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The Impact of Hospital Volume and Region on Mortality, Medical Costs, and Length of Hospital Stay in Elderly Patients Following Hip Fracture: A Nationwide Claims Database Analysis

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Background: The purpose of our study was to analyze the effects of hospital volume and region on in-hospital and long-term mortality, direct medical costs (DMCs), and length of hospital stay (LOS) in elderly patients following hip fracture, utilizing nationwide claims data.

Methods: This retrospective nationwide study sourced its subjects from the Korean National Health Insurance Review and Assessment Service database spanning from January 2011 to December 2018. A generalized estimating equation model with a Poisson distribution and logarithmic link function was used to estimate adjusted odds ratios (aORs) and 95% CIs to assess the association of hospital volume with in-hospital and 1-year mortality, DMCs, and LOS .

Results: A total of 172,144 patients were included. Comparing the risk of in-hospital death between high-volume and low-volume hospitals, the risk of in-hospital death was 1.2 times higher at low-volume hospitals (aOR, 1.20; 95% CI, 1.07–1.33; $p = 0.002$). Additionally, the risk of death at 1 year was 1.05 times higher at low-volume hospitals (aOR, 1.05; 95% CI, 1.01–1.09; $p = 0.008$) compared to high-volume hospitals. DMCs were 0.84 times lower at low-volume hospitals for in-hospital period (aOR, 0.84; 95% CI, 0.84–0.85; $p < 0.001$) and 0.87 times lower for 1 year (aOR, 0.87; 95% CI, 0.86–0.88; $p < 0.001$) compared to high-volume hospitals. In-hospital LOS was 1.21 times longer at low-volume hospitals (aOR, 1.21; 95% CI, 1.20–1.22; $p < 0.001$) than at high-volume hospitals. In addition, the risk of in-hospital death was 1.22 times higher (aOR, 1.22; 95% CI, 1.12–1.33; $p < 0.001$) and the risk of 1-year death was 1.07 times higher (aOR, 1.07; 95% CI, 1.04–1.10; $p < 0.001$) at rural hospitals compared to urban hospitals.

Conclusions: Clinicians should focus on improving clinical outcomes for hip fracture patients in low-volume and rural hospital settings, with a specific emphasis on reducing mortality rates.

Keywords: *Hip fracture, Hospital volume, Health care costs, Length of hospital stay, Health disparities*

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The increase in the elderly population has led to a growing number of elderly patients with hip fractures, and the resulting medical and socio-economic effects are well known. Annually, over 250,000 hip fractures occur in the United States (US) with a high mortality rate of 30% within a year of surgery.[1)] The financial burden of hip fracture care, costing $10 to $15 billion yearly, emphasizes the need to improve care and outcomes for elderly hip fractures and expanding surgical options.[2,3)] In addition, elderly hip fracture patients often present with various comorbidities, which may lead to a time-consuming perioperative evaluation process. However, delaying surgical intervention can result in increased mortality.[4)] Furthermore, not only during the perioperative period but also in the post-discharge phase, multidisciplinary management is an essential component for hip fracture patients.[5)] Therefore, the extent, availability, and accessibility of medical resources within the hospital can impact the treatment outcomes.

Hospital case volume is a well-established factor linked to postoperative outcomes in various surgical procedures, including pancreaticoduodenectomy, esophagectomy, coronary artery bypass graft surgery, and liver transplantation.[6,7)] Moreover, within the field of orthopedic surgery, there are various reports indicating that hospital volume influences patient outcomes, particularly in surgeries such as hip, knee, and shoulder arthroplasty, as well as spine surgery.[8-12)] Nearly 90% of the studies published on the relationship between hospital volume and outcomes in orthopedic surgery reported a positive effect of higher hospital volumes.[13)] However, the surgeries included in these studies are elective procedures, and they differ in nature from urgent surgeries required for hip fractures. Furthermore, the determination of a conclusive inference regarding the impact of hospital volume on hip fracture outcomes remains uncertain.[14)] Also, there appears to be a lack of evidence regarding the influence of hospital volume on the aspect of medical costs incurred by hip fracture patients.

