)	1,702	(34.6)
Residential area						
Metropolitan	3,128	(40.7)	1,196	(42.3)	2,144	(43.6)
City	3,430	(44.6)	1,252	(44.3)	2,112	(43.0)
Rural	1,135	(14.8)	380	(13.4)	660	(13.4)
Charlson comorbidity index[a]						
0-1	2,315	(30.1)	1,238	(43.8)	1,274	(25.9)
2-3	2,434	(31.6)	834	(29.5)	1,464	(29.8)
4-5	1,728	(22.5)	450	(15.9)	1,124	(22.9)
>5	1,216	(15.8)	306	(10.8)	1,054	(21.4)
Hypertension						
No	2,127	(27.7)	1,234	(43.6)	1,443	(29.4)
Without hypertensive complication	3,816	(49.6)	1,180	(41.7)	2,284	(46.5)
With hypertensive complication	1,750	(22.8)	414	(14.6)	1,189	(24.2)
Diabetes Mellitus						
No	4,406	(57.3)	2,093	(74.0)	2,833	(57.6)
Without diabetic complication	1,653	(21.5)	429	(15.2)	961	(19.6)
With diabetic complication	1,634	(21.2)	306	(10.8)	1,122	(22.8)
Dyslipidemia						
No	3,953	(51.4)	1,840	(65.1)	1,846	(41.0)
Yes	3,740	(48.6)	988	(34.9)	2,659	(59.0)
Disability						
None	6,398	(79.0)	2,209	(78.1)	4,119	(83.8)
Mild	986	(12.2)	289	(10.2)	511	(10.4)
Severe	716	(8.8)	330	(11.7)	286	(5.8)

[a], calculated comorbidity components; age score and diabetes scores were extracted.

Table 5. Treatment characteristics, stratified by diseases

Treatment Characteristics, n(%)	Ischemic Stroke (N=7,693)		Hemorrhagic Stroke (N=2,828)		Acute myocardial infarction (N=4,916)	
Intensive care unit service						
No use	6,690	(87.0)	587	(20.8)	2,027	(41.2)
Use	1,003	(13.0)	2,241	(79.2)	2,889	(58.8)
Intravenous thrombolytic agents						
No	6,808	(88.5)			4,714	(95.9)
Yes	885	(11.5)			202	(4.1)
Percutaneous coronary /cerebrovascular intervention[a]						
No	7,530	(97.9)			2,588	(52.6)
Yes	163	(2.1)			2,328	(47.4)
Weekend admission[b]						
Weekday admission	5,495	(71.4)	2,157	(71.0)	3,601	(73.3)
Weekend admission	2,198	(28.6)	879	(29.0)	1,315	(26.7)
Intervention for reducing ICP						
Intravenous antihypertensive agents			352	(12.5)		
Use of mannitol			1,691	(59.8)		
Endovascular coiling			459	(16.2)		
Trephination			229	(8.1)		
Craniotomy			97	(3.4)		

ICP denotes intracranial pressure.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

(3) Hospital Characteristics

Table 6 shows the proportion of hospital characteristics that the patients used, stratified according to disease. Regarding funding source, the proportion of funding of private nature was highest for ischemic stroke, followed by AMI and hemorrhagic stroke (93.5%, 88.7%, and 55.3%, respectively). The median of number of beds was 402 ± 414.0 for ischemic stroke, 504.5 ± 462.0 for AMI, and 503.0 ± 466.0 for hemorrhagic stroke. The median annual hospital volume was 9.0 ± 30.0 for ischemic stroke, 6.0 ± 25.0 for AMI, and 6.0 ± 20.0 for hemorrhagic stroke. The proportion of transfer rates to other hospital of ≥20% was highest for hemorrhagic stroke at 28.1%, followed by 15.8% for ischemic stroke and 13.5% for AMI, respectively. The distribution of patients admitted to a superior general hospital was 13.5% for ischemic stroke, 11.3% for AMI, and 15.3% for hemorrhagic stroke.

Table 6. Hospital characteristics that patients visited, stratified by diseases

Hospital Characteristics, n(%)	Ischemic Stroke (N=311)		Hemorrhagic Stroke (N=235)		Acute Myocardial Infarction (N=238)	
Characteristic of foundation						
Public	7	(2.3)	8	(3.4)	14	(5.9)
Educational foundation	13	(4.2)	97	(41.3)	13	(5.5)
Private	291	(93.5)	130	(55.3)	211	(88.7)
The number of beds (Median±IQR)	402.0±414.0		503.0±466.0		504.5±462.0	
The number of beds						
Quintile 1	57	(18.3)	39	(16.6)	47	(19.8)
Quintile 2	71	(22.8)	39	(16.6)	48	(20.2)
Quintile 3	59	(19.0)	44	(18.7)	47	(19.8)
Quintile 4	63	(20.3)	40	(17.0)	48	(20.2)
Quintile 5	61	(19.6)	73	(31.1)	48	(20.2)
Volume of patient (Median±IQR)	9.0 ±30.0		6.0 ±20.0		6.0 ±25.0	
Volume of patient						
Quintile 1	67	(21.5)	91	(38.7)	44	(18.5)
Quintile 2	55	(17.7)	38	(16.2)	46	(19.3)
Quintile 3	67	(21.5)	32	(13.6)	51	(21.4)
Quintile 4	59	(19.0)	54	(23.0)	49	(20.6)
Quintile 5	63	(20.3)	20	(8.5)	48	(20.2)
Proportion of transferred patient to other hospital						
<5%	167	(53.7)	98	(41.7)	175	(73.5)
5-9%	47	(15.1)	21	(8.9)	15	(6.3)
10-14%	32	(10.3)	28	(11.9)	10	(4.2)
15-19%	16	(5.1)	22	(9.4)	6	(2.5)
≥20%	49	(15.8)	66	(28.1)	32	(13.5)
The number of beds per one doctor (Median±IQR)	9.8±8.8		9.0 ±10.0		8.1±8.6	
The number of beds per one doctor						
2.5:1	27	(8.7)	27	(11.5)	26	(10.9)
3.5:1	36	(11.6)	35	(14.9)	36	(15.1)
5.5:1	32	(10.3)	29	(12.3)	30	(12.6)
8.5:1	33	(10.6)	25	(10.6)	31	(13.0)
>8.5:1	183	(58.8)	119	(50.6)	115	(48.3)
Ratio of beds per one nurse						
2.0:1	4	(1.3)	4	(1.7)	4	(1.7)
2.5:1	21	(6.8)	17	(7.2)	18	(7.6)
3.0:1	60	(19.3)	52	(22.1)	56	(23.5)
3.5:1	47	(15.1)	40	(17.0)	38	(16.0)
4.0:1	47	(15.1)	23	(9.8)	34	(14.3)
4.5:1	26	(8.4)	22	(9.4)	17	(7.1)
>6.0:1	106	(34.1)	77	(32.8)	71	(29.8)
Hospital function						
Superior general hospital	42	(13.5)	36	(15.3)	27	(11.3)
General hospital	269	(86.5)	199	(84.7)	211	(88.7)

IQR denotes interquartile range.

2. The Number of Deaths and the Cumulative Mortality

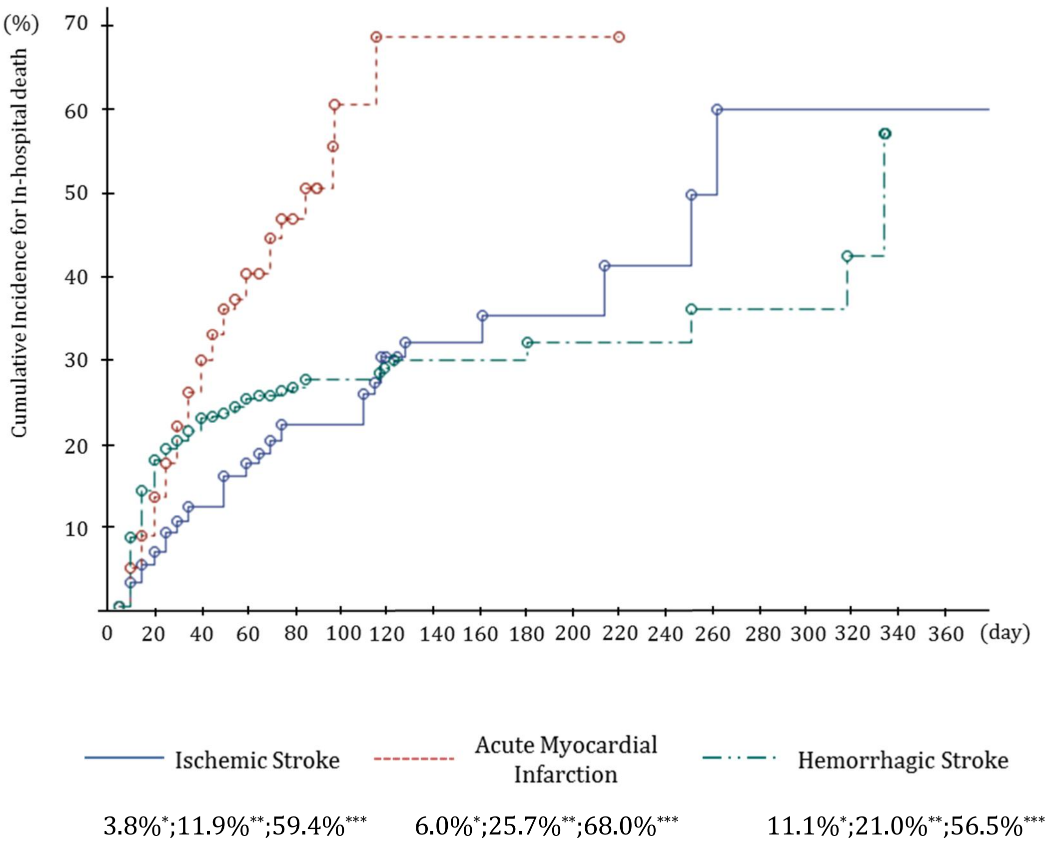
Table 7 presents the number of deaths stratified according to diseases. In 7-day mortality, 256 patients (3.3%) died from ischemic stroke, 305 (10.8%) from hemorrhagic stroke, and 244 (5.0%) from AMI. In 30-day mortality, 440 patients (5.7%) died from ischemic stroke, 522 (18.5%) from hemorrhagic stroke, and 375 (7.6%) from AMI. The number of deaths was highest for hemorrhagic stroke and two-fold higher than those for ischemic stroke and AMI. In in-hospital mortality, 500 patients (6.5%) died from ischemic stroke; 399 (8.1%), from AMI; and 569 (20.1%), from hemorrhagic stroke.

Figure 8 shows the cumulative mortality stratified according to disease. The 7-day cumulative mortality was 3.8% for ischemic stroke, 11.1% for hemorrhagic stroke, and, was 6.0% for AMI. The 7-day cumulative mortality was highest for hemorrhagic stroke. The 30-day cumulative mortality was 11.9% ischemic stroke, 25.7% for AMI, and 21.0% for hemorrhagic stroke. Regarding 30-day cumulative mortality, it was highest for AMI. The in-hospital cumulative mortality was 59.4% for ischemic stroke, 68.0% for AMI, and 56.5% for hemorrhagic stroke. The in-hospital cumulative mortality was highest for AMI

Table 7. Number of deaths according to diseases

Mortality	Ischemic Stroke (N=7,693)		Hemorrhagic Stroke (N=2,828)		Acute Myocardial Infarction (N=4,916)	
	The number of death (N, %)	Deaths per 1,000 PD	The number of death (N, %)	Deaths per 1,000 PD	The number of death (N, %)	Deaths per 1,000 PD
7-day Mortality	256 (3.3)	5.5	305 (10.8)	16.7	244 (5.0)	9.2
30-day Mortality	440 (5.7)	4.7	522 (18.5)	9.4	375 (7.6)	9.4
In-hospital Mortality	500 (6.5)	4.2	569 (20.1)	6.4	399 (8.1)	9.3

PD denotes person-days.



*, 7-day cumulative mortality;**, 30-day cumulative mortality;***, in-hospital cumulative mortality

Figure 8. The cumulative mortality, stratified by diseases

3. The Factors Influencing Mortality

(1) The patient factors that affect 7-day, 30-day and in-hospital mortality, stratified by diseases

Table 8, Table 9 and Table 10 shows the hazard ratios of 7-day, 30-day, and in-hospital mortality from Cox's proportional frailty hazard model for predicting patient characteristics and mortality in ischemic stroke, hemorrhagic stroke, and AMI. For ischemic stroke, age, sex, and individual household income were associated with 7-day mortality. For AMI, only age and hypertension were associated with 7-day mortality. For hemorrhagic stroke, age, CCI, and diabetes were associated with 7-day mortality after adjusting for all covariates, including treatment and hospital characteristics. For ischemic stroke, the hazard ratio (HR) for the males was 0.74 (95% confidence interval [CI], 0.58–0.96) compared with the females. For AMI and hemorrhagic stroke, the corresponding HR for males was not associated (Table 8). For ischemic and hemorrhagic stroke, the HRs for patients aged 40–49 years were 0.41 (95% CI, 0.20–0.85) and 0.68 (95% CI, 0.47–0.98), respectively, compared with the patients aged ≥70 years. For AMI, the HRs of the patients who had hypertension with and those without hypertensive complications were 0.60 (95% CI, 0.39–0.92) and 0.63 (95% CI, 0.44–0.90), respectively, compared with the patients without hypertension (Table 8). For hemorrhagic stroke, the HR of the patients who had diabetes mellitus with diabetic complication was 1.64 (95% CI, 1.15–2.34) compared with the patients without diabetes (Table 8).

Table 9 presents the association between the patient characteristics and 30-day mortality. Age, sex, individual household income, hypertension, and disability were associated with 30-day mortality for ischemic stroke. Age, hypertension, and diabetes were associated with 30-day mortality for AMI. Age, health insurance type, CCI, diabetes, and disability were associated with 30-day mortality for hemorrhagic stroke. In 30-day mortality, the risk of mortality decreased with the patients' younger age for all three diseases when compared with the reference group (age ≥ 70 years), the HR of the patients aged 20–39, 40–49, 50–59, and 60–69 years were 0.27 (95% CI, 0.08–0.84), 0.35 (95% CI, 0.19–0.63), 0.45 (95% CI, 0.31–0.66), and 0.66 (95% CI, 0.52–0.83) for ischemic stroke, respectively. Individual household income was strongly associated with 30-day mortality in ischemic stroke. Lower income levels significantly increased the risk of mortality (Table 9). The HRs of the patients with low and middle income levels were 1.31 (95% CI, 1.02–1.69) and 1.37 (95% CI, 1.10–1.71), respectively. In AMI, factors are similar with characteristics that affect 7-day mortality. The HR of any age

Table 8. Association between patient characteristics and 7-day mortality, stratified by diseases

	Ischemic Stroke		**Hemorrhagic Stroke**		**Acute Myocardial Infarction**	
Patient Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Age						
20-39	0.19	(0.03-1.40)	0.47	(0.26-0.86)	0.41	(0.13-1.32)
40-49	0.41	(0.20-0.85)	0.68	(0.47-0.98)	0.15	(0.05-0.40)
50-59	0.49	(0.30-0.79)	0.67	(0.49-0.92)	0.49	(0.31-0.78)
60-69	0.59	(0.43-0.82)	0.56	(0.41-0.76)	0.63	(0.45-0.89)
≥70	1.00		1.00		1.00	
Sex						
Male	0.74	(0.58-0.96)	1.16	(0.92-1.46)	0.99	(0.75-1.31)
Female	1.00		1.00		1.00	
Health insurance type						
National health insurance	1.00		1.00		1.00	
Medical aid	1.34	(0.79-2.39)	0.71	(0.38-1.30)	0.56	(0.23-1.35)
Individual household income						
Low	1.21	(0.87-1.70)	1.05	(0.78-1.41)	1.12	(0.76-1.66)
Middle	1.40	(1.05-1.87)	0.99	(0.76-1.29)	0.93	(0.69-1.26)
High	1.00		1.00		1.00	
Residential area						
Metropolitan	1.00		1.00		1.00	
City	0.95	(0.72-1.26)	0.94	(0.73-1.21)	0.86	(0.64-1.16)
Rural	0.98	(0.68-1.43)	0.95	(0.68-1.35)	1.02	(0.68-1.52)
Charlson comorbidity index						
0-1	1.00		1.00		1.00	
2-3	1.12	(0.78-1.60)	1.11	(0.82-1.49)	0.97	(0.63-1.49)
4-5	1.28	(0.86-1.90)	1.30	(0.90-1.88)	1.46	(0.93-2.28)
>5	1.49	(0.96-2.30)	2.04	(1.38-3.03)	1.29	(0.79-2.14)

Table 8. Association between patient characteristics and 7-day mortality, stratified by diseases *(Continued)*

	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
Patient Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Hypertension						
No	1.00		1.00		1.00	
Without hypertensive complication	1.16	(0.81-1.66)	0.96	(0.71-1.29)	0.63	(0.44-0.90)
With hypertensive complication	1.39	(0.91-2.11)	1.19	(0.81-1.74)	0.60	(0.39-0.92)
Diabetes Mellitus						
No	1.00		1.00		1.00	
Without diabetic complication	1.07	(0.78-1.47)	1.19	(0.86-1.66)	1.38	(0.98-1.95)
With diabetic complication	0.92	(0.66-1.30)	1.64	(1.15-2.34)	1.31	(0.93-1.86)
Dyslipidemia						
No	1.00		1.00		1.00	
Yes	0.84	(0.63-1.12)	0.79	(0.60-1.05)	0.80	(0.58-1.09)
Disability						
None	1.00		1.00		1.00	
Mild	1.09	(0.75-1.58)	1.00	(0.71-1.42)	0.81	(0.51-1.27)
Severe	0.66	(0.40-1.09)	0.70	(0.47-1.03)	1.31	(0.83-2.09)

*: adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

group was lower than that of the reference group (≥70 year old). Moreover, the HR of the patients with hypertension who had no hypertensive complication was 0.71 (95% CI, 0.52–0.97) compared with those without hypertension. In hemorrhagic stroke, compared with those with a CCI of 0–1, the HRs of those with a CCI of 2 or 3, 4 or 5, and >5 were 1.02 (95% CI, 0.81–1.27), 1.26 (95% CI, 0.95–1.67), and 2.01 (95% CI, 1.48–2.72), respectively. The tendency showed that the risk of 30-day mortality increased as the CCI increased.

