

Relationship between socioeconomic status and mortality after femur fracture in a Korean population aged 65 years and older

Nationwide retrospective cohort study

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Abstract

Femur fracture is an emerging public health concern in aging societies, owing to the substantially high morbidity and mortality. Because the recent increase in femur fracture incidence in Asian populations is comparable to that in the West, it is necessary to investigate the association between socioeconomic status (SES) and mortality after femur fracture in developed Asian societies.

Data were obtained from the National Health Insurance Claims Database. During 2002 to 2013, femur fractures were newly diagnosed in 5441 patients among 1025,340 enrollees. Multiple logistic regression and the Cox proportional model were used to investigate the associations between individual SES and probability of surgery and mortality after femur fracture.

Of 5441 patients, 1928 (35.4%) received surgery. Patients with low (odds ratio [OR]=0.87, 95% confidence interval [CI]: 0.75–0.99) and middle (OR=0.85, 95% CI: 0.74–0.98) income were less likely to undergo surgery than high-income patients. Patients with low (hazard ratio [HR]=1.12, 95% CI: 1.01–1.24) and middle (HR=1.20, 95% CI: 1.08–1.33) income had a higher HR for mortality. This difference was more prominent in patients who underwent surgery (low income: HR=1.07, 95% CI: 0.94–1.21; middle income: HR=1.18, 95% CI: 1.04–1.33) than in patients with conservative treatment (low income: HR=1.24, 95% CI: 1.04–1.49; middle income: HR=1.30, 95% CI: 1.08–1.56).

Femur-fracture patients with low SES are less likely to receive surgery for and more likely to die after femur fracture. The difference in mortality risk remained even when only the patients who received surgery were considered, suggesting that we need to consider support measures for these deprived patients.

Abbreviations: CCI = Charlson Comorbidity Index, CI = confidence interval, EDI = electronic data interchange, HR = hazard ratio, ICD = International Classification of Diseases, MRI = magnetic resonance imaging, NHI = National Health Insurance, OR = odds ratio, SES = socioeconomic status.

Keywords: femur fracture, inequity, mortality, socioeconomic status, surgery, treatment of choice

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1. Introduction

Femur fracture is an emerging public health concern in aging societies, with high morbidity and mortality.^[1] According to previous studies, 1/3 of femur-fracture patients die in the year following injury, and many experience significant functional loss.^[2–4]

Treating femur fracture, including rehabilitation treatment, is expensive to pay for, especially for patients with low socioeconomic status (SES). A typical femur fracture treatment may cost \$40,000 USD in direct medical costs within the first year.^[5,6] In Korea, the direct medical cost for femur fracture treatment was \$3000 USD during the period from 2002 to 2004.^[7] When we consider the Korean gross domestic product per capita (about \$15,000 USD during this period), the treatment cost is more than 20% of total income.

Adding to the disproportionate burden of disease is the well documented association between social disadvantage and most causes of morbidity.^[8] Various lifestyle factors related to increased risk of femur fracture, including smoking, lack of physical activity, and unbalanced diet, are more frequently and consistently found in people with lower SES.^[9–11]

Since the Korean society is rapidly aging, the recent increase in incidence of femur fracture in the Korean population is comparable to that in Western society.^[12,13] Given the

environmental and demographic differences in SES between Western and Asian societies such as Korea, Japan, and China, it is unknown whether patterns of femur fracture mortality rate across individual SES may render the same results as those seen in Western society. In addition, the association between SES and mortality after femur fracture has not been extensively examined in Korea.

The aim of this study was to investigate the association between SES and mortality after femur fracture in Korea.

2. Methods

2.1. Data

The Korean National Health Insurance (NHI) cohort data included health information of approximately 1 million patients. This is a random sample stratified dataset by age, sex, region, income decile, and individual total medical costs from 2002 to 2013. National Health Security System is mandated to cover all Korean people, and this comprised the NHI and Medical Aid and overseen by the Ministry of Health and Welfare. The data have its own identifiable random numbers for each patient with age, sex, type of insurance, a list of diagnoses according to the Korean Classification of Diseases, which is basically identical to International Classification of Disease-10 (ICD-10). Medical costs claimed, prescribed drugs, and medical history are also contained in the dataset. In addition, unique anonymous numbers are linked to information on mortality obtained from the Korean National Statistical Office.

