The Impact of Hospital Bed Size on Injury Mortality Using National Public Big Data: A Convergence Approach to Resource Optimization

Jung-Ja Jang [1]*, **Eun-Mee Choi** [2]**, **Kyunghee Lee** [3]***

**[1]Department of Healthcare Management, Eulji University, Gyeonggi-do, Korea*
***[2]Department of Healthcare Management, Catholic Kwandong University, Gangwon State, Korea*
****[3]Department of Healthcare Management, Eulji University, Gyeonggi-do, Korea* (*Corresponding author*)

Corresponding Author: Kyunghee Lee

Abstract:Injuries remain a leading cause of mortality and disability worldwide, and treatment outcomes are influenced not only by patient characteristics but also by the structural capacity of healthcare institutions. Hospital bed size is widely regarded as a proxy for institutional resources and clinical capability; however, the higher mortality observed in larger hospitals may largely reflect the concentration of severely injured patients rather than differences in the quality of care. Therefore, this study aimed to investigate the independent association between hospital bed size and in-hospital mortality among injury patients after sequentially adjusting for patient characteristics, injury severity-related factors, and treatment-related variables. Data were obtained from the Korea National Hospital Discharge In-depth Injury Survey (KNHDIS) from 2019 to 2023, including 131,772 injury patients. Hospital bed size was categorized into 100–299, 300–499, 500–999, and ≥1,000 beds. Complex samples logistic regression analyses were performed using hierarchical models that sequentially adjusted for general characteristics, injury characteristics, and treatment-related factors. In the unadjusted model, compared with hospitals with 100–299 beds, the odds of in-hospital mortality were 2.697 times higher in hospitals with 300–499 beds, 6.168 times higher in hospitals with 500–999 beds, and 9.829 times higher in hospitals with ≥1,000 beds. After comprehensive adjustment, the corresponding odds ratios decreased to 1.722, 2.614, and 3.409, respectively, but remained statistically significant. Advanced age, chronic comorbidities, Medical Aid coverage, emergency admission, self-harm, specific injury sites, surgical treatment, and length of stay were also significantly associated with mortality. These findings indicate that although the higher mortality observed in larger hospitals is largely attributable to differences in patient case-mix, hospital bed size remains an independent predictor of in-hospital mortality after comprehensive risk adjustment. Accordingly, evaluation of trauma care outcomes should rely on risk-adjusted measures rather than crude mortality rates, and future trauma policies should focus on strengthening regionalized trauma systems and severity-based triage to improve patient outcomes. Although residual risk remained higher in larger hospitals—likely reflecting unmeasured clinical severity—the substantial attenuation of odds ratios across models demonstrates that case-mix differences account for the majority of observed mortality variations.

Keywords:Injury Patients, Hospital Bed Size, In-Hospital Mortality, National Public Big Data, Complex Samples Logistic Regression

Introduction

Injuries represent a premier cause of global mortality and disability, constituting a profound public health crisis that imposes immense socioeconomic burdens beyond individual health consequences. According to the World Health Organization (WHO), over 4.4 million individuals succumb to injuries annually, accounting for approximately 8% of all global deaths (World Health Organization, 2024). In South Korea, injuries remain a persistent epidemiological challenge, with the incidence of specific trauma (such as falls) escalating concurrently with rapid population aging. Notably, the growing elderly demographic serves as a primary determinant driving up trauma severity and mortality risks post-injury, leading to a continuous rise in the social burden of medical expenditures (Korea Disease Control and Prevention Agency (KDCA), 2024). These shifting demographic and epidemiological dynamics underscore an urgent need to transition beyond mere injury prevention and toward establishing an efficient, optimized trauma care framework capable of delivering timely, appropriate tiers of medical services.

The clinical outcomes of injury patients are intimately intertwined not only with patient-level factors (such as age, baseline comorbidities, mechanisms of injury, and physiological severity) but also with the structural characteristics of the healthcare provider. According to Donabedian's (1988)

Structure-Process-Outcome model, the structural attributes of medical institutions serve as foundational pillars that directly shape clinical delivery processes and ultimate health outcomes (Donabedian, 1988). Within this paradigm, hospital bed size has historically been utilized as a pivotal structural proxy indicator that implicitly reflects medical staffing volumes, specialized diagnostic/therapeutic equipment, and acute emergency care capabilities. However, relying on bed size as a crude aggregate variable might obscure critical operational capabilities, as it fails to differentiate specialized clinical infrastructure—such as a designated Level-1 Regional Trauma Center—from a general tertiary facility with a similar bed capacity.

Particularly, the "volume–outcome relationship" which posits that institutional scale or patient caseloads correspond tightly with clinical performancehas been extensively documented across various medical domains. Large-scale or high-volume facilities often secure superior clinical outcomes when managing complex patient populations due to accumulated institutional experience and highly specialized care protocols (MacKenzie et al., 2006). Recently within the field of traumatology, the utility of a regionalized trauma systemwhich centralizes critically injured patients into dedicated trauma centers or high-capacity medical hubshas gained substantial traction, with prior literature demonstrating its efficacy in improving survival rates (Nathens et al., 2001).