Rural areas tend to have a higher proportion of elderly population and a greater need for medical services.[15)] As there is a shortage of medical facilities catering to this group, it is well-known that seniors living in rural areas experience increased morbidity and mortality.[15)] Hip fracture patients residing in rural areas not only face challenges in accessing medical facilities for appropriate treatment following fracture occurrence, but also encounter difficulties in utilizing medical facilities for post-discharge health management, rehabilitation. Moreover, rural hospitals often face shortages of medical personnel and equipment, which can inevitably hinder the comprehensive management of patients. We are concerned that these issues in rural hospitals might potentially affect the outcomes of hip fracture patients.

Hence, the aim of this study was to analyze the effects of hospital volume and region on in-hospital and long-term mortality, medical costs, and length of hospital stay (LOS) in patients following hip fracture, utilizing nationwide claims data.

METHODS

The study design and protocol were approved by the Institutional Review Board of Daejeon Eulji Medical Center (IRB No. EMC 2021-10-005). Written informed consent was waived for all patients involved in this study.

Database

This retrospective nationwide study sourced its subjects from the Korean National Health Insurance Review and Assessment Service (HIRA) database spanning from January 2011 to December 2018. HIRA compiles data from healthcare providers' reimbursement claims under the comprehensive healthcare insurance system, encompassing the entire South Korean population through a fee-for-service model.[16)] The dataset encompassed comprehensive inpatient and outpatient medical claims data, encompassing treatment procedure codes and diagnostic codes. Consequently, medical claims data pertaining to hip fracture surgeries within the study timeframe were extracted.

Identification of Patients with Hip Fracture

Eligibility criteria for patients with hip fracture were as follows: admission to an acute care hospital with diagnostic codes of femoral neck fractures (International Classification of Diseases, 10th Revision [ICD-10] S720) or intertrochanteric fracture (ICD-10 S721); undergoing specific surgical treatment including internal fixation (open reduction [N0601, N0611], closed pinning [N0991]), hemiarthroplasty (N0715, N2710), and total hip arthroplasty (N0711, N2070); and age 60 years and above. We did not include patients who underwent conservative treatment for hip fractures in our study. These patients were excluded due to differences in treatment choice processes and patterns of healthcare utilization compared to the majority who underwent surgical treatment.

Variables

Hospital volume was categorized into 3 groups according to the number of hip fracture surgery cases per year (> 66: low volume [lower 33%], 66–177: medium volume [middle 34–66%], and > 177: high volume [upper 33%]). Additionally, the region where the hospital performing the surgery was located was categorized into 2 groups (rural and urban). We defined urban hospitals as those located in Seoul, Busan, Incheon, Daegu, Gwangju, Daejeon, and Ulsan. These areas are also known as special cities or metropolitan areas because they have more than 1 million people and are financially independent. Hospitals located in other regions were categorized as rural hospitals, and these regions are as follows: Gyeonggi-do, Gangwon-do, Chungcheongbuk-do, Chungcheongnam-do, Jeollabuk-do, Jeollanam-do, South Jeolla-do, Gyeongsangbuk-do, Gyeongsangnam-do, Sejong-si, and Jeju-do.

In-hospital period and 1-year, cumulative mortality rate, cumulative direct medical cost (DMC), and cumulative length of stay were investigated. The DMCs are the sum of the amount paid by the National Health Insurance Service (NHIS) and the patient's co-payments for insured medical services, excluding uncovered payments. The DMCs included all costs for inpatient care and drugs, as well as all components covered by the NHIS.[17] The DMCs were inflated to 2023 Korean won using the 2023 conversion index.[18] In addition, the won was converted to US dollars by applying an exchange rate of 1,300 won per dollar.