Table 10 shows the association between patients' characteristics and in-hospital mortality. Age, sex, individual household income, hypertension, and disability were associated with in-hospital mortality for ischemic stroke. The factors that affected in-hospital mortality were similar with the factors that affected 30-day mortality for ischemic stroke. Age and hypertension were associated with in-hospital mortality in AMI. The factors that affected in-hospital mortality were similar with the factors that affected 7-day mortality in AMI. Age, sex, health insurance type, CCI, hypertension, and disability were associated with in-hospital mortality in hemorrhagic stroke. The factors that affected in-hospital mortality were similar with the factors that affected 30-day mortality for hemorrhagic stroke. Individual household income was strongly associated with in-hospital mortality in hemorrhagic stroke. Lower level of income significantly

Table 9. Association between patient characteristics and 30-day mortality, stratified by diseases

Patient Characteristics	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Age						
20-39	0.27	(0.08-0.84)	0.56	(0.37-0.85)	0.38	(0.14-1.05)
40-49	0.35	(0.19-0.63)	0.65	(0.49-0.86)	0.16	(0.07-0.37)
50-59	0.45	(0.31-0.66)	0.69	(0.54-0.88)	0.42	(0.28-0.64)
60-69	0.66	(0.52-0.83)	0.57	(0.45-0.72)	0.59	(0.45-0.78)
≥70	1.00		1.00		1.00	
Sex						
Male	0.79	(0.65-0.96)	1.16	(0.98-1.38)	0.93	(0.75-1.16)
Female	1.00		1.00		1.00	
Health insurance type						
National health insurance	1.00		1.00		1.00	
Medical aid	0.86	(0.53-1.41)	0.54	(0.33-0.87)	0.65	(0.35-1.26)
Individual household income						
Low	1.31	(1.02-1.69)	1.03	(0.82-1.29)	1.12	(0.82-1.52)
Middle	1.37	(1.10-1.71)	0.97	(0.79-1.18)	0.88	(0.69-1.12)
High	1.00		1.00		1.00	
Residential area						
Metropolitan	1.00		1.00		1.00	
City	1.09	(0.88-1.35)	0.91	(0.75-1.10)	0.99	(0.78-1.25)
Rural	1.11	(0.83-1.47)	0.84	(0.64-1.10)	1.10	(0.80-1.52)
Charlson comorbidity index						
0-1	1.00		1.00		1.00	
2-3	0.97	(0.74-1.27)	1.02	(0.81-1.27)	0.75	(0.53-1.07)
4-5	1.18	(0.87-1.58)	1.26	(0.95-1.67)	1.24	(0.87-1.77)
>5	1.28	(0.92-1.77)	2.01	(1.48-2.72)	1.01	(0.68-1.51)

Table 9. Association between patient characteristics and 30-day mortality, stratified by diseases *(Continued)*

	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
Patient Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Hypertension						
No	1.00		1.00		1.00	
Without hypertensive complication	1.12	(0.85-1.48)	1.06	(0.85-1.31)	0.71	(0.52-0.97)
With hypertensive complication	1.40	(1.02-1.93)	1.23	(0.92-1.63)	0.77	(0.54-1.09)
Diabetes Mellitus						
No	1.00		1.00		1.00	
Without diabetic complication	0.93	(0.73-1.19)	1.06	(0.82-1.38)	1.35	(1.02-1.78)
With diabetic complication	0.96	(0.74-1.23)	1.58	(1.20-2.08)	1.22	(0.92-1.60)
Dyslipidemia						
No	1.00		1.00		1.00	
Yes	0.85	(0.69-1.06)	0.82	(0.66-1.02)	0.80	(0.62-1.03)
Disability						
None	1.00		1.00		1.00	
Mild	0.88	(0.66-1.18)	0.89	(0.67-1.18)	0.97	(0.70-1.35)
Severe	0.61	(0.42-0.88)	0.63	(0.47-0.85)	1.18	(0.82-1.70)

*: adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

increased the risk of mortality (Table 10). The HRs of the patients with low and middle incomes were 1.30 (95% CI, 1.02–1.65) and 1.33 (95% CI, 1.08–1.64), respectively. Regarding sex, the HRs of the males were 0.82 for ischemic stroke (95% CI, 0.68–0.99) and 1.25 (95% CI, 1.06-1.48) for hemorrhagic stroke compared with the females. The risk of in-hospital mortality showed contrary result in relation to sex. The HR of any age group was lower than that of the reference group (≥70 years old) in AMI. In addition, the HR of the patients with hypertension who had no hypertensive complication was 0.68 (95% CI, 0.50–0.92) compared with the patients without hypertension.

Table 10. Association between patient characteristics and in-hospital mortality, stratified by diseases

	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
Patient Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Age						
20-39	0.23	(0.07-0.73)	0.54	(0.36-0.81)	0.36	(0.13-0.98)
40-49	0.38	(0.22-0.64)	0.64	(0.49-0.84)	0.18	(0.08-0.38)
50-59	0.42	(0.29-0.61)	0.65	(0.52-0.83)	0.40	(0.27-0.60)
60-69	0.61	(0.49-0.77)	0.58	(0.46-0.72)	0.58	(0.44-0.76)
≥70	1.00		1.00		1.00	
Sex						
Male	0.82	(0.68-0.99)	1.25	(1.06-1.48)	0.95	(0.77-1.17)
Female	1.00		1.00		1.00	
Health insurance type						
National health insurance	1.00		1.00		1.00	
Medical aid	0.96	(0.62-1.50)	0.54	(0.34-0.85)	0.68	(0.36-1.28)
Individual household income						
Low	1.30	(1.02-1.65)	1.04	(0.84-1.29)	1.13	(0.83-1.53)
Middle	1.33	(1.08-1.64)	0.96	(0.79-1.16)	0.91	(0.72-1.16)
High	1.00		1.00		1.00	
Residential area						
Metropolitan	1.00		1.00		1.00	
City	1.07	(0.87-1.31)	0.93	(0.78-1.12)	0.98	(0.78-1.24)
Rural	1.03	(0.78-1.37)	0.90	(0.70-1.16)	1.11	(0.81-1.52)
Charlson comorbidity index						
0-1	1.00		1.00		1.00	
2-3	0.99	(0.76-1.28)	1.01	(0.81-1.26)	0.76	(0.54-1.07)
4-5	1.27	(0.96-1.68)	1.30	(1.00-1.70)	1.23	(0.87-1.75)
>5	1.32	(0.97-1.80)	1.97	(1.47-2.64)	1.03	(0.69-1.52)

Table 10. Association between patient characteristics and in-hospital mortality, stratified by diseases *(Continued)*

	Ischemic Stroke		**Hemorrhagic Stroke**		**Acute Myocardial Infarction**	
Patient Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Hypertension						
No	1.00		1.00		1.00	
Without hypertensive complication	1.18	(0.91-1.53)	1.12	(0.91-1.37)	0.68	(0.50-0.92)
With hypertensive complication	1.42	(1.05-1.93)	1.22	(0.93-1.60)	0.78	(0.55-1.10)
Diabetes Mellitus						
No	1.00		1.00		1.00	
Without diabetic complication	0.89	(0.71-1.13)	1.03	(0.81-1.32)	1.32	(1.01-1.74)
With diabetic complication	0.93	(0.73-1.18)	1.52	(1.17-1.98)	1.17	(0.89-1.53)
Dyslipidemia						
No	1.00		1.00		1.00	
Yes	0.88	(0.72-1.08)	0.82	(0.67-1.01)	0.80	(0.62-1.02)
Disability						
None	1.00		1.00		1.00	
Mild	0.89	(0.68-1.17)	0.90	(0.69-1.17)	0.96	(0.70-1.33)
Severe	0.57	(0.40-0.81)	0.61	(0.46-0.81)	1.20	(0.85-1.68)

*: adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

(2) The treatment factors that affect 7-day, 30-day and in-hospital mortality, stratified by diseases

Table11, Table 12 and Table 13 show the association between treatment characteristics and 7-day, 30-day, and in-hospital mortality. Regarding the use of intensive care unit service, excluding 7-day mortality in hemorrhagic stroke, use of intensive care unit service was associated with 7-day, 30-day, and in-hospital mortality in all three diseases. As the length of hospital stay increased, the effect of use of the intensive care unit service was lowered in ischemic stroke and AMI. By contrast, as the length of hospital stay increased, the effect of use of the intensive care unit service increased in hemorrhagic stroke. In ischemic stroke, the HR of use of the intensive care unit service was 6.88 (95% CI, 5.34–8.86) for 7-day mortality, 5.86 (95% CI, 4.83–7.09) for 30-day mortality, and 5.54 (95% CI, 4.61–6.65) for in-hospital mortality. In hemorrhagic stroke, use of mannitol was associated with 7-day, 30-day, and in-hospital mortality. The HR of mannitol administration was 3.38 (95% CI, 2.05–5.58) for 7-day mortality, 2.73 (95% CI, 1.87–4.00) for 30-day mortality, and 2.48 (95% CI, 1.73–3.56) for in-hospital mortality. We observed that the risk of administration of mannitol tended to decrease with longer length of hospital stay. In addition, trephination and craniotomy were associated with increasing risks of 7-day, 30-day, and in-hospital mortality. In AMI, the HR of use of the intensive care unit service was 2.17 (95% CI, 1.59–2.97) for 7-day mortality, 1.97 (95% CI, 1.54–2.54) for 30-day mortality, and 1.92 (95% CI, 1.50–2.45) for in-hospital mortality. In hemorrhagic stroke, the HR of use of the intensive care unit service was 1.29 (95% CI, 1.01–1.65) for 30-day mortality and 1.31 (95% CI, 1.04–1.66) for in-hospital mortality. Weekend admission was associated with mortality only in AMI. The HR of weekend admission was 1.39 (95% CI, 1.11–1.74) for 30-day mortality and 1.42 (95% CI, 1.14–1.77) for in-hospital mortality. However, weekend admission was not associated with 7-day mortality in AMI (HR, 1.24; 95% CI, 0.93–1.65). In addition, performing PCI was associated with 7-day, 30-day, and in-hospital mortality in AMI. The HR of performing PCI was 0.40 (95% CI, 0.29–0.54) for 7-day mortality, 0.41 (95% CI, 0.32–0.53), and 0.42 (95% CI, 0.33–0.54) for in-hospital mortality.

Table 11. Association between treatment characteristics and 7-day mortality, stratified by diseases

Treatment Characteristics	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service						
No use	1.00		1.00		1.00	
Use	6.88	(5.34-8.86)	1.04	(0.77-1.40)	2.17	(1.59-2.97)
Intravenous thrombolytic agents						
No	1.00				1.00	
Yes	1.17	(0.84-1.64)			1.44	(0.82-2.53)
Percutaneous coronary /cerebrovascular intervention						
No	1.00				1.00	
Yes	1.17	(0.59-2.30)			0.40	(0.29-0.54)
Weekend admission						
Weekday admission	1.00		1.00		1.00	
Weekend admission	1.23	(0.95-1.59)	1.14	(0.89-1.46)	1.24	(0.93-1.65)
Intervention for reducing ICP						
Intravenous antihypertensive agents			1.00			
Use of mannitol			3.38	(2.05-5.58)		
Endovascular coiling			2.99	(1.73-5.19)		
Trephination			1.08	(0.47-2.47)		
Craniotomy			2.45	(1.07-5.61)		

ICP denotes intracranial pressure.

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

Table 12. Association between treatment characteristics and 30-day mortality, stratified by diseases

Treatment Characteristics	**Ischemic Stroke**		**Hemorrhagic Stroke**		**Acute Myocardial Infarction**	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service						
No use	1.00		1.00		1.00	
Use	5.86	(4.83-7.09)	1.31	(1.02-1.67)	1.97	(1.54-2.54)
Intravenous thrombolytic agents						
No	1.00				1.00	
Yes	1.07	(0.83-1.38)			1.33	(0.82-2.15)
Percutaneous coronary /cerebrovascular intervention						
No	1.00				1.00	
Yes	1.14	(0.71-1.84)			0.41	(0.32-0.53)
Weekend admission						
Weekday admission	1.00		1.00		1.00	
Weekend admission	1.16	(0.95-1.42)	1.05	(0.87-1.27)	1.39	(1.11-1.74)
Intervention for reducing ICP						
Intravenous antihypertensive agents			1.00			
Use of mannitol			2.73	(1.87-4.00)		
Endovascular coiling			1.17	(0.66-2.06)		
Trephination			3.04	(2.02-4.57)		
Craniotomy			3.41	(1.96-5.92)		

ICP denotes intracranial pressure.

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

Table 13. Association between treatment characteristics and in-hospital mortality, stratified by diseases

Treatment Characteristics	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service						
No use	1.00		1.00		1.00	
Use	6.88	(5.34-8.86)	1.34	(1.05-1.70)	1.92	(1.50-2.45)
Intravenous thrombolytic agents						
No	1.00				1.00	
Yes	1.17	(0.84-1.64)			1.33	(0.82-2.15)
Percutaneous coronary /cerebrovascular intervention						
No	1.00				1.00	
Yes	1.17	(0.59-2.30)			0.42	(0.33-0.54)
Weekend admission						
Weekday admission	1.00		1.00		1.00	
Weekend admission	1.23	(0.95-1.59)	1.03	(0.86-1.24)	1.42	(1.14-1.77)
Intervention for reducing ICP						
Intravenous antihypertensive agents			1.00			
Use of mannitol			2.48	(1.73-3.56)		
Endovascular coiling			1.14	(0.67-1.94)		
Trephination			2.84	(1.93-4.18)		
Craniotomy			3.10	(1.85-5.21)		

ICP denotes intracranial pressure.

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

(3) The hospital factors that affect 7-day, 30-day and in-hospital mortality, stratified by diseases

Table 14, Table 15, and Table 16 shows the association between hospital characteristics and 7-day, 30-day, and in-hospital mortality. In ischemic stroke, the characteristic of the funding source and the patient-to-nurse ratio were associated with 7-day mortality. The HR of the characteristic of the funding source that was educational in nature was 1.37 (95 % CI, 1.00–1.88; p = 0.05) compared with the reference private hospital (Table 14). The HR of the characteristic of the funding source that was public in nature was 1.48 (95% CI, 0.96–2.28), but the difference was not statistically significant. Regarding the patient-to-nurse ratio, the risk of 7-day mortality decreased as number of nurses increased. Compared with the reference hospital, where the patient-to-nurse ratio was 2.0:1, the HRs for 2.5:1, 3.0:1, 3.5:1, 4.01:1, 4.5:1, and >6.0:1 were 3.60 (95% CI, 0.44–29.31), 8.23 (95% CI, 1.07–63.41), 10.07 (95% CI,1.28–78.99), 10.90 (95% CI, 1.35–87.92), 9.71 (95% CI, 1.17–80.87), and 14.32 (95% CI, 1.74–118.02), respectively. In ischemic stroke, hospital volume was associated with 30-day mortality. The HR of the hospitals with a volume within quintile 1 was 1.92 (95% CI, 1.18–3.12) compared with the hospitals with volumes within quintile 5. In the analysis of the association between hospital characteristics and in-hospital mortality for AMI, the results were similar with the results for 30-daymortality.

The characteristic of the funding source, hospital volume, and patient-to-nurse ratio were associated with in-hospital mortality. In hemorrhagic stroke, hospital volume was associated with 7-day, 30-day, and in-hospital mortality. The patient-to-nurse ratio was associated with 7-day mortality, and transfer rate was associated with 30-day and in-hospital mortality. Compared with the reference hospital with a volume within quintile 5, the HRs of the hospitals with volumes within quintiles 1 and 2 were 2.74 (95% CI, 1.71–4.38) and 1.46 (95% CI, 1.00–2.12; p = 0.05) for 7-day mortality. In 30-day mortality, the corresponding HR was 2.74 (95% CI, 1.91–3.93) and 1.40 (95% CI, 1.05–1.87). In in-hospital mortality, the corresponding HR was 2.69 (95% CI, 1.17–3.81) and 1.49 (95% CI, 1.13–1.96). The HR of hospital volume was greater in hemorrhagic stroke and AMI.

In AMI, hospital volume was associated with 7-day, 30-day, and in-hospital mortality. The patient-to-physician ratio was associated with only 7-day mortality. Compared with the reference hospital, which had a volume within quintile 5, the HR of the hospital with a volume within quintile 1 was 1.88 (95% CI, 1.02–3.46) for 7-day mortality. However, the differences with the other hospitals that had volumes within quintile 2, 3, or quintile 4 were not statistically significant. In 30-day mortality, the corresponding HR for the hospitals with volumes within quintile 1 was 1.92 (95% CI, 1.18–3.12). In in-hospital mortality, the corresponding HR for the hospitals with volumes within quintile 1 was 1.88 (95% CI, 1.17–3.01). However, no statistically significant differences were found for the other hospitals with volumes within quintile 2, 3, or 4 in 7-day, 30-day, and in-hospital mortality.

Table 14. Association hospital characteristics and 7-day mortality, stratified by diseases

Hospital Characteristics	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation						
Public	1.48	(0.96-2.28)	1.07	(0.70-1.62)	1.07	(0.65-1.74)
Educational foundation	1.37	(1.00-1.88)	0.87	(0.65-1.17)	1.13	(0.81-1.58)
Private	1.00		1.00		1.00	
Volume of emergent stroke patient						
Quintile 1	1.73	(0.98-3.04)	2.74	(1.71-4.38)	1.88	(1.02-3.46)
Quintile 2	1.52	(0.90-2.57)	1.46	(1.00-2.12)	1.04	(0.55-1.96)
Quintile 3	1.11	(0.63-1.97)	1.36	(0.95-1.96)	0.96	(0.57-1.60)
Quintile 4	0.87	(0.55-1.37)	1.13	(0.79-1.60)	1.02	(0.71-1.46)
Quintile 5	1.00		1.00		1.00	
Proportion of transferred patient to other hospital						
<5%	1.00		1.00		1.00	
5-9%	1.00	(0.68-1.47)	1.37	(0.84-2.22)	1.42	(0.81-2.51)
10-14%	0.81	(0.44-1.49)	0.77	(0.41-1.46)	0.36	(0.09-1.46)
15-19%	0.74	(0.38-1.48)	1.27	(0.79-2.06)	0.81	(0.25-2.65)
≥20%	0.88	(0.42-1.82)	1.36	(0.93-2.00)	1.15	(0.49-2.68)
The number of beds						
Quintile 1	1.01	(0.59-1.73)	1.21	(0.72-2.02)	0.69	(0.36-1.30)
Quintile 2	0.92	(0.57-1.49)	0.84	(0.50-1.41)	0.87	(0.49-1.55)
Quintile 3	0.74	(0.48-1.14)	1.03	(0.66-1.63)	0.98	(0.60-1.59)
Quintile 4	1.15	(0.80-1.66)	1.00	(0.68-1.47)	1.01	(0.65-1.56)
Quintile 5	1.00		1.00		1.00	

Table 14. Association hospital characteristics and 7-day mortality, stratified by diseases *(Continued)*

Hospital Characteristics	**Ischemic Stroke** Adjusted* HR	95% CI	**Hemorrhagic Stroke** Adjusted* HR	95% CI	**Acute Myocardial Infarction** Adjusted* HR	95% CI
The number of beds per one doctor						
2.5:1	0.94	(0.60-1.48)	1.15	(0.77-1.72)	1.62	(1.03-2.56)
3.5:1	0.83	(0.47-1.48)	0.96	(0.58-1.59)	1.12	(0.62-2.02)
5.5:1	0.70	(0.33-1.46)	0.49	(0.25-0.98)	1.22	(0.61-2.44)
8.5:1	0.72	(0.35-1.47)	0.71	(0.37-1.38)	1.01	(0.45-2.24)
>8.5:1						
Ratio of beds per one nurse						
2.0:1	1.00		1.00		1.00	
2.5:1	3.60	(0.44-29.31)	0.36	(0.15-0.87)	1.66	(0.47-5.89)
3.0:1	8.23	(1.07-63.41)	0.46	(0.21-1.00)	2.93	(0.89-9.71)
3.5:1	10.07	(1.28-78.99)	0.53	(0.23-1.20)	2.91	(0.86-9.82)
4.0:1	10.90	(1.35-87.92)	0.41	(0.17-0.98)	2.51	(0.71-8.93)
4.5:1	9.71	(1.17-80.87)	0.33	(0.12-0.91)	2.26	(0.55-9.25)
>6.0:1	14.32	(1.74-118.02)	0.66	(0.26-1.69)	2.80	(0.69-11.25)
Hospital function						
Superior general hospital	1.00		1.00		1.00	
General hospital	0.71	(0.44-1.14)	1.25	(0.88-1.78)	1.12	(0.74-1.70)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table 15. Association hospital characteristics and 30-day mortality, stratified by diseases

