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Mortality and its determinants after hip fracture among the elderly people in Korea: a study of the National Health Insurance Service-Senior Cohort (2002-2013)

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ABSTRACT

Mortality and its determinants after hip fracture among the elderly people in Korea: a study of the National Health Insurance Service-Senior Cohort (2002-2013)

With an increasing elderly population owing to an increased average life expectancy worldwide, hip fracture has emerged as a major healthcare issue. In Korea, despite the expected increase in the incidence of hip fracture with the rapidly increasing percentage of elderly people aged ≥65 years in the aging population structure as a result of decreased fertility rate, studies on mortality after hip fracture are still lacking.

Accordingly, the present study aimed to use the 12-year data of the National Health Insurance Service-Senior Cohort (NHIS-SC) from 2002 to 2013, which represent most of the data in Korea, to analyze the risk of mortality after hip fracture among the Korean elderly population. The study also aimed to perform multi-faceted analysis of factors associated with the risk of mortality, with consideration of patients, treatments, and provider characteristics. Moreover, in undertaking a sex-stratified analysis, the study attempted to consider certain man versus woman characteristics**.** In this study, 14,273 elderly patients aged ≥65 years who were diagnosed and operated for hip fracture were examined. Cox proportional hazards frailty model was used to identify mortality risk and related factors within 1-year after hip fracture.

Results showed that men and women had different factors associated with the risk of mortality. Factors associated with a higher risk of mortality in elderly men were being of older age, being a medical-care aid beneficiary, not participating in national health screening, being a long-term care beneficiary, having ≤16 days of hospital stay, having a higher Charlson comorbidity index (CCI) score, and being treated at a general hospital. Meanwhile, the factors associated with a higher risk of mortality after hip fracture in elderly women were being of older age, residing in Seoul, belonging to the quintile 3 self-employed group, not participating in national health screening, having ≤16 days of hospital stay, having undergone a hip replacement, not having osteoporosis, having a higher CCI score, being treated at a hospital located in a non-metropolitan area, and being treated at a hospital with less than one form of medical imaging equipment available for use.

By identifying factors associated with the risk of post-hip fracture mortality in elderly Korean patients, the present study may provide basic data for raising awareness on the seriousness and importance of hip fractures. Moreover, the findings may provide evidence for public health policy makers to establish effective policies to prevent the incidence of hip fracture and to reduce mortality after hip fracture based on sex characteristics. Follow-up studies that consider factors not included in the present study, such as health behavior and disease severity, are required.

Keywords: Mortality, Hip fracture, Determinants, Elderly, Korea

Ⅰ. Introduction

1. Background

With an increasing elderly population owing to an increased average life expectancy worldwide, hip fracture has emerged as a major healthcare issue. Approximately 90% of hip fractures in the elderly population are due to a fall [1], which can result in a decline in quality of life due to disease morbidity and an increased use of medical institutions, while also causing premature death due to complications [2-4].

The World Health Organization (WHO) has reported on the seriousness of hip fracture, stating that a hip fracture is always accompanied with pain and hospitalization, while the average hospital stay of 30 days is longer than that of cardiovascular disease among woman patients, breast cancer patients, and those with chronic obstructive pulmonary disease [5]. The WHO predicted the worldwide incidence of hip fracture would show a gradually increasing trend, and various studies related to this topic are being reported. One study report indicated that 60,000 cases of hip fractures, mostly among elderly people, are reported each year in England, while the total number of patients with hip fracture in the US is also gradually increasing [6].

In Korea, the incidence and medical costs of hip fracture are also increased as the percentage of elderly aged ≥65 years is increasing sharply from rapid aging of the population structure of Korea as a result of decrease in fertility rate. According to the National Health Insurance Statistical Yearbook by the National Health Insurance Service (NHIS), the number of patients with hip fracture increased 75.1% over a 11-year period, from 43,459 in 2005 to 76,100 in 2015, while the medical expense also increased from 116.6 billion won in 2005 to 299.5 billion won in 2015 [7].

Along with the incidence of hip fracture, the mortality rate associated with hip fracture is also showing an increasing trend. A multiple cohort study conducted in Europe and the US indicated that the risk of one-year mortality after fracture in patients with hip fracture was 2.8 times higher than the control group [8]. In England, the mortality rate after hip fracture has been between 10% and 20%, which was higher than the expected mortality rate in the same age group. Moreover, it was reported that in the US, 18~33% of patients with a hip fracture die and, as such, hip fracture is considered a major public health concern in the US [9-11].

Meanwhile, other international studies have reported on the significance of mortality following hip fracture and associated factors. An Australian study [12] listed old age, being man, a higher Charlson Comorbidity Index (CCI) score, dementia, delirium, admission to ICU, and a shorter length of hospital stay as factors associated with mortality after hip fracture, whereas a study from Japan [13] reported being man, a trochanteric fracture, walking ability prior to injury, dementia, diabetes, gastrectomy, and pneumonia as major mortality factors. Moreover, a study from the US [14] reported old age, being man, a lower Parker mobility score, and a higher CCI score as factors associated with mortality after hip fracture.

Although several studies have reported on hip fractures, most studies have analyzed short-term data covering fewer than 3 years, or hip fracture and its clinical characteristics only, which means studies that considered various other characteristics are lacking. For example, studies from the US [15], Taiwan [16], and Spain [17] used data with a short total duration of only 2 years, 3 years, and 1 year, respectively. The disadvantage on findings of the analysis with short-term data is that they can only be applied in the short term when applying the results. In addition, studies from Japan [13], Taiwan [18], and Spain [17] considered the clinical characteristics but did not considered patient or provider characteristics.

In Korea, studies by Lee et al. [19], Kim et al. [20], and Kim et al. [21] reported hip fracture survival time, factors associated with mortality after hip fracture, and the risk of re-fracture; however, they used data that were not highly representative and the findings could not be generalized. Kang et al. [22] used highly representative claims data from the Health Insurance Review and Assessment Service (HIRA) when conducting a study on the incidence and mortality of hip fracture. However, Kang's study used short-term data that only covered 3 years, and the provider characteristics were not sufficiently controlled. Moreover, because the study did not perform sex-stratified analysis, it had the limitation of not fully accounting for sex characteristics.

As shown, despite the steady increase in the incidence of hip fracture in the elderly Korean population and the associated medical costs, studies on mortality after hip fracture are still lacking. Even within the NHIS, which holds nationwide insurance claims data, studies on cost of illness or medical costs of end-of-life have been reported, but there have been almost no reported studies related to mortality.

Accordingly, the present study aimed to use the 12-year data of the NHIS-SC from 2002 to 2013, which represent most of the representative data in Korea, to analyze the risk of mortality after hip fracture among the Korean elderly population for the first time in Korea. The study also aimed to perform multi-faceted analysis on factors associated with the risk of mortality, with consideration on patients, treatments, and provider characteristics. Moreover, in conducting a sex-stratified analysis, the study attempted to consider certain man versus woman characteristics.

2. Objectives

The main objective of the study was to provide basic data for developing effective policies to reduce mortality following hip fracture at a national level through performing multi-faceted analysis on the risk of mortality after hip fracture among elderly Korean population, using data from 2002 to 2013. Specific objectives were as follows:

First, to identify the distribution of hip fractures among elderly Korean people according to patients, treatment, and provider characteristics.

Second, to examine whether there are sex-based differences in the survival experiences of elderly Korean people with hip fracture.

Third, to calculate the post-operative 1-year mortality rate of the elderly Korean people with hip fracture and to analyze the differences according to characteristics.

Lastly, to identify the determinants of mortality through estimating the HRs of mortality after hip fracture among elderly Korean people by sex.

Ⅱ. Literature review

1. The importance of hip fracture in geriatric fractures

With an increase in the average life expectancy and progression of an aging society, hip fracture has emerged as one of the key global public health concern. This is because there is a growing trend in falls due to aging as well as hip fractures resulting from osteoporosis-related skeletal weakness [4,23].

Hip fracture has been reported to have negative physical and psychological effects on the individual, and also has negative effects on the family and the community. Approximately 50% of patients who suffer a hip fracture are unable to regain their pre-fracture mobility and independence, while 25% of patients require long-term care at home or within a medical institution. Moreover, study results have shown that 30% of patients who incur a hip fracture die within 1 year post-fracture or experience serious functional impairment or disability [11].

Among all geriatric fractures, hip fracture accounts for 18.2%, which is not high. However, hip fracture has a major effect on disability and mortality; therefore, its disability-adjusted life year is much higher than that of other fractures [4,8,23-25]. Moreover, hip fracture is closely associated with morbidity and mortality, with a significant effect on the elderly population [8,23,24].

As hip fracture has a major effect on disability and mortality, various studies related to this topic have been reported. The average length of hospital stay for a hip fracture has been reported to be between 10 and 15 days in Australia [26], while the related medical costs have been reported to range between USD $8,000 and $32,000 in the US [27]. However, because of the significant costs required for treating hip fracture post-discharge [28,29], the overall cost associated with hip fracture is estimated to be considerably higher [30,31].

According to a multiple cohort study conducted in Europe and the US, the risk of mortality in patients with hip fracture was 2.8 times higher than that of the control group at 12-months post-fracture [8]. In addition, hip fracture can cause a decline in quality of life due to disease morbidity and the increased use of medical institutions, while also causing premature death due to complications [2-4].

In England, approximately 60,000 cases of hip fractures, mostly among elderly people, are reported each year and the mortality rate has been reported to be between 10% and 20%, which is higher than the expected mortality rate for the same age group [6]. Other reports have indicated that the total number of hip fracture cases are also gradually increasing in the US, occurring in 80 per 100,000 persons each year, while between 18% and 33% of the patients with hip fracture die. As a result, hip fracture is considered a major public health concern in the US [9-11].

Several previous studies have reported the incidence of hip fracture to be lower in Asian countries than in northern European and north American countries [32-34].

However, the incidence in Asian countries has increased in recent years and other studies have reported that by 2050, the incidence of fractures in Asian countries may account for between 45% and 70% of all fractures globally [33,35,36].

Hip fracture has also emerged as a major public health concern in Korea due to accelerated aging of the population, with a lower fertility rate and a higher average life expectancy. According to data from Statistics Korea, the growth rate for the population 65 years or older in Korea has increased from 3.8% during the 1980s to 7.9% in 2002, which reflects the rapid increase seen among other Asian countries [37]. The incidence of hip fracture has increased sharply along with the rapid growth of the elderly population. According to the National Health Insurance Statistical Yearbook, the number of patients with hip fracture increased 75.1% over an 11-year period, from 43,459 in 2005 to 76,100 in 2015, while the total medical expense also increased from 116.6 billion won in 2005 to 299.5 billion won in 2015 [7].

2. Mortality after hip fracture

There have been some studies in Korea and abroad on mortality after hip fracture. In Korea, Yoon et al. (2011) used HIRA claims data to analyze the incidence of hip fractures and mortality after hip fracture. Using claims data from 2005 to 2008, the study analyzed data from patients aged 50 years or older who had undergone surgery for fracture of neck of femur (S72.0) or pertrochanteric fracture (S72.1), that is, open reduction of a fracture, closed pinning, closed intramedullary nailing, total hip arthroplasty, or hemiarthroplasty. Data were analyzed using a covariate-adjusted Poisson regression model for increasing trend identification and annual changes according to age groups, and a calculation of the standardized mortality ratio (SMR) was performed for determination of excess mortality.