Baseline characteristics, including sex, age, Charlson Comorbidity Index (CCI), type of fracture, type of anesthesia, transfusion during in-hospital period, past medical history (number of admissions within 1 year before hip fracture, diabetes mellitus, hypertension, Parkinson disease, dementia, chronic kidney disease, cardiovascular disease, use of osteoporosis medication, and steroid), and calendar year of surgery were investigated as covariates. The CCI was calculated by weighting and scoring comorbid conditions using Quan's method, with additional points given to comorbidities that affect the health outcomes of patients.[19]

Statistical Analysis

We used generalized estimating equations model that can reflect the characteristics of repeatedly measured retrospective cohorts. First, the impact of hospital volume and region on in-hospital and one-year mortality were assessed using a generalized estimating equation model with a binomial distribution and logit function. Furthermore, a generalized estimating equation model with a Poisson distribution and logarithmic link function was performed to estimate adjusted odds ratios (aORs) and 95% CIs to assess the association of hospital volume with the DMCs and LOS at different time frames (in-hospital and 1 year) by adjusting all independent variables. We used a generalized estimating equation using a robust standard error to avoid overestimating the standard errors of the parameter estimates. All calculated p-values were 2-sided, and p-values < 0.05 were considered significant. All analyses were performed using SAS Enterprise Guide version 7.1 software.

RESULTS

From 2011 to 2018, a total of 233,020 hip fracture patients were collected, with a final inclusion of 172,144 patients in the study (Fig. 1). The mean age of the included patients was 76.1 ± 12.1 years, with 120,597 (70.1%) being female (Table 1). Based on hospital volume, 57,147 patients received surgical treatment at high-volume hospitals, 57,325 at medium-volume hospitals, and 57,672 at low-volume hospitals. The number of patients undergoing surgical treatment at urban hospitals was 83,928, whereas the number of patients receiving surgical treatment at hospitals in rural areas totaled 88,216.

The in-hospital mortality rate was 1.4% (2,483 patients), while the 1-year mortality rate was 15.3% (26,267 patients) among all included patients (Table 1). Comparing the risk of in-hospital death at high-volume hospitals, the risk of in-hospital death was 1.2 times higher at both

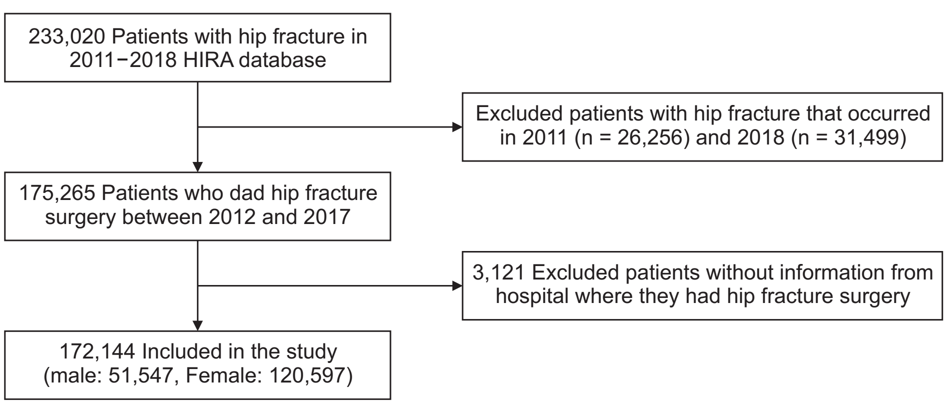

Fig. 1. Flowchart for study sample selection. HIRA: Health Insurance Review and Assessment Service.