Hospital Characteristics	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation						
Public	1.63	(1.18-2.25)	1.07	(0.77-1.48)	1.14	(0.78-1.66)
Educational foundation	1.27	(1.00-1.62)	1.04	(0.84-1.30)	1.21	(0.93-1.57)
Private	1.00		1.00		1.00	
Volume of emergent stroke patient						
Quintile 1	2.03	(1.30-3.16)	2.74	(1.91-3.93)	1.92	(1.18-3.12)
Quintile 2	2.01	(1.34-3.01)	1.40	(1.05-1.87)	1.04	(0.63-1.71)
Quintile 3	1.12	(0.71-1.75)	1.22	(0.92-1.61)	0.87	(0.57-1.34)
Quintile 4	1.11	(0.80-1.56)	1.21	(0.94-1.57)	1.01	(0.75-1.34)
Quintile 5	1.00		1.00		1.00	
Proportion of transferred patient to other hospital						
<5%	1.00		1.00		1.00	
5-9%	1.24	(0.93-1.65)	1.28	(0.87-1.88)	1.31	(0.82-2.11)
10-14%	1.17	(0.77-1.79)	1.02	(0.65-1.58)	0.57	(0.23-1.39)
15-19%	0.99	(0.63-1.56)	1.14	(0.78-1.66)	1.14	(0.49-2.65)
≥20%	1.19	(0.70-2.00)	1.34	(1.00-1.79)	0.90	(0.43-1.86)
The number of beds						
Quintile 1	0.87	(0.57-1.34)	0.98	(0.66-1.45)	0.82	(0.50-1.35)
Quintile 2	0.79	(0.54-1.17)	0.84	(0.57-1.21)	0.89	(0.57-1.40)
Quintile 3	0.74	(0.53-1.03)	0.90	(0.64-1.27)	0.99	(0.67-1.46)
Quintile 4	0.97	(0.72-1.29)	0.97	(0.73-1.28)	1.05	(0.74-1.49)
Quintile 5	1.00		1.00		1.00	

Table 15. Association hospital characteristics and 30-day mortality, stratified by diseases *(Continued)*

Hospital Characteristics	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
The number of beds per one doctor						
2.5:1	1.00		1.00		1.00	
3.5:1	0.96	(0.68-1.36)	1.09	(0.81-1.47)	1.22	(0.87-1.72)
5.5:1	0.86	(0.55-1.35)	1.01	(0.70-1.46)	0.91	(0.57-1.44)
8.5:1	0.73	(0.42-1.28)	0.76	(0.47-1.24)	0.99	(0.58-1.68)
>8.5:1	0.75	(0.43-1.31)	0.89	(0.54-1.44)	0.94	(0.50-1.75)
Ratio of beds per one nurse						
2.0:1	1.00		1.00		1.00	
2.5:1	3.10	(1.03-9.37)	0.65	(0.31-1.39)	1.60	(0.60-4.29)
3.0:1	4.08	(1.38-12.08)	0.77	(0.37-1.60)	2.15	(0.79-5.82)
3.5:1	4.35	(1.44-13.16)	0.82	(0.38-1.74)	2.62	(0.95-7.22)
4.0:1	4.54	(1.45-14.19)	0.68	(0.31-1.49)	1.89	(0.65-5.46)
4.5:1	3.73	(1.15-12.09)	0.69	(0.30-1.60)	1.76	(0.55-5.68)
>6.0:1	5.37	(1.68-17.20)	0.96	(0.42-2.18)	2.40	(0.78-7.39)
Hospital function						
Superior general hospital	1.00		1.00		1.00	
General hospital	0.75	(0.52-1.09)	1.28	(0.99-1.66)	1.30	(0.85-1.98)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table 16. Association hospital characteristics and in-hospital mortality, stratified by diseases

Hospital Characteristics	Ischemic Stroke		Hemorrhagic Stroke		Acute Myocardial Infarction	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation						
Public	1.51	(1.11-2.07)	1.08	(0.79-1.46)	1.10	(0.76-1.60)
Educational foundation	1.19	(0.94-1.50)	1.04	(0.85-1.28)	1.20	(0.93-1.55)
Private	1.00		1.00		1.00	
Volume of emergent stroke patient						
Quintile 1	1.85	(1.21-2.83)	2.69	(1.90-3.81)	1.88	(1.17-3.01)
Quintile 2	1.98	(1.35-2.90)	1.49	(1.13-1.96)	1.06	(0.66-1.73)
Quintile 3	1.14	(0.75-1.74)	1.19	(0.91-1.56)	0.88	(0.58-1.33)
Quintile 4	1.16	(0.85-1.59)	1.24	(0.97-1.59)	0.96	(0.73-1.28)
Quintile 5	1.00		1.00		1.00	
Proportion of transferred patient to other hospital						
<5%	1.00		1.00		1.00	
5-9%	1.21	(0.92-1.59)	1.40	(0.98-2.02)	1.25	(0.78-2.00)
10-14%	1.03	(0.68-1.56)	1.08	(0.71-1.64)	0.67	(0.29-1.53)
15-19%	0.96	(0.62-1.49)	1.20	(0.84-1.71)	1.12	(0.48-2.59)
≥20%	1.05	(0.63-1.77)	1.31	(1.00-1.74)	1.02	(0.53-1.96)
The number of beds						
Quintile 1	0.95	(0.64-1.43)	1.03	(0.71-1.50)	0.82	(0.50-1.33)
Quintile 2	0.83	(0.57-1.20)	0.85	(0.59-1.21)	0.99	(0.64-1.52)
Quintile 3	0.77	(0.56-1.06)	0.97	(0.71-1.34)	0.95	(0.65-1.39)
Quintile 4	0.99	(0.75-1.31)	0.96	(0.73-1.25)	1.04	(0.74-1.47)
Quintile 5	1.00		1.00		1.00	

Table 16. Association hospital characteristics and in-hospital mortality, stratified by diseases *(Continued)*

Hospital Characteristics	**Ischemic Stroke** Adjusted* HR	95% CI	**Hemorrhagic Stroke** Adjusted* HR	95% CI	**Acute Myocardial Infarction** Adjusted* HR	95% CI
The number of beds per one doctor						
2.5:1	1.00		1.00		1.00	
3.5:1	1.02	(0.73-1.43)	1.11	(0.84-1.49)	1.20	(0.86-1.66)
5.5:1	0.93	(0.60-1.43)	1.03	(0.72-1.47)	0.86	(0.55-1.35)
8.5:1	0.74	(0.43-1.27)	0.75	(0.47-1.19)	0.93	(0.56-1.56)
>8.5:1	0.82	(0.48-1.40)	0.93	(0.59-1.49)	0.94	(0.51-1.72)
Ratio of beds per one nurse						
2.0:1	1.00		1.00		1.00	
2.5:1	2.48	(0.90-6.84)	0.66	(0.32-1.35)	1.39	(0.56-3.47)
3.0:1	3.26	(1.21-8.81)	0.77	(0.38-1.55)	1.75	(0.69-4.41)
3.5:1	3.57	(1.30-9.84)	0.83	(0.40-1.71)	2.32	(0.91-5.96)
4.0:1	3.77	(1.33-10.72)	0.72	(0.34-1.53)	1.62	(0.6-4.37)
4.5:1	3.09	(1.05-9.12)	0.71	(0.32-1.59)	1.62	(0.55-4.81)
>6.0:1	4.36	(1.50-12.66)	0.98	(0.45-2.14)	1.87	(0.66-5.36)
Hospital function						
Superior general hospital	1.00		1.00		1.00	
General hospital	0.74	(0.52-1.05)	1.20	(0.88-1.63)	1.34	(0.89-2.03)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

(4) The model fitness to identify powerful factors

This study was performed with multilevel logistic regression divided into 4 models. Model 1 was a null model, model 2 was adjusted for patient characteristics, model 3 was adjusted for patient and treatment characteristics, and model 4 was adjusted for patient, treatment, and hospital characteristics. Table 17 shows the model fitness stratified according to disease.

In ischemic stroke, the AIC score was 2247.35 for model 1, 2206.19 for model 2, 1983.62 for model 3, and 1991.05 for model 4. The best model fitness for 7-day mortality was model 3, which was adjusted for patient and treatment characteristics. The treatment factors were significant factors that affected 7-day mortality in ischemic stroke. For 30-day mortality, the best model fitness was model 3 and the treatment factors were significant. For in-hospital mortality, the best model was model. However, the patient factors significantly affected in-hospital mortality.

In hemorrhagic stroke, the best model was the full model of model 4 for 7-day mortality. The AIC score of the null model of model 1 was 1925.15, 1896.22 for model 2, 1864.78 for model 3, and 1862.36 for model 4. However, the difference in AIC score was the greatest in model 4. The treatment factor significantly affected 7-day mortality in hemorrhagic stroke. For 30-day and in-hospital mortality, the best model was model 4 and the treatment factors significantly affected 30-day mortality.

In AMI, the AIC scores of the null model of model 1 were 1943.49. The AIC scores of models 2, 3, and 4 were 1972.49, 1698.65, and 1709.99, respectively, for 7-day mortality. The best model was model 3 for 7-day mortality in AMI. The patient factors significantly affected 7-day mortality in AMI. For 30-day and in-hospital mortality, the best model fitness was model 3 and the patient factors significantly affected 30-day and in-hospital mortality in AMI.

Table 17. Model fitness for mortality from calculating of multilevel logistic regression, stratified by diseases

		Ischemic Stroke			Hemorrhagic Stroke			Acute Myocardial Infarction		
		N	AIC	-2LL statistics, χ^2 (p-value)	N	AIC	-2LL statistics, χ^2 (p-value)	N	AIC	-2LL statistics, χ^2 (p-value)
7-day mortality	Model 1	7,693	2247.35	2195.63 (0.1094)	2,828	1925.15	1830.86 (0.008)	4,916	1943.49	1908.56 (0.1460)
	Model 2	7,693	2206.19	2132.95 (0.2061)	2,828	1896.22	1776.70 (0.020)	4,916	1762.49	1687.61 (0.1214)
	Model 3	7,693	1983.62	1901.42 (0.2099)	2,828	1864.78	1724.22 (0.0125)	4,916	1698.65	1616.58 (0.1223)
	Model 4	7,693	1991.05	1886.05 (0.4414)	2,828	1862.36	1688.37 (0.0269)	4,916	1709.99	1611.99 (.)
30-day mortality	Model 1	7,693	1991.05	1886.05 (0.4414)	2,828	2702.43	2633.42 (0.0289)	4,916	2649.98	2592.59 (0.0679)
	Model 2	7,693	3363.95	3264.08 (0.0088)	2,828	2638.99	2545.69 (0.0694)	4,916	2375.05	2295.49 (0.1102)
	Model 3	7,693	3274.00	3143.68 (0.0124)	2,828	2574.21	2465.43 (0.0577)	4,916	2239.73	2153.27 (0.1047)
	Model 4	7,693	2885.69	2779.51 (0.0812)	2,828	2575.38	2436.76 (0.1406)	4,916	2241.18	2143.18 (.)
In-hospital mortality	Model 1	7,693	3686.57	2565.05 (0.0033)	2,828	2834.78	2752.73 (0.0175)	4,916	2762.49	2675.93 (0.0219)
	Model 2	7,693	3262.35	3419.02 (0.0067)	2,828	2762.24	2663.24 (0.0616)	4,916	2470.7	2369.23 (0.0434)
	Model 3	7,693	3091.10	2975.86 (0.0617)	2,828	2684.84	2570.48 (0.0526)	4,916	2316.31	2211.62 (0.0494)
	Model 4	7,693	3100.48	2982.47 (0.3128)	2,828	2683.23	2549.73 (0.1880)	4,916	2324.22	2219.61 (0.4478)

Model 1: null model
Model 2: adjusted for patient characteristics.
Model 3: adjusted for patient characteristics and treatment characteristics.
Model 4: adjusted for patient characteristics, treatment characteristics and hospital characteristics.

4. Summary of Main Findings

Table 18 presents a summary of the factors that affected 7-day, 30-day, and in-hospital mortality in ischemic stroke, AMI, and hemorrhagic stroke. In all three conditions, regardless of 7-day, 30-day, and in-hospital mortality, the patients were younger and the risk of mortality was lower. Compared with the women, the men had lower risk of mortality after controlling for all covariates. The association between individual household income and 7-day mortality was not statistically significant for stroke. As length of stay was longer, the risks of 30-day and in-hospital mortality were increased for the low-income patients compared with the reference group, which was composed of high income earners. In AMI, regardless of 7-day, 30-day, and in-hospital mortality, the association between individual household income and mortality was not statistically significant. The risk of mortality tended to gradually increase as the CCI increased in hemorrhagic stroke. Especially in the analysis of 7-day mortality, the adjusted HR was 1.53 (95% CI, 1.01–2.34) for the patients with CCIs of >6, relative with patients who had CCIs of 0 or 1. For 30-day and in-hospital mortality, the adjusted HRs were 1.38 (95% CI, 1.01–1.89) and 1.39 (95% CI, 1.04–1.88), respectively. The risk of mortality in relation to CCI was highest for 7-day mortality. In ischemic stroke and AMI, the risk of mortality tended to gradually increase as CCI increased, but

Table 18. Summary factors that affect 7-day, 30-day and in-hospital mortality in ischemic stroke, hemorrhagic stroke and AMI

	Patient characteristics			**Treatment characteristics**			**Hospital characteristics**		
	Ischemic stroke	Hemorrhagic stroke	Acute myocardial infarction	Ischemic stroke	Hemorrhagic stroke	Acute myocardial infarction	Ischemic stroke	Hemorrhagic stroke	Acute myocardial infarction
7-day mortality	age sex income	Age CCI diabetes	age hypertension	use of ICU service,	administration of mannitol	use of ICU, PCI	characteristic of funding source, the number of patients per one nurse	hospital volume, the number of patients per one doctor the number of patients per one nurse	the number of patients per one doctor
30-day mortality	age sex income hypertension disability	Age CCI diabetes, health insurance type disability	age hypertension diabetes	use of ICU,	use of ICU, administration of mannitol	use of ICU, PCI, weekend admission	characteristic of funding source, the number of patients per one nurse, hospital volume	hospital volume, transferred rate	hospital volume
In-hospital mortality	age sex income hypertension disability	age health insurance CCI hypertension disability sex	age hypertension	use of ICU,	use of ICU, administration of mannitol	use of ICU, PCI, weekend admission	characteristic of funding source, hospital volume, the number of patients per one nurse	hospital volume, transferred rate	hospital volume

the difference was not statistically significant. In the analysis of the association between mortality and the major risk factors that affected the occurrence of stroke and AMI, in ischemic and hemorrhagic stroke, the association between 7-day mortality and hypertensive patients with/without hypertensive complication was not statistically significant, compared with the patients without hypertension. However, the risk of mortality increased for the patients who had hypertension with/without hypertensive complication in 30-day and in-hospital mortality. Diabetes mellitus and dyslipidemia were not significant factors of mortality in stroke. By contrast, the risks of 7-day, 30-day, and in-hospital mortality were lower for the patients who had hypertension with/without hypertensive than for those who did not have hypertension. However, the risk of mortality was higher for the patients who had diabetes mellitus without diabetic complications than for those who did not have diabetes. The pattern was the same for the patients who had diabetes mellitus with diabetic complications, but the difference was not significant.

Excluding 7-day mortality in ischemic stroke, the risks of 7-day, 30-day, and in-hospital mortality in all three diseases were higher for the patients admitted to the intensive care unit than for those not admitted to the intensive care unit. In AMI, the risk of 7-day, 30-day, and in-hospital mortality was higher for the patient who did not receive percutaneous coronary intervention (PCI) than for those who received PCI. The risk of the patients who received PCI was consistently low for 7-day, 30-day, and in-hospital mortality relative to those who did not receive PCI. In addition, the HR for 30-day mortality was higher for the patients admitted on a weekend than for those admitted on a weekday. In ischemic stroke, the association between weekend admission and mortality was not statistically significant. However, in the analysis of the subset group, stratified according to patients admitted to a superior general hospital and those admitted to a general hospital, the HR of weekend admission was higher than that of weekday admission for the patients admitted to a superior general hospital (Appendix A1-Appendix C3). In hemorrhagic stroke, the risk of 7-day, 30-day, and in-hospital mortality was higher for the patients who received than for those who did not receive mannitol. The risk of mortality decreased as the length of hospital stay increased.

In ischemic stroke, the risk of mortality was higher for the patients whose health-care providers had a public source of funding than for those whose health-care providers had a private source of funding. The risk of mortality tended to increase as the patient-to-nurse ratio increased. In AMI and hemorrhagic stroke, the risk of mortality was higher for the patients whose health-care providers had a volume within quintile 1 or 2 than for the patients whose health-care providers had a volume within quintile 5. However, after excluding health-care providers with a patient-to-nurse ratio of 3.5:1 or 6.0:1, the risk of mortality was decreased as the patient-to-nurse ratio increased in hemorrhagic stroke. In the analysis of the association between hospital characteristics and 30-day mortality, the risk of 30-day mortality was higher for the patients whose health-care providers had a volume within quintile 1 or 2 than for those whose health-care providers had a volume within quintile 5. These results showed a similar pattern for all three diseases. In addition, the risk of mortality tended to increase as the proportion of patients transferred to another hospital increased. However, this was statistically significant only for the hospitals with a transfer rate of >20%. In ischemic stroke, the dose-response relationship tended to increase the risk of 30-day mortality gradually as the patient-to-nurse ratio increased (p for trend < 0.0001). In the analysis of the association between the hospital characteristics and in-hospital mortality, the association showed a similar pattern with that found in an analysis of results between hospital characteristics and 30-day mortality. As the hospital volume increased, the risk of mortality decreased for all three diseases. The transfer rate to another hospital was associated with mortality in hemorrhagic stroke, and the patient-to-nurse ratio and characteristic of funding source were associated with mortality.

V. Discussion

1. Discussion of Study Methods

This study examined the associations of patient, treatment, and hospital characteristics with in-hospital mortality by applying an algebra effectiveness model by using representative nationwide cohort data. Some issues could be raised related with the study methods.

First was an issue related to data source. These data were extracted from a national health insurance claims database from 2002 to 2013. These subjects represent a stratified random sample selected according to age, sex, region, health insurance type, income quintile, and individual total medical cost based on the year 2002. These data were not from a representative organization. Therefore, the definitions of the hospital characteristics could not be generalized.

Second was the selection of the study sample. The study data were obtained from a claims database. To determine the study sample, we used ICD-10 code as primary diagnostic criteria. The diagnostic accuracy in the KNHI claims data is roughly 70%[70]. Although this study tried to identify throughout real patients by using medication and clinical test information, the diagnostic accuracy might have been compromised in the study. In addition, to identify history of hypertension, diabetes, and dyslipidemia as main risk factors that affect stroke and AMI, this study used only billing information claimed before the stroke and AMI episode.

2. Discussion of Study Results

Comparing a cumulative mortality according to diseases, in early stage within 20 days, the cumulative mortality was the highest in hemorrhagic stroke. The cumulative mortality had started to increase since 20 days in AMI, and 6-month cumulative mortality was almost 70%. In contrast, the cumulative mortality of hemorrhagic stroke was the highest within 20 days, the cumulative mortality became steady since 30 days passed, and 6-month cumulative mortality was the lowest in all three diseases. In the case of ischemic stroke, the cumulative mortality was the lowest within 120 days. The cumulative mortality of hemorrhagic stroke was the highest after 120 days passed. And 6-month cumulative mortality was almost the same in ischemic stroke and hemorrhagic stroke. The cumulative mortality of early stage within 20 days was high in hemorrhagic stroke and AMI. All three diseases need specialized interventions. Especially, hemorrhagic stroke and AMI need specific interventions such as PCI or craniotomy and available personal sources that can do these specific interventions. On the other hand, the proportion of patients who needed percutaneous cerebrovascular intervention is small than those of patients with the other two conditions. Most cases of ischemic stroke can be controlled by medications such as thrombolytic agents. These features of the aforementioned diseases likely led to this result. The cumulative mortality in hemorrhagic stroke was steady as the length of hospital stay exceeded 40 days. Of the hemorrhagic stroke patients, those who had a severe stroke died in the early stage. Thereafter, the cumulative mortality was likely steady. By contrast, early cumulative mortality in ischemic stroke was relatively lower than those of the other two diseases but tended to increased steadily. In case of AMI, early cumulative mortality was high and the cumulative mortality increased sharply over time. A previous study found that the acute case-fatality of stroke was about 15%, but that of AMI ranged from 34% to 43%[71]. Acute case-fatality was higher in AMI than in stroke. Considering these results, in the case of hemorrhagic stroke, acute care is likely to be relatively more important than long-term care. In the case of ischemic stroke, anything is not more important than acute care and long-term care, but overall care is important throughout the hospitalization period. In the case of AMI, the 6-month cumulative mortality was almost two-fold higher than those in the other two diseases and length of hospital stay was relatively short. This showed that acute and long-term care was both important.