The results showed that the incidence of hip fracture increased from 94.8 per 100,000 in 2005 to 97.8 per 100,000 in 2008 for men and 191.9 per 100,000 in 2005 to 207.0 per 100,000 in 2008 for women. With respect to the cumulative mortality rate after hip fracture, the 1-year mortality rate for men and for women was 21.8% and 16.2%, respectively, while the 2-year mortality rate was 1.3 times higher in men (31.0%) than in women (24.1%).

With respect to the SMR adjusted for sex and age, the SMR of 3-month, 1-year, and 2-year mortality was 6.1, 3.5, and 2.3, respectively, with 3-month mortality showing the highest ratio, followed by a gradually decreasing trend. The same pattern was observed in all age groups. Through demonstrating the gradual increase in the incidence of hip fracture in elderly people aged 50 years or older, and through showing an increase in post-hip fracture mortality rates, Yoon et al. raised awareness of the serious public health issues concerning hip fracture, and their results suggest the need for public health programs designed to prevent fractures. However, that study used data covering a short period of only 3 years and, because the age groups were divided in 10-year units, the results did not account for details of age characteristics [38].

A study by Lee et al. (2014) used medical records from medical institution to calculate the 5-year cumulative mortality rate of patients with hip fracture and compared the relative survival rate with a cancer survivor population. This was a retrospective study of 727 patients who had undergone surgery for osteoporotic hip fracture (femoral neck and intertrochanteric fracture) between 2003 and 2009. The study measured cumulative mortality rates over time and calculated the 5-year absolute survival rate using Kaplan-Meier survival analysis. Moreover, the study also calculated the relative survival rate based on the general population for comparison with the relative survival rate of a cancersurvivor population. To derive relative survival rates, the study used the life-table of Statistics Korea for the general population and data from the National Cancer Information Center of Korea for the cancersurvivor population. In the results, patients with hip fracture showed 1-year cumulative, 5-year cumulative, and 5-year absolute survival rates of 12.2%, 32.3%, and 63.0%, respectively. Compared with the general population, the 5-year relative survival rate of patients with hip fracture was 93.9%, and among the cancer survivor population, the rate for patients with thyroid, breast, prostate, and colon cancer was 99.8%, 91.0%, 90.2%, and 72.6%, respectively. However, this study analyzed medical records from a single hospital, and thus, selection bias may have occurred, making it difficult to generalize the findings [19].

Among studies undertaken outside Korea, a US study by Miller et al. (2012) used Medicare claims data to investigate the risk of mortality associated with hip fracture in residents of a rural area who experienced delays in treatment due to poor accessibility to medical institutions. The study population consisted of Medicare recipients who had been diagnosed with a femoral neck fracture between July 2006 and June 2008. Through linking the Medicare Provider Analysis and Review (Med-PAR) Part A data with the American Hospital Association (AHA) annual survey data, hospital level information was also used in the analysis. The variables used included age, ethnicity, sex, distance to an admitting hospital, distance to the nearest hospital, bypassing the nearest hospital, the number of comorbidities, hospital location, number of beds, the nursing staff ratio, admission source, type of fracture, type of treatment, days from admission to surgery, length of hospital stay, and discharge destination.

To compare the provider and demographic characteristics according to regions, ANOVA and chi-square tests were performed, while generalized estimating equation (GEE) models were used to examine the independent effects of patient residence on mortality rates after hip fracture.

The results showed that the ORs for in-hospital mortality were similar between regions, while the OR for mortality among patients residing in urban areas was the lowest. However, the OR for 1-year mortality was lower in patients residing in rural areas than in urban areas. Moreover, compared with patients residing in urban areas, patients residing in rural areas had to travel a greater distance to reach their hospital, but they did not experience delays prior to surgery or a longer hospital stay. However, the study used data that covered a short period of only 2 years and the results did not account for treatment characteristics. Moreover, since the analysis did not involve sex stratification, the results did not account for sex characteristics [15].

A study in Taiwan included not only hip fracture, but spinal, iliac, wrist, and other osteoporotic fractures. Chang et al. (2015) used national health insurance data to estimate the osteoporosis-related mortality rate and the direct medical costs of menopausal women, accdording to fracture type and age group. The study population consisted of menopausal women aged 50 years or older who had been diagnosed with hip, spinal, iliac, wrist, or multiple fractures between 2006 and 2009. After 1:1 matching of the reference control cohort from the national health insurance database, the mortality rate and direct medical costs were compared. The variables used for matching were age, income-level insurance amount, urbanization level, and the CCI. Student t-tests were performed to compare the mortality rate and the direct medical costs between the two cohorts. The results showed that for almost all types of fractures, the case group had an appreciably higher mortality rate and higher direct medical costs than the control group.

With respect to each fracture type, spinal fracture showed the highest incidence, while hip fracture showed the highest mortality rate and direct medical costs. This study suggested that hip fracture is the most serious fracture among osteoporotic fractures and that related prevention policies must be established. However, this study was limited in that it used short-term data, and the results did not account for detailed age characteristics because the age groups were categorized according to 10-year units [16].

3. Determinants of mortality after hip fracture

Studies have been conducted in Korea and abroad regarding determinants of mortality after hip fracture. In Korea, a study by Kang et al. (2010) used HIRA claims data to estimate the annual incidence of hip fractures in Korea and analyze the determinants of mortality after hip fracture. The study was comprised of patients aged 50 years or older who had been diagnosed with femoral neck or intertrochanteric femoral fracture in 2003, and who had subsequently undergone an open reduction and internal fixation, a closed reduction and percutaneous fixation, a total hip replacement, or a hip hemiarthroplasty. The dependent variables were incidence and mortality rates, while the independent variables were age, sex, residence, health insurance, comorbidity, type of hospital, type of hip fracture, type of operation, and treatment of osteoporosis.

With respect to the analysis methods, the annual incidence of hip fracture according to age and sex was calculated, after which an analysis was performed using a Cox's proportional hazard model to examine the relationship between subsequent survival time and patient and provider characteristics.

The results showed that the age standardized annual incidence of hip fracture was 146.38 in 100,000 for women and 61.72 in 100,000 for men. Meanwhile, the 1-year mortality rate after hip fracture was 16.55%, which was 2.85 times higher than that of the general population. The risk of mortality after hip fracture was statistically significantly higher among men, in those belonged to a low income group, residing in an area outside the capital area, who did not receive subsequent anti-osteoporotic therapy after fracture, and in those who had undergone surgery at a general hospital or a tertiary hospital. This study raised awareness of hip fractures in relation to Korean elderly people and suggested the need for effective osteoporosis prevention strategies to prevent fractures. However, this study did not include personal income in the patient characteristics. In the provider characteristics, since only one variable was used for type of hospital, the location, facility, personnel, and equipment of hospital could not be fully controlled. In the treatment characteristics, length of hospital stay was not used as a variable and, as sex stratification had not been applied, the results did not account for sex characteristics [22].

Kim et al. (2012) analyzed medical records from medical institution to investigate the predictors of post-operative 24-month mortality, secondary fracture, and functional recovery in an elderly Korean population with hip fracture. The study population consisted of elderly patients aged 60 years or older who had been diagnosed with an acute hip fracture between 2005 and 2009. The variables used included age, sex, body mass index, previous fracture history, pre-operative ambulatory ability and residency type, eight comorbidity items, cognitive impairment, smoking, and American Society of Anesthesiologists' classification, delay prior to surgery, fracture type, operation time, operation method, and post-operative history of falls. The study performed logistic regression analysis to determine the effects on fracture type and used Cox regression models to investigate these effects on post-operative 24-month mortality, secondary fracture, and functional recovery. Moreover, a Kaplan-Meier analysis was performed to investigate the cumulative survival rate and secondary fracture rate in hip fracture patients. The results showed that the 1- and 2-year mortality rates post-hip fracture were 14.7% and 24.3%, respectively, while the secondary fracture rate and functional recovery rate within 2 years was 9.2% and 38.6%, respectively. Older age, the presence of cancer, a previous fracture history, and living alone were factors associated with a higher 2-year mortality rate, while a history of falls and living alone were factors associated with a higher secondary fracture rate within 1 year following the initial hip fracture. In addition, malignant tumor and cognitive impairment were factors associated with a lower functional recovery rate. This study analyzed the medical records from the medical institution and did not use the representative data, and thus, it is difficult to generalize the findings. Moreover, since sex stratification was not applied in all analyses, the results do not fully account for sex characteristics [20].

Kim et al. (2013) also used medical records from hospital to investigate the association between clinical outcomes and risk factors for intertrochanteric femoral fracture in an elderly Korean population. The study population consisted of patients aged 65 years or older who had undergone surgery for intertrochanteric femoral fracture between 2000 and 2012. The variables used included age, sex, smoking, history of alcohol consumpting, cardiovascular disease, cerebrovascular disease, delayed days to surgery, admission day of the week, anesthetic method, and operation time. A chi-square test and a t-test were performed on single variables, and logistic regression analysis was performed on the dependent variables that had been affected due to a single variable through the substitution independent variables that were statistically significant. The results showed that being woman, a surgery time longer than 3 hours, a hematocrit level ≥30%, and a period of at least 4 days from hospitalization to surgery were factors associated with higher 1-year mortality rate after hip fracture. This study suggested that the post-operative mortality rate could be lowered through considering adjusting the time to surgery and the operating time during pre- and post-operative treatment for hip fracture. However, since this study also analyzed medical records from hospital and did not use the representative data, it is difficult to generalize the findings. Moreover, because the age groups were divided into 10-year units, the results did not account for detailed age characteristics [21].

With respect to studies outside Korea, a 2006 study in Japan by Muraki et al. used medical records from medical institution to analyze the risk of mortality after hip fracture based on a detailed classification of comorbidities. This study examined 480 patients who had been treated for hip fractures between 1991 and 1996. The variables used included age, sex, comorbidity, complications, body mass index (BMI), walking ability prior to injury, discharge destination, type of therapy, and type of fracture. In particular, comorbidities were analyzed through categorizing these variables into dementia, cardiovascular disease, pulmonary disease, diabetes mellitus, digestive disease, chronic renal failure, rheumatoid arthritis, and chronic liver disease, while complications were analyzed through classification of the variables into pneumonia during hospitalization, urinary tract infection, and a decubitus. The study used the Kaplan-Meier method for deriving the survival curve and Cox proportional hazards regression models to identify risk factors of mortality. The results showed a 1-year survival rate post-hip fracture of 88.5%, which was slightly lower than the expected survival rate (91.7%). In the analysis of factors associated with mortality post-hip fracture, old age, being man, trochanteric fracture, dementia and/or diabetes as comorbidities, a history of gastrectomy and/or colectomy, pneumonia as a complication, and a lower walking ability prior to injury were factors associated with a higher risk of mortality post-hip fracture. However, since this study also analyzed medical records from medical institution and did not use the representative data, it is difficult to generalize the findings. Moreover, the study did not account for patient characteristics, and sex stratification was not applied in the analyses; therefore, the results did not fully account for sex characteristics [13].

In Taiwan, Jou et al. (2012) used national health insurance data to analyze factors associated with re-hospitalization and in-hospital mortality of woman patients with hip fracture. The study population consisted of menopausal women aged 50 years or older who had been diagnosed with hip fracture in 2003. Major variables included age, geographic region, urbanization level, CCI, hospital level, and length of stay. A chi-square test and a t-test was performed to identify the differences between women aged <75 years and ≥75 years, while a Cox proportional hazard model was used to analyze the associations of personal and hospital levels in relation to in-hospital mortality and the risk of re-hospitalization in hip fracture patients. The results showed that the 3-year cumulative re-hospitalization rate was 11.01%, while the in-hospital mortality rate was

7.10%. Moreover, age, hospital level, length of hospital stay, and CCI were identified as factors that affected the re-hospitalization rate, while factors that affected in-hospital mortality were age, the urbanization level of the insurance coverage area, the hospital level, length of hospital stay, and the CCI. The significance of this study was that it used the most representative data in Taiwan, namely, the national health insurance data, to study factors associated with mortality post-hip fracture. However, this study used data that only covered a short period of 3 years. Moreover, in dividing the age groups into <75 years and ≥75 years, detailed age characteristics were not considered, nor did the study fully account for the provider and treatment characteristics [18].