2.2. Participants

We conducted a cohort study using data on newly diagnosed femur-fracture patients (ICD-10 code: S72) using a 2.5% stratified random sample (N=1025,340) of all Koreans enrolled in the Korean NHI Data on December 31, 2002 (Supplementary figure 1, <http://links.lww.com/MD/B439>). From the 9031 patients with a primary diagnosis of femur fracture between 2002 and 2013, we excluded 1117 patients with preexisting femur fracture history from January 2002 to December 2003 and 2473 patients who were aged under 65 years at initial diagnosis. The remaining 5441 patients aged 65 years and older and free of femur fracture before the study were enrolled.

If patients had disqualification due to any reason such as emigration and imprisonment, they did not have further information for NHI in sequent years. Then, we censored them at the end of year with the last medical record.

2.3. Covariates

Demographic characteristics including age, sex, and residential area, as well as medical history of hypertension, prior fracture history due to osteoporosis, and disabled status were included in the data. Age group is divided into 2 categories, aged below 75 years and 75 years or over. Residential area means whether patients are living in urban and rural. There are 18 provinces in Korea, 1 capital (Seoul), 6 metropolitans (Busan, Daegu, Incheon, Daejeon, Gwangju, and Ulsan), and 11 rural provinces. Thus, urban means whether the patients are living in capital or metropolitans, while rural means the other provinces in Korea. We adjusted the Charlson Comorbidity Index (CCI) for the potential effect of preexisting medication conditions.^[15] The CCI is the most widely studied morbidity index, and its validity has been confirmed by comparison with other indices. It has been

validated for application to longitudinal study design. The CCI takes into account both the number and severity of the comorbid condition. However, since we are also interested in the medical history of dementia, which is included in calculating the equation for the CCI, we excluded dementia in the calculation for the CCI to avoid overadjustment.

In addition, we included neurologic disorders such as parkinsonism, dementia, and others related to aging and movement because they are well known risk factors to femur fracture. Since patients in nursing facilities and their families usually do not prefer aggressive and invasive treatment such as surgery, the history of staying in nursing facilities before the date of femur fracture was also included. Nursing facilities means long-term healthcare hospitals or facilities which are very popular organizations for caring elderlies in Korea.

We also considered the level of hospitals where patients were first treated and categorized them using a hierarchy with 3 components: general hospitals, hospitals, and clinics. According to the healthcare delivery system in Korea, we divided all healthcare organizations into 3 categories. General hospital means a healthcare organization which is able to provide specific specialist care for rare and almost incurable diseases. Hospital usually provides professional treatments in community level. Clinics are the primary healthcare organizations for general health problems. The location of the hospital, the number of beds and doctors, and the presence of magnetic resonance imaging (MRI) were included as indicators of medical performance.

2.4. Individual-level income measures

The NHI premium was used as a proxy measure of precise income because it is proportional to monthly income, including earnings and capital gains. For employees, *a monthly insurance premium is calculated based on annual salary, while self-employees pay for their premium according to the value of their own property including house, account, car ownership, and so on.* We categorized participants' household incomes into 3 categories (low, 0–30 percentile; middle, 31–70 percentile; and high, 71–100 percentile).

2.5. Outcome variables

Femur fracture fixation using surgical electronic data interchange (EDI) transaction codes was used to identify surgical treatments for femur fractures. The extracted EDI transaction codes are given in Supplementary table 1, <http://links.lww.com/MD/B439>. We also set another outcome variable of mortality, defined as all-cause mortality, after the initial diagnosis of femur fracture.

2.6. Statistical analysis

First of all, we evaluated the distribution of participants' demographic characteristics at baseline. We described means and standard deviations for continuous and analyzed using *t* tests or the Kruskal–Wallis test where appropriate. In terms of categorical variables, we expressed as numbers and percentages and compared using the χ^2 test.

We also estimated the adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of the probability of surgical treatment by applying the multiple logistic regression model. It was also provided that another logistic model using backward stepwise

regression. A significance level of 0.3 is required to allow a variable into the model, and a significance level of 0.35 is required for a variable to stay in the model. Model fitting was performed using the PROC LOGISTIC procedure in SAS version 9.3 (SAS Institute Inc., Cary, NC). The essential assumption of proportional hazard model was satisfied by graphical proof. In addition, we calculated mean survival time by each categorical variable with log-rank test. The adjusted hazard ratios (HRs) for mortality by the Cox proportional hazard model were performed using the PROC PHREG procedure in SAS.