In the analysis of the association between patient characteristics and mortality, diabetes and dyslipidemia were not statistically significant factors of stroke. However, the risk of mortality was higher for the patients with than for those without hypertension. Previous studies found that the population-attributable risk (PAR) of hypertension was 22.7%–28.5%, but the PAR of diabetes was 14.6%[72]. The difference was >10%. Our results were consistent with those of previous studies that showed that the PAR of hypertension was higher than the PAR of stroke in diabetes. The PAR of diabetes was 5%[73] and that of hypertension was 25% for AMI. The PAR of hypertension was higher than that of diabetes. Our results showed that the risk of mortality was lower for the patients with than for those without hypertension, and the risk of mortality in AMI was higher for the patients with than for those without diabetes. As we used claims data, we could identify whether patients had hypertension/diabetes, but we could not consider medication compliance. In addition, we defined patients without hypertension or diabetes who had never claimed I10-I14 and E11-E14 of the *ICD-10* codes. We could not distinguish among these patients those who did not have hypertension or diabetes, or those with undiagnosed hypertension or diabetes. AMI is a more common disease than stoke and occurs easily in young people. In Korea, according to the report of the Korean National Nutrition and Health Examination, the perception and treatment rates of hypertension or diabetes are low for young people[74]. Therefore, patients without hypertension or diabetes might include patients who do not recognize their diseases. We could not consider the dynamic interaction of all three conditions according to medication compliance. In 7-day mortality, clinical factors were associated with mortality in ischemic and hemorrhagic strokes. Non-clinical factors such as health insurance type and individual household income were associated with 30-day and in-hospital mortality. The effects of the non-clinical factors were demonstrated in the intermediate and long-term mortality. Previous studies found that the predictors of stroke included recurrent stroke, increased ICT, increased mass effect and size of lesion, or new onset of AMI or aspiration pneumonia during hospital day[75-77]. Age, heart rate, systolic pressure, presentation after cardiac arrest, presentation in cardiogenic shock, heart failure, presentation with ST-segment elevation myocardial infarction, creatinine clearance, and troponin ratio were associated with acute mortality[78-81]. Patient's physical condition is more important in short-term mortality than the use of available resources[82]. In the case of an unstable phase of the patient's physical condition, patient's clinical factors were associated with mortality. However, patient's condition became stable over time. From the stable phase, access to costly medication, treatment, and advanced care might differ according to health insurance coverage and individual household income[83,84].

The HR of mortality was higher for the patients admitted to the intensive care unit than for those who were not in all three diseases. Admission in the intensive care unit might proxy for disease severity itself. However, the risk of mortality among the patients admitted to the intensive care unit was highest in ischemic stroke, followed by AMI, and the lowest in hemorrhagic stroke. The admission rate to the intensive care unit was 13% in ischemic stroke, approximately 60% in AMI, and 80% in hemorrhagic stroke. The difference in admission rate between the patients admitted to the intensive care unit and those who were not was the greatest in ischemic stroke, followed by AMI and then hemorrhagic stroke. We thought the difference likely reflects the difference in disease severity between the two patient groups. Performing PCI reduced the risk of mortality in AMI[85]. PCI was one of the most important processes. Moreover, considering that the cumulative mortality was the greatest of all three conditions, performing PCI was the most effective way of reducing the risk of mortality. For the patients admitted to a superior general hospital because of ischemic stroke and AMI, we could observe the weekend effect. Especially in the case of AMI, if we consider that performing PCI could decrease the risk of mortality, the availability of personal resources that can perform a PCI during a weekend or holiday might be a critical factor.

In case of ischemic stroke, the risk of mortality was higher for the patients admitted to hospitals with public sources of funding or to hospitals with sources of funding for educational purposes than for those admitted to hospitals with private funding. The hospitals with public funding tended to be weaker financially than the other hospitals, which leads to poor quality of care[86]. We observed a steady increase in cumulative mortality regardless of an acute or chronic phase. Our findings suggest that the overall hospital quality was more important during the whole admission period relative to the other factors of ischemic stroke. Hospitals with private funding are likely to invest in improving quality of care. Therefore, considering the characteristic of ischemic stroke, we thought that the characteristic of funding sources is associated with mortality. The patient-to-nurse ratio was associated with mortality in ischemic stroke. We thought this variable was likely to represent the overall quality of care provided by hospitals. AMI and hemorrhagic stroke are diseases that need specialized techniques such as PCI or craniotomy. In these two diseases, hospital volume and transfer rate to another hospital were associated with mortality. This finding was consistent with those of previous studies[87-90]. In addition, in the case of AMI, the patient-to-physician ratio was associated with mortality for some groups. Considering these results, we think organizational or individual competence might be a critical factor. In hemorrhagic stroke, the patient-to-nurse or physician ratio was greater, but the hazard ratio was smaller. This finding contradicts the general idea. Thus, this study performed two tests to resolve the issues that led to these results. The first test excluded patients who died within 7 days to analyze the risk of 30-day mortality and patients who died within 30 days to analyze the risk of in-hospital mortality. The results of this analysis are presented in Appendixes D1–D3. In addition, considering that patients with severe illnesses tend to visit a superior hospital, another analysis was performed to improve the homogeneity of the study population in terms of disease severity only for hospitals that had volumes within the fourth or fifth quintile in terms of total beds. The results of this analysis are presented in Appendixes E1–E3. After adjusting for the hospital size, although the difference was not statistically significant among all the groups, we identified greater volume, more physicians, and more nurses to be associated with reduced risk of mortality. However, in hemorrhagic stroke, the results indicated that the risk of mortality decreased as the number of nurses decreased. We examined the proportion of patients with severe conditions according to the ratio of beds per nurse (Appendix F). The proportion of patients with severe conditions was highest in the group with a 2.0:1 ratio.

3. Implication of Study

Hypertension, diabetes, and dyslipidemia were associated with increased risk of mortality in stroke and AMI. These factors are preventable; thus, policies should focus on primary prevention by changing to healthy lifestyles. In AMI, performing PCI was strongly associated with reduced risk of mortality. Considering this finding, change of the standard for pay for performance is needed from the rate of performing PCI within 90 minutes to the number of experts who can provide PCI effectively. There is inequality in the number of experts who can provide PCI according to region. Therefore, regarding this problem, training programs and providing equal numbers of experts should be implemented at the national level. In addition, the risk of mortality varied according to day of admission. The standard of hospital accreditation should be set to identify which health-care system can provided consistent care regardless of day of admission. In hemorrhagic stroke, only 7 quality indicators have been currently used. To evaluate quality of hemorrhagic care, development of quality indicators might be needed. In AMI and hemorrhagic stroke, which individual/organizational competence is more important than organizational structures should be identified and a central system for sharing information such as the lists of medical institutions that can manage these diseases will be needed. This was can be a realistic plan for managing patients with these diseases.

4. Limitation of Study

With regard to patients who did not make claims for hypertension, diabetes, and dyslipidemia, they might be real individuals who did not have hypertension, diabetes, and dyslipidemia, or might have undiagnosed hypertension, diabetes, and dyslipidemia. Patients without billing information for hypertension, diabetes, and dyslipidemia could be mixed.

In defining dependent variables, this study determined the death date by examining whether the patient received discharge medication and/or used medical services after discharge. Although the death date month/year and the discharge date month/year were identical, it is possible that some patients were discharged against medical advice, did not take discharge medication, and did not use medical services after discharge.

Furthermore, in stroke and AMI, prehospital intervention is one of the most important factors. However, this study could not consider prehospital intervention because this study used claims data. This study did not include patients who died on arrival because they did not use hospital services. Thus, this study could not include patients with DOA (death on arrival). To measure disease severity, although this study considered use of intensive care unit service and intervention, it could not consider stroke severity and AMI severity such as location of a blocked coronary artery and the number of blocked arteries. However, this study tried to adjust for patient age, comorbid conditions by using the CCI, and medical/surgical intervention, which are also important to adjust for disease complexity. Finally, because this study was an observation study, unmeasured bias might be present.

Despite these limitations, this study used a representative data and included all data on all-cause mortality. This study used socioeconomic status, which could affect mortality, unlike studies that used administrative data. Finally, this study used a robust study design and Cox's proportional hazard frailty model to investigate factors at the individual, treatment, and hospital levels that could impact mortality.

Ⅵ. Conclusion

This study evaluated the factors that affected 7-day (acute), 30-day (sub-acute), and in-hospital (latent) mortality in patients with ischemic and hemorrhagic stroke, and acute myocardial infarction using algebra effectiveness model. After adjusting for all independent variables including patient characteristics, treatment characteristics and hospital characteristics, in terms of patient's factors, clinical factors such as age, sex, hypertension, and diabetes was associated with 7-day mortality among patients with all three diseases, and non-clinical factors such as individual household income and health insurance type was associated with 30-day and in-hospital mortality. In terms of treatment factors, performing PCI was associated with reducing the risk of 7-day, 30-day and in-hospital mortality in AMI. Use of intensive care unit and weekend admission was associated with increasing the risk of mortality in ischemic stroke and AMI. In hemorrhagic stroke, the risk of mortality was higher for receiving of surgical intervention than receiving of medical intervention. In hospital factors, the ratio of number of patient per one nurse was associated with mortality in ischemic stroke. The volume was associated with mortality in all three diseases, and the transferred rate was associated with mortality in hemorrhagic stroke. This study's findings suggested that we need policies that focus on primary prevention to change to patients' healthy life style. To secure experts, we need policies that can supply experts and train the experts at national level who can perform intervention such as PCI. In case of diseases that organizational and hospital staff's competence is important, an introduction of system is needed that can share the list of organization which can manage patients with these diseases between institutions.

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Appendix

Appendix A. Results for association between patient characteristics and 7-day, 30-day and in-hospital mortality from Cox's proportional hazard frailty model, stratified by hospital function (Table A1-Table A3)

Appendix B. Results for association between treatment characteristics and 7-day, 30-day and in-hospital mortality from Cox's proportional hazard frailty model, stratified by hospital function (Table B1-Table B3)

Appendix C. Results for association between hospital characteristics and 7-day, 30-day and in-hospital mortality from Cox's proportional hazard frailty model, stratified by hospital function (Table C1-Table C3)

Appendix D. Results for association between patient characteristics, treatment characteristics and hospital characteristics, and 30-day mortality form Cox's proportional hazard frailty model except patients who were dead within 7-day, stratified by diseases (Table D1-Table D3)

Appendix E. Results for association between patient characteristics, treatment characteristics and hospital characteristics, and in-hospital mortality form Cox's proportional hazard frailty model except patients who were dead within 30-day, stratified by diseases (Table E1-Table E3)

Appendix F. Results for association between patient characteristics, treatment characteristics, and hospital characteristics and mortality form Cox's proportional hazard frailty model in patient with ischemic stroke who utilized 4th quintile of hospital size and 5th quintile of hospital size (Table F1-Table F3)

Appendix G. The proportion of patient who received intervention to reduce ICP, according to the ratio of patients per one nurse/doctor in hemorrhagic stroke

Table A1-1. Adjusted hazard ratio for association between patient characteristics and 7-day mortality in ischemic stroke, stratified by hospital function

	Superior General Hospital		**General Hospital**	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.34	(0.05-2.50)	-	
40-49	0.52	(0.20-1.34)	0.33	(0.10-1.08)
50-59	0.51	(0.25-1.02)	0.47	(0.24-0.93)
60-69	0.58	(0.36-0.93)	0.58	(0.36-0.91)
≥70	1.00		1.00	
Sex				
Male	0.79	(0.54-1.16)	0.67	(0.47-0.96)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.71	(0.28-1.81)	1.07	(0.47-2.41)
Individual household income				
Low	1.50	(0.91-2.48)	0.90	(0.57-1.44)
Middle	1.53	(0.98-2.39)	1.29	(0.87-1.91)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	0.94	(0.60-1.47)	0.99	(0.67-1.47)
Rural	0.81	(0.47-1.40)	1.13	(0.66-1.93)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	0.83	(0.47-1.47)	1.37	(0.85-2.21)
4-5	1.11	(0.60-2.06)	1.50	(0.88-2.57)
>5	1.86	(0.98-3.54)	1.19	(0.64-2.21)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	1.27	(0.72-2.23)	1.08	(0.67-1.74)
With hypertensive complication	1.50	(0.78-2.87)	1.42	(0.81-2.49)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	0.98	(0.59-1.62)	1.16	(0.76-1.78)
With diabetic complication	1.05	(0.63-1.73)	0.77	(0.48-1.25)
Dyslipidemia				
No	1.00		1.00	
Yes	0.89	(0.57-1.39)	0.81	(0.55-1.19)
Disability				
None	1.00		1.00	
Mild	0.86	(0.48-1.54)	1.35	(0.83-2.21)
Severe	0.75	(0.34-1.64)	0.65	(0.33-1.25)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics

Table A1-2. Adjusted hazard ratio for association between patient characteristics and 7-day mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.49	(0.21-1.15)	0.55	(0.23-1.31)
40-49	0.70	(0.40-1.24)	0.69	(0.42-1.13)
50-59	0.88	(0.54-1.43)	0.54	(0.35-0.85)
60-69	0.50	(0.31-0.83)	0.60	(0.40-0.90)
≥70	1.00		1.00	
Sex				
Male	1.01	(0.71-1.43)	1.26	(0.92-1.71)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.42	(0.16-1.11)	1.02	(0.50-2.10)
Individual household income				
Low	1.18	(0.77-1.82)	0.96	(0.63-1.45)
Middle	0.90	(0.60-1.36)	1.02	(0.72-1.46)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	0.69	(0.46-1.03)	1.05	(0.74-1.50)
Rural	0.90	(0.54-1.51)	1.02	(0.63-1.65)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	1.11	(0.70-1.75)	1.17	(0.78-1.75)
4-5	1.22	(0.66-2.27)	1.55	(0.96-2.49)
>5	3.27	(1.76-6.06)	1.63	(0.96-2.77)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	0.69	(0.44-1.07)	1.12	(0.77-1.64)
With hypertensive complication	1.02	(0.57-1.81)	1.36	(0.84-2.21)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	0.88	(0.52-1.50)	1.45	(0.94-2.25)
With diabetic complication	1.47	(0.84-2.56)	1.80	(1.11-2.92)
Dyslipidemia				
No	1.00		1.00	
Yes	0.85	(0.54-1.32)	0.76	(0.52-1.12)
Disability				
None	1.00		1.00	
Mild	0.84	(0.46-1.53)	1.12	(0.72-1.76)
Severe	1.05	(0.61-1.82)	0.46	(0.26-0.83)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table A1-3. Adjusted hazard ratio for association between patient characteristics and 7-day mortality in acute myocardial infarction, stratified to hospital function

	Superior General Hospital		**General Hospital**	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.43	(0.06-3.25)	0.42	(0.10-1.81)
40-49	0.18	(0.04-0.77)	0.13	(0.03-0.57)
50-59	0.47	(0.25-0.91)	0.56	(0.28-1.09)
60-69	0.66	(0.42-1.06)	0.62	(0.37-1.04)
≥70	1.00		1.00	
Sex				
Male	1.11	(0.74-1.66)	0.84	(0.57-1.25)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	1.07	(0.30-3.77)	0.43	(0.13-1.46)
Individual household income				
Low	1.14	(0.63-2.07)	1.14	(0.67-1.92)
Middle	1.05	(0.68-1.62)	0.83	(0.54-1.27)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	0.72	(0.45-1.14)	0.93	(0.62-1.40)
Rural	1.18	(0.69-2.01)	0.95	(0.50-1.82)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	0.80	(0.45-1.40)	1.28	(0.65-2.51)
4-5	0.95	(0.51-1.77)	2.38	(1.20-4.69)
>5	0.85	(0.42-1.72)	2.14	(1.01-4.57)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	0.83	(0.49-1.42)	0.48	(0.29-0.81)
With hypertensive complication	0.90	(0.48-1.68)	0.43	(0.24-0.79)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	1.69	(1.02-2.79)	1.17	(0.72-1.90)
With diabetic complication	1.80	(1.10-2.97)	0.96	(0.59-1.58)
Dyslipidemia				
No	1.00		1.00	
Yes	0.73	(0.47-1.15)	0.82	(0.53-1.27)
Disability				
None	1.00		1.00	
Mild	0.78	(0.38-1.57)	0.79	(0.43-1.43)
Severe	1.27	(0.63-2.57)	1.39	(0.73-2.65)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics

Table A2-1. Adjusted hazard ratio for association between patient characteristics and 30-day mortality in ischemic stroke, stratified by hospital function

Patient Characteristics	Superior General Hospital		General Hospital	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.48	(0.15-1.58)	-	-
40-49	0.42	(0.19-0.92)	0.29	(0.12-0.72)
50-59	0.45	(0.25-0.80)	0.45	(0.27-0.76)
60-69	0.72	(0.51-1.02)	0.59	(0.42-0.83)
≥70	1.00		1.00	
Sex				
Male	0.83	(0.62-1.11)	0.75	(0.57-0.98)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.79	(0.37-1.68)	1.51	(0.78-2.94)
Individual household income				
Low	1.29	(0.87-1.90)	1.26	(0.90-1.78)
Middle	1.27	(0.91-1.77)	1.47	(1.09-1.99)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	1.29	(0.93-1.81)	1.00	(0.74-1.35)
Rural	0.97	(0.63-1.49)	1.21	(0.81-1.81)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	0.77	(0.50-1.20)	1.14	(0.79-1.62)
4-5	1.19	(0.76-1.89)	1.23	(0.82-1.84)
>5	1.55	(0.95-2.53)	1.08	(0.68-1.71)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	1.19	(0.77-1.85)	1.07	(0.75-1.54)
With hypertensive complication	1.58	(0.96-2.59)	1.32	(0.86-2.05)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	0.92	(0.63-1.33)	1.00	(0.71-1.40)
With diabetic complication	0.91	(0.62-1.34)	0.98	(0.69-1.40)
Dyslipidemia				
No	1.00		1.00	
Yes	0.99	(0.70-1.39)	0.75	(0.56-1.01)
Disability				
None	1.00		1.00	
Mild	0.68	(0.43-1.09)	1.06	(0.71-1.58)
Severe	0.60	(0.33-1.09)	0.62	(0.38-1.01)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table A2-2. Adjusted hazard ratio for association between patient characteristics and 30-day mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.62	(0.34-1.14)	0.58	(0.32-1.07)
40-49	0.67	(0.43-1.03)	0.65	(0.45-0.95)
50-59	0.87	(0.60-1.27)	0.59	(0.42-0.81)
60-69	0.62	(0.43-0.89)	0.55	(0.40-0.76)
≥70	1.00		1.00	
Sex				
Male	1.03	(0.79-1.34)	1.27	(1.00-1.60)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.29	(0.11-0.73)	0.79	(0.44-1.43)
Individual household income				
Low	1.08	(0.78-1.49)	1.00	(0.73-1.36)
Middle	0.81	(0.59-1.11)	1.08	(0.83-1.42)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	0.73	(0.54-0.99)	0.97	(0.75-1.26)
Rural	0.66	(0.43-1.02)	0.96	(0.67-1.37)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	1.00	(0.71-1.42)	1.03	(0.76-1.39)
4-5	1.19	(0.75-1.87)	1.42	(0.98-2.04)
>5	2.76	(1.73-4.41)	1.69	(1.12-2.53)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	0.88	(0.63-1.22)	1.19	(0.90-1.59)
With hypertensive complication	1.18	(0.76-1.82)	1.33	(0.91-1.94)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	0.92	(0.62-1.37)	1.15	(0.81-1.64)
With diabetic complication	1.55	(1.02-2.35)	1.65	(1.13-2.40)
Dyslipidemia				
No	1.00		1.00	
Yes	0.85	(0.61-1.19)	0.81	(0.60-1.08)
Disability				
None	1.00		1.00	
Mild	0.85	(0.54-1.34)	0.91	(0.63-1.31)
Severe	0.75	(0.48-1.17)	0.51	(0.34-0.79)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table A2-3. Adjusted hazard ratio for association between patient characteristics and 30-day mortality in acute myocardial infarction, stratified by hospital function