Meanwhile, in a 2015 study in Spain by Ariza-Vega et al., medical records from hospital and patient and guardian interview data were used to conduct a prospective study on the predisposing factors of the 1-year mortality rate following surgery for hip fracture in an elderly population. The study population consisted of patients aged 65 years or older who had been admitted to a hospital for hip fracture surgery between 2009 and 2010. The variables used in the study included age, sex, CCI, psychiatric symptoms, cognitive impairment, BMI, cognitive status, pre-fracture functional level, residential status after discharge, type of fracture, type of surgery, weight-bearing status within 2 to 4 weeks post-surgery, post-operative complications, time from admission to surgery, length of stay, and surgical risk/health status. A Kaplan-Meier survival analysis was performed to determine the post-operative cumulative survival rate in these elderly patients with hip fracture, and a log-rank test was used to assess the differences in the Kaplan-Meier chart.

Moreover, Cox proportional hazard models were used to analyze the factors associated with mortality post-hip fracture. The results showed that the 1-year mortality rate post-hip fracture was 21%, while the factors associated with higher risk of mortality post-fracture were identified as older age, man, poor health status, poor pre-fracture functional level, and change in residence. However, because this study also analyzed the medical records from the hospital and did not use the representative data, it is difficult to generalize the findings. Moreover, the study did not account for patient characteristics and, as sex stratification was not applied in the analyses, the results did not fully account for sex characteristics [17].

Table 1-1. Summary of previous studies concerning the determinants of mortality after hip fracture

Study	Data	Outcome variables	Covariates	Main findings	Limitations
Kang et al. (2010)	Claim data	1-year mortality	- age - sex - residence - health insurance - comorbidity - type of hospital - type of hip fracture - type of operation - treatment of osteoporosis	- Factors associated with a higher risk of mortality post-fracture were being man, a low income level, residence outside the capital area, no anti-osteoporotic therapy post-fracture, and surgery at a general hospital of a tertiary hospital.	- Used short-term data - Did not sufficiently control provider characteristics - Did not account for xex characteristics
Kim et al. (2012)	Hospital medical records	2-year mortality	- age - sex - BMI - history of previous fracture - pre-operative ambulatory ability and residency type - comorbidity - cognitive impairment - smoking - American society of anesthesiologists' classification: - delay prior to surgery - fracture type - operation time - operation method - post-operative fall history	- Factors associated with a higher 2-year mortality post-hip fracture were old age, the presence of cancer, a previous history of fracture, and living alone.	- Used medical records from a hospital, lacking representativeness - Did not account for sex characteristics
Kim et al. (2013)	Hospital medical record	1-year mortality	- age - sex - smoking - drinking history - cardiovascular disease - cerebrovascular disease - delayed days to surgery - admission day of the week - anesthetic method - operation time	- Factors associated with higher 1-year mortality post-hip fracture were being woman, a surgery time longer than 3 hours, a hematocrit level ≥30%, and at least a 4-day or over from hospitalization to surgery.	- Used medical records from a hospital, lacking representativeness - Did not sufficiently control for age characteristics

Table 1-2. (Continued) Summary of previous studies concerning the determinants of mortality after hip fracture

Study	Data	Outcome variables	Covariates	Main findings	Limitations
Muraki et al. (2006)	Hospital medical record	Mortality	- age - sex - comorbidity - complications - BMI - walking ability prior to injury - discharge destination - type of therapy - type of fracture	- Factors associated with higher mortality were being man, a trochanteric fracture, walking with a walker/or with an assistant, or a non-ambulatory patient, dementia and/or diabetes as comorbidities, pneumonia as a complication, and a history of gastrectomy and/or colectomy.	- Used medical records, lacking representativeness - Did not sufficiently control patient characteristics - Did not account for sex characteristics
Jou et al. (2012)	NHID claims data	In-hospital mortality	- age - geographic region - urbanization level - Charlson comorbidity index (CCI) - hospital level - length of stay	- Factors associated with a higher in-hospital mortality rate were older age, a higher urbanization level of the residential area, a longer hospital stay, and a higher CCI score.	- Used short-term data - Did not fully account for age characteristics - Did not sufficiently control for provider and treatment characteristics
Ariza-Vega et al. (2015)	Hospital medical record, survey data	1-year mortality	- age - sex - CCI - psychiatric symptoms - cognitive impairment - BMI - cognitive status - pre-fracture functional level - residential status after discharge - type of fracture - type of surgery - time from admission to surgery - length of stay - surgical risk/health status	- Factors associated with higher mortality post-hip fracture were older age, being a man, a poor health status, a poor pre-fracture functional level, and a change in residence.	- Used medical records, lacking representativeness - Did not sufficiently control for patient characteristics - Did not account for sex characteristics

Ⅲ. Methods

1. Data source

This longitudinal study used NHIS-SC data from 2002 to 2013. These research data are not personally identifiable, and have been established in cohort format to support studies of the elderly population, including analyses of prognosis and risk factors for geriatric diseases. The NHIS established sample data from 558,147 elderly persons using simple random sampling of 10% of approximately 5.5 million elderly persons aged 60 years or older who maintained their eligibility for health insurance and medical care aid as at the end of 2002. The data contained qualification information (socioeconomic information and disabilities), healthcare utilization (healthcare and health screening information), medical institution status, and application and utilization of long-term care services. In particular, qualification information is linked to Statistics Korea's cause of death data to provide date of death and cause of death information additionally [39].

The NHIS holds extensive big data consisting of 1.3 trillion cases involving insurance qualification, insurance premiums, health screening results, medical history, long-term care insurance, medical institution status, and cancer and rare incurable disease patient registration information for all Korean nationals. Using such data, the NHIS established a sample cohort database in 2012. Subsequently, a pilot study was conducted to refine the data in 2013, and the data has been available for academic research purposes since 2014. Once a researcher submits a request for data, along with the study proposal and institutional review board (IRB) approval, the NHIS reviews the request, and compiles and provides the necessary data to the researcher.

The present study was approved by the IRB of the Graduate School of Public Health, Yonsei University (IRB No. 2-1040939-AB-N-01-2016-409-01).

2. Study sample

Of a total of 558,147 elderly persons aged ≥60 years who were part of the senior cohort sample, the present study excluded 4,751 people (0.85%) <65 years of age and 4,928 people (0.88%) with interval censored data, and selected 548,468 elderly persons as the initial study population.

The operational definition of hip fracture was established through combining diagnosis, treatment and surgery codes, while also referencing criteria used in previous studies [40-46]. In addition, an expert panel comprised of two orthopedic surgeons and one orthopedic surgery nurse were invited to consult on the operational definition to ensure objectivity in the final determination of the definition.

The operational definition of hip fracture for this study was determined as involving cases with a start of treatment year between 2002 and 2013, and with at least one entry of hip fracture-related codes S72.0 (fracture of neck of femur), S72.1

(pertrochanteric fracture), or S72.2 (subtrochanteric fracture), as a main diagnosis code, and having been admitted for surgery under any one of the following procedural codes: T6040 (hip spica, long leg); N0601 (open reduction of femur); N0991 (open reduction of femur with closed pinning); N0981 (external fixation of femur); N0641 (closed reduction of femur); N0711 (replacement arthroplasty of hip); and N0715 (hemiarthroplasty of hip). Based on this definition, the following persons were excluded from the initial study population of 548,468 persons: 524,094 persons who had not been diagnosed with a hip fracture, 9,353 persons who did not have a hip fracture-related procedure code, 318 patients who had been treated as outpatients without hospitalization, and 430 patients who had been diagnosed in 2002[1]. Consequently, a total of 14,273 patients were selected for this hip fracture study population.

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[1] Among NHIS-SC data, Statistics Korea cause of death data were established starting from 2003, meaning information concerning people who died in 2002 is unavailable. Accordingly, the present study excluded people who had been diagnosed with hip fracture in 2002 since death-related information for that year is unavailable.

Table 2. Definition of index fracture

ICD code	Procedure code
• S72.0: Fracture of neck of femur • S72.1: Pertrochanteric fracture • S72.2: Subtrochanteric fracture	• T6040: Hip Spica, Long leg • N0601: Open reduction of femur • N0991: Open reduction of femur with closed pinning • N0981: External fixation of femur • N0641: Closed reduction of femur • N0711: Replacement arthroplasty of hip • N0715: Hemiarthroplasty of hip

Note: ICD, International Classification of Disease

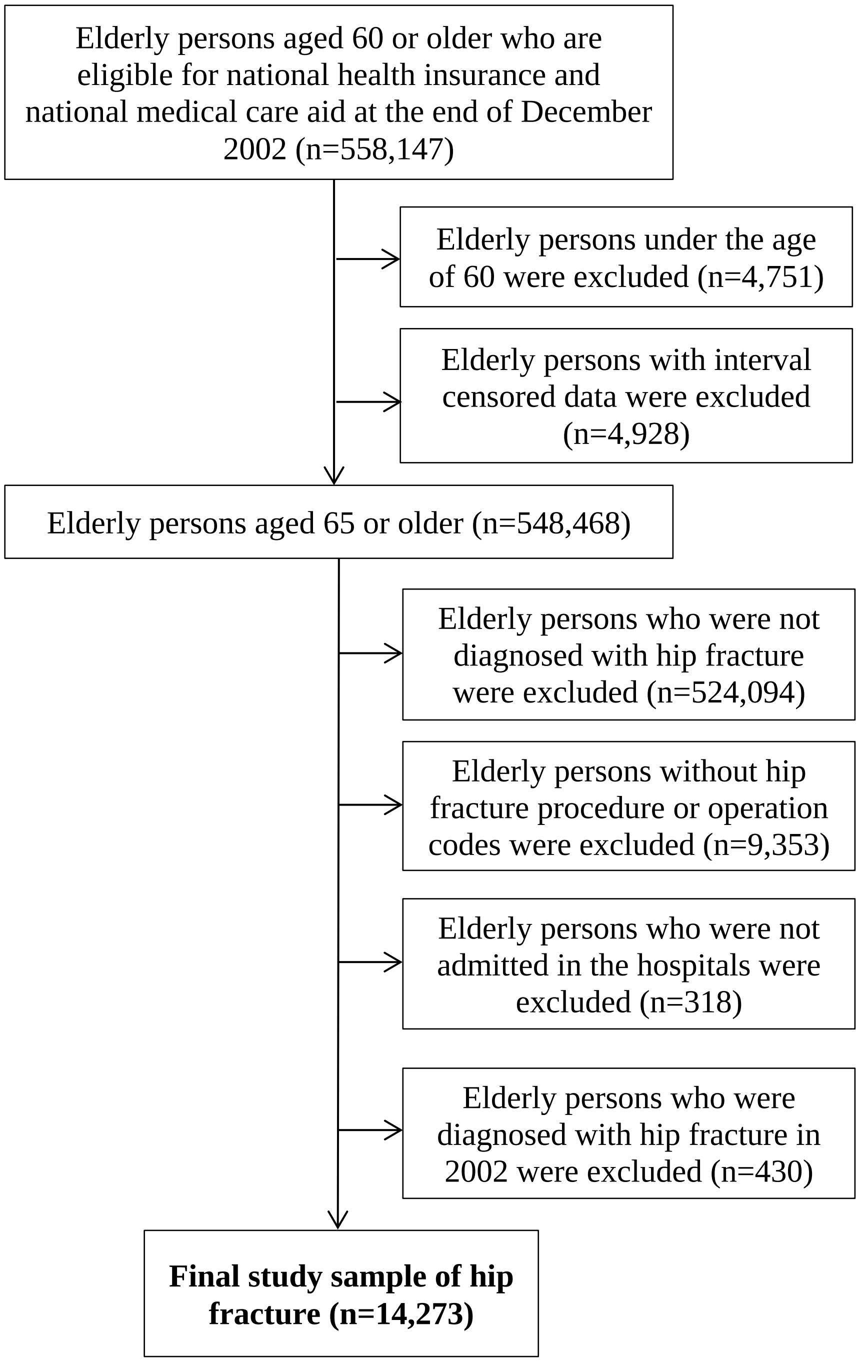

Figure 1. Flow diagram showing the selection process for hip fracture study sample