3. Results

3.1. Demographic characteristics

The demographic characteristics of participants are presented in Table 1 and Supplementary table 2, <http://links.lww.com/MD/B439>. A total number of 5441 patients were newly diagnosed with femur fractures from 2004 to 2013 and were enrolled in this study. Among all cases, 1928 patients (35.4%) were treated with surgery. The number of patients aged between 65 and 74 years was 1690 (31.1%) and another of aged 75 years and over was 3751 (68.9%). Of all patients, 2025 patients (37.2%) lived in urban areas, while the other 3416 (62.8%) patients lived in rural areas. Of all participants, 1561 (28.7%) were in the low-income category, 1388 (25.5%) were in the middle-income category, and 2492 (45.8%) were in the high-income category.

According to bivariate analysis, higher age group, low income, previous fracture history due to osteoporosis, medical history of parkinsonism and dementia, prior history staying nursing facilities, and absence of MRIs in hospitals were statistically associated with a lower probability of surgical treatment among femur-fracture patients.

3.2. Adjusted odds ratios for surgical treatment

Table 2 demonstrates the results of our logistic regression analysis in terms of ORs and 95% CIs of the relationships between covariates and the probability of surgical treatment of femur fracture. In terms of model fit statistics, $-2\log L$ was 34,374, and Akaike information criterion was 34,406 with covariates. The patients in the elder age group of 75 years or over (OR=0.87, 95% CI: 0.77–0.99) had statistically lower ORs of surgical treatment than those aged between 65 and 74 years. In terms of the income level, the low- (OR=0.87, 95% CI: 0.75–0.99) and middle-income categories (OR=0.85, 95% CI: 0.74–0.98) were associated with a lower probability of receiving surgery, compared to the high-income category reference group. The medical histories of fracture related to osteoporosis (OR=1.43, 95% CI: 1.22–1.68) and dementia (OR=0.77, 95% CI: 0.66–0.91) were statistically significantly associated with surgical treatment. However, the CCI was not associated with surgery. The patients with prior admissions to nursing facilities were less likely to get surgery (OR=0.82, 95% CI: 0.69–0.97). The presence of MRIs in hospitals was associated with a higher OR of surgery (OR=1.58, 95% CI: 1.30–1.93).

In terms of the sensitivity analysis using backward stepwise regression, there were similar results that low- (OR=0.83, 95% CI: 0.72–0.96) and middle-income (OR=0.85, 95% CI: 0.73–0.99) patients in community were associated with lower ORs for surgical treatments, compared to the other high-income patients (Supplementary table 3, <http://links.lww.com/MD/B439>).

According to a subgroup analysis of patients with prior stays in nursing facilities, the income level was not associated with the

probability of surgery, while the low-income group still had a lower OR (OR=1.58, 95% CI: 1.30–1.93) in another subgroup analysis of patients without a history of stays in nursing facilities. Moreover, the medical conditions of neurodegenerative disorders including parkinsonism were not associated with ORs in the subgroup analysis of patients with a history of stays in nursing facilities.

3.3. Unadjusted probability of mortality

First, we did not adjust any covariates to investigate the association between tertile income level and death. Through this process, we could figure out the approximate trend of mortality across tertile income groups. When we compared the mortality cases per 100 person-years (PYs), the low- (15.0 cases/100 PYs) and middle-income (14.6 cases/100 PYs) patients had higher rates than high-income patients (12.7 cases/100 PYs) (Fig. 1). We also calculated mean survival time by categorical variables and performed statistical assessment using log-rank test (Table 3). In terms of income level, the mean survival time was extended as the income level was increased ($P < 0.013$).

According to the Kaplan–Meier survival analysis by specific type of treatment (Fig. 2), there is no statistical difference across income levels among femur-fracture patients with conservative treatments. However, the unadjusted survival analysis for the patients with surgical treatment showed statistical significance by the income level ($P = 0.003$).

3.4. Adjusted hazard ratio for mortality

Table 4 demonstrates the result of Cox proportional analysis for mortality by both treatments and each type of treatment. In terms of gender, men had higher HRs than women in total (HR=1.52, 95% CI: 1.39–1.67) and in treatment subgroups (conservative—HR=1.49, 95% CI: 1.33–1.67; surgical—HR=1.61, 95% CI: 1.38–1.89). In terms of age group and residential area, the elder age group of 75 years or above (HR=2.60, 95% CI: 2.33–2.89) and those living in urban areas (HR=1.24, 95% CI: 1.08–1.41) had statistically significantly higher HRs compared to patients aged between 65 and 74 years and patients living in rural areas, respectively.