Patient Characteristics	Superior General Hospital		General Hospital	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.28	(0.04-2.10)	0.47	(0.14-1.57)
40-49	0.20	(0.06-0.65)	0.16	(0.05-0.52)
50-59	0.44	(0.25-0.78)	0.47	(0.26-0.87)
60-69	0.60	(0.41-0.89)	0.61	(0.40-0.93)
≥70	1.00		1.00	
Sex				
Male	0.98	(0.71-1.34)	0.86	(0.63-1.18)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.89	(0.30-2.63)	0.57	(0.24-1.31)
Individual household income				
Low	0.89	(0.56-1.43)	1.37	(0.89-2.11)
Middle	0.87	(0.62-1.23)	0.92	(0.65-1.32)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	0.87	(0.60-1.26)	0.98	(0.70-1.36)
Rural	1.26	(0.82-1.95)	0.97	(0.58-1.63)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	0.58	(0.36-0.92)	1.09	(0.62-1.90)
4-5	0.91	(0.56-1.47)	1.88	(1.07-3.31)
>5	0.65	(0.38-1.13)	1.80	(0.97-3.35)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	0.86	(0.55-1.35)	0.63	(0.41-0.99)
With hypertensive complication	1.03	(0.62-1.71)	0.62	(0.37-1.03)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	1.52	(1.02-2.27)	1.20	(0.81-1.78)
With diabetic complication	1.50	(1.02-2.22)	0.95	(0.64-1.42)
Dyslipidemia				
No	1.00		1.00	
Yes	0.81	(0.57-1.17)	0.78	(0.54-1.13)
Disability				
None	1.00		1.00	
Mild	0.92	(0.54-1.55)	1.00	(0.64-1.54)
Severe	0.98	(0.55-1.75)	1.51	(0.92-2.49)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics

Table A3-1. Adjusted hazard ratio for association between patient characteristics and in-hospital mortality in ischemic stroke, stratified by hospital function

Patient Characteristics	Superior General Hospital Adjusted HR*	95% CI	General Hospital Adjusted HR*	95% CI
Age				
20-39	0.44	(0.14-1.45)	-	-
40-49	0.48	(0.24-0.97)	0.29	(0.13-0.68)
50-59	0.41	(0.23-0.73)	0.43	(0.26-0.71)
60-69	0.69	(0.50-0.97)	0.54	(0.38-0.75)
≥70	1.00		1.00	
Sex				
Male	0.89	(0.67-1.17)	0.77	(0.60-1.00)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.80	(0.39-1.65)	1.23	(0.69-2.18)
Individual household income				
Low	1.28	(0.88-1.86)	1.23	(0.89-1.70)
Middle	1.22	(0.89-1.68)	1.43	(1.07-1.89)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	1.32	(0.96-1.81)	0.98	(0.74-1.29)
Rural	0.93	(0.61-1.42)	1.13	(0.76-1.66)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	0.85	(0.56-1.29)	1.10	(0.78-1.54)
4-5	1.31	(0.85-2.02)	1.33	(0.91-1.93)
>5	1.63	(1.03-2.59)	1.11	(0.72-1.69)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	1.28	(0.83-1.95)	1.10	(0.78-1.56)
With hypertensive complication	1.64	(1.01-2.64)	1.30	(0.86-1.97)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	0.96	(0.67-1.36)	0.91	(0.66-1.26)
With diabetic complication	0.89	(0.62-1.28)	0.97	(0.70-1.34)
Dyslipidemia				
No	1.00		1.00	
Yes	0.95	(0.69-1.31)	0.82	(0.62-1.09)
Disability				
None	1.00		1.00	
Mild	0.73	(0.48-1.13)	1.02	(0.71-1.48)
Severe	0.55	(0.31-0.98)	0.58	(0.38-0.91)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table A3-2. Adjusted hazard ratio for association between patient characteristics and in-hospital mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.62	(0.35-1.12)	0.52	(0.29-0.95)
40-49	0.70	(0.46-1.07)	0.62	(0.43-0.90)
50-59	0.85	(0.59-1.23)	0.55	(0.40-0.75)
60-69	0.65	(0.46-0.91)	0.55	(0.41-0.74)
≥70	1.00		1.00	
Sex				
Male	1.12	(0.87-1.45)	1.35	(1.08-1.69)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.33	(0.14-0.77)	0.72	(0.41-1.28)
Individual household income				
Low	1.08	(0.79-1.48)	1.00	(0.75-1.35)
Middle	0.82	(0.61-1.11)	1.03	(0.80-1.33)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	0.76	(0.57-1.01)	1.00	(0.78-1.28)
Rural	0.69	(0.46-1.04)	1.05	(0.75-1.48)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	1.02	(0.73-1.42)	0.99	(0.74-1.33)
4-5	1.21	(0.79-1.87)	1.47	(1.05-2.07)
>5	2.62	(1.67-4.13)	1.68	(1.14-2.47)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	0.93	(0.68-1.28)	1.30	(0.99-1.70)
With hypertensive complication	1.13	(0.74-1.73)	1.33	(0.92-1.91)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	0.92	(0.63-1.36)	1.09	(0.78-1.52)
With diabetic complication	1.49	(1.00-2.22)	1.62	(1.14-2.32)
Dyslipidemia				
No	1.00		1.00	
Yes	0.89	(0.64-1.23)	0.78	(0.59-1.03)
Disability				
None	1.00		1.00	
Mild	0.82	(0.53-1.27)	0.96	(0.69-1.35)
Severe	0.71	(0.46-1.09)	0.51	(0.35-0.76)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table A3-3. Adjusted hazard ratio for association between patient characteristics and in-hospital mortality in acute myocardial infarction, stratified by hospital function

Patient Characteristics	Superior General Hospital		General Hospital	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	0.24	(0.03-1.77)	0.47	(0.14-1.56)
40-49	0.19	(0.06-0.60)	0.20	(0.07-0.56)
50-59	0.40	(0.23-0.70)	0.47	(0.26-0.86)
60-69	0.58	(0.40-0.84)	0.61	(0.40-0.92)
≥70	1.00		1.00	
Sex				
Male	1.02	(0.75-1.39)	0.85	(0.62-1.16)
Female	1.00		1.00	
Health insurance type				
National health insurance	1.00		1.00	
Medical aid	0.89	(0.30-2.61)	0.63	(0.28-1.40)
Individual household income				
Low	0.84	(0.52-1.34)	1.43	(0.94-2.20)
Middle	0.87	(0.62-1.22)	0.98	(0.70-1.39)
High	1.00		1.00	
Residential area				
Metropolitan	1.00		1.00	
City	0.82	(0.57-1.18)	1.06	(0.76-1.47)
Rural	1.20	(0.78-1.85)	1.08	(0.66-1.78)
Charlson comorbidity index				
0-1	1.00		1.00	
2-3	0.58	(0.37-0.93)	1.09	(0.63-1.88)
4-5	0.94	(0.58-1.50)	1.79	(1.02-3.13)
>5	0.67	(0.39-1.15)	1.78	(0.97-3.28)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	0.79	(0.51-1.22)	0.62	(0.40-0.96)
With hypertensive complication	1.01	(0.62-1.65)	0.62	(0.38-1.02)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	1.43	(0.96-2.12)	1.22	(0.84-1.79)
With diabetic complication	1.41	(0.96-2.06)	0.95	(0.64-1.41)
Dyslipidemia				
No	1.00		1.00	
Yes	0.83	(0.58-1.19)	0.77	(0.54-1.11)
Disability				
None	1.00		1.00	
Mild	0.87	(0.51-1.47)	1.01	(0.66-1.54)
Severe	1.05	(0.62-1.78)	1.37	(0.85-2.24)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table B1-1. Adjusted hazard ratio for association between treatment characteristics and 7-day mortality in ischemic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	5.45	(3.64-8.15)	8.76	(6.19-12.39)
Intravenous thrombolytic agents				
No	1.00		1.00	
Yes	1.02	(0.56-1.87)	1.32	(0.87-2.01)
Percutaneous coronary/ cerebrovascular intervention[a]				
No	1.00		1.00	
Yes	1.48	(0.59-3.68)	0.87	(0.30-2.52)
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.48	(1.01-2.18)	1.02	(0.71-1.46)
Intervention for reducing ICP				
Intravenous antihypertensive agents	NA		NA	
Use of mannitol				
Endovascular coiling				
Trephination				
Craniotomy				

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table B1-2. Adjusted hazard ratio for association between treatment characteristics and 7-day mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	0.80	(0.52-1.21)	1.28	(0.81-2.00)
Intravenous thrombolytic agents				
No	NA		NA	
Yes				
Percutaneous coronary/ cerebrovascular intervention[a]				
No	NA		NA	
Yes				
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.32	(0.92-1.91)	1.05	(0.75-1.48)
Intervention for reducing ICP				
Intravenous antihypertensive agents	1.00		1.00	
Use of mannitol	5.57	(2.16-14.32)	2.82	(1.55-5.15)
Endovascular coiling	1.97	(0.54-7.15)	0.93	(0.29-2.98)
Trephination	6.03	(2.25-16.20)	1.92	(0.96-3.82)
Craniotomy	5.76	(1.54-21.48)	1.41	(0.44-4.50)

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table B1-3. Adjusted hazard ratio for association between treatment characteristics and 7-day mortality in acute myocardial infarction, stratified by hospital function

Treatment Characteristics	Superior General Hospital		General Hospital	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	2.22	(1.44-3.44)	2.26	(1.44-3.54)
Intravenous thrombolytic agents				
No	1.00		1.00	
Yes	0.80	(0.28-2.27)	2.08	(1.03-4.18)
Percutaneous coronary/ cerebrovascular intervention[a]				
No	1.00		1.00	
Yes	0.35	(0.23-0.55)	0.43	(0.27-0.67)
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.30	(0.86-1.96)	1.25	(0.83-1.90)
Intervention for reducing ICP				
Intravenous antihypertensive agents	NA		NA	
Use of mannitol				
Endovascular coiling				
Trephination				
Craniotomy				

ICP denotes intracranial pressure; NA, not applicable.

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

Table B2-1. Adjusted hazard ratio for association between treatment characteristics and 30-day mortality in ischemic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	4.77	(3.53-6.43)	7.00	(5.39-9.09)
Intravenous thrombolytic agents				
No	1.00		1.00	
Yes	1.35	(0.89-2.05)	0.98	(0.69-1.37)
Percutaneous coronary/ cerebrovascular intervention[a]				
No	1.00		1.00	
Yes	1.20	(0.65-2.18)	0.84	(0.35-1.99)
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.38	(1.02-1.86)	1.02	(0.77-1.34)
Intervention for reducing ICP				
Intravenous antihypertensive agents	NA		NA	
Use of mannitol				
Endovascular coiling				
Trephination				
Craniotomy				

ICP denotes intracranial pressure; NA, not applicable.

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

Table B2-2. Adjusted hazard ratio for association between treatment characteristics and 30-day mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	4.81	(3.58-6.46)	6.96	(5.37-9.03)
Intravenous thrombolytic agents				
No	NA		NA	
Yes				
Percutaneous coronary/ cerebrovascular intervention[a]				
No	NA		NA	
Yes				
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.07	(0.81-1.43)	1.00	(0.77-1.31)
Intervention for reducing ICP				
Intravenous antihypertensive agents	1.00		1.00	
Use of mannitol	3.38	(1.73-6.62)	2.61	(1.63-4.16)
Endovascular coiling	1.82	(0.78-4.25)	0.86	(0.37-2.00)
Trephination	4.56	(2.27-9.16)	2.33	(1.39-3.92)
Craniotomy	7.50	(3.23-17.44)	1.65	(0.71-3.82)

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table B2-3. Adjusted hazard ratio for association between treatment characteristics and 30-day mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	1.86	(1.31-2.64)	2.16	(1.51-3.11)
Intravenous thrombolytic agents				
No	1.00		1.00	
Yes	0.82	(0.35-1.92)	1.82	(1.00-3.31)
Percutaneous coronary/ cerebrovascular intervention[a]				
No	1.00		1.00	
Yes	0.38	(0.27-0.55)	0.44	(0.30-0.65)
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.49	(1.08-2.05)	1.34	(0.96-1.88)
Intervention for reducing ICP				
Intravenous antihypertensive agents	NA		NA	
Use of mannitol				
Endovascular coiling				
Trephination				
Craniotomy				

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table B3-1. Adjusted hazard ratio for association between treatment characteristics and in-hospital mortality in ischemic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	4.95	(3.72-6.60)	6.09	(4.76-7.79)
Intravenous thrombolytic agents				
No	1.00		1.00	
Yes	1.27	(0.85-1.91)	0.98	(0.72-1.36)
Percutaneous coronary/ cerebrovascular intervention[a]				
No	1.00		1.00	
Yes	1.09	(0.60-1.95)	0.97	(0.45-2.10)
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.27	(0.95-1.70)	1.02	(0.79-1.32)
Intervention for reducing ICP				
Intravenous antihypertensive agents	NA		NA	
Use of mannitol				
Endovascular coiling				
Trephination				
Craniotomy				

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table B3-2. Adjusted hazard ratio for association between treatment characteristics and in-hospital mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	1.18	(0.84-1.67)	1.47	(1.04-2.09)
Intravenous thrombolytic agents				
No	NA		NA	
Yes				
Percutaneous coronary/ cerebrovascular intervention[a]				
No	NA		NA	
Yes				
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.13	(0.86-1.48)	0.93	(0.72-1.20)
Intervention for reducing ICP				
Intravenous antihypertensive agents	1.00		1.00	
Use of mannitol	2.42	(1.36-4.32)	2.71	(1.70-4.32)
Endovascular coiling	1.41	(0.66-2.99)	0.96	(0.43-2.17)
Trephination	3.30	(1.80-6.04)	2.52	(1.51-4.21)
Craniotomy	5.27	(2.49-11.17)	1.77	(0.81-3.89)

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table B3-3. Adjusted hazard ratio for association between treatment characteristics and in-hospital mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		**General Hospital**	
Treatment Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	1.89	(1.34-2.67)	2.01	(1.42-2.86)
Intravenous thrombolytic agents				
No	1.00		1.00	
Yes	0.82	(0.35-1.93)	1.75	(0.97-3.14)
Percutaneous coronary/ cerebrovascular intervention[a]				
No	1.00		1.00	
Yes	0.39	(0.27-0.55)	0.46	(0.32-0.67)
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	1.48	(1.08-2.03)	1.39	(1.00-1.93)
Intervention for reducing ICP				
Intravenous antihypertensive agents	NA		NA	
Use of mannitol				
Endovascular coiling				
Trephination				
Craniotomy				

ICP denotes intracranial pressure; NA, not applicable.

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

Table C1-1. Adjusted hazard ratio for association between hospital characteristics and 7-day mortality in ischemic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Hospital Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	0.59	(0.06-5.48)	1.41	(0.87-2.30)
Educational foundation	1.43	(0.89-2.29)	1.05	(0.63-1.76)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	13.34	(2.59-68.78)	1.85	(0.95-3.62)
Quintile 2	1.57	(0.36-6.82)	1.76	(0.94-3.28)
Quintile 3	-		1.41	(0.74-2.68)
Quintile 4	0.80	(0.28-2.28)	0.99	(0.57-1.73)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	0.83	(0.50-1.36)	1.30	(0.66-2.57)
10-14%	0.85	(0.43-1.72)	0.66	(0.15-2.79)
15-19%	0.58	(0.21-1.65)	0.92	(0.36-2.33)
≥20%	1.50	(0.46-4.93)	0.61	(0.24-1.56)
The number of beds				
Quintile 1	0.61	(0.21-1.79)	1.12	(0.54-2.33)
Quintile 2	1.15	(0.54-2.44)	0.75	(0.35-1.61)
Quintile 3	0.99	(0.51-1.91)	0.51	(0.25-1.06)
Quintile 4	1.71	(0.91-3.19)	0.81	(0.47-1.40)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	0.97	(0.58-1.62)	0.64	(0.11-3.70)
5.5:1	0.71	(0.33-1.54)	0.57	(0.10-3.10)
8.5:1	1.28	(0.14-11.63)	0.51	(0.09-2.88)
>8.5:1	-		0.50	(0.09-2.66)
Ratio of beds per one nurse				
2.0:1	1.00		1.00	
2.5:1	2.09	(0.23-19.31)	2.10	(0.27-16.47)
3.0:1	4.76	(0.54-41.89)	3.43	(0.45-26.39)
3.5:1	4.82	(0.53-44.1)	3.12	(0.39-25.04)
4.0:1	7.06	(0.70-71.12)	2.75	(0.32-23.71)
4.5:1	6.09	(0.59-62.95)	4.20	(0.52-34.06)
>6.0:1	-		0.98	(0.45-2.14)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C1-2. Adjusted hazard ratio for association between hospital characteristics and 7-day mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Hospital Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	0.43	(0.13-1.50)	1.40	(0.87-2.24)
Educational foundation	0.74	(0.48-1.14)	1.14	(0.74-1.76)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	5.20	(1.77-15.23)	2.06	(1.19-3.56)
Quintile 2	2.21	(1.15-4.27)	1.13	(0.70-1.83)
Quintile 3	2.11	(1.21-3.68)	0.88	(0.54-1.44)
Quintile 4	1.36	(0.82-2.26)	0.86	(0.52-1.43)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.83	(1.03-3.27)	0.23	(0.03-1.71)
10-14%	1.05	(0.50-2.24)	0.40	(0.09-1.67)
15-19%	1.55	(0.87-2.76)	1.26	(0.48-3.30)
≥20%	0.78	(0.39-1.55)	1.82	(1.13-2.94)
The number of beds				
Quintile 1	1.71	(0.63-4.66)	1.04	(0.50-2.18)
Quintile 2	1.24	(0.46-3.36)	0.65	(0.31-1.37)
Quintile 3	1.15	(0.42-3.13)	1.10	(0.63-1.94)
Quintile 4	1.68	(0.66-4.28)	0.79	(0.50-1.26)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.49	(0.67-3.34)	1.38	(0.36-5.33)
5.5:1	0.73	(0.31-1.72)	1.13	(0.30-4.28)
8.5:1	0.74	(0.36-1.54)	0.62	(0.15-2.51)
>8.5:1	0.89	(0.44-1.80)	0.94	(0.25-3.55)
Ratio of beds per one nurse				
2.0:1	1.00			
2.5:1	0.17	(0.05-0.56)	1.00	
3.0:1	0.23	(0.07-0.78)	0.89	(0.33-2.42)
3.5:1	0.28	(0.08-1.01)	1.05	(0.38-2.89)
4.0:1	0.22	(0.06-0.89)	0.79	(0.27-2.30)
4.5:1	0.10	(0.02-0.62)	0.92	(0.27-3.14)
>6.0:1	-		1.32	(0.44-3.96)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C1-3. Adjusted hazard ratio for association between hospital characteristics and 7-day mortality in acute myocardial infarction, stratified by hospital function