3. Measures and variables

The present study used 18 covariates, classified as patient, treatment, or provider characteristics (Table 3). Patient characteristics consisted mostly of sociodemographic variables of the patients, including age (classified into intervals of 5 years); sex; residential area (Seoul/Metropolitan/Non-metropolitan); individual income by insurance program(Medical-care aid beneficiary/Self-employees, quintile1/Self-employees, quintile2/Self-employees, quintile3/Self-employees, quintile4/Self-employees, quintile5/Industrial workers, quintile1/ Industrial workers, quintile2/ Industrial workers, quintile3/ Industrial workers, quintile4/ Industrial workers, quintile5); national health screening (No/Yes); and long-term care beneficiary (No/Yes). The study used individual income by insurance program as the variable for individual income level. Originally, the NHIS-SC classified income brackets into 10 quantiles for industrial workers and self-employees, and 0 quantile for medical-care aid beneficiaries. However, even with such income brackets, there are limitations in representing individual income levels using income bracket variables since subscription type may differ within the same income bracket. Accordingly, the present study combined income bracket and subscription type to re-categorize according to individual income by insurance program. With respect to national health screening, as general checkup is scheduled once every two years, the study reviewed data from not only the year in which a hip fracture had been diagnosed, but from the previous year as well. In addition, the study also took into account lifetime transition period health checkup at the age of 66 years to make the final determination concerning the health screening status. With respect to long-term care, the study used a long-term care rating variable. The rating consisted of classes 1 to 3, and others were determined by the Need Assessment Committee, based on a long-term care score where people classified and designated between class 1 and class 3 were recognized as eligible long-term care beneficiaries. Accordingly, the present study divided the study population into people with or without class 1 to 3 designations when applying the long-term care beneficiary variable.

Treatment characteristics consisted of variables related to treatment received, including length of stay (classified as a quartile); type of fracture (Neck of femur/Trochanteric); hip replacement (No/Yes); diagnosis of osteoporosis (No/Yes); CCI (0/1/2/3+); and year of procedure (from 2003 to 2013). With respect to type of fracture, the operational definition divided fractures into 3 types, based on IDC-10 codes for fracture (S72.0 - neck of femur, S72.1 - pertrochanteric, and S72.2 - subtrochanteric). However, after the baseline analysis, type of fracture was regrouped into neck of femur (S72.0) and trochanteric (S72.1 and S72.2) fracture according to patient distribution.

With respect to adjusting for comorbidities, because the original NHIS-SC data consisted of health insurance claims data, the severity of disease could not be determined. However, comorbidities could be tracked through previous medical history. Methods for adjusting comorbidities that could be applied to administrative data have been developed in previous studies based on the observation period [47-49], determination of data scope

[50], and adjustment methods [51,52]. In these studies, the predictive power of the models was sufficiently explained with observation of comorbidities for just 1 year [49], while studies on post-operative mortality reported that a short observation period of less than 1 year was appropriate [48]. Moreover, for the diagnosis, it was deemed more efficient to use only the main diagnosis and the sub-diagnosis instead of considering all diagnoses. Several codes have been suggested by various researchers for the CCI diagnosis code, but Quan's code has been reported to have the highest predictive power [53]. Accordingly, this study defined CCI as having a diagnosis of CCI according to Quan's code, based on observation of the main diagnosis and sub-diagnosis for a period of 1 year prior to the hip fracture. After assigning the scores defined by Charlson et al. to each disease (Table 4), the sum of these scores was categorized as 0, 1, 2, and ≥3 points.

Provider characteristics consisted of the variables in relation to the medical institution that the patient had used at the time of hip fracture diagnosis, which included type of hospital (General hospital/Hospital/Clinic and others); ownership/management of hospital (Public/Private); hospital location (Seoul/Metropolitan/Non-metropolitan); number of beds (classified as a quartile); number of physicians per 100 beds (classified as a quartile); and possession of medical imaging equipment (no equipment or one, two, or three forms of medical imaging equipment available for use). With respect to medical equipment, the original NHIS-SC data detailed the presence of CT, MRI, and PET equipment as three separate variables. However, the present study regrouped these three variables and determined how many types of high-priced equipment (CT, MRI, and PET) the facility had available for use.

Table 3. Categories of independent variables

Variables	Categories
Patient characteristics	
Sex	Men/Women
Age	Classified into intervals of 5 years
Residential area	Seoul/Metropolitan/Non-metropolitan
Individual income by insurance program	Medical-care aid beneficiary/ Self-employees, quintile1(low)/ Self-employees, quintile2/ Self-employees, quintile3/ Self-employees, quintile4/ Self-employees, quintile5(high)/ Industrial workers, quintile1(low)/ Industrial workers, quintile2/ Industrial workers, quintile3/ Industrial workers, quintile4/ Industrial workers, quintile5(high)
National health screening	No/Yes
Long-term care beneficiary	No/Yes
Treatment characteristics	
Length of stay	Classified as a quartile
Type of fracture	Neck of femur/Trochanteric
Hip replacement	No/Yes
Diagnosis of osteoporosis	No/Yes
Charlson comorbidity index	0/1/2/3+
Year of procedure	2003-2013
Provider characteristics	
Type of hospital	General hospital/Hospital/Clinic and others
Ownership/management of hospital	Public/Private
Hospital location	Seoul/Metropolitan/Non-metropolitan
The number of beds	Classified as a quartile
The number of physicians per 100 beds	Classified as a quartile
Possession of medical imaging equipment	No or one/Two/Three

Table 4. Algorithms for CCI ICD-10 codes

	Disease	ICD-10 code	Score
1	AIDS/HIV	B24.x	6
2	Cerebrovascular disease	G45.x, G46.x, H34.0, I60.x-I68.x	1
3	Congestive heart failure	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5-I42.9, I43.x, P29.0	1
4	Chronic pulmonary disease	I27.8, I27.9, J40.x, J67.x, J68.4, J70.1, J70.3	1
5	Dementia	F03.x, F05.1, G30.x, G31.1	1
6	Diabetes without chronic complication	E10.0, E10.6, E10.8, E11.0, E11.6, E11.8, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.6, E13.8, E14.0, E14.6, E14.8	1
7	Diabetes with chronic complication	E10.5, E10.7,E11.5,E11.7, E12.2-E12.5, E12.7, E13.5, E13.7, E14.5, E14.7	2
8	Hemiplegia or paraplegia	G04.1, G11.4, G80.1, G80.2, G82.3-G82.5, G83.0-G83.4, G83.9	2
9	Mild liver disease	B18.x, K70.0-K70.2, K70.9, K71.3-K71.5, K74.0-K74.2, K76.0, K76.2-K76.4, K76.8, K76.9, Z94.4	1
10	Moderate or severe liver disease	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K76.5	3
11	Any malignancy including leukemia and lymphoma	C43.x, C88.0-C88.2, C90.2, C94.4, C97.x	2
12	Metastatic solid tumor	C80.x	6
13	Myocardial infarction	I21.x, I22.x	1
14	Peripheral vascular disease	I70.x, I73.1, I73.8, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9	1
15	Peptic ulcer disease	K25.0-K25.3, K25.9, K26.0-K26.3, K26.9, K27.0-K27.3, K27.9, K28.0-K28.3, K28.9	1
16	Rheumatologic disease	M06.0-M06.4, M06.8, M06.9, M31.5, M33.0, M33.1, M33.9, M35.1, M36.0	1
17	Renal disease	I12.0, I13.1, N03.2-N03.7, N05.2-N05.7, N19.X, N25.0, Z49.0-Z49.2, Z94.0, Z99.2	2

Note: CCI, Charlson comorbidity index; ICD, International Classification of Disease
Source: Kim. Comparative study on three algorithms of the ICD-10 Charlson comorbidity index with myocardial infarction patients, 2010

4. Statistical analyses

The analyses in the present study consisted of four major steps.

First, the baseline characteristics of the patients were presented as frequency and distribution in each category, while a χ^2 test was used to analyze sex differences.

Second, to determine sex differences with regard to the risk of mortality after hip fracture surgery, the Kaplan-Meier method was used to derive up to one year survival curves following inpatient surgery for hip fracture according to sex, after which a log-rank test was performed. In this analysis, as the results showed a significant sex-based difference in survival experience, subsequent analyses were performed with sex stratification.

Third, for those among the study population who died, the mean period (± standard deviation) from hip fracture surgery to death was 65.9 (±0.5) months. Although various factors may have had an effect during this period, we did not possess information about such factors as the data used in the analysis were based on claims reimbursement data. Consequently, the present study analyzed the 1-year (within 12 months) mortality rate after surgery. Accordingly, the study determined the 1-year post-hip fracture mortality rate for each category of baseline characteristics and used a χ^2 test to analyze the differences between the categories.

Fourth, to estimate the odds ratios (ORs) for 1-year mortality after inpatient surgery for hip fracture, the present study performed survival analysis using a Cox's proportional hazards frailty model. The frailty model is one of the approaches used to adjust within-cluster correlations [54]. The present study applied clustering according to medical institution and performed univariate and multivariate analyses.

The test statistics for the Cox regression analysis are presented as hazard ratios (HRs) and 95% confidence intervals (CIs), and SAS ver. 9.4 (SAS Institute Inc., Cary, NC, USA) was used for all data analyses.

Ⅳ. Results

1. Baseline characteristics of the study sample

Tables 5 shows the frequency and distribution in each category of baseline characteristics at the time of hip fracture surgery. Of 14,273 elderly patients with hip fracture, 3,526 (24.7%) were men and 10,747 (75.3%) were women, with a mean age of 79.4 ± 6.9 years (men, 77.8 ± 6.7 years; women, 79.9 ± 6.8 years). With respect to the variables for each category of patient characteristics, age, residential area, individual income by insurance program, national health screening, and being a long-term care beneficiary showed statistically significant differences between the sexes (Table 5-1).

In terms of treatment characteristics, the length of stay, type of fracture, hip replacement, and diagnosis of osteoporosis showed statistically significant differences between the sexes, whereas CCI and year of procedure showed no statistically significant differences (Table 5-2).

With regard to provider characteristics, the type of hospital and availability of medical imaging equipment showed statistically significant differences between the sexes, whereas all other variables showed no statistically significant differences (Table 5-3).