In terms of the income level, the patients with low (HR=1.12, 95% CI: 1.01–1.24) and middle incomes (HR=1.20, 95% CI: 1.08–1.33) had statistically significantly higher HRs. This difference by income level was more prominent in the subgroup analysis in the surgical treatment group (low income: HR=1.07, 95% CI: 0.94–1.21; middle income: HR=1.18, 95% CI: 1.04–1.33) than another among the conservative treatment group (low income—HR=1.24, 95% CI: 1.04–1.49; middle income—HR=1.30, 95% CI: 1.08–1.56).

Parkinsonism was associated with higher HR among total population (HR=1.23, 95% CI: 1.02–1.1.47) and subpopulation with surgical treatment (HR=1.66, 95% CI: 1.18–2.33), while dementia was consistently associated with both total and subpopulation with surgical and conservative treatment both (total—HR=1.47, 95% CI: 1.31–1.65; conservative treatment—HR=1.38, 95% CI: 1.21–1.59; surgical treatment—HR=1.71, 95% CI: 1.39–2.11). Patients who received surgical treatment had lower HRs (HR=0.82, 95% CI: 0.75–0.90) than those who received conservative treatment.

The hospitals in urban areas had lower mortality rates (HR=0.82, 95% CI: 0.72–0.93) than hospitals in rural areas. There were similar trends in both subgroup analyses. In addition, the

Table 1**Demographic characteristics of enrolled subjects with femur fracture by treatment type, at baseline.**

	Conservative treatment		Surgery		Total N	P	
	N	%	N	%			
Sex							
Male	1003	63.3	581	36.7	1584	0.219	
Female	2510	65.1	1347	34.9	3857		
Age group							
65–74 y	1037	61.4	653	38.6	1690	<0.001	
75 y or over	2476	66.0	1275	34.0	3751		
Residential area							
Urban	1300	64.2	725	35.8	2025	0.662	
Rural	2213	64.8	1203	35.2	3416		
Income group							
Low	1041	66.7	520	33.3	1561	0.006	
Middle	919	66.2	469	33.8	1388		
High	1553	62.3	939	37.7	2492		
Fracture due to osteoporosis							
No	3047	65.7	1591	34.3	4638	<0.001	
Yes	466	58.0	337	42.0	803		
Parkinsonism							
No	3328	64.2	1856	35.8	5184	0.011	
Yes	185	72.0	72	28.0	257		
Dementia (Alzheimer and vascular)							
No	2800	63.1	1634	36.9	4434	<0.001	
Yes	713	70.8	294	29.2	1007		
Prior admission in nursing facilities							
No	2936	63.6	1680	36.4	4616	<0.001	
Yes	577	69.9	248	30.1	825		
Year							
2004	231	61.1	147	38.9	378	0.181	
2005	250	61.0	160	39.0	410		
2006	281	61.2	178	38.8	459		
2007	327	66.7	163	33.3	490		
2008	327	64.8	178	35.2	505		
2009	373	67.8	177	32.2	550		
2010	343	63.2	200	36.8	543		
2011	470	66.9	233	33.1	703		
2012	427	64.1	239	35.9	666		
2013	484	65.7	253	34.3	737		
Level of hospital							
General hospital	1733	63.0	1016	37.0	2749		<0.001
Hospital	1047	63.3	607	36.7	1654		
Clinics	733	70.6	305	29.4	1038		
Presence of MRI*							
No	1212	70.3	513	29.7	1725	<0.001	
Yes	2301	61.9	1415	38.1	3716		
Location of hospital							
Urban	1218	63.7	693	36.3	1911	0.347	
Rural	2295	65.0	1235	35.0	3530		
	Mean	SD	Mean	SD	Mean	SD	
CCI†, except for dementia	3.6	2.7	3.7	2.6	3.7	2.7	0.232
The number of beds in hospital	404.4	443.5	421.0	440.3	410.3	442.4	0.187
The number of doctors in hospital	95.3	190.8	99.7	190.8	96.8	190.8	0.412
Total	3513	64.6	1928	35.4	5441		

P value was calculated by chi-square test when variables were categorical or by *t* test when variables were continuous.

* MRI, magnetic resonance imaging.

† CCI is Charlson Comorbidity Index.

number of doctors per 1000 beds was inversely associated with HR (HR=0.93, 95% CI: 0.87–1.00).