However, meticulous caution is warranted when interpreting the correlation between institutional scale and trauma mortality. Because large-scale medical centers naturally exhibit a higher influx of transferred, critically ill, and high-risk patients, judging performance via crude mortality rates introduces severe case-mix bias. Consequently, trauma outcomes literature continuously emphasizes the necessity of rigorous risk adjustment that accounts for injury severity, age, comorbidities, and physiological status; it was under this exact mandate that the Korea Trauma and Injury Severity Score (K-TRISS) model was engineered(Sewalt et al., 2021; So et al., 2025).

To date, domestic injury research in South Korea has predominantly centered on specific injury mechanisms, the localized clinical performance of regional trauma centers, or descriptive epidemiological profiles (Hwang & Lee,2024; Zafar et al., 2015). Empirical investigations utilizing nationwide representative data to scrutinize the systemic association between hospital bed size and overall injury mortality remain sparse. In particular, robust evidence regarding whether hospital bed size retains an independent, statistically manifest effect after sequentially controlling for socio-demographics, injury profiles, and clinical treatment variables is still lacking.

To address these knowledge gaps, this study aimed to investigate the determinants of injury-related mortality using the KNHDIS data from 2019 to 2023, focusing specifically on isolating the independent effect of hospital bed size on in-hospital mortality. By employing a complex samples hierarchical logistic regression framework, we systematically adjusted for socio-demographic factors, injury profiles, and treatment-related variables to map the shifting risk trajectories across varying institutional scales. The empirical insights derived from this study are anticipated to serve as a foundational baseline for establishing risk-adjusted trauma delivery networks and formulating public health policies aimed at enhancing the quality of trauma care.

Materials and Methods

Study Design and Data Source

This study employed a retrospective secondary data analysis design to investigate the independent association between hospital bed size and in-hospital mortality among injury patients.The analytical dataset was extracted from the Korean National Hospital Discharge In-depth Injury Survey (KNHDIS), an ongoing national surveillance program conducted by the Korea Disease Control and Prevention Agency (KDCA).

The KNHDIS monitors discharged patients across a nationally representative sample of medical institutions to capture data on injury occurrence profiles, diagnostic codes, and clinical endpoints. Built upon a complex sample design utilizing stratified, cluster sampling methodologies, the dataset incorporates institutional sampling weights to ensure that estimates accurately mirror the nationwide population of hospitalized injury cases.

For this study, multi-year waves of the KNHDIS from 2019 to 2023 were pooled and integrated. The inclusion criteria restricted the study population to hospitalized patients whose primary diagnosis corresponded to injury codes within the International Classification of Diseases, 10th Revision (ICD-10: S00–T79). After excluding records with missing values for key analytical variables, a final sample size of 131,772 patients was retained for analysis.

ICD-10 codes were included to account for broad diagnostic categories; however, they serve as aggregate controls and do not fully capture anatomical/physiological severity measured by dedicated scoring systems such as the Injury Severity Score (ISS) or New Injury Severity Score (NISS)

Measurements and Procedures

Outcome Variable

The primary dependent variable was defined as in-hospital mortality. Based on the clinical disposition recorded at discharge, patients were categorized into a binary outcome framework: "Deceased" or "Survived."

Main Exposure Variable

The primary independent variable was hospital bed size. Medical institutions were stratified into four distinct tiers based on total licensed beds: 100–299 beds, 300–499 beds, 500–999 beds, and ≥1,000 beds. The 100–299 beds tier was designated as the reference group across all models.

Covariates

To isolate the independent association between institutional scale and trauma mortality, a comprehensive suite of covariates was introduced hierarchically:

Socio-demographic characteristics: Sex, age, geographic region, presence of chronic comorbidities, insurance type, and admission route.

Injury characteristics: Season of injury, intentionality, place of occurrence, act of injury, and primary diagnosis.

Treatment-related factors: Surgical operation and length of stay.

Statistical Analysis

All statistical procedures were executed in strict accordance with the complex sample design of the KNHDIS, incorporating institutional strata, clusters, and sampling weights.

The baseline distributions of socio-demographic, injury-specific, and treatment characteristics were expressed via frequencies and weighted percentages. Disparities in categorical variables across patient outcomes were evaluated via complex samples cross-tabulation using the Rao–Scott chi-square test, reporting the Wald F statistic and its associated p-value.

To quantify the independent association between hospital bed size and in-hospital mortality among injury patients, complex samples logistic regression analyses were conducted using a sequential, risk-adjusted framework. Model 1 represented the unadjusted model containing only hospital bed size. Model 2 incorporated adjustments for socio-demographic characteristics. Model 3 further introduced injury-specific variables, and Model 4 served as the fully adjusted final model by incorporating treatment-related attributes.