Table 1. General Characteristics and Mortality Rate of the Study Population

Variable		In-hospital death		*p*-value	Death within 1 year		*p*-value
		Yes	No		Yes	No	
Number	172,144	2,483 (1.4)	169,661 (98.6)		26,267 (15.3)	145,877 (84.7)	
Hospital volume				< 0.001			0.001
High	57,147	719 (1.3)	56,428 (98.7)		8,648 (15.1)	48,499 (84.9)	
Medium	57,325	885 (1.5)	56,440 (98.5)		8,558 (14.9)	48,767 (85.1)	
Low	57,672	879 (1.5)	56,793 (98.5)		9,061 (15.7)	48,611 (84.3)	
Region of hospital				< 0.001			< 0.001
Urban	83,928	1,039 (1.2)	82,889 (98.8)		12,073 (14.4)	71,855 (85.6)	
Rural	88,216	1,444 (1.6)	86,772 (98.4)		14,194 (16.1)	74,022 (83.9)	
Age (yr, mean ± SD)	76.1 ± 12.1	82.9 ± 8.6	76.0 ± 12.1	< 0.001	81.5 ± 8.8	75.2 ± 12.4	< 0.001
Sex				< 0.001			< 0.001
Male	51,547	936 (1.8)	50,611 (98.2)		10,083 (19.6)	41,464 (80.4)	
Female	120,597	1,547 (1.3)	119,050 (98.7)		16,184 (13.4)	104,413 (86.6)	
Fracture type				0.017			< 0.001
Neck	89,168	1,227 (1.4)	87,941 (98.6)		12,538 (14.1)	76,630 (85.9)	
Intertrochanter	82,976	1,256 (1.5)	81,720 (98.5)		13,723 (16.5)	69,247 (83.5)	
Anesthesia				0.588			< 0.001
General	50,347	714 (1.4)	49,633 (98.6)		7,616 (15.1)	42,731 (84.9)	
Spinal	121,797	1,769 (1.5)	120,028 (98.5)		18,651 (15.3)	103,146 (84.7)	
Transfusion				< 0.001			< 0.001
No	47,521	335 (0.7)	47,186 (99.3)		4,384 (9.2)	43,137 (90.8)	
Yes	124,623	2,148 (1.7)	122,475 (98.3)		21,883 (17.6)	102,740 (82.4)	
Charlson Comorbidity Index				< 0.001			< 0.001
0	67,924	866 (1.3)	67,058 (98.7)		8,776 (12.9)	59,148 (87.1)	
1	47,677	651 (1.4)	47,026 (98.6)		6,690 (14.0)	40,987 (86.0)	
2	25,454	421 (1.7)	25,033 (98.3)		4,176 (16.4)	21,278 (83.6)	
3	15,832	248 (1.6)	15,584 (98.4)		2,799 (17.7)	13,033 (82.3)	
4	7,770	113 (1.5)	7,657 (98.5)		1,525 (19.6)	6,245 (80.4)	
≥ 5	7,487	184 (2.5)	7,303 (97.5)		2,301 (30.7)	5,186 (69.3)	
Admission				< 0.001			< 0.001
0	92,267	1,125 (1.2)	91,142 (98.8)		11,374 (12.3)	80,893 (87.7)	
1	31,263	475 (1.5)	30,788 (98.5)		4,643 (14.9)	26,620 (85.1)	
≥ 2	48,614	883 (1.8)	47,731 (98.2)		10,250 (21.1)	38,364 (78.9)	

Table 1. Continued

Variable		In-hospital death		*p*-value	Death within 1 year		*p*-value
		Yes	No		Yes	No	
Diabetes mellitus				0.181			0.006
Yes	40,703	559 (1.4)	40,144 (98.6)		6,384 (15.7)	34,319 (84.3)	
No	131,441	1,924 (1.5)	129,517 (98.5)		19,883 (15.1)	111,558 (84.9)	
Hypertension				0.893			0.893
Yes	100,879	1,472 (1.5)	99,407 (98.5)		15,383 (15.2)	85,496 (84.8)	
No	71,265	1,011 (1.4)	70,254 (98.6)		10,884 (15.3)	60,381 (84.7)	
Use of steroid				< 0.001			< 0.001
Yes	14,618	278 (1.9)	14,340 (98.1)		2,501 (17.1)	12,117 (82.9)	
No	157,526	2,205 (1.4)	155,321 (98.6)		23,766 (15.1)	133,760 (84.9)	
Parkinson disease				0.755			< 0.001
Yes	9,044	127 (1.4)	8,917 (98.6)		1,682 (18.6)	7,362 (81.4)	
No	163,100	2,356 (1.4)	160,744 (98.6)		24,585 (15.1)	138,515 (84.9)	
Dementia				< 0.001			< 0.001
Yes	29,033	519 (1.8)	28,514 (98.2)		6,425 (22.1)	22,608 (77.9)	
No	143,111	1,964 (1.4)	141,147 (98.6)		19,842 (13.9)	123,269 (86.1)	
Chronic kidney disease				< 0.001			< 0.001
Yes	6,300	209 (3.3)	6,091 (96.7)		1,850 (29.4)	4,450 (70.6)	
No	165,844	2,274 (1.4)	163,570 (98.6)		24,417 (14.7)	141,427 (85.3)	
Cardiovascular disease				< 0.001			< 0.001
Yes	15,620	299 (1.9)	15,321 (98.1)		2,720 (17.4)	12,900 (82.6)	
No	156,524	2,184 (1.4)	154,340 (98.6)		23,547 (15.0)	132,977 (85.0)	
Year of surgery				0.109			0.492
2012	27,506	418 (1.5)	27,088 (98.5)		4,178 (15.2)	23,328 (84.8)	
2013	27,555	406 (1.5)	27,149 (98.5)		4,144 (15.0)	23,411 (85.0)	
2014	28,239	440 (1.6)	27,799 (98.4)		4,394 (15.6)	23,845 (84.4)	
2015	28,620	389 (1.4)	28,231 (98.6)		4,343 (15.2)	24,277 (84.8)	
2016	29,374	385 (1.3)	28,989 (98.7)		4,445 (15.1)	24,929 (84.9)	
2017	30,850	445 (1.4)	30,405 (98.6)		4,763 (15.4)	26,087 (84.6)	