With respect to the variables for each sex, the proportion of elderly aged ≥85 years was higher in men than in women (16.8% and 26.1%, respectively). Moreover, not only the participation rate of national health screening but also the proportions of the elderly population in the quintile 5 industrial workers were higher in men than in women (25.4% and 17.4%, 30.4% and 26.4%, respectively). On the contrary, the proportion of the elderly population that underwent hip replacement was higher in women than in men (52.5% and 46.5%, respectively). Moreover, the proportion of the elderly population that had been diagnosed with osteoporosis was higher in women than in men (42.5% and 32.1%, respectively). Regarding the type of hospital, the proportion of the elderly population that had been treated at a general hospital was higher in men than in women (67.2% and 65.6%, respectively).

Table 5-1. Baseline characteristics of hip fracture patients according to sex

Characteristics	Total (N=14273)		Men (N=3526)		Women (N=10747)		p-value
	No.	(%)	No.	(%)	No.	(%)	
Age, y							<0.001
65-69	1047	(7.3)	373	(10.6)	674	(6.3)	
70-74	2681	(18.8)	844	(23.9)	1837	(17.1)	
75-79	3625	(25.4)	958	(27.2)	2667	(24.8)	
80-84	3520	(24.7)	758	(21.5)	2762	(25.7)	
≥85	3400	(23.8)	593	(16.8)	2807	(26.1)	
Residential area							0.035
Seoul	2659	(18.6)	639	(18.1)	2020	(18.8)	
Metropolitan	3106	(21.8)	722	(20.5)	2384	(22.2)	
Non-metropolitan	8508	(59.6)	2165	(61.4)	6343	(59.0)	
Individual income by insurance program							<0.001
Medical-care aid beneficiary	1899	(13.3)	337	(9.6)	1562	(14.5)	
Self-employees, quintile 1	1230	(8.6)	265	(7.5)	965	(9.0)	
Self-employees, quintile 2	666	(4.7)	199	(5.6)	467	(4.4)	
Self-employees, quintile 3	687	(4.8)	179	(5.1)	508	(4.7)	
Self-employees, quintile 4	639	(4.5)	150	(4.3)	489	(4.6)	
Self-employees, quintile 5	1040	(7.3)	275	(7.8)	765	(7.1)	
Industrial workers, quintile 1	746	(5.2)	175	(5.0)	571	(5.3)	
Industrial workers, quintile 2	752	(5.3)	171	(4.9)	581	(5.4)	
Industrial workers, quintile 3	1000	(7.0)	231	(6.6)	769	(7.2)	
Industrial workers, quintile 4	1707	(12.0)	473	(13.4)	1234	(11.5)	
Industrial workers, quintile 5	3907	(27.4)	1071	(30.4)	2836	(26.4)	
National health screening							<0.001
No	11509	(80.6)	2630	(74.6)	8879	(82.6)	
Yes	2764	(19.4)	896	(25.4)	1868	(17.4)	
Long-term care beneficiary							<0.001
No	11737	(82.2)	3035	(86.1)	8702	(81.0)	
Yes	2536	(17.8)	491	(13.9)	2045	(19.0)	

Table 5-2. (Continued) Baseline characteristics of hip fracture patients according to sex

Characteristics	Total (N=14273)		Men (N=3526)		Women (N=10747)		p-value
	No.	(%)	No.	(%)	No.	(%)	
Length of stay, days							<0.001
≤16	3573	(25.0)	976	(27.7)	2597	(24.2)	
17-22	3873	(27.1)	968	(27.5)	2905	(27.0)	
23-30	3334	(23.4)	777	(22.0)	2557	(23.8)	
≥31	3493	(24.5)	805	(22.8)	2688	(25.0)	
Type of fracture							0.011
Neck of femur	7388	(51.8)	1760	(49.9)	5628	(52.4)	
Trochanteric	6885	(48.2)	1766	(50.1)	5119	(47.6)	
Hip replacement							<0.001
No	6990	(49.0)	1888	(53.6)	5102	(47.5)	
Yes	7283	(51.0)	1638	(46.5)	5645	(52.5)	
Diagnosis of osteoporosis							<0.001
No	8577	(60.1)	2393	(67.9)	6184	(57.5)	
Yes	5696	(39.9)	1133	(32.1)	4563	(42.5)	
Charlson comorbidity index							0.209
0	7910	(55.4)	1935	(54.9)	5975	(55.6)	
1	4010	(28.1)	1014	(28.8)	2996	(27.9)	
2	1572	(11.0)	367	(10.4)	1205	(11.2)	
3+	781	(5.5)	210	(6.0)	571	(5.3)	
Year of procedure							0.712
2003	648	(4.5)	175	(5.0)	473	(4.4)	
2004	806	(5.7)	203	(5.8)	603	(5.6)	
2005	959	(6.7)	238	(6.8)	721	(6.7)	
2006	1251	(8.8)	312	(8.9)	939	(8.7)	
2007	1236	(8.7)	286	(8.1)	950	(8.8)	
2008	1353	(9.5)	330	(9.4)	1023	(9.5)	
2009	1467	(10.3)	373	(10.6)	1094	(10.2)	
2010	1616	(11.3)	388	(11.0)	1228	(11.4)	
2011	1520	(10.7)	376	(10.7)	1144	(10.6)	
2012	1717	(12.0)	445	(12.6)	1272	(11.8)	
2013	1700	(11.9)	400	(11.3)	1300	(12.1)	

Table 5-3. (Continued) Baseline characteristics of hip fracture patients according to sex

Characteristics	Total (N=14273)		Men (N=3526)		Women (N=10747)		p-value
	No.	(%)	No.	(%)	No.	(%)	
Type of hospital							<0.001
General hospital	9415	(66.0)	2370	(67.2)	7045	(65.6)	
Hospital	4364	(30.6)	1006	(28.5)	3358	(31.3)	
Clinic and others	494	(3.5)	150	(4.3)	344	(3.2)	
Ownership/management of hospital							0.899
Public	767	(5.4)	188	(5.3)	579	(5.4)	
Private	13506	(94.6)	3338	(94.7)	10168	(94.6)	
Hospital location							0.302
Seoul	3141	(22.0)	745	(21.1)	2396	(22.3)	
Metropolitan	3753	(26.3)	926	(26.3)	2827	(26.3)	
Non-metropolitan	7379	(51.7)	1855	(52.6)	5524	(51.4)	
The number of beds							0.134
Lowest	3639	(25.5)	851	(24.1)	2788	(25.9)	
2nd lowest	3579	(25.1)	883	(25.0)	2696	(25.1)	
2nd highest	3659	(25.6)	919	(26.1)	2740	(25.5)	
Highest	3396	(23.8)	873	(24.8)	2523	(23.5)	
The number of physicians per 100 beds							0.869
Lowest	3559	(24.9)	865	(24.5)	2694	(25.1)	
2nd lowest	3656	(25.6)	899	(25.5)	2757	(25.7)	
2nd highest	3531	(24.7)	888	(25.2)	2643	(24.6)	
Highest	3527	(24.7)	874	(24.8)	2653	(24.7)	
Possession of medical imaging equipment							0.010
No or one	1862	(13.1)	484	(13.7)	1378	(12.8)	
Two	6607	(46.3)	1555	(44.1)	5052	(47.0)	
Three	5804	(40.7)	1487	(42.2)	4317	(40.2)	

Note: *P*-values are based on chi-squared tests
Medical imaging equipment included CT, MRI, and PET

2. Survival time curves after hip fracture according to sex

Figures 2 and 3 show the 1-year survival curves after hip fracture surgery for the entire study population, and according to sex. As shown in Figure 3, the survival rate of elderly men was lower than that of elderly women, and log-rank test results indicated a significant difference in survival experience between men and women ($p < 0.001$).

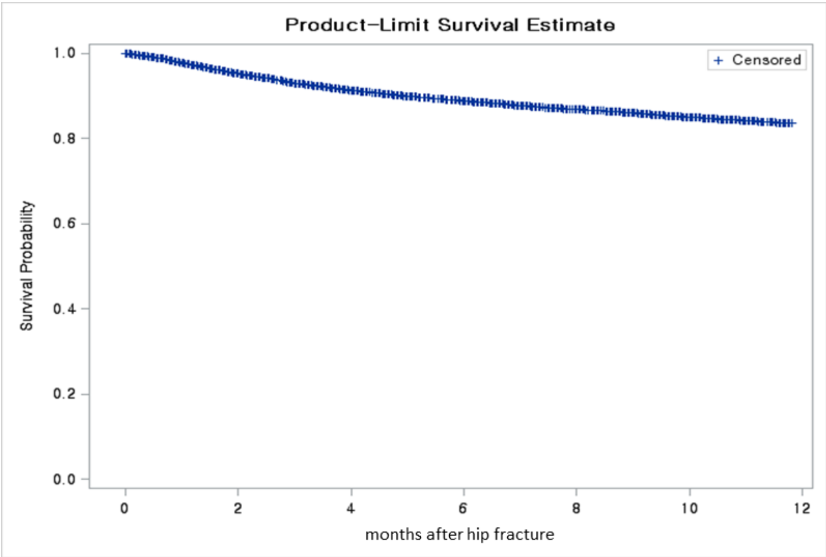

Figure 2. Observed survival curves for patients with hip fracture

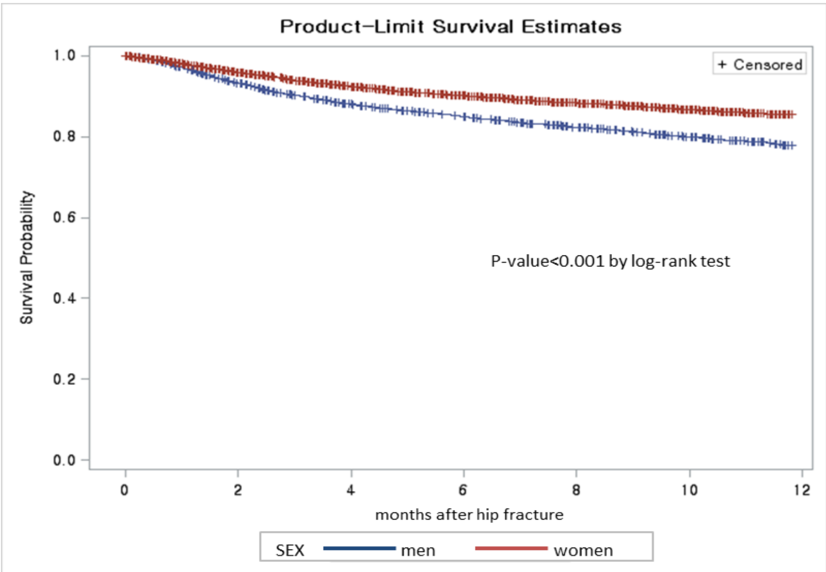

Figure 3. Observed survival curves for patients with hip fracture according to sex

3. One-year mortality rates for baseline characteristics according to sex

Tables 6 shows the 1-year mortality rates of elderly men according to their baseline characteristics. The overall 1-year mortality rate after hip fracture in elderly men was 21.2% and significantly increased with age, individual income by insurance program, national health screening, being a long-term care beneficiary, length of hospital stay, Charlson comorbidity index, and year of procedure.

With respect to baseline characteristics, elderly men residing in non-metropolitan areas had a mortality rate of 21.9%, which was higher than 21.1% and 18.9% observed in those residing in metropolitan areas and in Seoul, respectively. With respect to individual income by insurance program, elderly men who were medical-care aid beneficiaries showed the highest mortality rate of 25.5%, which was more than twice the 12.0% seen in the quintile 1 industrial workers group. Moreover, the mortality rate in elderly men who did not participate in national health screening was 24.2%, which was higher than in those who did participate (Table 6-1).