	Superior General Hospital		General Hospital	
Hospital Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	1.24	(0.30-5.18)	1.21	(0.68-2.14)
Educational foundation	1.41	(0.85-2.34)	1.02	(0.60-1.73)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	3.24	(0.62-17.06)	1.64	(0.81-3.32)
Quintile 2	0.48	(0.06-3.76)	0.92	(0.44-1.94)
Quintile 3	0.91	(0.38-2.19)	0.77	(0.40-1.52)
Quintile 4	1.18	(0.71-1.95)	0.73	(0.43-1.27)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.88	(0.99-3.58)	0.58	(0.13-2.54)
10-14%	0.42	(0.10-1.75)	-	
15-19%	0.47	(0.06-3.68)	1.32	(0.30-5.79)
≥20%	1.56	(0.44-5.53)	0.76	(0.22-2.59)
The number of beds				
Quintile 1	1.38	(0.44-4.30)	0.28	(0.09-0.89)
Quintile 2	1.36	(0.45-4.13)	0.64	(0.26-1.61)
Quintile 3	1.28	(0.44-3.77)	0.97	(0.51-1.83)
Quintile 4	1.82	(0.67-4.99)	0.75	(0.41-1.37)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.60	(0.95-2.71)	1.30	(0.29-5.83)
5.5:1	1.06	(0.44-2.58)	0.88	(0.19-3.99)
8.5:1	-		1.13	(0.25-5.22)
>8.5:1	-		0.98	(0.20-4.80)
Ratio of beds per one nurse				
2.0:1	1.00			
2.5:1	0.91	(0.22-3.75)	1.00	
3.0:1	1.48	(0.34-6.50)	0.53	(0.18-1.58)
3.5:1	1.40	(0.29-6.68)	0.52	(0.17-1.58)
4.0:1	1.48	(0.28-7.96)	0.48	(0.15-1.54)
4.5:1	1.15	(0.18-7.57)	0.43	(0.10-1.89)
>6.0:1	-		0.65	(0.18-2.32)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C2-1. Adjusted hazard ratio for association between hospital characteristics and 30-day mortality in ischemic stroke, stratified by hospital function

Hospital Characteristics	Superior General Hospital		General Hospital	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	1.37	(0.47-3.97)	1.54	(1.05-2.24)
Educational foundation	1.35	(0.94-1.93)	1.04	(0.70-1.54)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	14.91	(3.75-59.33)	2.05	(1.23-3.42)
Quintile 2	2.12	(0.63-7.10)	2.17	(1.35-3.47)
Quintile 3			1.34	(0.81-2.20)
Quintile 4	0.70	(0.30-1.64)	1.27	(0.85-1.91)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.16	(0.81-1.67)	1.26	(0.74-2.15)
10-14%	1.32	(0.81-2.15)	0.85	(0.30-2.37)
15-19%	0.82	(0.40-1.69)	1.20	(0.64-2.23)
≥20%	1.55	(0.56-4.35)	1.08	(0.58-2.01)
The number of beds				
Quintile 1	0.58	(0.26-1.30)	0.91	(0.51-1.62)
Quintile 2	0.91	(0.51-1.64)	0.69	(0.37-1.26)
Quintile 3	0.91	(0.55-1.50)	0.61	(0.36-1.04)
Quintile 4	1.20	(0.73-1.99)	0.81	(0.53-1.22)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.02	(0.69-1.50)	0.63	(0.16-2.45)
5.5:1	0.76	(0.41-1.41)	0.66	(0.18-2.49)
8.5:1	0.89	(0.17-4.55)	0.52	(0.13-2.02)
>8.5:1	-		0.51	(0.14-1.92)
Ratio of beds per one nurse				
2.0:1	1.00		1.00	
2.5:1	2.59	(0.78-8.62)	2.37	(0.54-10.38)
3.0:1	3.43	(1.02-11.51)	3.11	(0.72-13.45)
3.5:1	3.28	(0.93-11.54)	3.01	(0.67-13.48)
4.0:1	3.65	(0.92-14.6)	2.67	(0.57-12.58)
4.5:1	2.23	(0.51-9.73)	3.50	(0.77-15.82)
>6.0:1	-		0.98	(0.45-2.14)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C2-2. Adjusted hazard ratio for association between hospital characteristics and 30-day mortality in hemorrhagic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Hospital Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	0.52	(0.18-1.54)	1.31	(0.92-1.87)
Educational foundation	0.97	(0.70-1.34)	1.20	(0.88-1.63)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	3.40	(1.36-8.51)	2.57	(1.69-3.89)
Quintile 2	1.48	(0.90-2.42)	1.35	(0.94-1.95)
Quintile 3	1.39	(0.90-2.14)	1.02	(0.70-1.48)
Quintile 4	1.17	(0.81-1.68)	1.16	(0.80-1.69)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.45	(0.92-2.29)	0.69	(0.27-1.77)
10-14%	1.03	(0.58-1.84)	0.98	(0.48-2.00)
15-19%	1.17	(0.73-1.87)	1.24	(0.63-2.45)
≥20%	1.12	(0.71-1.77)	1.51	(1.02-2.22)
The number of beds				
Quintile 1	1.92	(0.89-4.16)	0.78	(0.45-1.37)
Quintile 2	1.77	(0.84-3.73)	0.57	(0.33-0.98)
Quintile 3	1.52	(0.71-3.26)	0.84	(0.55-1.27)
Quintile 4	1.85	(0.91-3.77)	0.79	(0.57-1.09)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.16	(0.83-1.62)	1.02	(0.42-2.48)
5.5:1	1.07	(0.64-1.77)	0.94	(0.39-2.24)
8.5:1	0.92	(0.11-7.52)	0.81	(0.33-2.02)
>8.5:1	-		0.96	(0.40-2.31)
Ratio of beds per one nurse				
2.0:1	1.00			
2.5:1	0.30	(0.11-0.78)	1.00	
3.0:1	0.34	(0.13-0.89)	0.93	(0.43-2.01)
3.5:1	0.36	(0.13-1.00)	0.95	(0.44-2.07)
4.0:1	0.32	(0.11-0.96)	0.76	(0.34-1.71)
4.5:1	0.25	(0.07-0.86)	0.98	(0.39-2.43)
>6.0:1	-		1.15	(0.49-2.65)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C2-3. Adjusted hazard ratio for association between hospital characteristics and 30-day mortality in acute myocardial infarction, stratified to hospital function

	Superior General Hospital		**General Hospital**	
Hospital Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	0.82	(0.26-2.57)	1.51	(0.97-2.35)
Educational foundation	1.35	(0.91-1.99)	1.21	(0.79-1.85)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	2.86	(0.60-13.77)	1.91	(1.08-3.39)
Quintile 2	0.97	(0.28-3.43)	0.98	(0.53-1.79)
Quintile 3	0.74	(0.35-1.58)	0.81	(0.46-1.42)
Quintile 4	1.21	(0.81-1.81)	0.79	(0.50-1.24)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.72	(1.01-2.94)	0.66	(0.20-2.22)
10-14%	0.60	(0.24-1.50)	-	
15-19%	0.95	(0.27-3.30)	1.44	(0.43-4.84)
≥20%	0.81	(0.24-2.78)	0.84	(0.33-2.16)
The number of beds				
Quintile 1	1.43	(0.59-3.48)	0.47	(0.21-1.03)
Quintile 2	1.60	(0.68-3.77)	0.50	(0.24-1.05)
Quintile 3	1.35	(0.58-3.12)	0.92	(0.55-1.56)
Quintile 4	1.88	(0.85-4.16)	0.75	(0.46-1.22)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.21	(0.81-1.80)	1.29	(0.38-4.40)
5.5:1	0.94	(0.48-1.86)	0.96	(0.28-3.28)
8.5:1	-		1.25	(0.37-4.31)
>8.5:1	-		1.20	(0.33-4.38)
Ratio of beds per one nurse				
2.0:1	1.00			
2.5:1	0.97	(0.32-2.93)	1.00	
3.0:1	1.00	(0.30-3.34)	0.57	(0.21-1.51)
3.5:1	1.31	(0.37-4.60)	0.58	(0.22-1.53)
4.0:1	0.96	(0.24-3.83)	0.45	(0.16-1.26)
4.5:1	0.84	(0.17-4.14)	0.40	(0.11-1.38)
>6.0:1	-		0.58	(0.19-1.76)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C3-1. Adjusted hazard ratio for association between hospital characteristics and in-hospital mortality in ischemic stroke, stratified by hospital function

	Superior General Hospital		General Hospital	
Hospital Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	1.55	(0.56-4.24)	1.42	(0.99-2.04)
Educational foundation	1.33	(0.94-1.89)	0.98	(0.68-1.42)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	14.12	(3.63-54.96)	1.82	(1.12-2.96)
Quintile 2	2.05	(0.62-6.82)	2.06	(1.32-3.20)
Quintile 3			1.31	(0.82-2.08)
Quintile 4	0.78	(0.36-1.67)	1.30	(0.89-1.89)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.17	(0.83-1.65)	1.16	(0.69-1.94)
10-14%	1.17	(0.72-1.89)	0.66	(0.24-1.84)
15-19%	0.78	(0.39-1.54)	1.15	(0.64-2.08)
≥20%	1.37	(0.49-3.82)	0.97	(0.52-1.79)
The number of beds				
Quintile 1	0.56	(0.26-1.21)	1.06	(0.62-1.83)
Quintile 2	0.96	(0.54-1.68)	0.70	(0.39-1.26)
Quintile 3	0.87	(0.53-1.41)	0.70	(0.43-1.15)
Quintile 4	1.17	(0.71-1.91)	0.85	(0.58-1.25)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.03	(0.70-1.50)	0.71	(0.19-2.72)
5.5:1	0.84	(0.47-1.52)	0.75	(0.20-2.79)
8.5:1	0.79	(0.15-4.06)	0.56	(0.15-2.12)
>8.5:1	-		0.59	(0.16-2.17)
Ratio of beds per one nurse				
2.0:1	1.00			
2.5:1	2.34	(0.77-7.06)	1.00	
3.0:1	3.03	(0.99-9.25)	2.85	(0.66-12.37)
3.5:1	3.31	(1.04-10.59)	3.46	(0.80-14.89)
4.0:1	3.45	(0.95-12.52)	3.56	(0.80-15.77)
4.5:1	1.85	(0.46-7.50)	3.23	(0.70-14.95)
>6.0:1	-		4.00	(0.90-17.82)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C3-2. Adjusted hazard ratio for association between hospital characteristics and in-hospital mortality in hemorrhagic stroke, stratified by hospital function

Hospital Characteristics	Superior General Hospital		General Hospital	
	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	0.69	(0.25-1.91)	1.25	(0.89-1.75)
Educational foundation	1.00	(0.73-1.37)	1.15	(0.85-1.54)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	3.36	(1.35-8.33)	2.49	(1.67-3.71)
Quintile 2	1.43	(0.88-2.32)	1.43	(1.02-2.02)
Quintile 3	1.35	(0.88-2.06)	0.99	(0.69-1.41)
Quintile 4	1.28	(0.90-1.82)	1.08	(0.75-1.55)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.73	(1.13-2.67)	0.62	(0.24-1.57)
10-14%	1.03	(0.59-1.81)	1.17	(0.61-2.24)
15-19%	1.27	(0.81-1.97)	1.23	(0.64-2.36)
≥20%	1.17	(0.75-1.83)	1.46	(1.00-2.14)
The number of beds				
Quintile 1	2.21	(1.04-4.69)	0.84	(0.50-1.42)
Quintile 2	1.93	(0.93-3.99)	0.60	(0.36-1.00)
Quintile 3	1.81	(0.86-3.79)	0.87	(0.59-1.29)
Quintile 4	1.97	(0.98-3.97)	0.77	(0.56-1.05)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.19	(0.86-1.64)	1.12	(0.46-2.68)
5.5:1	1.07	(0.66-1.73)	1.04	(0.44-2.45)
8.5:1	0.85	(0.11-6.81)	0.83	(0.34-2.05)
>8.5:1	-		1.03	(0.44-2.44)
Ratio of beds per one nurse				
2.0:1	1.00			
2.5:1	0.31	(0.12-0.78)	1.00	
3.0:1	0.36	(0.14-0.91)	0.94	(0.44-2.02)
3.5:1	0.38	(0.14-1.03)	0.99	(0.46-2.13)
4.0:1	0.35	(0.12-1.00)	0.85	(0.38-1.89)
4.5:1	0.24	(0.07-0.80)	1.10	(0.45-2.67)
>6.0:1	-		1.21	(0.53-2.76)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table C3-3. Adjusted hazard ratio for association between hospital characteristics and in-hospital mortality in acute myocardial infarction, stratified by hospital function

	Superior General Hospital		General Hospital	
Hospital Characteristics	Adjusted* HR	95% CI	Adjusted* HR	95% CI
Characteristic of foundation				
Public	0.73	(0.24-2.25)	1.43	(0.93-2.22)
Educational foundation	1.28	(0.88-1.89)	1.21	(0.80-1.84)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	2.81	(0.59-13.39)	1.89	(1.09-3.27)
Quintile 2	1.20	(0.38-3.73)	0.97	(0.54-1.76)
Quintile 3	0.68	(0.32-1.45)	0.86	(0.50-1.49)
Quintile 4	1.13	(0.76-1.68)	0.78	(0.50-1.22)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	1.62	(0.95-2.76)	0.71	(0.21-2.37)
10-14%	0.70	(0.30-1.63)	-	
15-19%	0.98	(0.28-3.40)	1.32	(0.40-4.40)
≥20%	1.02	(0.34-3.05)	0.87	(0.36-2.09)
The number of beds				
Quintile 1	1.49	(0.62-3.57)	0.45	(0.20-0.98)
Quintile 2	1.74	(0.75-4.05)	0.64	(0.33-1.26)
Quintile 3	1.43	(0.63-3.24)	0.87	(0.52-1.45)
Quintile 4	1.90	(0.87-4.14)	0.79	(0.49-1.26)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.22	(0.83-1.80)	1.14	(0.34-3.87)
5.5:1	0.89	(0.46-1.75)	0.80	(0.23-2.75)
8.5:1	-		1.03	(0.30-3.53)
>8.5:1	-		1.02	(0.28-3.71)
Ratio of beds per one nurse				
2.0:1	1.00			
2.5:1	0.84	(0.29-2.38)	1.00	
3.0:1	0.81	(0.26-2.54)	0.71	(0.26-1.95)
3.5:1	1.08	(0.32-3.63)	0.82	(0.30-2.25)
4.0:1	0.77	(0.20-2.93)	0.62	(0.22-1.79)
4.5:1	0.70	(0.15-3.32)	0.64	(0.19-2.21)
>6.0:1	-		0.75	(0.24-2.30)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table D1. Adjusted hazard ratio for association between patient characteristics and 30-day mortality, stratified by diseases except patients who were dead within 7-day

	Ischemic stroke (N=7,437)		**Hemorrhagic stroke (N=2,523)**		**Acute myocardial infarction (N=4,672)**	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age						
20-39	0.32	(0.08-1.33)	0.84	(0.46-1.56)	0.39	(0.05-3.16)
40-49	0.22	(0.07-0.71)	0.71	(0.44-1.13)	0.20	(0.05-0.83)
50-59	0.43	(0.23-0.82)	0.72	(0.48-1.07)	0.25	(0.09-0.65)
60-69	0.78	(0.54-1.13)	0.61	(0.41-0.89)	0.52	(0.31-0.87)
≥70	1.00		1.00		1.00	
Sex						
Male	0.83	(0.61-1.13)	1.04	(0.78-1.38)	0.82	(0.56-1.18)
Female	1.00		1.00		1.00	
Health insurance type						
Medical aid	0.59	(0.24-1.41)	0.16	(0.05-0.53)	1.00	
National health insurance	1.00		1.00		0.74	(0.26-2.12)
Individual household income						
Low	1.45	(0.97-2.16)	1.30	(0.86-1.98)	1.12	(0.66-1.89)
Middle	1.38	(0.97-1.95)	1.05	(0.76-1.45)	0.81	(0.53-1.23)
High	1.00		1.00		1.00	
Residential area						
Metropolitan	1.00				1.00	
City	1.32	(0.93-1.86)	0.89	(0.66-1.2)	1.26	(0.82-1.92)
Rural	1.11	(0.68-1.80)	0.65	(0.40-1.05)	1.37	(0.78-2.38)
Charlson comorbidity index				1.00		1.00
0-1	1.00		1.00		1.00	
2-3	0.91	(0.59-1.41)	1.01	(0.70-1.45)	0.43	(0.22-0.81)
4-5	1.25	(0.78-1.99)	1.46	(0.94-2.28)	0.88	(0.49-1.61)
>5	1.17	(0.71-1.96)	2.13	(1.29-3.53)	0.58	(0.29-1.15)

Table D1. Adjusted hazard ratio for association between patient characteristics and 30-day mortality, stratified by diseases except patients who were dead within 7-day *(Continued)*

	Ischemic stroke (N=7,437)		**Hemorrhagic stroke (N=2,523)**		**Acute myocardial infarction (N=4,672)**	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Hypertension						
No	1.00		1.00		1.00	
Without hypertensive complication	0.96	(0.62-1.49)	1.21	(0.86-1.70)	1.39	(0.45-4.34)
With hypertensive complication	1.21	(0.73-2.01)	1.25	(0.78-2.00)	1.10	(0.30-4.02)
Diabetes Mellitus						
No	1.00		1.00		1.00	
Without diabetic complication	0.81	(0.54-1.20)	0.83	(0.54-1.28)	0.94	(0.40-2.23)
With diabetic complication	1.00	(0.67-1.48)	1.36	(0.86-2.16)	0.84	(0.38-1.83)
Dyslipidemia						
No	1.00		1.00		1.00	
Yes	0.89	(0.63-1.26)	0.77	(0.54-1.11)	0.97	(0.49-1.96)
Disability						
None	1.00		1.00		1.00	
Mild	0.65	(0.40-1.08)	0.81	(0.51-1.29)	1.11	(0.47-2.62)
Severe	0.51	(0.29-0.91)	0.48	(0.29-0.80)	0.30	(0.10-0.91)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table D2. Adjusted hazard ratio for association between treatment characteristics and 30-day mortality, stratified by diseases except patients who were dead within 7-day

	Ischemic stroke (N=7,437)		Hemorrhagic stroke (N=2,523)		Acute myocardial infarction (N=4,672)	
Treatment Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service						
No use	1.00		1.00		1.00	
Use	4.55	(3.34-6.18)	2.17	(1.35-3.49)	1.62	(1.05-2.51)
Intravenous thrombolytic agent						
No	1.00		1.00		1.00	
Yes	0.90	(0.58-1.39)	0.93	(0.69-1.26)	1.21	(0.47-3.10)
Percutaneous cerebrovascular intervention[a]						
No	1.00				1.00	
Yes	1.01	(0.50-2.02)			0.42	(0.27-0.67)
Weekend admission[b]						
Weekday admission	1.00				1.00	
Weekend admission	1.10	(0.79-1.52)			1.70	(1.15-2.52)
Intervention for reducing ICP						
Intravenous antihypertensive agents			1.00			
Use of mannitol			2.05	(1.14-3.69)		
Endovascular coiling			1.20	(0.54-2.66)		
Trephination			3.10	(1.67-5.76)		
Craniotomy			4.47	(2.07-9.69)		

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table D3. Adjusted hazard ratio for association between hospital characteristics and 30-day mortality, stratified by diseases except patients who were dead within 7-day

Hospital Characteristics	**Ischemic stroke (N=7,437)** Adjusted HR*	95% CI	**Hemorrhagic stroke (N=2,523)** Adjusted HR*	95% CI	**Acute myocardial infarction (N=4,672)** Adjusted HR*	95% CI
Characteristic of foundation						
Public	1.43	(0.63-3.27)	1.06	(0.60-1.88)	1.46	(0.75-2.86)
Educational foundation	0.93	(0.64-1.37)	1.48	(1.05-2.08)	1.41	(0.89-2.24)
Private	1.00		1.00		1.00	
Volume of emergent stroke patient						
Quintile 1	0.50	(0.06-4.16)	2.48	(0.75-8.26)	1.28	(0.28-5.87)
Quintile 2	2.37	(0.91-6.15)	2.15	(0.86-5.40)	2.68	(0.78-9.26)
Quintile 3	2.47	(1.22-4.97)	1.55	(0.77-3.13)	1.15	(0.42-3.20)
Quintile 4	0.97	(0.56-1.67)	1.29	(0.85-1.95)	0.78	(0.42-1.44)
Quintile 5	1.00		1.00		1.00	
Proportion of transferred patient to other hospital						
<5%	1.00		1.00		1.00	
5-9%	1.33	(0.88-2.03)	0.95	(0.57-1.58)	0.58	(0.31-1.11)
10-14%	1.48	(0.88-2.50)	1.11	(0.69-1.81)	1.14	(0.46-2.85)
15-19%	1.03	(0.43-2.45)	1.63	(0.95-2.80)	2.64	(0.95-7.34)
≥20%	1.02	(0.47-2.21)	0.72	(0.41-1.26)	0.39	(0.13-1.20)
The number of beds						
Quintile 1	0.45	(0.15-1.31)	0.46	(0.16-1.28)	0.73	(0.20-2.59)
Quintile 2	0.53	(0.21-1.31)	0.52	(0.22-1.23)	0.61	(0.17-2.25)
Quintile 3	0.40	(0.18-0.88)	0.51	(0.25-1.04)	1.63	(0.68-3.90)
Quintile 4	0.84	(0.49-1.42)	0.58	(0.34-1.00)	1.17	(0.66-2.10)
Quintile 5	1.00		1.00		1.00	