Values are presented as number (%).
SD: standard deviation.

medium-volume hospitals (aOR, 1.20; 95% CI, 1.08–1.34; p = 0.001) and low-volume hospitals (aOR, 1.20; 95% CI, 1.07–1.33; p = 0.002) (Table 2). Compared to the risk of 1-year death at high-volume hospitals, the risk of 1-year death at low-volume hospitals was 1.05 times higher (aOR, 1.05; 95% CI, 1.01–1.09; p = 0.008). The in-hospital DMCs were 0.84 times (aOR, 0.84; 95% CI, 0.84–0.85; p < 0.001) lower at low-volume hospitals and 0.95 times (aOR, 0.95;

Table 2. Association between Volume and Region of Hospital and Mortality, Direct Medical Cost and Length of Stay after Hip Fracture Surgery

	aOR	95% CI	*p*-value	aOR	95% CI	*p*-value	aOR	95% CI	*p*-value
Hospital volume		In-hospital mortality			Direct medical cost during hospitalization			In-hospital length of stay	
High	1.00			1.00			1.00		
Medium	1.20	1.08–1.34	0.001	0.95	0.94–0.95	< 0.001	1.24	1.23–1.25	< 0.001
Low	1.20	1.07–1.33	0.002	0.84	0.84–0.85	< 0.001	1.21	1.20–1.22	< 0.001
Region of hospital									
Urban	1.00			1.00			1.00		
Rural	1.22	1.12–1.33	< 0.001	1.01	1.01–1.02	< 0.001	1.04	1.04–1.05	< 0.001
		1-Year mortality			Direct medical cost during 1 year			Length of stay during 1 year	
Hospital volume									
High	1.00			1.00			1.00		
Medium	0.98	0.94–1.01	0.242	0.92	0.91–0.93	< 0.001	1.04	1.02–1.05	< 0.001
Low	1.05	1.01–1.09	0.008	0.87	0.86–0.88	< 0.001	1.08	1.07–1.09	< 0.001
Region of hospital									
Urban	1.00			1.00			1.00		
Rural	1.07	1.04–1.10	< 0.001	0.97	0.96–0.98	< 0.001	0.96	0.95–0.97	< 0.001

aOR: adjusted odds ratio.

95% CI, 0.94–95; $p < 0.001$) lower at medium-volume hospitals compared to high-volume hospitals. The 1-year DMCs were 0.87 times (aOR, 0.87; 95% CI, 0.86–0.88; $p < 0.001$) lower at low-volume hospitals and 0.92 times (aOR, 0.92; 95% CI, 0.91–0.93; $p < 0.001$) lower at medium-volume hospitals compared to high-volume hospitals (Table 2). The in-hospital LOS was 1.21 times (aOR, 1.21; 95% CI, 1.20–1.22; $p < 0.001$) longer at low-volume hospitals and 1.24 times (aOR, 1.24; 95% CI, 1.23–1.25; $p < 0.001$) longer at medium-volume hospitals compared to high-volume hospitals. The 1-year LOS per patients was 1.08 times (aOR, 1.08; 95% CI, 1.07–1.09; $p < 0.001$) longer at low-volume hospitals and 1.04 times (aOR, 1.04; 95% CI, 1.02–1.05; $p < 0.001$) longer at medium-volume hospitals compared to high-volume hospitals (Table 2).