The results of the regression models are presented as odds ratios (OR) accompanied by 95% confidence intervals (CI). To evaluate the goodness-of-fit across the hierarchical modeling stages, the Cox & Snell R^2, NagelkerkeR^2, and McFadden R^2 values were computed, with overall model significance validated via the Wald F test. All statistical procedures were performed using IBM SPSS Statistics version 30.0 (IBM Corp., Armonk, NY, USA), with the threshold for statistical significance set at $p < 0.05$.

Results

Verification of Statistical Appropriateness and Model Validity

To evaluate the statistical appropriateness of the analytical models utilized in this study, multicollinearity diagnostics were performed for the included independent variables by calculating tolerance values and variance inflation factors (VIF); the results are presented in Table 1.

Table 1. Multicollinearity Diagnostics

Coefficients[a]							
Model	Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity Statistics	
	B	SE	ß			Tolerance	VIF
(Constant)	1.050	0.002		534.819	< .001		
Sex	0.004	0.000	0.019	7.652	< .001	0.911	1.097
Age	-0.003	0.000	-0.028	-10.519	< .001	0.791	1.265
Hospital bed size	0.002	0.000	0.021	8.113	< .001	0.786	1.272
Region	-0.003	0.000	-0.017	-7.088	< .001	0.964	1.037
Insurance type	0.002	0.000	0.015	6.019	< .001	0.870	1.149
Admission route	0.002	0.000	0.010	3.978	< .001	0.852	1.174
Chronic comorbidity	-0.002	0.001	-0.007	-2.871	.004	0.915	1.093
Season of injury	0.000	0.000	-0.001	-0.551	.582	0.998	1.002
Intentionality of injury	0.001	0.001	0.003	1.434	.152	0.957	1.045
Place of occurrence	0.000	0.000	0.008	3.244	< .001	0.889	1.125
Act of injury	-0.000	0.000	-0.010	-3.983	< .001	0.878	1.138
Primary diagnosis	0.004	0.000	0.067	25.413	< .001	0.795	1.257
Operation	-0.006	0.001	-0.031	-11.181	< .001	0.724	1.380
Length of stay	0.003	0.000	0.041	15.675	< .001	0.805	1.243
a. Dependent Variable: in-hospital mortality Note. VIF: Variance Inflation Factor							

General characteristics of injury patients according to in-hospital mortality

The total study population encompassed 131,772 patients; among these, 1,261 patients (approximately 1.0%) deceased in-hospital, while 130,511 patients (approximately 99.0%) survived. The results of the complex samples chi-square analysis demonstrated that in-hospital mortality among injury patients varied with statistically significant differences across socio-demographic, injury-related, and treatment-related characteristics (Table 2).

In terms of socio-demographic characteristics, significant differences were observed across sex, age, presence of chronic comorbidities, insurance type, and admission route,whereas no significant difference was observed by region.Notably, the proportion of deceased patients was prominently higher in the elderly cohort, and a distinct trend toward a higher risk of mortality was identified among patients with concurrent chronic comorbidities and those admitted via the emergency department.

Regarding injury-related characteristics, statistically significant differences were confirmed in the intentionality of injury, place of occurrence, act of injury, and primary anatomical site of diagnosis. In particular, substantially higher mortality rates were manifest within the critical injury subgroups, including those presenting with head injuries and polytrauma.

For treatment-related characteristics, a significant difference was observed in length of stay, whereas surgical intervention status was not significantly associated with in-hospital mortality.These comprehensive findings underscore that the clinical severity of injury patients and their subsequent inpatient care delivery pathways are intimately intertwined with in-hospital mortality outcomes.

Table 2. Characteristics of injury patients according to in-hospital mortality

Variables		Categories	Total (n=131,772)		Deceased (n=1,261)		Survived (n=130,511)		Wald F	p
			n	%	n	%	n	%		
Characterist	Hospital	100-299 beds	53,88	68.	139	29.	53,74	68.	310.0	< .00