Table D3. Adjusted hazard ratio for association between hospital characteristics and 30-day mortality, stratified by diseases except patients who were dead within 7-day *(Continued)*

Hospital Characteristics	**Ischemic stroke (N=7,437)**		**Hemorrhagic stroke (N=2,523)**		**Acute myocardial infarction (N=4,672)**	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
The number of beds per one doctor						
2.5:1	1.00		1.00		1.00	
3.5:1	0.98	(0.59-1.64)	0.96	(0.61-1.50)	0.72	(0.41-1.25)
5.5:1	1.11	(0.54-2.26)	0.96	(0.54-1.71)	0.62	(0.28-1.38)
8.5:1	0.92	(0.37-2.30)	1.21	(0.58-2.52)	0.76	(0.30-1.93)
>8.5:1	0.95	(0.36-2.49)	1.49	(0.65-3.38)	1.11	(0.36-3.43)
Ratio of beds per one nurse						
2.0:1	1.00		1.00		1.00	
2.5:1	2.54	(0.68-9.47)	5.47	(0.69-43.51)	2.11	(0.40-11.21)
3.0:1	1.88	(0.51-6.95)	4.86	(0.62-37.88)	1.99	(0.38-10.50)
3.5:1	1.63	(0.42-6.32)	4.46	(0.57-35.26)	3.44	(0.64-18.42)
4.0:1	1.80	(0.43-7.45)	4.15	(0.52-33.40)	1.56	(0.26-9.35)
4.5:1	1.15	(0.25-5.32)	5.33	(0.64-44.46)	1.35	(0.18-9.97)
>6.0:1	1.83	(0.42-7.98)	5.44	(0.65-45.70)	1.88	(0.28-12.43)
Hospital function						
Superior general hospital	1.00		1.00			
General hospital	1.03	(0.60-1.77)	1.23	(0.79-1.90)	1.25	(0.64-2.44)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table E1. Adjusted hazard ratio for association between patient characteristics and in-hospital mortality, stratified by diseases except patients who were dead within 30-day

	Ischemic stroke (N=7,253)		Hemorrhagic stroke (N=2,306)	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age				
20-39	-		0.21	(0.02-1.98)
40-49	0.53	(0.13-2.12)	0.47	(0.13-1.68)
50-59	-		0.21	(0.06-0.74)
60-69	0.30	(0.12-0.78)	0.47	(0.20-1.13)
≥70	1.00		1.00	
Sex				
Male	1.34	(0.69-2.59)	3.18	(1.51-6.70)
Female	1.00		1.00	
Health insurance type				
Medical aid	2.02	(0.49-8.25)	0.50	(0.08-3.26)
National health insurance	1.00		1.00	
Individual household income				
Low	0.79	(0.29-2.13)	1.04	(0.35-3.06)
Middle	0.81	(0.38-1.69)	0.65	(0.28-1.49)
High	1.00		1.00	
Residential area				
Metropolitan	1.00			
City	1.06	(0.53-2.11)	1.45	(0.62-3.41)
Rural	0.42	(0.11-1.65)	2.74	(0.90-8.36)
Charlson comorbidity index			1.00	1.00
0-1	1.00		1.00	
2-3	1.91	(0.66-5.51)	1.11	(0.45-2.73)
4-5	3.68	(1.21-11.16)	2.19	(0.77-6.22)
>5	3.27	(1.04-10.29)	1.83	(0.49-6.88)
Hypertension				
No	1.00		1.00	
Without hypertensive complication	1.39	(0.45-4.34)	2.37	(0.98-5.72)
With hypertensive complication	1.10	(0.30-4.02)	0.90	(0.23-3.47)
Diabetes Mellitus				
No	1.00		1.00	
Without diabetic complication	0.94	(0.40-2.23)	0.87	(0.29-2.59)
With diabetic complication	0.84	(0.38-1.83)	1.16	(0.36-3.74)
Dyslipidemia				
No	1.00		1.00	
Yes	0.97	(0.49-1.96)	0.60	(0.24-1.48)

Table E1. Adjusted hazard ratio for association between patient characteristics and in-hospital mortality, stratified by diseases except patients who were dead within 30-day *(Continued)*

	Ischemic stroke (N=7,253)		Hemorrhagic stroke (N=2,306)	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Disability				
None	1.00		1.00	
Mild	1.11	(0.47-2.62)	0.72	(0.24-2.20)
Severe	0.30	(0.10-0.91)	0.44	(0.16-1.20)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
Note: could not calculate the hazard ratio for in-hospital mortality in patients with AMI.

Table E2. Adjusted hazard ratio for association between treatment characteristics and in-hospital mortality, stratified by diseases except patients who were dead within 30-day

	Ischemic stroke (N=7,253)		Hemorrhagic stroke (N=2,306)	
Treatment Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service				
No use	1.00		1.00	
Use	3.59	(1.83-7.01)	2.66	(0.72-9.83)
Intravenous thrombolytic agent				
No	1.00		1.00	
Yes	0.92	(0.38-2.21)	0.93	(0.69-1.26)
Percutaneous cerebrovascular intervention[a]				
No	1.00			
Yes	1.53	(0.33-7.04)		
Weekend admission[b]				
Weekday admission	1.00		1.00	
Weekend admission	0.79	(0.37-1.68)	0.91	(0.43-1.91)
Intervention for reducing ICP				
Intravenous antihypertensive agents			1.00	
Use of mannitol			0.69	(0.18-2.54)
Endovascular coiling			0.86	(0.16-4.81)
Trephination			1.32	(0.35-4.99)
Craniotomy			1.01	(0.18-5.69)

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.
Note: could not calculate the hazard ratio for in-hospital mortality in patients with AMI.

Table E3. Adjusted hazard ratio for association between hospital characteristics and in-hospital mortality, stratified by diseases except patients who were dead within 30-day

	Ischemic stroke (N=7,253)		Hemorrhagic stroke (N=2,306)	
Hospital Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Characteristic of foundation				
Public	2.16	(0.38-12.36)	2.99	(0.76-11.77)
Educational foundation	1.75	(0.70-4.37)	1.72	(0.65-4.57)
Private	1.00		1.00	
Volume of emergent stroke patient				
Quintile 1	0.05	(0.01-2.09)	2.60	(0.17-39.23)
Quintile 2	0.38	(0.03-4.73)	1.89	(0.24-15.28)
Quintile 3	2.13	(0.56-8.09)	2.23	(0.43-11.68)
Quintile 4	1.16	(0.41-3.29)	1.04	(0.32-3.37)
Quintile 5	1.00		1.00	
Proportion of transferred patient to other hospital				
<5%	1.00		1.00	
5-9%	0.95	(0.38-2.36)	3.32	(0.82-13.51)
10-14%	1.26	(0.42-3.78)	1.71	(0.44-6.73)
15-19%	1.54	(0.33-7.29)	0.63	(0.12-3.42)
≥20%	1.30	(0.34-4.89)	1.48	(0.38-5.76)
The number of beds				
Quintile 1	3.67	(0.60-22.38)	2.63	(0.30-22.87)
Quintile 2	3.72	(0.71-19.56)	0.89	(0.12-6.67)
Quintile 3	1.43	(0.34-6.03)	1.75	(0.33-9.27)
Quintile 4	0.57	(0.17-1.99)	0.90	(0.22-3.72)
Quintile 5	1.00		1.00	
The number of beds per one doctor				
2.5:1	1.00		1.00	
3.5:1	1.73	(0.43-6.87)	1.36	(0.33-5.57)
5.5:1	0.67	(0.10-4.62)	1.02	(0.18-5.74)
8.5:1	0.43	(0.05-3.63)	0.77	(0.08-7.28)
>8.5:1	0.47	(0.06-3.73)	2.15	(0.23-20.49)
Ratio of beds per one nurse				
2.0:1	1.00		1.00	
2.5:1	0.73	(0.04-12.39)	0.63	(0.02-17.26)
3.0:1	1.09	(0.08-14.66)	0.40	(0.02-8.33)
3.5:1	2.00	(0.14-29.16)	0.75	(0.03-16.97)
4.0:1	3.27	(0.19-56.29)	1.33	(0.06-31.90)
4.5:1	2.52	(0.12-52.04)	0.61	(0.02-19.28)
>6.0:1	2.29	(0.13-40.84)	0.73	(0.03-19.59)

Table E3. Adjusted hazard ratio for association between hospital characteristics and in-hospital mortality, stratified by diseases except patients who were dead within 30-day *(Continued)*

	Ischemic stroke (N=7,253)		Hemorrhagic stroke (N=2,306)	
Hospital Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Hospital function				
Superior general hospital	1.00		1.00	
General hospital	0.67	(0.18-2.49)	1.05	(0.29-3.72)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Note: could not calculate the hazard ratio for in-hospital mortality in patients with AMI.

Table F1-1. Adjusted hazard ratio for association between patient characteristics and mortality in ischemic stroke who utilized only hospital size≥4 quintile

Patient Characteristics	7-day mortality		30-day mortality		In-hospital mortality	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age						
20-39	0.18	(0.03-1.34)	0.27	(0.08-0.85)	0.24	(0.08-0.77)
40-49	0.40	(0.18-0.89)	0.33	(0.17-0.63)	0.38	(0.21-0.68)
50-59	0.48	(0.28-0.81)	0.49	(0.32-0.73)	0.45	(0.30-0.67)
60-69	0.60	(0.41-0.86)	0.67	(0.51-0.89)	0.63	(0.49-0.82)
≥70	1.00		1.00		1.00	
Sex						
Male	0.74	(0.55-1.00)	0.79	(0.63-0.98)	0.82	(0.66-1.02)
Female	1.00		1.00		1.00	
Health insurance type						
Medical aid	1.02	(0.51-2.03)	0.84	(0.48-1.47)	0.89	(0.53-1.49)
National health insurance	1.00		1.00		1.00	
Individual household income						
Low	1.69	(1.14-2.49)	1.58	(1.18-2.11)	1.56	(1.18-2.07)
Middle	1.64	(1.16-2.31)	1.51	(1.17-1.94)	1.46	(1.14-1.86)
High	1.00		1.00		1.00	
Residential area						
Metropolitan	1.00		1.00		1.00	
City	1.08	(0.78-1.49)	1.21	(0.95-1.55)	1.25	(0.99-1.59)
Rural	0.74	(0.47-1.18)	0.89	(0.63-1.26)	0.85	(0.60-1.20)
Charlson comorbidity index						
0-1	1.00		1.00		1.00	
2-3	1.15	(0.76-1.75)	1.03	(0.75-1.41)	1.06	(0.78-1.44)
4-5	1.17	(0.73-1.88)	1.15	(0.81-1.63)	1.31	(0.94-1.82)
>5	1.31	(0.78-2.22)	1.29	(0.88-1.89)	1.41	(0.98-2.03)

Table F1-1. Adjusted hazard ratio for association between patient characteristics and mortality in ischemic stroke who utilized only hospital size≥4 quintile *(Continued)*

Patient Characteristics	7-day mortality Adjusted HR*	95% CI	30-day mortality Adjusted HR*	95% CI	In-hospital mortality Adjusted HR*	95% CI
Hypertension						
No	1.00		1.00		1.00	
Without hypertensive complication	0.94	(0.62-1.42)	0.94	(0.69-1.29)	0.99	(0.73-1.33)
With hypertensive complication	1.21	(0.75-1.96)	1.26	(0.87-1.81)	1.22	(0.86-1.74)
Diabetes Mellitus						
No	1.00		1.00		1.00	
Without diabetic complication	1.02	(0.71-1.48)	0.88	(0.66-1.16)	0.86	(0.65-1.12)
With diabetic complication	0.89	(0.60-1.34)	0.88	(0.66-1.19)	0.83	(0.62-1.10)
Dyslipidemia						
No	1.00		1.00		1.00	
Yes	0.96	(0.68-1.35)	0.97	(0.75-1.25)	0.97	(0.76-1.24)
Disability						
None	1.00		1.00		1.00	
Mild	1.02	(0.66-1.58)	0.80	(0.57-1.13)	0.88	(0.64-1.21)
Severe	0.53	(0.27-1.04)	0.50	(0.31-0.80)	0.47	(0.30-0.74)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table F1-2. Adjusted hazard ratio for association between treatment characteristics and mortality in ischemic stroke who utilized only hospital size≥4 quintile

Treatment Characteristics	7-day mortality		30-day mortality		In-hospital mortality	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service						
No use	1.00		1.00		1.00	
Use	7.49	(5.55-10.10)	5.83	(4.66-7.29)	5.64	(4.55-7.00)
Intravenous thrombolytic agent						
No	1.00		1.00		1.00	
Yes	1.11	(0.74-1.68)	1.12	(0.82-1.52)	1.09	(0.81-1.46)
Percutaneous cerebrovascular intervention[a]						
No	1.00		1.00		1.00	
Yes	1.19	(0.60-2.37)	1.07	(0.65-1.74)	1.05	(0.66-1.68)
Weekend admission[b]						
Weekday admission	1.00		1.00		1.00	
Weekend admission	1.46	(1.08-1.96)	1.28	(1.02-1.61)	1.19	(0.95-1.48)

ICP denotes intracranial pressure; NA, not applicable.
*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.
[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.
[b], included weekend admission plus national official holidays.

Table F1-3. Adjusted hazard ratio for association between hospital characteristics and mortality in ischemic stroke who utilized only hospital size≥4 quintile

Hospital Characteristics	7-day mortality Adjusted HR*	95% CI	30-day mortality Adjusted HR*	95% CI	In-hospital mortality Adjusted HR*	95% CI
Characteristic of foundation						
Public	1.66	(0.46-5.99)	1.45	(0.63-3.34)	1.41	(0.62-3.19)
Educational foundation	0.70	(0.50-0.99)	0.77	(0.59-0.99)	0.78	(0.61-1.01)
Private	1.00		1.00		1.00	
Volume of emergent stroke patient						
Quintile 1	4.66	(0.62-34.88)	2.32	(0.32-17.00)	2.30	(0.31-16.9)
Quintile 2	0.84	(0.11-6.42)	1.76	(0.53-5.86)	1.75	(0.52-5.83)
Quintile 3	0.48	(0.16-1.46)	1.26	(0.67-2.37)	1.28	(0.68-2.40)
Quintile 4	0.66	(0.39-1.11)	0.73	(0.49-1.07)	0.80	(0.55-1.16)
Quintile 5	1.00		1.00		1.00	
Proportion of transferred patient to other hospital						
<5%	1.00		1.00		1.00	
5-9%	1.48	(1.03-2.11)	1.35	(1.01-1.79)	1.30	(0.98-1.72)
10-14%	1.25	(0.74-2.11)	1.32	(0.90-1.94)	1.28	(0.87-1.87)
15-19%	1.19	(0.52-2.75)	1.03	(0.54-1.98)	0.99	(0.52-1.88)
≥20%	0.54	(0.17-1.75)	0.74	(0.34-1.63)	0.56	(0.25-1.26)
The number of beds per one doctor						
2.5:1	1.00		1.00		1.00	
3.5:1	1.03	(0.67-1.60)	1.00	(0.72-1.40)	1.05	(0.76-1.46)
5.5:1	1.17	(0.65-2.10)	1.11	(0.70-1.75)	1.10	(0.70-1.73)
8.5:1	1.29	(0.57-2.95)	0.98	(0.51-1.87)	0.92	(0.49-1.72)
>8.5:1	1.21	(0.45-3.22)	1.26	(0.61-2.62)	1.08	(0.53-2.20)

Table F1-3. Adjusted hazard ratio for association between hospital characteristics and mortality in ischemic stroke who utilized only hospital size≥4 quintile *(Continued)*

Hospital Characteristics	7-day mortality		30-day mortality		In-hospital mortality	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Ratio of beds per one nurse						
2.0:1	1.00		1.00		1.00	
2.5:1	2.74	(0.33-22.79)	2.59	(0.87-7.71)	2.15	(0.79-5.85)
3.0:1	8.29	(1.08-63.59)	3.43	(1.18-9.99)	2.89	(1.09-7.65)
3.5:1	8.46	(1.08-66.3)	3.23	(1.08-9.67)	2.88	(1.06-7.83)
4.0:1	10.23	(1.25-83.62)	3.91	(1.25-12.21)	3.48	(1.22-9.93)
4.5:1	9.09	(1.05-78.37)	2.40	(0.69-8.31)	2.19	(0.70-6.90)
>6.0:1	8.93	(0.96-83.03)	2.58	(0.73-9.08)	2.67	(0.84-8.49)
Hospital function						
Superior general hospital	1.00		1.00		1.00	
General hospital	0.83	(0.55-1.26)	0.91	(0.66-1.27)	0.87	(0.63-1.20)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table F2-1. Adjusted hazard ratio for association between patient characteristics and mortality in hemorrhagic stroke who utilized only hospital size≥4 quintile

Patient Characteristics	7-day mortality		30-day mortality		In-hospital mortality	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age						
20-39	0.51	(0.26-0.99)	0.61	(0.38-0.98)	0.60	(0.38-0.95)
40-49	0.73	(0.48-1.10)	0.72	(0.52-0.99)	0.70	(0.52-0.96)
50-59	0.64	(0.44-0.93)	0.66	(0.50-0.88)	0.64	(0.49-0.85)
60-69	0.49	(0.34-0.71)	0.55	(0.42-0.73)	0.57	(0.44-0.73)
≥70	1.00		1.00		1.00	
Sex						
Male	1.09	(0.83-1.42)	1.11	(0.91-1.35)	1.18	(0.97-1.43)
Female	1.00		1.00		1.00	
Health insurance type						
Medical aid	0.56	(0.28-1.14)	0.37	(0.20-0.68)	0.40	(0.22-0.72)
National health insurance	1.00		1.00		1.00	
Individual household income						
Low	1.09	(0.74-1.61)	1.14	(0.84-1.53)	1.16	(0.87-1.54)
Middle	0.90	(0.67-1.21)	0.95	(0.76-1.19)	0.94	(0.76-1.17)
High	1.00		1.00		1.00	
Residential area						
Metropolitan	1.00		1.00		1.00	
City	0.85	(0.63-1.15)	0.88	(0.71-1.09)	0.91	(0.74-1.12)
Rural	0.82	(0.54-1.23)	0.70	(0.50-0.96)	0.74	(0.54-1.01)
Charlson comorbidity index						
0-1	1.00		1.00		1.00	
2-3	1.24	(0.88-1.75)	1.13	(0.87-1.46)	1.14	(0.89-1.46)
4-5	1.24	(0.80-1.92)	1.27	(0.92-1.75)	1.31	(0.96-1.78)
>5	2.04	(1.28-3.25)	2.09	(1.47-2.95)	2.08	(1.49-2.91)

Table F2-1. Adjusted hazard ratio for association between patient characteristics and mortality in hemorrhagic stroke who utilized only hospital size≥4 quintile *(Continued)*

	7-day mortality		30-day mortality		In-hospital mortality	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Hypertension						
No	1.00		1.00		1.00	
Without hypertensive complication	0.91	(0.65-1.26)	1.03	(0.81-1.32)	1.05	(0.83-1.34)
With hypertensive complication	1.32	(0.87-2.00)	1.36	(0.99-1.88)	1.33	(0.97-1.82)
Diabetes Mellitus						
No	1.00		1.00		1.00	
Without diabetic complication	1.14	(0.78-1.66)	1.03	(0.77-1.38)	1.03	(0.78-1.36)
With diabetic complication	1.37	(0.89-2.11)	1.41	(1.03-1.95)	1.42	(1.05-1.93)
Dyslipidemia						
No	1.00		1.00		1.00	
Yes	0.86	(0.62-1.20)	0.83	(0.64-1.07)	0.83	(0.65-1.06)
Disability						
None	1.00		1.00		1.00	
Mild	1.00	(0.67-1.49)	0.95	(0.70-1.30)	0.93	(0.69-1.25)
Severe	0.69	(0.44-1.08)	0.56	(0.39-0.80)	0.52	(0.37-0.74)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table F2-2. Adjusted hazard ratio for association between treatment characteristics and mortality in hemorrhagic stroke who utilized only hospital size≥4 quintile

Treatment Characteristics	7-day mortality		30-day mortality		In-hospital mortality	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service						
No use	1.00		1.00		1.00	
Use	0.95	(0.68-1.33)	1.23	(0.93-1.62)	1.26	(0.96-1.64)
Weekend admission[b]						
Weekday admission	1.00		1.00		1.00	
Weekend admission	1.30	(1.00-1.70)	1.19	(0.97-1.46)	1.18	(0.97-1.44)
Intervention for reducing ICP						
Intravenous antihypertensive agents	1.00		1.00		1.00	
Use of mannitol	3.98	(2.21-7.16)	3.04	(1.97-4.69)	2.63	(1.76-3.94)
Endovascular coiling	1.40	(0.58-3.39)	1.39	(0.76-2.54)	1.29	(0.73-2.28)
Trephination	3.72	(1.96-7.05)	3.39	(2.13-5.40)	3.01	(1.95-4.65)
Craniotomy	3.42	(1.41-8.28)	4.43	(2.44-8.06)	3.78	(2.16-6.62)

ICP denotes intracranial pressure; NA, not applicable.