The risks of in-hospital death and 1-year death at rural hospitals were 1.22 times (aOR, 1.22; 95% CI, 1.12–1.33; $p < 0.001$) and 1.07 times (aOR, 1.07; 95% CI, 1.04–1.10; $p < 0.001$) higher, respectively, than those at urban hospitals. The 1-year DMCs for patients at rural hospitals were 0.97 times (aOR, 0.97; 95% CI, 0.96–0.98; $p < 0.001$) lower compared to those for patients at urban hospitals (Table 2). The mean in-hospital LOS per patient for those who received surgery at urban hospitals was 21.2 days, while those at rural hospitals had an in-hospital LOS of 23.1 days ($p < 0.001$) (Table 3). Patients who underwent surgery at rural hospitals had in-hospital LOS 1.04 times (aOR, 1.04; 95% CI, 1.01–1.01; $p < 0.001$) longer than those of patients at urban hospitals. However, the 1-year LOS for patients at rural hospitals was 0.96 times (aOR, 0.96; 95% CI, 0.95–0.97; $p < 0.001$) shorter compared to that for patients at urban hospitals (Table 2). The in-hospital cumulative DMCs and LOS per hip fracture, as well as the 1-year cumulative DMCs and LOS per hip fracture, are presented in Table 3 according to hospital volume and the region of the hospital.

DISCUSSION

The main findings of our study are as follows: First, hip fracture patients who underwent surgery at high-volume hospitals, despite incurring higher in-hospital DMCs and 1-year after surgery DMCs compared to those treated at low-volume hospitals, exhibited lower in-hospital and 1-year mortality rates. Additionally, their in-hospital and postoperative 1-year LOS was shorter. Second, hip fracture

Table 3. Direct Medical Cost and Length of Hospital Stay during Hospitalization and 1 Year after Hip Fracture Surgery

Variable	Mean ± SD	*p*-value	Mean ± SD	*p*-value
	Direct medical cost during hospitalization (dollars per hip fracture)		Direct medical cost during 1 year (dollars per hip fracture)	
Total	7,730 ± 4,044	< 0.001	12,177 ± 10,306	< 0.001
Hospital volume		< 0.001		< 0.001
High	8,315 ± 4,549		13,338 ± 11,606	
Medium	7,902 ± 3,897		11,943 ± 9,865	
Low	6,980 ± 3,505		11,257 ± 9,199	
Region of hospital		< 0.001		< 0.001
Urban	7,804 ± 4,254		12,446 ± 10,719	
Rural	7,659 ± 3,832		11,920 ± 9,890	
	In-hospital length of stay (days per hip fracture)		Length of stay during 1 year (days per hip fracture)	
Total	22.2 ± 11.9	< 0.001	101.7 ± 111.3	< 0.001
Hospital volume		< 0.001		< 0.001
High	18.8 ± 10.6		97.8 ± 109.3	
Medium	24.1 ± 12.5		100.9 ± 110.0	
Low	23.6 ± 11.93		106.4 ± 114.3	
Region of hospital		< 0.001		0.662
Urban	21.2 ± 12.0		101.9 ± 111.9	
Rural	23.1 ± 11.8		101.6 ± 110.7	

SD: standard deviation.

patients who received surgery at rural hospitals, when compared to patients who underwent surgery at urban hospitals, exhibited higher in-hospital and 1-year mortality rates. In addition, patients from rural hospitals had lower DMCs during the postoperative 1-year period compared to urban hospital patients.