With respect to length of hospital stay, elderly men with ≤16 days of hospital stay showed the highest mortality rate of 25.4%, while elderly men with a CCI score of 2 or ≥3 points showed a mortality rate of 24.8%, which was higher than those with a score of 0 or 1. Moreover, elderly men who underwent surgery for hip fracture at a public hospital showed a higher mortality rate of 25.0% than those who underwent surgery at a private hospital, while those who underwent surgery at a hospital with no or only one form of medical imaging equipment available for use showed higher mortality rates than better equipped hospitals (Table 6-2, Table 6-3).

Table 6-1. One-year mortality according to baseline characteristics in men

Characteristics	Total	Alive	Dead	Mortality rate	p-value
Overall	3526	2779	747	21.2	
Age, y					<0.001
65-69	373	328	45	12.1	
70-74	844	725	119	14.1	
75-79	958	778	180	18.8	
80-84	758	565	193	25.5	
≥85	593	383	210	35.4	
Residential area					0.273
Seoul	639	518	121	18.9	
Metropolitan	722	570	152	21.1	
Non-metropolitan	2165	1691	474	21.9	
Individual income by insurance program					0.007
Medical-care aid beneficiary	337	251	86	25.5	
Self-employees, quintile 1	265	200	65	24.5	
Self-employees, quintile 2	199	150	49	24.6	
Self-employees, quintile 3	179	136	43	24.0	
Self-employees, quintile 4	150	116	34	22.7	
Self-employees, quintile 5	275	232	43	15.6	
Industrial workers, quintile 1	175	154	21	12.0	
Industrial workers, quintile 2	171	140	31	18.1	
Industrial workers, quintile 3	231	188	43	18.6	
Industrial workers, quintile 4	473	368	105	22.2	
Industrial workers, quintile 5	1071	844	227	21.2	
National health screening					<0.001
No	2630	1993	637	24.2	
Yes	896	786	110	12.3	
Long-term care beneficiary					<0.001
No	3035	2434	601	19.8	
Yes	491	345	146	29.7	

Table 6-2. (Continued) One-year mortality according to baseline characteristics in men

Characteristics	Total	Alive	Dead	Mortality rate	p-value
Overall	3526	2779	747	21.2	
Length of stay, days					0.002
≤16	976	728	248	25.4	
17-22	968	778	190	19.6	
23-30	777	623	154	19.8	
≥31	805	650	155	19.3	
Type of fracture					0.465
Neck of femur	1760	1396	364	20.7	
Trochanteric	1766	1383	383	21.7	
Hip replacement					0.621
No	1888	1494	394	20.9	
Yes	1638	1285	353	21.6	
Diagnosis of osteoporosis					0.425
No	2393	1877	516	21.6	
Yes	1133	902	231	20.4	
Charlson comorbidity index					0.045
0	1935	1556	379	19.6	
1	1014	789	225	22.2	
2	367	276	91	24.8	
3+	210	158	52	24.8	
Year of procedure					0.030
2003	175	139	36	20.6	
2004	203	171	32	15.8	
2005	238	187	51	21.4	
2006	312	244	68	21.8	
2007	286	230	56	19.6	
2008	330	264	66	20.0	
2009	373	300	73	19.6	
2010	388	295	93	24.0	
2011	376	278	98	26.1	
2012	445	337	108	24.3	
2013	400	334	66	16.5	

Table 6-3. (Continued) One-year mortality according to baseline characteristics in men

Characteristics	Total	Alive	Dead	Mortality rate	p-value
Overall	3526	2779	747	21.2	
Type of hospital					0.353
General hospital	2370	1853	517	21.8	
Hospital	1006	803	203	20.2	
Clinic and others	150	123	27	18.0	
Ownership/management of hospital					0.188
Public	188	141	47	25.0	
Private	3338	2638	700	21.0	
Hospital location					0.131
Seoul	745	601	144	19.3	
Metropolitan	926	740	186	20.1	
Non-metropolitan	1855	1438	417	22.5	
The number of beds					0.671
Lowest	851	674	177	20.8	
2nd lowest	883	691	192	21.7	
2nd highest	919	735	184	20.0	
Highest	873	679	194	22.2	
The number of physicians per 100 beds					0.391
Lowest	865	686	179	20.7	
2nd lowest	899	697	202	22.5	
2nd highest	888	692	196	22.1	
Highest	874	704	170	19.5	
Possession of medical imaging equipment					0.806
No or one	484	376	108	22.3	
Two	1555	1229	326	21.0	
Three	1487	1174	313	21.1	

Note: *P*-values are based on chi-squared tests
Medical imaging equipment included CT, MRI, and PET

Tables 7 shows the 1-year mortality rates of elderly women according to their baseline characteristics. The overall 1-year post-hip fracture mortality rate in elderly women was 13.9%, which was lower than the 21.2% observed in elderly men. Moreover, the mortality rate was significantly increased with age, individual income by insurance program, national health screening, length of hospital stay, hip replacement, diagnosis of osteoporosis, year of procedure, type of hospital, hospital location, number of beds, number of physicians per 100 beds, and possession of medical imaging equipment.

With respect to baseline characteristics, elderly women in the quintile 3 self-employed group showed a higher mortality (17.9%) compared to other groups. Moreover, the mortality rate in elderly women who did not participate in national health screening was 15.5%, which was more than twice that of those who participated in such screening (Table 7-1).

Elderly women with ≤16 days of hospital stay showed a mortality rate of 17.4%, which was higher than for those with ≥17 days of hospital stay, while elderly women who had not been diagnosed with osteoporosis showed a higher mortality rate than those who had been diagnosed with osteoporosis (Table 7-2).

Elderly women who had been treated at a hospital following a fracture showed a mortality rate of 15.3%, which was higher than for those who had been treated at a general hospital or clinic and others. Moreover, elderly women who visited hospitals in non-metropolitan areas showed a higher mortality rate of 15.0% than those who visited hospitals in other locations (Table 7-3).

Table 7-1. One-year mortality according to baseline characteristics in women

Characteristics	Total	Alive	Dead	Mortality rate	p-value
Overall	10747	9255	1492	13.9	
Age, y					<0.001
65-69	674	631	43	6.4	
70-74	1837	1692	145	7.9	
75-79	2667	2394	273	10.2	
80-84	2762	2357	405	14.7	
≥85	2807	2181	626	22.3	
Residential area					0.465
Seoul	2020	1742	278	13.8	
Metropolitan	2384	2070	314	13.2	
Non-metropolitan	6343	5443	900	14.2	
Individual income by insurance program					0.046
Medical-care aid beneficiary	1562	1322	240	15.4	
Self-employees, quintile 1	965	832	133	13.8	
Self-employees, quintile 2	467	398	69	14.8	
Self-employees, quintile 3	508	417	91	17.9	
Self-employees, quintile 4	489	417	72	14.7	
Self-employees, quintile 5	765	673	92	12.0	
Industrial workers, quintile 1	571	485	86	15.1	
Industrial workers, quintile 2	581	495	86	14.8	
Industrial workers, quintile 3	769	670	99	12.9	
Industrial workers, quintile 4	1234	1066	168	13.6	
Industrial workers, quintile 5	2836	2480	356	12.6	
National health screening					<0.001
No	8879	7500	1379	15.5	
Yes	1868	1755	113	6.1	
Long-term care beneficiary					0.064
No	8702	7520	1182	13.6	
Yes	2045	1735	310	15.2	

Table 7-2. (Continued) One-year mortality according to baseline characteristics in women

Characteristics	Total	Alive	Dead	Mortality rate	p-value
Overall	10747	9255	1492	13.9	
Length of stay, days					<0.001
≤16	2597	2144	453	17.4	
17-22	2905	2563	342	11.8	
23-30	2557	2207	350	13.7	
≥31	2688	2341	347	12.9	
Type of fracture					0.423
Neck of femur	5628	4861	767	13.6	
Trochanteric	5119	4394	725	14.2	
Hip replacement					0.037
No	5102	4431	671	13.2	
Yes	5645	4824	821	14.5	
Diagnosis of osteoporosis					<0.001
No	6184	5227	957	15.5	
Yes	4563	4028	535	11.7	
Charlson comorbidity index					0.923
0	5975	5156	819	13.7	
1	2996	2577	419	14.0	
2	1205	1034	171	14.2	
3+	571	488	83	14.5	
Year of procedure					<0.001
2003	473	408	65	13.7	
2004	603	510	93	15.4	
2005	721	606	115	16.0	
2006	939	803	136	14.5	
2007	950	821	129	13.6	
2008	1023	859	164	16.0	
2009	1094	946	148	13.5	
2010	1228	1043	185	15.1	
2011	1144	992	152	13.3	
2012	1272	1076	196	15.4	
2013	1300	1191	109	8.4	

Table 7-3. (Continued) One-year mortality according to baseline characteristics in women

Characteristics	Total	Alive	Dead	Mortality rate	p-value
Overall	10747	9255	1492	13.9	
Type of hospital					0.019
General hospital	7045	6107	938	13.3	
Hospital	3358	2846	512	15.3	
Clinic and others	344	302	42	12.2	
Ownership/management of hospital					0.864
Public	579	500	79	13.6	
Private	10168	8755	1413	13.9	
Hospital location					0.002
Seoul	2396	2103	293	12.2	
Metropolitan	2827	2457	370	13.1	
Non-metropolitan	5524	4695	829	15.0	
The number of beds					0.018
Lowest	2788	2380	408	14.6	
2nd lowest	2696	2287	409	15.2	
2nd highest	2740	2393	347	12.7	
Highest	2523	2195	328	13.0	
The number of physicians per 100 beds					<0.001
Lowest	2694	2252	442	16.4	
2nd lowest	2757	2379	378	13.7	
2nd highest	2643	2314	329	12.5	
Highest	2653	2310	343	12.9	
Possession of medical imaging equipment					<0.001
No or one	1378	1140	238	17.3	
Two	5052	4368	684	13.5	
Three	4317	3747	570	13.2	

Note: *P*-values are based on chi-squared tests
Medical imaging equipment included CT, MRI, and PET

4. Determinants of one-year mortality after hip fracture according to sex

Prior to using the Cox's proportional hazards frailty model, the study confirmed whether proportionality, which is the most fundamental assumption of the Cox's model, could be established. For this, the study performed a proportionality test in three steps, in the order of a log-rank test, a Wilcoxon test, and an LLS graph method. The results showed that proportionality was established for all variables associated with patient, treatment, and provider characteristics.

Tables 8 shows the estimated hazards ratio (HR) of mortality after hip fracture in elderly men. In the unadjusted model, age, individual income by insurance program, national health screening, being a long-term care beneficiary, length of stay, and Charlson comorbidity index variable were statistically significant. Similar results were obtained in the adjusted model, and statistically significant differences were also observed in the type of hospital.

With respect to baseline characteristics, compared to the medical-care aid beneficiaries, elderly men belonging to the quintile 5 self-employed or quintile 1 industrial worker groups showed a statistically significant lower risk of mortality. The HRs of 1-year mortality were 0.61 (95% CI: 0.41-0.90) and 0.48 (95% CI: 0.29-0.78), respectively. Moreover, elderly men who had participated in national health screening showed a significantly lower risk of mortality than those who had not, while those who were long-term care beneficiaries showed a significantly higher risk of mortality than those who were not in this category. The HRs were 0.50 (95% CI: 0.41-0.62) for elderly men who had participated in the national health screening and 1.30 (95% CI: 1.06-1.60) for those who were long-term care beneficiaries.