4. Discussion

Among the 5441 femur-fracture patients included in the study, the low- and middle-income groups were less likely to receive

surgical treatment, compared to the high-income group. In addition, the patients with prior admission to nursing facilities and the patients with degenerative neurologic disorders of parkinsonism and dementia also had lower ORs of surgery. Prior stays at nursing facilities and medical histories of neurodegenerative disorders might make the patients, their family, and healthcare professionals opt out of surgical treatment because of

Table 2
Adjusted OR for surgical treatment among femur-fracture patients.

	Total (N = 5441)		Community (N = 4616)		Nursing facilities (N = 825)	
	aOR	95% CI	aOR	95% CI	aOR	95% CI
Sex						
Male	1.06	(0.93–1.20)	1.03	(0.90–1.18)	1.28	(0.88–1.87)
Female	1.00		1.00		1.00	
Age group						
65–74y	1.00		1.00		1.00	
75y or over	0.87*	(0.77–0.99)	0.90	(0.79–1.03)	0.69*	(0.48–0.99)
Residential area						
Urban	1.00		1.00		1.00	
Rural	1.04	(0.87–1.24)	1.06	(0.87–1.28)	0.94	(0.60–1.49)
Income group						
Low	0.87*	(0.75–0.99)	0.86*	(0.74–1.00)	0.97	(0.68–1.41)
Middle	0.85*	(0.74–0.98)	0.87	(0.75–1.01)	0.81	(0.54–1.21)
High	1.00		1.00		1.00	
Fracture history due to osteoporosis						
No	1.00		1.00		1.00	
Yes	1.43†	(1.22–1.68)	1.42†	(1.19–1.70)	1.53*	(1.06–2.20)
Parkinsonism						
No	1.00		1.00		1.00	
Yes	0.75	(0.57–1.00)	0.60*	(0.42–0.84)	1.35	(0.80–2.27)
Dementia (Alzheimer and vascular)						
No	1.00		1.00		1.00	
Yes	0.77*	(0.66–0.91)	0.78*	(0.64–0.94)	0.78	(0.57–1.08)
Year						
2004	1.00		1.00		1.00	
2005	0.98	(0.73–1.31)	0.96	(0.71–1.28)	2.68	(0.22–32.38)
2006	0.95	(0.71–1.26)	0.94	(0.71–1.26)	1.71	(0.15–19.61)
2007	0.75	(0.57–1.00)	0.74*	(0.55–0.98)	1.49	(0.14–16.28)
2008	0.84	(0.64–1.12)	0.78	(0.59–1.05)	2.41	(0.23–25.25)
2009	0.73*	(0.55–0.97)	0.69*	(0.51–0.93)	1.61	(0.16–16.55)
2010	0.89	(0.68–1.18)	0.89	(0.66–1.19)	1.56	(0.15–16.00)
2011	0.76*	(0.58–0.99)	0.76	(0.57–1.00)	1.29	(0.13–13.21)
2012	0.88	(0.67–1.16)	0.94	(0.70–1.25)	1.18	(0.12–12.06)
2013	0.80	(0.61–1.05)	0.79	(0.59–1.05)	1.44	(0.14–14.55)
Prior admission in nursing facilities						
No	1.00					
Yes	0.82*	(0.69–0.97)				
Level of hospital						
General hospital	1.00		1.00		1.00	
Hospital	1.16	(0.98–1.38)	1.22*	(1.01–1.46)	0.86	(0.54–1.37)
Clinics	1.00	(0.76–1.32)	1.04	(0.77–1.40)	0.87	(0.41–1.84)
Presence of MRI*						
No	1.00		1.00		1.00	
Yes	1.58†	(1.30–1.93)	1.62†	(1.30–2.01)	1.44	(0.89–2.32)
Location of hospital						
Urban	1.00		1.00		1.00	
Rural	0.86	(0.72–1.03)	0.84	(0.69–1.02)	0.99	(0.63–1.58)
CCI†, except for dementia	1.02	(0.99–1.04)	1.02	(1.00–1.05)	1.01	(0.95–1.07)
The number of beds in hospital	0.97	(0.94–1.02)	0.98	(0.94–1.02)	0.96	(0.85–1.10)
The number of doctors in hospital	1.04	(0.96–1.13)	1.04	(0.95–1.14)	0.99	(0.75–1.30)

The multiple logistic regression is performed for calculating odds ratio and 95% confidential interval (CI). aOR = adjusted odds ratio, CI = confidential interval.