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

Table F2-3. Adjusted hazard ratio for association between hospital characteristics and mortality in hemorrhagic stroke who utilized only hospital size≥4 quintile

	7-day mortality		30-day mortality		In-hospital mortality	
Hospital Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Characteristic of foundation						
Public	0.84	(0.46-1.54)	0.74	(0.48-1.16)	0.81	(0.53-1.24)
Educational foundation	0.91	(0.65-1.28)	1.10	(0.87-1.4)	1.11	(0.89-1.40)
Private	1.00		1.00		1.00	
Volume of emergent stroke patient						
Quintile 1	4.23	(0.48-37.62)	6.09	(1.61-22.97)	4.50	(1.21-16.76)
Quintile 2	1.91	(0.39-9.32)	2.57	(1.00-6.62)	2.65	(1.09-6.42)
Quintile 3	1.39	(0.67-2.86)	1.36	(0.81-2.26)	1.37	(0.85-2.20)
Quintile 4	1.50	(0.98-2.29)	1.25	(0.93-1.67)	1.26	(0.95-1.66)
Quintile 5						
Proportion of transferred patient to other hospital						
<5%	1.00		1.00		1.00	
5-9%	1.54	(0.90-2.65)	1.27	(0.88-1.82)	1.33	(0.94-1.87)
10-14%	1.70	(0.99-2.91)	1.38	(0.97-1.98)	1.38	(0.98-1.94)
15-19%	1.70	(0.93-3.11)	1.67	(1.12-2.50)	1.61	(1.10-2.37)
≥20%	1.00	(0.51-1.97)	0.93	(0.60-1.45)	0.83	(0.54-1.28)
The number of beds per one doctor						
2.5:1	1.00		1.00		1.00	
3.5:1	1.25	(0.81-1.93)	1.20	(0.88-1.64)	1.22	(0.90-1.64)
5.5:1	0.87	(0.50-1.53)	1.04	(0.70-1.55)	1.02	(0.70-1.50)
8.5:1	0.63	(0.28-1.43)	0.93	(0.53-1.64)	0.92	(0.54-1.59)
>8.5:1	0.70	(0.25-1.95)	1.04	(0.51-2.14)	1.11	(0.57-2.17)

Table F2-3. Adjusted hazard ratio for association between hospital characteristics and mortality in hemorrhagic stroke who utilized only hospital size≥4 quintile *(Continued)*

Hospital Characteristics	**7-day mortality** Adjusted HR*	95% CI	**30-day mortality** Adjusted HR*	95% CI	**In-hospital mortality** Adjusted HR*	95% CI
Ratio of beds per one nurse						
2.0:1	1.00		1.00		1.00	
2.5:1	0.37	(0.15-0.95)	0.73	(0.35-1.52)	0.72	(0.36-1.46)
3.0:1	0.39	(0.16-0.94)	0.73	(0.36-1.46)	0.72	(0.37-1.41)
3.5:1	0.53	(0.22-1.31)	0.83	(0.41-1.68)	0.84	(0.43-1.66)
4.0:1	0.43	(0.16-1.11)	0.73	(0.35-1.53)	0.77	(0.38-1.57)
4.5:1	0.14	(0.03-0.58)	0.47	(0.19-1.15)	0.43	(0.18-1.03)
>6.0:1	0.43	(0.13-1.43)	0.65	(0.26-1.65)	0.77	(0.32-1.82)
Hospital function						
Superior general hospital	1.00		1.00		1.00	
General hospital	1.57	(1.04-2.37)	1.32	(0.99-1.76)	1.27	(0.96-1.68)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table F3-1. Adjusted hazard ratio for association between patient characteristics and mortality in acute myocardial infarction who utilized only hospital size≥4 quintile

	7-day mortality		30-day mortality		In-hospital mortality	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Age						
20-39	0.42	(0.13-1.37)	0.41	(0.15-1.12)	0.38	(0.14-1.04)
40-49	0.15	(0.05-0.41)	0.16	(0.07-0.37)	0.18	(0.08-0.38)
50-59	0.49	(0.31-0.77)	0.41	(0.27-0.63)	0.39	(0.26-0.59)
60-69	0.64	(0.46-0.91)	0.60	(0.45-0.79)	0.58	(0.44-0.76)
≥70	1.00		1.00		1.00	
Sex						
Male	0.99	(0.75-1.30)	0.93	(0.75-1.15)	0.94	(0.76-1.16)
Female	1.00		1.00		1.00	
Health insurance type						
Medical aid	1.00		1.00		1.00	
National health insurance	0.56	(0.23-1.34)	0.93	(0.75-1.15)	0.65	(0.34-1.22)
Individual household income						
Low	1.10	(0.75-1.61)	1.10	(0.81-1.50)	1.11	(0.82-1.50)
Middle	0.92	(0.68-1.24)	0.88	(0.69-1.12)	0.90	(0.71-1.14)
High	1.00		1.00		1.00	
Residential area						
Metropolitan	1.00		1.00		1.00	
City	0.88	(0.66-1.19)	0.99	(0.78-1.26)	0.99	(0.79-1.25)
Rural	1.10	(0.74-1.64)	1.17	(0.85-1.62)	1.18	(0.86-1.62)
Charlson comorbidity index						
0-1	1.00		1.00		1.00	
2-3	0.96	(0.63-1.48)	0.73	(0.52-1.04)	0.74	(0.52-1.04)
4-5	1.44	(0.92-2.24)	1.20	(0.84-1.71)	1.18	(0.83-1.68)
>5	1.30	(0.79-2.14)	1.00	(0.67-1.50)	1.00	(0.68-1.49)

Table F3-1. Adjusted hazard ratio for association between patient characteristics and mortality in acute myocardial infarction who utilized only hospital size≥4 quintile *(Continued)*

	7-day mortality		30-day mortality		In-hospital mortality	
Patient Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Hypertension						
No	1.00		1.00		1.00	
Without hypertensive complication	0.62	(0.43-0.89)	0.71	(0.52-0.97)	0.68	(0.51-0.92)
With hypertensive complication	0.59	(0.38-0.91)	0.75	(0.53-1.07)	0.77	(0.55-1.08)
Diabetes Mellitus						
No	1.00		1.00		1.00	
Without diabetic complication	1.37	(0.97-1.94)	1.33	(1.01-1.76)	1.30	(0.99-1.71)
With diabetic complication	1.34	(0.95-1.90)	1.23	(0.94-1.62)	1.18	(0.90-1.54)
Dyslipidemia						
No	1.00		1.00		1.00	
Yes	0.79	(0.58-1.08)	0.81	(0.63-1.05)	0.82	(0.64-1.05)
Disability						
None	1.00		1.00		1.00	
Mild	0.81	(0.51-1.27)	0.93	(0.67-1.30)	0.93	(0.67-1.29)
Severe	1.28	(0.81-2.03)	1.14	(0.79-1.63)	1.14	(0.82-1.60)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Table F3-2. Adjusted hazard ratio for association between treatment characteristics and mortality in acute myocardial infarction who utilized only hospital size≥4 quintile

Treatment Characteristics	7-day mortality		30-day mortality		In-hospital mortality	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Intensive care unit service						
No use	1.00		1.00		1.00	
Use	2.17	(1.59-2.95)	1.93	(1.51-2.48)	1.90	(1.49-2.42)
Intravenous thrombolytic agent						
No	1.00		1.00		1.00	
Yes	1.47	(0.84-2.57)	1.37	(0.85-2.21)	1.34	(0.84-2.14)
Percutaneous coronary intervention[a]						
No	1.00		1.00		1.00	
Yes	1.21	(0.91-1.62)	1.36	(1.08-1.71)	1.37	(1.10-1.71)
Weekend admission[b]						
Weekday admission	1.00		1.00		1.00	
Weekend admission	0.39	(0.29-0.54)	0.42	(0.33-0.54)	0.43	(0.33-0.55)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

[a], was included the following as percutaneous transluminal coronary angioplasty, percutaneous transcatheter placement of intracoronary stent, percutaneous transluminal coronary atherectomy, percutaneous transluminal cerebral angioplasty, percutaneous cerebral angioplasty with drug (installation of metallic stent), and percutaneous intravascular atherectomy.

[b], included weekend admission plus national official holidays.

Table F3-3. Adjusted hazard ratio for association between hospital characteristics and mortality in acute myocardial infarction who utilized only hospital size≥4 quintile

Hospital Characteristics	7-day mortality		30-day mortality		In-hospital mortality	
	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Characteristic of foundation						
Public	1.16	(0.72-1.87)	1.24	(0.85-1.80)	1.20	(0.83-1.73)
Educational foundation	1.17	(0.85-1.60)	1.23	(0.95-1.58)	1.23	(0.96-1.57)
Private	1.00		1.00		1.00	
Volume of emergent stroke patient						
Quintile 1	1.56	(0.52-4.74)	1.47	(0.62-3.50)	1.66	(0.74-3.74)
Quintile 2	1.24	(0.51-3.02)	1.45	(0.74-2.84)	1.61	(0.84-3.05)
Quintile 3	1.41	(0.76-2.62)	1.26	(0.74-2.13)	1.33	(0.79-2.22)
Quintile 4	1.13	(0.78-1.63)	1.03	(0.76-1.40)	1.08	(0.80-1.45)
Quintile 5	1.00		1.00		1.00	
Proportion of transferred patient to other hospital						
<5%	1.00		1.00		1.00	
5-9%	1.11	(0.75-1.63)	0.92	(0.67-1.26)	0.93	(0.68-1.26)
10-14%	1.06	(0.53-2.14)	1.22	(0.72-2.07)	1.15	(0.68-1.92)
15-19%	0.62	(0.22-1.74)	1.11	(0.55-2.20)	1.19	(0.62-2.29)
≥20%	1.28	(0.72-2.30)	0.97	(0.58-1.61)	0.96	(0.58-1.57)
The number of beds per one doctor						
2.5:1	1.00		1.00		1.00	
3.5:1	1.57	(1.00-2.46)	1.19	(0.85-1.66)	1.15	(0.83-1.60)
5.5:1	1.10	(0.61-1.96)	0.89	(0.57-1.41)	0.83	(0.53-1.31)
8.5:1	1.21	(0.61-2.41)	1.03	(0.60-1.75)	0.93	(0.55-1.57)
>8.5:1	1.00	(0.46-2.22)	0.97	(0.52-1.82)	0.95	(0.52-1.74)

Table F3-3. Adjusted hazard ratio for association between hospital characteristics and mortality in acute myocardial infarction who utilized only hospital size≥4 quintile *(Continued)*

	7-day mortality		30-day mortality		In-hospital mortality	
Hospital Characteristics	Adjusted HR*	95% CI	Adjusted HR*	95% CI	Adjusted HR*	95% CI
Ratio of beds per one nurse						
2.0:1	1.00		1.00		1.00	
2.5:1	1.37	(0.39-4.88)	1.72	(0.64-4.61)	1.44	(0.58-3.57)
3.0:1	2.25	(0.67-7.59)	2.27	(0.87-5.92)	1.77	(0.73-4.28)
3.5:1	2.26	(0.66-7.71)	2.74	(1.04-7.23)	2.34	(0.96-5.70)
4.0:1	2.03	(0.57-7.22)	2.01	(0.73-5.54)	1.66	(0.65-4.25)
4.5:1	1.99	(0.49-8.07)	1.83	(0.59-5.62)	1.60	(0.57-4.52)
>6.0:1	2.69	(0.69-10.43)	2.46	(0.83-7.25)	1.85	(0.67-5.05)
Hospital function						
Superior general hospital	1.00		1.00		1.00	
General hospital	1.33	(0.88-2.00)	1.33	(0.95-1.86)	1.34	(0.97-1.87)

*, adjusted for all covariates including patient characteristics, treatment characteristics and hospital characteristics.

Appendix G. The proportion of patient who received intervention to reduce ICP, according to the ratio of patients per one nurse/doctor in hemorrhagic stroke (N=2,828)

		Use of Intravenous antihypertensive agent (N=352)		**Use of mannitol** (N=1,691)		**Endovascular coiling** (N=229)		**Trephination** (N=459)		**Craniotomy** (N=97)	
	Total	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Ratio of beds per one nurse											
2.0:1	73	22	(30.1)	33	(45.2)	4	(5.5)	13	(17.8)	1	(1.4)
2.5:1	247	33	(13.4)	139	(56.3)	32	(13.0)	33	(13.4)	10	(4.1)
3.0:1	914	124	(13.6)	475	(52.0)	121	(13.2)	156	(17.1)	38	(4.2)
3.5:1	771	82	(10.6)	492	(63.8)	42	(5.5)	127	(16.5)	28	(3.6)
4.0:1	421	42	(10.0)	287	(68.2)	17	(4.0)	64	(15.2)	11	(2.6)
4.5:1	421	42	(10.0)	287	(68.2)	17	(4.0)	64	(15.2)	11	(2.6)
>6.0:1	277	39	(14.1)	179	(64.6)	6	(2.2)	46	(16.6)	7	(2.5)
The number of beds per one doctor											
2.5:1	549	74	(13.5)	294	(53.6)	65	(11.8)	90	(16.4)	26	(4.7)
3.5:1	1,019	119	(11.7)	606	(59.5)	98	(9.6)	164	(16.1)	32	(3.1)
5.5:1	627	88	(14.0)	369	(58.9)	46	(7.3)	101	(16.1)	23	(3.7)
8.5:1	218	23	(10.6)	140	(64.2)	13	(6.0)	34	(15.6)	8	(3.7)
>8.5:1	415	48	(11.6)	282	(68.0)	7	(1.7)	70	(16.9)	8	(1.9)

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Korean Abstract

뇌졸중 및 급성심근경색증 환자에서 원내 사망에 영향을 미치는 요인 : Algebra Effectiveness Model 적용

서론: 심뇌혈관질환은 전체사망의 사분의 일을 자치하는 질환으로서, 향후 한국의 고령화를 감안할 때, 질병부담은 더욱 커질 것으로 예상된다. 뇌졸중과 급성심근경색증으로 인한 사망을 줄이고자, 정부와 의료기관의 끊임없는 노력을 해왔음에도 불구하고, 여전히 병원 내 사망률이 높다.

연구목적: Algebra Effectiveness Model를 적용하여 뇌졸중과 심근경색증 환자에서 환자요인, 치료요인, 병원요인이 단기사망 (S hort-term mortality), 중기사망 (intermediate mortality), 장기사망 (long-term mortality)에 어떠한 영향을 미쳤는지를 평가하고자 하였다.

연구방법: 이 연구는 2002년부터 2013년까지의 국민건강보험공단 표본코흐트 자료를 이용하여 분석하였다. 연구대상자는 혈성 뇌졸중, 출혈성 뇌졸중, 급성심근경색증을 주진단으로 응급실을 통해 입원한 환자로서, 종합병원급 이상의 의료기관을 이용하고, 다른 의료기관을 경유하거나 전원되지 않은 환자로 한정하였다. 허혈성뇌졸중 환자 7,693명, 출혈성뇌졸중 환자 2,828명, 급성심근경색증 환자 4,916명을 연구대상자로 하였다. 통계분석방법은 개인수준과 병원수준을 동시에 고려하기 위해 Cox’s Proportional Frailty Model을 이용하였다.

연구결과: 7,693명의 허혈성 뇌졸중 환자 중 500명 (6.5%), 2,828명의 출혈성 뇌졸중 환자 중 569명 (20.1%)이, 4,916명의 급성심근경색증 환자 중 399명 (8.1%)이 병원 내 사망하였다. 환자요인과 사망과의 관련성은 세 개의 모든 질환에서, 연령, 성별, 고혈압 및 당뇨병 같은 임상적 요인이 7일내 사망과 관련이 있었고, 소득이나 건강보험유형 같은 비임상 요인은 30일내 사망과 병원 내 사망과 관련성이 있었다. 치료요인과 사망과의 관련성 분석에서, 급성심근경색증 환자에서 PCI의 수행이 7일내사망, 30일내 사망, 병원 내 사망 모두에서 보정사망의 위험이 감소하였다 (aHR,0.40; 95% CI,0.29-0.54; aHR, 0.35; 95% CI, 0.23-0.55; aHR, 0.43; 95% CI, 0.27-0.67, 순서대로). 급성심근경색과 허혈성 뇌졸중에서 중환자실을 이용한 사람들이 그렇지 않은 사람들에 비해서 7일내 사망, 30일내 사망, 병원 내 사망의 보정 사망위험이 높았고, 출혈성 뇌졸중 환자군 에서 뇌압 상승을 조절하기 위해 만니톨 투여와 같은 내과적 중재보다 천두술이나 개두술과 같은 외과적 중재를 받는 환자들의 7일내 사망, 30일내 사망, 병원 내 사망의 보정 사망위험이 높았다 (eg, 30일내 사망; 만니톨 사용군의 aHR, 2.42; 95% CI, 1.36-4.32 vs 천두술 중재군 aHR, 3.30; 95% CI, 1.80-6.04; 개두술 중재군 aHR, 5.27; 95% CI, 2.49-11.17). 병원요인과 사망과의 관련성은 허혈성 뇌졸중에서 간호사수가 커질수록 7일내사망, 30일내사망, 병원 내 사망의 보정위험 사망비가 감소하였다. 세 개의 모든 질환에서 진료량과 사망과 관련성이 있었고, 출혈성 뇌졸중환자에서 전원량이 사망과 관련성이 있었다.

결론: 건강한 생활습관으로 전환할 수 있도록 일차예방에 초점을 둔 정책과 아울러, PCI와 같은 중요한 시술을 수행할 수 있는 전문의를 확보를 위해 국가차원에서의 노력이 필요하며, 의사 및 의료기관의 능숙함이 중요한 급성심근경색과 출혈성 뇌졸중환자 관리를 위해 이런 환자들을 관리할 수 있는 의료기관 리스트에 대한 정보 공유를 위한 중앙시스템이 마련되어야 할 것이다.

핵심어: 뇌졸중, 급성심근경색증, 원내사망, algebra effectiveness model