Meanwhile, elderly men with ≥17 days of hospital stay showed a statistically significantly lower risk of mortality than those with ≤16 days of hospital stay, whereas those with two or more comorbidities showed a statistically significantly higher risk of mortality than those with no comorbidity. The HRs were 0.60 (95% CI: 0.48-0.75) for elderly men with ≥31 days of hospital stay and 1.52 (95% CI: 1.12-2.08) for elderly men with three or more comorbidities.

Among the provider characteristics, elderly men who had been treated at a general hospital showed the highest risk of mortality, and the risk of mortality tended to decrease as the size of the hospital decreased. The HR was 0.47 (95% CI: 0.26-0.85) for elderly men who had been treated at a clinic and others. The random effect value in elderly men was 0.0018, showing a clustering effect on medical institution.

Table 8-1. Risk of death according to baseline characteristics in man patients with hip fracture

Characteristics	Univariate Cox proportional hazards model		Multivariate Cox proportional hazards model	
	HR	95% CI	HR	95% CI
Age, y				
65-69	1.00		1.00	
70-74	1.24	0.88-1.75	1.18	0.83-1.68
75-79	1.74**	1.25-2.41	1.66**	1.18-2.34
80-84	2.45***	1.77-3.40	2.34***	1.66-3.30
≥85	3.82***	2.76-5.28	3.62**	2.57-5.11
Residential area				
Seoul	1.00		1.00	
Metropolitan	1.18	0.90-1.54	1.14	0.80-1.63
Non-metropolitan	1.19	0.95-1.49	1.06	0.80-1.40
Individual income by insurance program				
Medical-care aid beneficiary	1.00		1.00	
Self-employees, quintile 1	0.96	0.70-1.33	1.15	0.81-1.62
Self-employees, quintile 2	0.96	0.67-1.37	1.33	0.91-1.93
Self-employees, quintile 3	0.90	0.62-1.30	1.14	0.77-1.68
Self-employees, quintile 4	0.85	0.57-1.27	1.07	0.70-1.62
Self-employees, quintile 5	0.57**	0.39-0.82	0.61*	0.41-0.90
Industrial workers, quintile 1	0.42***	0.26-0.68	0.48**	0.29-0.78
Industrial workers, quintile 2	0.67	0.45-1.02	0.82	0.53-1.26
Industrial workers, quintile 3	0.69*	0.48-0.99	0.82	0.56-1.21
Industrial workers, quintile 4	0.85	0.64-1.13	1.13	0.83-1.53
Industrial workers, quintile 5	0.80	0.63-1.03	0.90	0.69-1.18
National health screening				
No	1.00		1.00	
Yes	0.47***	0.38-0.58	0.50***	0.41-0.62
Long-term care beneficiary				
No	1.00		1.00	
Yes	1.58***	1.31-1.89	1.30*	1.06-1.60

Table 8-2. (Continued) Risk of death according to baseline characteristics in man patients with hip fracture

Characteristics	Univariate Cox proportional hazards model		Multivariate Cox proportional hazards model	
	HR	95% CI	HR	95% CI
Length of stay, days				
≤16	1.00		1.00	
17-22	0.69***	0.57-0.84	0.64***	0.52-0.78
23-30	0.68***	0.56-0.84	0.64***	0.51-0.79
≥31	0.67***	0.54-0.82	0.60***	0.48-0.75
Type of fracture				
Neck of femur	1.00		1.00	
Trochanteric	1.06	0.91-1.22	1.11	0.92-1.34
Hip replacement				
No	1.00		1.00	
Yes	1.04	0.90-1.21	1.06	0.87-1.28
Diagnosis of osteoporosis				
No	1.00		1.00	
Yes	0.95	0.81-1.11	0.93	0.79-1.11
Charlson comorbidity index				
0	1.00		1.00	
1	1.16	0.99-1.37	1.17	0.99-1.40
2	1.30*	1.03-1.63	1.29*	1.01-1.65
3+	1.32	0.99-1.76	1.52**	1.12-2.08
Year of procedure				
2003	1.00		1.00	
2004	0.76	0.47-1.22	0.79	0.48-1.29
2005	1.06	0.69-1.63	1.07	0.69-1.67
2006	1.08	0.72-1.62	1.09	0.72-1.66
2007	0.94	0.62-1.43	0.94	0.61-1.46
2008	0.98	0.65-1.47	0.91	0.59-1.41
2009	0.95	0.64-1.42	0.89	0.58-1.36
2010	1.20	0.81-1.76	1.09	0.72-1.65
2011	1.33	0.91-1.96	1.17	0.77-1.77
2012	1.21	0.83-1.77	1.03	0.69-1.55
2013	1.33	0.88-2.00	1.12	0.72-1.73

Table 8-3. (Continued) Risk of death according to baseline characteristics in man patients with hip fracture

Characteristics	Univariate Cox proportional hazards model		Multivariate Cox proportional hazards model	
	HR	95% CI	HR	95% CI
Type of hospital				
General hospital	1.00		1.00	
Hospital	0.92	0.76-1.11	0.64**	0.46-0.90
Clinic and others	0.77	0.51-1.17	0.47*	0.26-0.85
Ownership/management of hospital				
Public	1.00		1.00	
Private	0.82	0.60-1.12	0.92	0.62-1.38
Hospital location				
Seoul	1.00		1.00	
Metropolitan	1.06	0.84-1.33	1.08	0.74-1.58
Non-metropolitan	1.20	0.99-1.47	1.21	0.88-1.66
The number of beds				
Lowest	1.00		1.00	
2nd lowest	1.07	0.85-1.33	0.86	0.62-1.18
2nd highest	0.98	0.77-1.23	0.81	0.54-1.23
Highest	1.08	0.85-1.37	1.08	0.64-1.84
The number of physicians per 100 beds				
Lowest	1.00		1.00	
2nd lowest	1.14	0.91-1.42	1.04	0.81-1.35
2nd highest	1.02	0.81-1.30	0.79	0.57-1.11
Highest	0.95	0.73-1.23	0.67	0.44-1.03
Possession of medical imaging equipment				
No or one	1.00		1.00	
Two	0.98	0.77-1.25	0.86	0.62-1.20
Three	0.94	0.72-1.22	0.80	0.50-1.30

Note: *P<0.05; **P<0.01; ***P<0.001
Medical imaging equipment included CT, MRI, and PET
Random effect=0.0018

Tables 9 shows the estimated HR of post-hip fracture mortality in elderly women. In the unadjusted model, age, individual income by insurance program, national health screening, length of stay, diagnosis of osteoporosis, type of hospital, hospital location, number of physicians per 100 beds, and possession of medical imaging equipment were statistically significant. On the contrary, when the model was adjusted for all variables, the results showed statistically significant differences in age, residential area, individual income by insurance program, national health screening, length of stay, hip replacement, diagnosis of osteoporosis, Charlson comorbidity index, type of hospital, hospital location, and possession of medical imaging equipment.

With respect to the baseline characteristics, compared to elderly women residing in Seoul, those residing in metropolitan and non-metropolitan areas showed a statistically significant lower risk of mortality. The HR was 0.77 (95% CI: 0.61-0.99) for elderly women residing in the metropolitan area.

Regarding the individual income by insurance program, elderly women in the quintile 3 self-employed group showed a statistically significantly higher risk of mortality than medical-care aid beneficiaries. The HR was 1.40 (95% CI: 1.10-1.79) for elderly women in the quintile 3 self-employed group. Moreover, elderly women who had participated in the national health screening showed a statistically significantly lower risk of mortality than those who had not, while those with ≥17 days of hospital stay showed a statistically significantly lower risk of mortality than those with ≤16 days of hospital stay. The HRs were 0.46 (95% CI: 0.38-0.56) for elderly women who had participated in the national health screening and 0.63 (95% CI: 0.55-0.73) for those with 17-22 days of hospital stay.

Elderly women who underwent a hip replacement showed a higher risk of mortality than those who had not, and the HR was 1.16 (95% CI: 1.03-1.31). Elderly women who had been diagnosed with osteoporosis showed a statistically significantly lower risk of mortality than those who did not have osteoporosis, while a higher number of comorbidities resulted in a statistically significantly higher risk of mortality in elderly women. The HRs were 0.77 (95% CI: 0.69-0.86) for elderly women who had been diagnosed with osteoporosis and 1.36 (95% CI: 1.08-1.71) for those with three or more comorbidities.

Among the provider characteristics, elderly women who had been treated at a clinic showed a lower risk of mortality than those treated at a general hospital, while those treated at a hospital located in a small city showed a statistically significantly higher risk of mortality than those treated at a hospital located in Seoul. The HRs were 0.59 (95% CI: 0.40-0.88) for elderly women who had been treated at clinic and others and 1.49 (95% CI: 1.23-1.81) for elderly women treated at a hospital located in non-metropolitan.

Finally, elderly women who had been treated at a hospital with two forms of medical imaging equipment available for use showed a statistically significantly lower risk of mortality than those treated at a hospital with no or only one form of medical imaging equipment available for use. The HR was 0.78 (95% CI: 0.64-0.95). The random effect value in elderly women was 0.1979, which showed no clustering effect on medical institution.

Table 9-1. Risk of death according to baseline characteristics in woman patients with hip fracture

Characteristics	Univariate Cox proportional hazards model		Multivariable Cox proportional hazards model	
	HR	95% CI	HR	95% CI
Age, y				
65-69	1.00		1.00	
70-74	1.30	0.92-1.83	1.25	0.89-1.75
75-79	1.73***	1.25-2.38	1.66**	1.21-2.29
80-84	2.56***	1.87-3.50	2.34***	1.71-3.20
≥85	4.15***	3.04-5.65	3.81***	2.79-5.19
Residential area				
Seoul	1.00		1.00	
Metropolitan	0.94	0.79-1.11	0.77*	0.61-0.99
Non-metropolitan	1.02	0.89-1.18	0.81*	0.67-0.98
Individual income by insurance program				
Medical-care aid beneficiary	1.00		1.00	
Self-employees, quintile 1	0.90	0.73-1.11	1.03	0.83-1.28
Self-employees, quintile 2	0.95	0.73-1.25	1.21	0.92-1.59
Self-employees, quintile 3	1.19	0.93-1.51	1.40**	1.10-1.79
Self-employees, quintile 4	0.97	0.75-1.26	1.07	0.82-1.40
Self-employees, quintile 5	0.78*	0.62-1.00	0.82	0.64-1.06
Industrial workers, quintile 1	0.99	0.77-1.27	1.10	0.85-1.41
Industrial workers, quintile 2	0.98	0.76-1.25	1.08	0.84-1.38
Industrial workers, quintile 3	0.84	0.66-1.06	0.93	0.74-1.19
Industrial workers, quintile 4	0.89	0.73-1.08	0.96	0.78-1.17
Industrial workers, quintile 5	0.82*	0.69-0.96	0.94	0.79-1.11
National health screening				
No	1.00		1.00	
Yes	0.37***	0.31-0.45	0.46***	0.38-0.56
Long-term care beneficiary				
No	1.00		1.00	
Yes	1.10	0.97-1.25	0.93	0.81-1.07

Table 9-2. (Continued) Risk of death according to baseline characteristics in woman patients with hip fracture