* MRI, magnetic resonance imaging.

† CCI is Charlson Comorbidity Index.

the difficulty of rehabilitation and the lower chance for full recovery.^[14,15] Furthermore, patients are not the sole decision-makers in their care plans.^[16]

However, we have to consider the negative associations between income level and probability of surgery, regardless of the adjustment for each patient's medical condition. The accessibility to health care for low-income groups is insufficient. However, because surgical treatment is one of the most favorable independent variables associated with lower mortality

rates,^[17,18] the accessibility to surgery should ideally not be different across income levels. Unfortunately, it still seems that there is a difference in accessibility depending on individuals' SES, according to many studies. Chopra et al^[19] reported that US patients with annual incomes of over \$39,000 USD and private insurance were more likely to receive curable primary femur arthroplasty according to the 2009 Nationwide Inpatient Sample data. Moreover, whites were more likely to undergo surgery, which is consistent with results from studies by Liu et al^[20] and



Figure 1. Mortality cases per 100 person-years, by tertile income groups. The 95% confidential intervals are presented in figure together.

Jain et al.^[21] Moreover, it is a universal phenomenon that femur-fracture patients with low incomes have a lower chance of receiving surgery in both Western and Asian societies. The Korean government offers universal health coverage for all citizens, while the US government has a different system that is now in transition, with the implementation of the Accountable Care Act. Out-of-pocket costs for femur surgery can be an even bigger burden for patients and families with low incomes, even under the universal health coverage system.

In terms of the mortality rate, male gender and the elder age group (75 years or over) were associated with higher HRs. Both advanced age and male gender have been recognized as strong mortality predictors among femur-fracture patients.^[22,23] However, since overall medical conditions and surgical treatment are also highly associated with mortality, it is important to perform separate Cox analyses by specific treatment type.

In both patients who received surgery and patients who received conservative treatment, the patients with low and middle incomes had relatively higher HRs for mortality than others with high incomes. Interestingly, the magnitudes of increasing HRs for

Table 3

Mean survival time and its standard error by each categorical variable.

	Mean (mo)	Standard error (mo)	P
Sex			
Male	58.72	1.27	<0.001
Female	69.52	0.93	
Age group			
65–74y	87.27	1.25	<0.001
75y or over	56.38	0.90	
Residential area			
Urban	66.13	0.95	0.970
Rural	67.20	1.27	
Income group			
Low	61.15	1.34	0.017
Middle	64.16	1.47	
High	69.26	1.12	
Fracture history due to osteoporosis			
No	66.45	0.83	0.089
Yes	65.71	1.84	
Parkinsonism			
No	67.73	0.79	<0.001
Yes	45.27	2.69	
Dementia (Alzheimer and vascular)			
No	69.82	0.83	<0.001
Yes	42.01	1.24	
Prior admission in nursing facilities			
No	68.36	0.82	<0.001
Yes	50.51	1.72	
Treatment of choice			
Conservative treatment	68.36	0.82	<0.001
Surgical treatment	71.92	1.27	
Level of hospital			
General hospital	63.51	0.95	0.117
Hospital	71.92	1.27	
Clinics	61.32	1.52	
Presence of MRI*			
No	59.49	1.19	<0.001
Yes	69.14	0.95	
Location of hospital			
Urban	67.54	0.94	0.010
Rural	64.61	1.30	

P value is calculated by log-rank test.

* MRI, magnetic resonance imaging.

Bold values indicate statistical significance of $P < 0.05$.