ics of General	beds		8	1		2	9	3	34	1
		300-499 beds	23,682	12.6	153	14.6	23,529	12.7		
		500-999 beds	42,732	15.5	676	40.5	42,056	15.3		
		≥1000 beds	11,470	3.8	293	15.7	11,177	3.7		
	Sex	Male	70,408	52.3	844	61.8	69,564	52.2	29.866	< .001
		Female	61,364	47.7	417	38.2	60,947	47.8		
	Age	0-39 years	34,188	23.1	87	4.7	34,101	23.3	358.218	< .001
		40-64 years	48,878	39.0	310	21.4	48,568	39.1		
		≥ 65 years	48,706	37.8	864	73.9	47,842	37.6		
	Region	Metropolitan	50,887	37.2	453	38.1	50,434	37.2	0.273	0.602
		Non-Metropolitan	80,885	62.8	808	61.9	80,077	62.8		
	Chronic disease	Yes	14,944	10.8	319	27.5	14,625	10.7	243.95	< .001
		No	116,828	89.2	942	72.5	115,886	89.3		
	Insurance Type	National Health Insurance	94,417	69.4	868	71	93,549	69.4	36.81	< .001
		Medical Aid	7,931	6.3	129	12.3	7,802	6.3		
		Other	29,424	24.3	264	16.7	29,160	24.3		
	Admission Route	Emergency	68,240	44.4	1159	86.1	67,081	44.4	409.734	< .001
		Outpatient	63,532	55.6	102	13.9	63,430	55.6		
Characteristics of Injury	Season of injury	Spring	32,720	24.6	302	23.9	32,418	24.6	2.125	0.077
		Summer	33,684	25.5	315	24.2	33,369	25.5		
		Autumn	34,202	26	363	29.4	33,839	26		
		Winter	29,832	22.7	267	20.7	29,565	22.7		
		Unknown	1,334	1.2	14	1.9	1,320	1.2		
	Intentionality of Injury	Unintentional	128,729	98.2	1,213	96.8	127,516	98.3	44.524	< .001
		Intentional Self-harm	702	0.3	22	1.6	680	0.3		
		Assault	2,181	1.3	12	0.7	2,169	1.3		
		Other and Undetermined	160	0.1	14	0.9	146	0.1		
	Place of Occurrence	Home	26,259	17.7	393	32.1	25,866	17.6	42.365	< .001
		Residential Institution	1,358	1	39	4.7	1,319	1		
		School and	1,275	0.9	4	0.2	1,271	0.9		

		Public Area							
		Sports and Athletics Area	4,659	3.1	1	0.1	4,658	3.1		
		Street and Highway	39,964	30.7	392	26.2	39,572	30.7		
		Entertainment and Cultural Facility	1,364	0.9	10	0.8	1,354	0.9		
		Commercial Area	3,346	2.3	36	2.2	3,310	2.4		
		Industrial and Construction Area	6,144	4.1	55	3.5	6,089	4.1		
		Other and Unspecified	47,403	39.4	331	30.3	47,072	39.4		
	Act of Injury	Sports and Athletics	4,428	3.2	3	0.1	4,425	3.2	43.717	< .001
		Leisure and Recreation	6,089	3.8	33	2.4	6,056	3.8		
		Occupational Activity	18,420	13.7	119	7.7	18,301	13.8		
		Education	744	0.5	2	0.1	742	0.5		
		Traveling	23,677	16.7	280	18.9	23,397	16.7		
		Daily Living Activity	22,028	14.4	305	25.4	21,723	14.3		
		Medical Treatment	797	0.5	35	2.8	762	0.5		
		Other and Unspecified	55,589	47.2	484	42.6	55,105	47.2		
	Primary Diagnosis	Injuries to the Head and Neck	31,592	20.5	878	65.4	30,714	20.2	196.058	< .001
		Injuries to the Thorax	12,862	10.5	72	5.9	12,790	10.5		
		Injuries to the Abdomen and Pelvis	17,011	14.1	123	9.1	16,888	14.1		
		Injuries to the Shoulder and Upper Limb	31,615	25.1	12	1.3	31,603	25.2		
		Injuries to the Hip and Lower Limb	37,867	29.2	174	18	37,693	29.3		
		MultipleInjuries &Other/Unknown	825	0.6	2	0.3	823	0.6		
Treatment Outcomes	Operation	Yes	72,678	50	666	51	72,012	50	0.332	0.564
		No	59,094	50	595	49	58,499	50		
	Length of Stay	≤ 3 days	32,925	24.5	447	31.2	32,478	24.5	46.172	< .001
		4–7 days	32,230	23.5	210	16.5	32,020	23.5		
		8–14 days	29,79	23	216	18.	29,58	23		

			7			4	1			
		15–29 days	26,708	21.5	185	15.6	26,523	21.5		
		≥ 30 days	10,112	7.6	203	18.2	9,909	7.5		

Note 1. Values are presented as unweighted frequency (n) and weighted percentage (%).
Note 2. Rao-Scott χ^2 test (presented as Wald F) was used to account for the complex sampling design.

Characteristics of deceased injury patients according to hospital bed size

The analysis of the characteristics of deceased injury patients across different hospital bed sizes revealed statistically significant differences in patients' socio-demographic, injury-related, and treatment-related attributes (Table 3).

Large-scale medical institutions exhibited a substantially higher proportion of emergency admissions and demonstrated a distinct trend toward the concentration of critically ill patients, such as those with traumatic head injuries. Conversely, small- to medium-sized medical institutions tended to manage a relatively higher proportion of elderly patients and sustained injuries primarily associated with falls.

These findings indicate that prominent disparities exist in patients' clinical presentations and injury severity depending on the institutional bed capacity. Furthermore, this underscores that case-mix differences must be meticulously accounted for when comparing mortality rates across varying hospital scales.