Hip fractures are one of the main contributors to morbidity and mortality in the elderly population.[20] Moreover, the prevalence of perioperative complications substantially rises as patients with hip fractures advance in age.[21] To address these concerns, it is imperative to address early surgical intervention by providing intensive medical services during a short-term perioperative period. This approach should go beyond comorbidity management and encompass multidisciplinary medical services, including rehabilitative therapy and post-discharge care. In our study, we analyzed the impact of hospital volume on clinical outcomes for hip fracture patients. We observed that high-volume hospitals demonstrated superior outcomes in terms of both mortality and LOS compared to low-volume hospitals, not only during in-hospital period but also up to postoperative 1 year. Yoo et al.[7] proposed that the advantages observed in high-volume hospitals, such as shorter time to surgery and in-hospital LOS, were attributed to more effective perioperative management, which in turn contributed to lower in-hospital and 1-year mortality rates. However, some studies have reported that hospital volume does not have an impact on 30–180 day mortality rates. In fact, there have even been studies suggesting higher mortality rates in high-volume hospitals.[22,23] The impact of hospital volume on LOS is also subject to debates.[6] The variations in clinical outcomes based on hospital volume across studies are thought to be attributed to several factors. Firstly, the limited number of patients enrolled in the studies could be a reason.[13] Even when using big data to incorporate a large number of patients into the study, the number of cases from low-volume hospitals could decrease, and this could impact the statistical analysis.[7] Additionally, the criteria for cut-offs, such as 204 and 277 cases, could be clinically insignificant divisions.[24] Secondly, differences in the characteristics of patients included in the study could be a factor. Ultimately, one of the key determinants of mortality is the severity of patients' comorbid conditions, which is likely to increase in high-volume hospitals.[3,25] Okike et al.[3] argued that the lack of difference in 1-year mortality rates based on hospital volume could be attributed to demographic differences. Thirdly, variations in care processes among hospitals could also play a role. While the expertise of medical staff might increase with higher patient caseloads, this does not necessarily indicate effective co-management by multidisciplinary teams.[26] Furthermore, in cases where a large number of patients exceeding the hospital volume are visiting, there might be instances where appropriate medical services cannot be promptly provided, leading to prolonged hospitalization or delayed time to surgery.[13] In order to address the limitations of previous studies, we included a large cohort of 172,144 patients. Our study not only analyzed LOS and mortality during the in-hospital period, but also extended the analysis to outcomes over a 1-year duration. Moreover, we employed statistical analysis that considered the health status of patients and the region of hospital. Our key emphasis lies in interpreting our findings holistically, rather than in isolation. As mentioned, our study did not consider factors like surgical delay or care processes. Nevertheless, the observation that the in-hospital LOS was shorter and a higher amount of DMC was incurred in high-volume hospitals suggests a potential reduction in surgical delay. Also, this could be linked to the substantial allocation of medical resources and personnel to perioperative evaluation and management, facilitating the implementation of suitable care processes. Consequently, it can be interpreted that high-volume hospitals exhibited a lower in-hospital mortality rate. Furthermore, we demonstrated that such differences could also impact long-term 1-year outcomes. In order to enhance clinical outcomes for hip fracture patients in low-volume hospitals, medical teams need to evaluate and enhance the care process. From a healthcare policy standpoint, government agencies should implement monitoring of the clinical outcomes for hip fracture patients and offer policy support to ensure a greater allocation of medical resources to patients in low-volume hospitals.

In the US, there are reports of racial disparities in clinical outcomes of hip fractures in New York. This racial discrepancy is attributed to factors such as the geographic location of surgeons, patients, and hospitals, as well as economic disparities that impact hospital utilization.[2] Applying these findings to different countries can be challenging due to variations in social systems and healthcare frameworks. However, in countries like South Korea that implements universal healthcare, regional disparities might not necessarily signify economic differences. Instead, these regional disparities may need to be interpreted as issues related to insufficient healthcare facilities and accessibility rather than economic disparities. Despite the increasing demand for medical services due to the increasing proportion of elderly population in rural areas, medical facilities are decreasing due to population decline.[15,27,28] This has been reported to contribute to an increase in morbidity and mortality among the elderly population.[15] In our study, we also believe that similar results were analyzed. In rural hospitals, we observed that in-hospital LOS for hip fracture patients was longer, and the risk of death during hospitalization was higher. This could be attributed to potential surgical delay or complications due to limited medical resources in rural areas. Moreover, these factors might impact long-term health conditions, contributing to a higher 1-year mortality rate. Conversely, the lower 1-year LOS and 1-year DMCs observed in urban hospitals suggest that reduced accessibility to medical facilities hindered proper medical utilization. Furthermore, it has been reported that a significant number of patients find independent living challenging after hip fracture, and this incidence increases with advancing age.[29] To address these issues, we believe that not only medical policies that provide transportation options or support for patients with reduced ambulation ability, such as hip fracture patients, but also systemic changes in healthcare are required. These changes could include implementing systems for home visit cares and home rehabilitation therapy to manage patients' health conditions effectively. This is essential to ensure easier access to medical facilities for patients and enhance their overall healthcare experience.