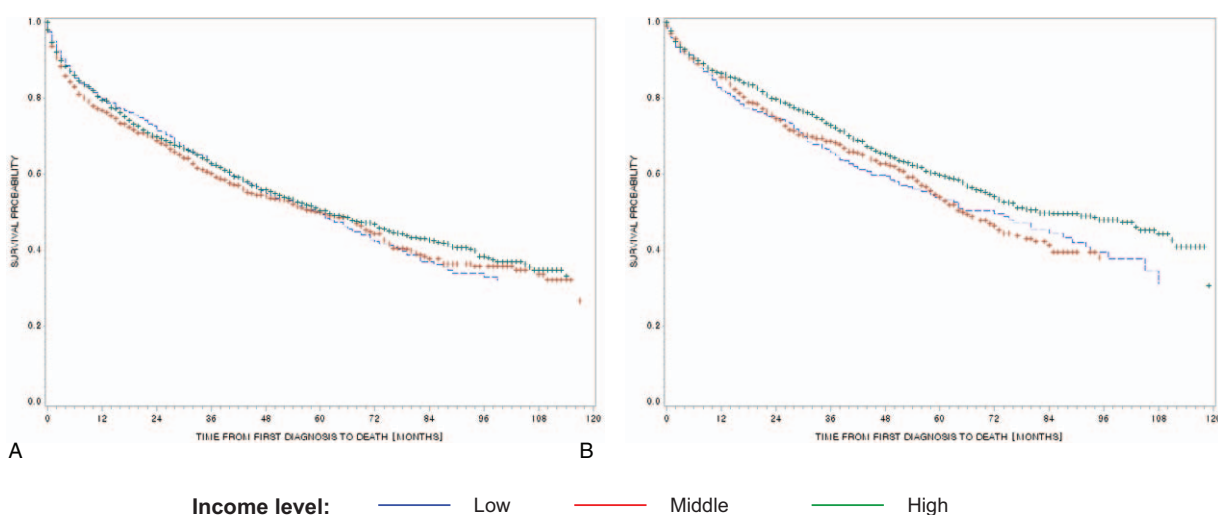


Figure 2. (A) Patients with conservative treatment, by income level ($P=0.4592$). (B) Patients with surgical treatment, by income level.

mortality in low- and middle-income groups among surgical treatment groups are higher than those in the conservative treatment group. Since the primary goal for surgical treatment is to make the patients resume normal activity and daily life without serious discomfort, and ultimately reduce the mortality rate, the differences in HRs by income level are a matter of great concern in public health. According to studies of other medical conditions, the postoperative outcome is associated with SES as well as preexisting medical conditions.^[24,25] Moreover, the higher mortality rate for surgery after femur fracture in Italy has been shown to be related to lower SES.^[26] Korean femur-fracture patients with National Medical Aid, the public health coverage system for the poor, had a 30% higher risk of mortality after femur fracture than those with NHI.^[27] However, this previous Korean study did not have a distinguishable individual income variable, which our study has.

Although the clear mechanism between low SES and high mortality rate among femur-fracture patients has remained unknown, we can suggest some possible explanations. One is that hospitals are located in areas where patients of lower SES live. In Korea, hospital profit is mainly derived from out-of-pocket money from patients, because of low coverage rates in universal health coverage. This less-favorable inflow may translate into lower operating margin and less capacity to invest in infrastructure associated with higher surgical quality. Some of these structural components, such as health professionals staffing in the intensive care unit, nurse staffing, and technology in postoperative care, are well known predictors of lower surgical mortality rates.^[28,29]

Another possibility is participation in appropriate rehabilitation programs following surgery. In the cases of cardiovascular and cancer patients, rehabilitation services are not equally distributed by SES group, even after adjustment for other demographic characteristics and medical conditions.^[30,31] According to the study from the United States, femur-fracture patients with low SES, such as Black, Hispanic, and Medicaid patients, had lower use of institutional care, which has the more dramatic outcomes than home care.^[32] Through rehabilitation programs, patients are able to increase performance in daily life and reduce the reoccurrence of fractures, which is consequently associated with lower mortality rates.

This study has several limitations. First, we could not adjust for the daily activities for each patient, such as activities of daily living or instrumental activities of daily living. These are related to the incidence of femur fracture and overall mortality rate in the elderly population. Nevertheless, we took into account the other medical conditions and general health of all participants using the CCI and the medical history of neurodegenerative disorders, which are among the most well known predictors for survival among femur-fracture patients. Second, there are some issues with using administrative claim data. The reliance on the ICD-10 code for femur fracture might yield some misclassification due to the unavoidable miscoding in claim data, whether intended or unintentional. However, through the efforts of both the government and hospitals, nearly 70% of primary, secondary, and tertiary diagnosis codes from claims records coincide with those from medical records in hospitals.^[33] Third, we could not account for femur-fracture patients who did not use health facilities in spite of the fracture. However, since femur fracture is life threatening, it was assumed that virtually all femur-fracture patients visited healthcare facilities. Finally, we did not clearly suggest the higher HR in middle-income than another in high-income patients, although it was not statistically meaningful. One possible hypothesis is that the adjusted variables are not enough to control different characteristics across 3 income groups. However, we still need some further investigations for this result.