Table 3. Characteristics of Deceased Injury Patients According to Hospitalbed size

Variables	Category	Total (n=1,261)		100-299 beds (n=139)		300-499 beds (n=153)		500-999 beds (n=676)		≥1000 beds (n=293)		Wald F	p
		n	%	N	%	n	%	n	%	n	%		
Sex	Male	844	61.8	64	45	97	62.1	468	68.9	215	74.2	16.91	< .001
	Female	417	38.2	75	55	56	37.9	208	31.1	78	25.8		
Age	0-39 years	87	4.7	0	0	6	3.5	54	7.2	27	7.7	11.435	< .001
	40-64 years	310	21.5	20	13.7	23	14.9	168	24.6	99	33.9		
	≥ 65 years	864	73.9	119	86.3	124	81.6	454	68.1	167	58.4		
Region	Metropolitan	453	38.1	59	41.6	67	45	213	32.1	114	40.6	3.425	0.023
	Non-Metropolitan	808	61.9	80	58.4	86	55	463	67.9	179	59.4		
Chronic disease	Yes	319	27.5	48	34.1	33	23.3	169	25.4	69	24.3	2.868	0.044
	No	942	72.5	91	65.9	120	76.7	507	74.6	224	75.7		
Insurance Type	National Health Insurance	868	71	106	76.5	108	71.8	453	67.7	201	68.8	9.763	< .001
	Medical Aid	129	12.3	27	19.3	18	11.2	69	10.4	15	5.2		
	Other	264	16.7	6	4.2	27	17	154	21.9	77	26		
Admission routes	Emergency	1,159	86.1	92	65.2	142	92.4	648	95.7	277	94.7	55.2	< .001
	Outpatient	102	13.9	47	34.8	11	7.6	28	4.3	16	5.3		

Season of injury	Spring	302	23.9	32	23	40	26.1	156	23.1	74	25.3	1.42	0.164
	Summer	315	25.0	31	22.3	43	28.1	171	25.3	70	23.9		
	Autumn	363	28.8	42	30.2	39	25.5	189	28	93	31.7		
	Winter	267	21.2	28	20.1	27	17.6	156	23.1	56	19.1		
	Unknown	14	1.1	6	4.3	4	2.6	4	0.6	0	0		
Intentionality of injury	Unintentional	1213	96.2	136	97.8	147	96.1	655	96.9	275	93.9	1.483	0.172
	Intentional Self-harm	22	1.7	2	1.4	4	2.6	11	1.6	5	1.7		
	Assault	12	1	0	0	2	1.3	5	0.7	5	1.7		
	Other and Undetermined	14	1.1	1	0.7	0	0	5	0.7	8	2.7		
Place of occurrence	Home	393	31.2	44	31.7	60	39.2	203	30	86	29.4	5.714	< .001
	Residential Institution	39	3.1	17	12.2	7	4.6	12	1.8	3	1		
	School and Public Area	4	0.3	0	0	1	0.7	0	0	3	1		
	Sports and Athletics Area	1	0.1	0	0	0	0	1	0.1	0	0		
	Street and Highway	392	31.1	18	12.9	26	17	236	34.9	112	38.2		
	Entertainment and Cultural Facility	10	0.8	1	0.7	0	0	7	1	2	0.7		
	Commercial Area	36	2.9	1	0.7	1	0.7	23	3.4	11	3.8		
	Industrial and Construction Area	55	4.4	1	0.7	8	5.2	26	3.8	20	6.8		
	Other and Unspecified	331	26.2	57	41	50	32.7	168	24.9	56	19.1		
Act of Injury	Sports and Athletics	3	0.2	0	0	0	0	3	0.4	0	0	3.857	< .001
	Leisure and Recreation	33	2.6	2	1.4	1	0.7	21	3.1	9	3.1		
	Occupational Activity	119	9.4	4	2.9	13	8.5	59	8.7	43	14.7		
	Education	2	0.2	0	0	0	0	0	0	2	0.7		
	Traveling	280	22.2	14	10.1	19	12.4	170	25.1	77	26.3		
	Daily Living Activity	305	24.2	39	28.1	44	28.8	161	23.8	61	20.8		
	Medical Treatment	35	2.8	3	2.2	5	3.3	23	3.4	4	1.4		
	Other and Unspecified	484	38.4	77	55.4	71	46.4	239	35.4	97	33.1		
Primary Diagnosis	Injuries to the Head and Neck	878	70	70	50.4	99	64.7	508	75.1	201	68.6	4.875	< .001
	Injuries to the	72	5.7	10	7.2	10	6.5	29	4.3	23	7.8		

	Thorax												
	Injuries to the Abdomen and Pelvis	123	9.9	11	7.9	9	5.9	59	8.7	44	15		
	Injuries to the Shoulder and Upper Limb	12	1	4	2.9	1	0.7	4	0.6	3	1		
	Injuries to the Hip and Lower Limb	174	13.8	43	30.9	34	22.2	75	11.1	22	7.5		
	Multiple Injuries & Other/Unknown	2	0.2	1	0.7	0	0	1	0.1	0	0		
Primary Operation	Yes	595	47.2	74	53.2	79	51.6	318	47	124	42.3	1.872	0.143
	No	666	52.8	65	46.8	74	48.4	358	53	169	57.7		
Length of stay	≤ 3 days	447	35.4	29	20.9	47	30.7	246	36.4	125	42.7	3.735	< .001
	4–7 days	210	16.7	18	12.9	27	17.6	113	16.7	52	17.7		
	8–14 days	216	17.1	32	23	25	16.3	110	16.3	49	16.7		
	15–29 days	185	14.7	23	16.5	26	17	107	15.8	29	9.9		
	≥ 30 days	203	16.1	37	26.6	28	18.3	100	14.8	38	13		

Note 1. Values are presented as unweighted frequency (n) and weighted percentage (%).