There are several limitations in our study. Firstly, certain potentially significant clinical variables were not incorporated into the analysis due to the administrative nature of the data. The national claims database lacked detailed clinical information regarding surgical procedures, implants, laboratory results, pre-fracture functional status, time to surgery, and care protocols. Therefore, analyzing clinical complication rates is challenging and less precise. Additionally, analysis of total medical costs is not feasible because national claims data do not include out-of-pocket medical expenses. However, we tried to address these limitations by considering a diverse range of patient conditions and making comprehensive interpretations of our results. Furthermore, based on studies analyzing medical costs in other conditions where the ratio of uncovered medical costs to covered medical costs remains consistent in Korea, it is presumed that this ratio would also be stable in hip fracture patients.[30)] Therefore, even though our analysis did not include uncovered medical costs, we estimate that it would not significantly impact the conclusions of our study. Additionally, medical costs and the LOS are variables that not only influence patients' treatment courses but are associated with the management of complications. Therefore, we believe that our study may reflect hospital complication rates based on volume or region. Secondly, we did not consider surgeon volume in our analysis. However, a recent meta-analysis reported that for hip fractures, hospital volume is more significant than surgeon volume. This is attributed to the fact that comprehensive management holds greater importance than surgical technique.[6)] Thirdly, post-discharge care following acute care hospitalization is not taken into account in the analysis. For instance, the course of treatment, such as rehabilitation, may vary depending on the discharge destination, and this could potentially impact treatment costs and outcomes. Fourthly, medical costs and length of hospitalization may reflect the characteristics of the healthcare system in South Korea. Due to the relatively lower hospitalization costs compared to other countries, patients tend to have longer hospital stays. Since healthcare systems vary from country to country, making direct comparisons of absolute values with other nations can be challenging. However, the issues related to hospital volume and region appear to be pervasive in any country, and our study results, which involve relative comparisons between groups based on hospital volume and region, are believed to be generalizable in terms of the key findings of the study. However, the impact of hospital volume and region on elderly hip fracture patients may vary across healthcare systems, requiring analysis in diverse settings. Fifthly, the mechanism of injury for hip fractures was not taken into account in our study. High-energy trauma is a significant factor that can influence LOS and medical costs. However, since we limited our subjects to those aged 60 and above and designed the study based on previous research analyzing elderly hip fractures in South Korea's claims database, we believe that the majority of hip fracture patients were likely affected by low-energy trauma. Furthermore, even if certain high-energy trauma patients were included in the study, they were more likely to have been admitted to urban or high-volume hospitals. This leads us to speculate that our study results might have been underestimated. Lastly, we did not consider the type of surgery in our analysis due to accessibility issues with the database. However, since fracture type and comorbidities were included in the analysis, we believe our results would not change.

In conclusion, patients undergoing hip fracture surgery at high-volume hospitals experienced higher DMCs but demonstrated more favorable in-hospital and 1-year outcomes in terms of mortality and LOS compared to those treated at low-volume hospitals. Moreover, hip fracture patients treated at rural hospitals exhibited higher in-hospital and 1-year mortality rates than those at urban hospitals. Clinicians should focus on improving clinical outcomes for hip fracture patients in low-volume and rural hospital settings, with a specific emphasis on reducing mortality rates. National policymakers need to ensure supportive policies aimed at enhancing healthcare facility accessibility and service quality in rural areas, as well as improving care standards in low-volume hospitals.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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