In spite of these limitations, our study had a number of key strengths. First, it is the first investigation to reveal the association between individual SES using income and probability of receiving surgery and probability of mortality after femur fracture, by type of treatment, in a developed Asian society. Although 1 study had already looked at the incidence of and mortality after femur fracture, the researchers did not concretely specify indicator variables for individual SES and analyzed only the patients who underwent surgical treatment alone. Second, our results are highly representative because we used data from nationwide claim data and because the target population had been identified by random stratified sampling methods. Third, as the study design is an observational cohort study, the association between the independent variables and survival is more confirmative than in a cross-sectional study. Fourth, we used survival and medical history data from national statistics and the NHI, which are the

Table 4**HRs for death among femur-fracture patients, depending on the type of treatments after femur fractures.**

	Total (number of death = 2201 [40.5%])		Conservative treatment (number of death = 1485)		Surgical treatment (number of death = 716)	
	HR	95% CI	HR	95% CI	HR	95% CI
Sex						
Male	1.52 [†]	(1.39–1.67)	1.49 [†]	(1.33–1.67)	1.61 [†]	(1.38–1.89)
Female	1.00		1.00		1.00	
Age group						
65–74	1.00		1.00		1.00	
75–	2.60 [†]	(2.33–2.89)	2.82 [†]	(2.45–3.23)	2.25 [†]	(1.89–2.69)
Residential area						
Urban	1.24*	(1.08–1.41)	1.19*	(1.02–1.40)	1.30*	(1.03–1.65)
Rural	1.00		1.00		1.00	
Income group						
Low	1.12*	(1.01–1.24)	1.07	(0.94–1.21)	1.24*	(1.04–1.49)
Middle	1.20*	(1.08–1.33)	1.18*	(1.04–1.33)	1.30*	(1.08–1.56)
High	1.00		1.00		1.00	
Fracture history due to osteoporosis						
No	1.00		1.00		1.00	
Yes	0.91	(0.80–1.04)	0.92	(0.79–1.08)	0.91	(0.74–1.13)
Parkinsonism						
No	1.00		1.00		1.00	
Yes	1.23*	(1.02–1.47)	1.12	(0.90–1.39)	1.66*	(1.18–2.33)
Dementia (Alzheimer and vascular)						
No	1.00		1.00		1.00	
Yes	1.47 [†]	(1.31–1.65)	1.38 [†]	(1.21–1.59)	1.71 [†]	(1.39–2.11)
Prior admission in nursing facilities						
No	1.00				1.00	
Yes	1.12	(0.99–1.28)	1.22*	(1.06–1.42)	0.86	(0.67–1.11)
Treatment of choice						
Conservative treatment	1.00					
Surgical treatment	0.82 [†]	(0.75–0.90)				
Level of hospital						
General hospital	1.00		1.00		1.00	
Hospital	0.89	(0.78–1.02)	0.92	(0.78–1.09)	0.85	(0.67–1.06)
Clinics	0.90	(0.74–1.09)	0.95	(0.74–1.21)	0.82	(0.58–1.16)
Presence of MRI						
No						
Yes	0.83*	(0.72–0.96)	0.85	(0.71–1.01)	0.80	(0.62–1.04)
Location of hospital						
Urban	0.82*	(0.72–0.93)	0.85*	(0.73–0.99)	0.75*	(0.59–0.96)
Rural	1.00		1.00		1.00	
CCI except for dementia	1.02	(1.00–1.03)	1.01	(0.99–1.03)	1.02	(0.99–1.06)
The number of beds in hospital	1.02	(0.99–1.05)	1.03	(0.99–1.07)	0.99	(0.94–1.05)
The number of doctors in hospital	0.93*	(0.87–1.00)	0.90*	(0.82–0.98)	1.01	(0.90–1.13)

Cox proportional models were used to investigate the associations between individual socioeconomic status and probability of surgery and mortality after femur fracture. CI = confidence interval, HR = hazard ratio.

* MRI, magnetic resonance imaging.

[†] CCI is Charlson Comorbidity Index.

most accurate survival and disease databases. Therefore, our data on previous medical conditions and mortality were highly reliable.

5. Conclusion

In summary, femur-fracture patients with low SES were less likely to get surgical treatment and had higher mortality rates, compared with patients with high SES. Moreover, after surgical treatment, the difference in survival between low/middle and high SES groups was still apparent. This suggests that further investigation is needed to reveal the exact mechanism relating SES and femur fracture survival. It is also necessary to consider support measures to increase the probability of surgery and survival among patients with low SES.

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