Note 2. Rao-Scott χ^2 test (presented as Wald F) was used to account for the complex sampling design.

Independent association between hospital bed size and in-hospital mortality

The results of the complex samples logistic regression analysis demonstrated that hospital bed size was significantly associated with in-hospital mortality among injury patients (Figure 1).

In Model 1, which adjusted only for hospital bed size, using the 100–299 beds tier as the reference category, the odds of in-hospital mortality were 2.697 times higherfor 300–499 beds (95% CI: 2.129–3.418), 6.168-fold higher for 500–999 beds (95% CI: 5.120–7.431), and 9.829-fold higher for ≥1,000 beds (95% CI: 7.998–12.080).

In Model 2, which adjusted for patients' general characteristics, the odds ratios (OR) across hospital bed sizes attenuated. This indicates that the elevated mortality risk observed in larger medical institutions can be partially explained by the sociodemographic attributes of the patients.

Upon further adjustment for injury-related characteristics in Model 3, the risk of mortality associated with hospital bed size decreased even more prominently. Notably, the OR for institutions with ≥1,000 beds experienced a substantial decline from 9.829 in Model 1 to 4.058 in Model 3. This robust reduction confirms that a considerable portion of the higher mortality risk observed in larger hospitals is attributable to differences in trauma severity and case-mix.

However, even in the final Model 4, where all socio-demographic, injury-related, and treatment-related characteristics were fully controlled, the significant association between hospital bed size and mortality persisted. Relative to the 100–299 beds group, the odds of in-hospital mortality remained 1.722 times higherfor 300–499 beds (95% CI: 1.352–2.195), 2.614-fold higher for 500–999 beds (95% CI: 2.104–3.249), and 3.409-fold higher for ≥1,000 beds (95% CI: 2.655–4.378).

These empirical findings suggest that although the higher mortality rates in large-scale medical institutions are heavily driven by the concentration of critically ill patients, an independent association inherently tied to the structural attributes of the institutions remains manifest even after fully accounting for all patient- and injury-level covariates.

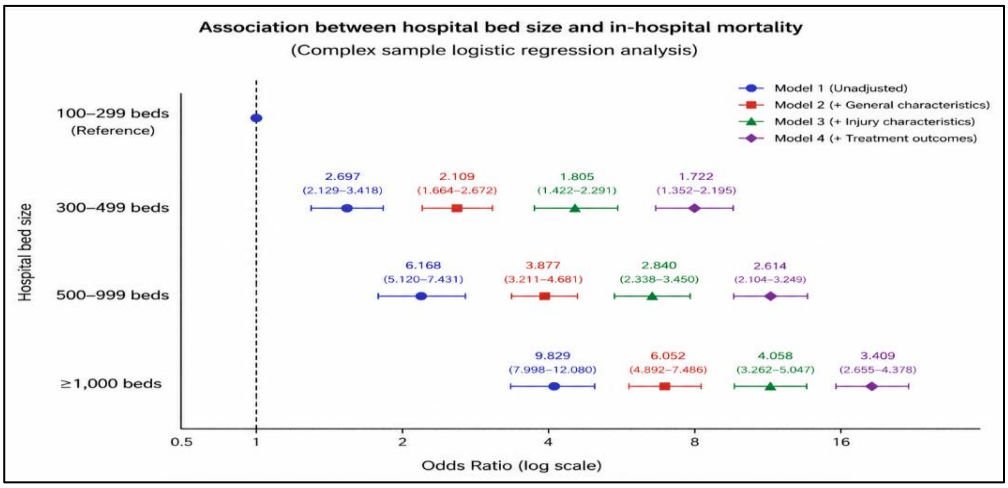

Figure 1. Association between hospital bed size and in-hospital mortality: Complex sample logistic regression analysis

Model fit of complex sample logistic regression models

The evaluation of the model fit for the complex samples logistic regression models indicated that the explanatory power of the models systematically increased as adjusting covariates were sequentially introduced (Figure 2).

In Model 1, which included only hospital bed size, the explanatory power was reflected by a Cox & Snell R^2 of 0.005, a NagelkerkeR^2 of 0.066, and a McFadden R^2 of 0.064. Upon incorporating patients' general characteristics in Model 2, these values increased to a Cox & Snell R^2 of 0.011, a NagelkerkeR^2 of 0.160, and a McFadden R^2 of 0.155.

The introduction of injury-related characteristics in Model 3 yielded the most pronounced increment in explanatory power, with the Cox & Snell,R^2NagelkerkeR^2,and McFadden R^2 reaching 0.017, 0.246, and 0.239, respectively. This substantial shift underscores that injury profiles serve as the pivotal determinants in explaining in-hospital mortality.

Finally, Model 4, which comprehensively encompassed treatment-related characteristics, demonstrated the highest explanatory power, yielding a Cox & Snell R^2 of 0.018, a NagelkerkeR^2 of 0.265, and a McFadden R^2 of 0.258. However, compared to Model 3, the marginal gain in explanatory power was relatively limited. This suggests that mortality outcomes among injury patients are predominantly driven by baseline patient-level demographics and the clinical severity of the trauma sustained prior to the initiation of in-hospital treatment processes.

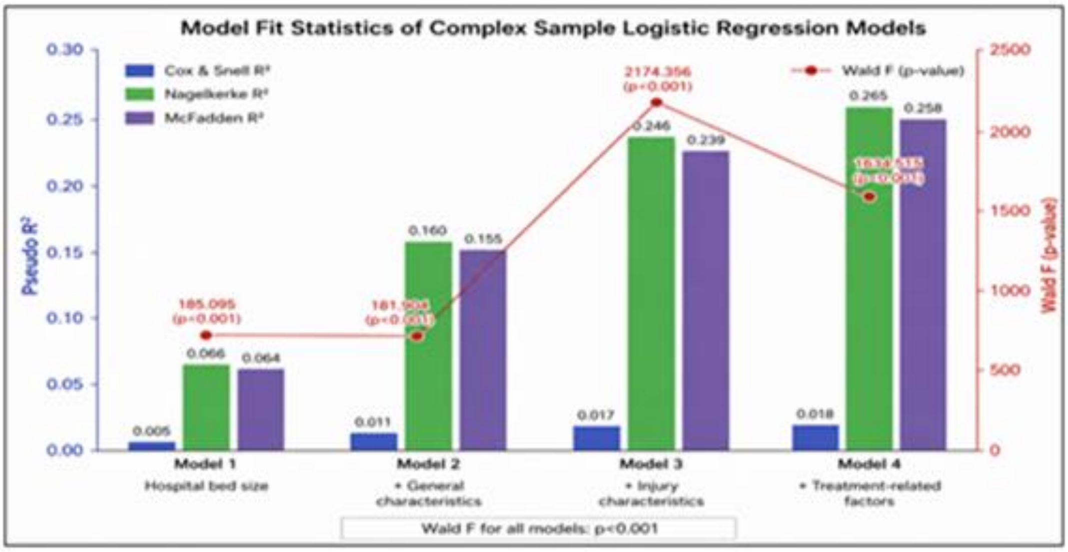

Figure 2. Model fit statistics of complex sample logistic regression models

Discussion

This study investigated the association between hospital bed size and in-hospital mortality among injury patients using data from the Korea National Hospital Discharge In-depth Injury Survey (KNHDIS) from 2019 to 2023. Its methodological significance lies in the use of a complex samples hierarchical logistic regression model to examine this independent association while systematically and sequentially adjusting for patients' sociodemographic characteristics, injury-related characteristics, and treatment-related variables.

First, this study demonstrated that hospital bed size is significantly associated with in-hospital mortality among injury patients. In Model 1, which included only hospital bed size, the odds of mortality for medical institutions with ≥1,000 beds were 9.829-fold higher compared to those with 100–299 beds; however, this risk attenuated to 3.409-fold in the final Model 4, where all covariates were fully adjusted. This finding implies that the elevated mortality risk observed in large-scale medical institutions can be largely attributed to the concentration of severely injured patients and discrepancies in case-mix (Donabedian, 1988).Nevertheless, the persistence of the significant effect of bed size even after fully adjusting for socio-demographic, injury, and treatment characteristics suggests that hospital capacity may be intertwined with structural attributes that extend beyond mere differences in case-mix.

According to Donabedian’s (1988) Structure-Process-Outcome model, the structural attributes of a healthcare provider can directly or indirectly influence patient health outcomes through the quality of the clinical delivery processes. Within this framework, hospital bed size serves as a structural proxy indicator that implicitly reflects medical staffing levels, specialized equipment, emergency response infrastructure, and capabilities for treating critically ill patients. Furthermore, research on the volume-outcome relationship in healthcare delivery has consistently reported that high-volume institutions achieve superior clinical outcomes when managing complex patient populations (MacKenzie et al., 2006).However, in the context of trauma care, severe injury cases are heavily concentrated in tertiary hospitals and regional trauma centers. Consequently, a crude comparison of mortality rates fails to accurately reflect institutional performance, underscoring that rigorous risk adjustment incorporating patient-level severity is indispensable when evaluating injury treatment outcomes.

Second, the substantial reduction in the odds ratios (OR) for hospital bed size from Model 1 to Model 4 highlights the profound impact that injury severity and case-mix exert on mortality outcomes. Specifically, the OR for institutions with ≥1,000 beds decreased from 9.829 to 3.409, confirming that a considerable portion of the initial mortality risk was driven by the selective concentration of severe cases. To compare the actual quality of trauma care across facilities, risk adjustment utilizing standardized severity scores is paramount. It was under this necessity that the Korea Trauma and Injury Severity Score (K-TRISS) was developed, and previous literature has validated K-TRISS as a highly effective tool for predicting survival probabilities by reflecting the unique clinical characteristics of Korean trauma patients (So et al., 2025). Due to the inherent limitations of secondary survey data, the present study could not incorporate direct physiological severity metrics, such as K-TRISS, and instead relied on indirect severity proxies including the anatomical site of injury, intentionality, and injury circumstances. Nonetheless, this study retains high validity by executing a rigorous hierarchical risk adjustment using a nationally representative database.

Third, in the hierarchical modeling process, the model's explanatory power experienced the most pronounced increment when injury characteristics were introduced in Model 3 (NagelkerkeR^2: 0.160 to 0.246). This robust shift demonstrates that injury-specific profiles and trauma severity are far more decisive determinants of injury mortality than crude socio-demographic factors. Prior epidemiological literature corroborates this finding, identifying head injuries, polytrauma, high-energy injury mechanisms, and emergency transport modes as major risk factors for trauma mortality. Particularly within integrated trauma care systems, appropriate triage based on injury severity and rapid pre-hospital transport systems are recognized as core components for improving patient survival rates (Alharbi et al., 2021).

Fourth, the empirical findings of this study offer crucial insights for healthcare delivery networks and public health policy. Interpreting the higher mortality rates observed in large-scale hospitals as a reflection of inferior clinical performance is fundamentally flawed; rather, the underlying disparities in case-mix driven by the concentration of critically ill patients must be factored into the equation. Therefore, institutional performance evaluations regarding injury care must transition toward risk-adjusted assessment frameworks. Simultaneously, policy interventions should focus on strengthening regionalized trauma systems (Jung et al., 2020; Lee et al., 2012) to ensure that severely injured patients are triaged and transferred to the appropriate level of care within the golden hour.

In conclusion, this study successfully elucidated the independent association between hospital bed size and injury mortality by utilizing nationally representative KNHDIS data and employing a complex samples,risk-adjusted hierarchical model. Despite these strengths, several limitations warrant acknowledgment. First, due to the retrospective nature of secondary data, direct physiological and anatomical severity indicators at the time of injury—such as vital signs, Glasgow Coma Scale (GCS), blood pressure, respiratory rate, and the Injury Severity Score (ISS)—could not be included. Second, although hospital bed size was utilized as a proxy variable for institutional capacity, it could not directly capture real-time variations in trauma-specific human resources, specialized equipment, or actual care processes. Therefore, future research warrants more granular analyses that integrate standardized trauma severity metrics like K-TRISS alongside facility-level structural resources.

Conclusion

Using the Korea National Hospital Discharge In-depth Injury Survey (KNHDIS) data from 2019 to 2023, this study investigated the association between hospital bed size and in-hospital mortality among injury patients. The results of the complex samples hierarchical logistic regression analysis revealed that the elevated risk of mortality initially observed in larger medical institutions attenuated after adjusting for patients' socio-demographic, injury-related, and treatment characteristics. This finding indicates that the higher mortality rates in large-scale hospitals can be substantially explained by the concentration of severely injured patients and disparities in case-mix.

However, even in the final model where all potential confounding factors were fully controlled, a statistically significant association between hospital bed size and in-hospital mortality persisted. Notably, medical institutions with ≥1,000 beds exhibited an approximately 3.4-fold higher risk of mortality compared to those with 100–299 beds. These results suggest that when evaluating injury treatment outcomes based on institutional scale, judging hospital performance solely through crude mortality rates is limited; therefore, risk adjustment incorporating patient severity and clinical characteristics is indispensable.

Furthermore, the observation that the explanatory power of the model increased most prominently during the adjustment of injury characteristics underscores that injury type and severity are the primary determinants of mortality. Consequently, there is an urgent need to establish a systematic trauma care delivery framework for the appropriate triage and rapid transfer of severely injured patients, alongside roles division among medical institutions and the enhancement of regional trauma care capacities.

This study is significant in that it elucidated the independent association between hospital bed size and in-hospital mortality by utilizing nationally representative survey data and employing complex samples, risk-adjusted hierarchical modeling. To eliminate unmeasured clinical confounding in future institutional performance assessments, health policy should mandate the integration of clinical trauma registries—containing standardized physiological and anatomical scoring systems such as RTS(Revised Trauma Score)and ISS (or K-TRISS)—with national discharge datasets like the KNHDIS. Future research warrants more sophisticated analyses that incorporate standardized injury severity indices, such as the Korea Trauma and Injury Severity Score (K-TRISS), as well as structural factors, including institutional staffing levels and facility capabilities.

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Conflicts of Interest: The authors declare no conflicts of interest.

Ethical Considerations

This study obtained ethical approval from the Institutional Review Board (IRB) of Eulji University

to ensure research ethics and participant confidentiality (Approval No.: EUIRB-2026-000838).

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