Characteristics	Univariate Cox proportional hazards model		Multivariable Cox proportional hazards model	
	HR	95% CI	HR	95% CI
Length of stay, days				
≤16	1.00		1.00	
17-22	0.62***	0.54-0.71	0.63***	0.55-0.73
23-30	0.72***	0.62-0.83	0.70***	0.61-0.81
≥31	0.66***	0.57-0.76	0.66***	0.57-0.76
Type of fracture				
Neck of femur	1.00		1.00	
Trochanteric	1.06	0.95-1.17	1.06	0.94-1.20
Hip replacement				
No	1.00		1.00	
Yes	1.11	1.00-1.23	1.16*	1.03-1.31
Diagnosis of osteoporosis				
No	1.00		1.00	
Yes	0.74***	0.66-0.82	0.77***	0.69-0.86
Charlson comorbidity index				
0	1.00		1.00	
1	1.02	0.91-1.15	1.14*	1.01-1.28
2	1.05	0.89-1.23	1.23*	1.04-1.45
3+	1.05	0.84-1.31	1.36**	1.08-1.71
Year of procedure				
2003	1.00		1.00	
2004	1.10	0.80-1.51	1.08	0.78-1.48
2005	1.16	0.85-1.58	1.18	0.86-1.60
2006	1.03	0.77-1.39	1.03	0.76-1.39
2007	0.95	0.70-1.29	0.88	0.65-1.20
2008	1.15	0.86-1.54	1.07	0.80-1.44
2009	0.96	0.71-1.28	0.86	0.64-1.17
2010	1.07	0.80-1.43	1.02	0.76-1.37
2011	0.93	0.69-1.25	0.83	0.61-1.12
2012	1.09	0.82-1.45	0.96	0.71-1.28
2013	0.95	0.70-1.30	0.84	0.61-1.15

Table 9-3. (Continued) Risk of death according to baseline characteristics in woman patients with hip fracture

Characteristics	Univariate Cox proportional hazards model		Multivariable Cox proportional hazards model	
	HR	95% CI	HR	95% CI
Type of hospital				
General hospital	1.00		1.00	
Hospital	1.15*	1.01-1.30	0.96	0.78-1.17
Clinic and others	0.86	0.63-1.19	0.59**	0.40-0.88
Ownership/management of hospital				
Public	1.00		1.00	
Private	1.00	0.77-1.29	0.98	0.76-1.26
Hospital location				
Seoul	1.00		1.00	
Metropolitan	1.09	0.92-1.28	1.34*	1.06-1.71
Non-metropolitan	1.28***	1.11-1.48	1.49***	1.23-1.81
The number of beds				
Lowest	1.00		1.00	
2nd lowest	1.07	0.92-1.23	1.09	0.91-1.31
2nd highest	0.87	0.75-1.01	0.86	0.67-1.10
Highest	0.89	0.76-1.05	0.86	0.63-1.16
The number of physicians per 100 beds				
Lowest	1.00		1.00	
2nd lowest	0.85*	0.73-0.99	0.89	0.76-1.04
2nd highest	0.78**	0.66-0.92	0.82	0.66-1.01
Highest	0.79**	0.66-0.94	0.88	0.68-1.14
Possession of medical imaging equipment				
No or one	1.00		1.00	
Two	0.80**	0.68-0.93	0.78*	0.64-0.95
Three	0.77**	0.66-0.90	0.99	0.74-1.33

Note: *P < 0.05; **P < 0.01; ***P < 0.001
Medical imaging equipment included CT, MRI, and PET
Random effect=0.1979

Ⅴ. Discussion

1. Comparison to previous studies

The present study used NHIS-SC data to identify the distribution according to categories, survival time, and 1-year mortality with respect to hip fracture in a Korean elderly population and to analyze the determinants of 1-year post-hip fracture mortality.

Analysis of the determinants of 1-year post-hip fracture mortality according to sex showed that the risk of mortality was higher among elderly men in older age groups. Previous studies have also reported that there was a higher post-hip fracture mortality risk associated with a higher age among men, which was consistent with the findings in the present study [55-57]. Moreover, elderly men who participated in national health screening showed a lower post-hip fracture mortality risk than those who did not, but the possibility of this difference being the result of selection bias could not be discounted. Selection bias may have existed in the present study as the health screening status of specific patients selected using the operational definition from NHIS-SC data was used as one of the variables. In addition, because there were factors associated with screening, such as reasons for not participating in health screening, that were not controlled, caution should be taken in interpreting the results. For example, elderly patients who were day workers might not have had the time to participate in national health screening due to their work hours or may have been too tired to do so and, as a result, their risk of mortality could be higher due to a poorer health status than those who participated in screening. In addition, elderly patients who had not participated in the screening might already be in poor health and under-treated, which may increase the risk of mortality.

Meanwhile, elderly men long-term care beneficiaries showed higher post-hip fracture mortality rates than their counterparts. However, the possibility of uncontrolled variables could not be discounted. Long-term care insurance provides services to persons ≥65 years or to those <65 years of age who have a geriatric disease, (a disease designated by Presidential decree, such as dementia, cerebrovascular disease, or Parkinson's disease, for example). Based on functional conditions, disease and symptoms, environmental conditions, and need for benefit services, an eligibility score is calculated and the candidate is classified accordingly [58]. However, since the present study did not sufficiently control for factors associated with the eligibility criteria of long-term care insurance for elderly persons, caution should be taken in interpreting the results.

With respect to the length of hospital stay for elderly men, those with ≥17 days of hospital stay showed a lower risk of post-hip fracture mortality than those with ≤16 days of hospital stay. Wehren et al. [59] and William et al. [60] reported that post-hip fracture mortality decreased when the length of hospital stay increased to ≥7 days, which was consistent with the findings in the present study. A longer length of hospital stay may have financial implications, but implementation of a clinical pathway may actually reduce the financial burden and offer health benefits, leading to positive outcomes [61,62]. Compared to elderly men with a CCI score of 0, those with a score of ≥2 showed a higher risk of post-hip fracture mortality, which was consistent with existing studies that have reported a higher comorbidities index as associated with a higher risk of mortality due to a hip fracture [12,14,22].

Moreover, compared to elderly men who received treatment and/or surgery at a general hospital, those who received treatment and/or surgery at a hospital-level facility or below showed lower mortality after hip fracture. However, in this study, the severity of fracture was not controlled due to limitations of the claims data. Therefore, it is difficult to consider the factors of mortality after hip fracture as the characteristics of type of hospital. However, the possibility that the risk of mortality of clinics is relatively low because the more patients with the higher severity usually receive the surgery at the general hospital could not be discounted.

Analysis of factors associated with the risk of mortality after hip fracture in elderly women showed that the risk of mortality after hip fracture was higher in older age groups among elderly women, as with elderly men. Previous studies on the association between age of women and hip fracture reported that the risk of mortality post-hip fracture increased with increase in age, which was consistent with the findings in the present study [18,55,57,63].

With respect to the risk of mortality according to residential area, elderly women residing in metropolitan and non-metropolitan areas showed a lower risk of mortality than those residing in Seoul, with a decrease in risk as the cities involved decreased in size. These findings were consistent with a study from Taiwan, which reported that the in-hospital mortality rate post-hip fracture was lower when the residential area of the patient was at a lower urban density [18]. There have been other studies outside Korea that have investigated the association between residential area and mortality. Tsai et al. [64] reported that elderly people who lived outside a major city have lower mortality rates because they tended to have good mobility and mental health. Leung et al. [65] published study reports indicating that people who lived in urban areas have a higher risk of fall-related injury than people who live in rural areas due to their life-style habit of walking faster.

With respect to the risk of mortality according to individual income by insurance program, elderly women in the quintile 3 self-employed group showed a higher risk of mortality than medical-care aid beneficiaries, which was an interesting finding when compared to other studies. There have been previous studies that have analyzed the association between mortality post-hip fracture and health insurance type or income levels, but no study had combined insurance type and income level data. A study by Kang et al. [22] analyzed mortality rates according to health insurance type and found that medical-care aid beneficiaries had a higher risk of mortality after having sustained a hip fracture than national health insurance subscribers. In addition, Leslie et al. [66] analyzed mortality rates according to income levels and found that those belonging to a low income level group showed a higher risk of mortality following hip fracture than those belonging to a high income level. However, findings in the present study were slightly different to findings in previous studies, which may be attributed to the health security structure in Korea. In other words, medical-care aid beneficiaries may have low incomes, but they have very good accessibility to health care due to almost no co-payment or out-of-pocket costs when using a care facility, whereas health insurance subscribers face somewhat high co-payments or out-of-pocket costs, which diminish their accessibility to health care, creating an environment which may hinder them from seeking appropriate health care.

With respect to length of hospital stay for elderly women, those with ≥17 days of hospital stay showed a lower risk of mortality post-hip fracture than those with ≤16 days of hospital stay, which was consistent with results for elderly men. For Korean women, the patriarchal environment in Korea also has a major effect on the risk of mortality with respect to the length of hospital stay. Korean women, especially elderly women, are not likely to have anyone at home who can be a caregiver for them, and thus, receiving care from a medical institution would have had a positive effect on the risk of mortality in elderly women.

Meanwhile, elderly women who had been diagnosed with osteoporosis showed a lower risk of mortality post-hip fracture than those who had not, which was consistent with the findings in the studies by Kang et al. [22] and Chaysri et al. [67]. These results may be attributable to drug prescription for the diagnosis of osteoporosis. One study undertaken in Finland reported that women who had been prescribed calcium and vitamin D showed a 43% decrease in the hip fracture-associated mortality rate [68], while a study in Canada also reported that the post-hip fracture mortality rate dropped noticeably in people who had been prescribed anti-osteoporotic medication [69].

Compared to elderly women who had been treated in medical institution located in Seoul, those who had been treated at facilities in a non-metropolitan area showed a higher risk of mortality after hip fracture. This may be due to the fact that high-quality medical institutions are concentrated in Seoul and nearby areas.

Meanwhile, elderly women who had been treated at a hospital with two forms of medical imaging equipment available for use showed a lower risk of mortality than those treated in a hospital with no or only one form of medical imaging equipment available for use, which indicates that medically well-equipped institutions facilitate better health outcomes in elderly women.

2. Major contributions

Many studies in Korea and elsewhere have performed analyses using data from a single hospital or care facility with little representativeness, which present difficulties for generalizing the findings. The present study, on the other hand, used NHIS-SC data, the most representative claim data available in Korea that is also linked to cause of death data provided by Statistics Korea, with the aim of building reliability and increasing the utilization of the study findings.

Moreover, most existing studies have primarily focused on clinical characteristics, while there have been no studies that have considered the diverse range of characteristics, such as patient or provider characteristics. However, the present study conducted multi-faceted analyses that considered all patient, treatment, and provider characteristics associated with the risk of mortality.

Moreover, there have been no studies that have performed post-hip fracture sex-stratified analysis. The present study analyzed survival experience post-hip fracture separately for men and women and found statistically significant differences between the sexes. Through performing a sex-stratified analysis on the risk factors associated with post-hip fracture mortality, the present study was able to consider the different characteristics between the sexes.

Considering these points, the present study is significant in that it is the first study in Korea or elsewhere to have performed a sex-stratified analysis on post-hip fracture mortality rates in elderly persons aged ≥65 years using the most recent, highly representative data.

The health insurance system in Korea is designed to perform the functions of health security, social solidarity, and income redistribution [70]. Hip fracture has the highest prevalence and mortality rate among all geriatric fractures, while medical costs associated with hip fractures are also rapidly increasing, which can have negative physical, psychological, and financial effects on individuals [40-46]. For the elderly population who engage in little economic activity, a continuing increase in the prevalence and mortality rate associated with fractures will ultimately cause the income redistribution function to be lost, and thus, policies are needed to prevent this. However, while there have been studies on cost of illness or medical costs of end-of-life within the NHIS, there have been almost no reported studies related to mortality.

Accordingly, the present study presented data on survival time and 1-year post-hip fracture mortality rates for elderly Korean patients and identified factors associated with mortality through estimating the HRs for mortality. The findings in the present study may be used as basic data to increase awareness of the seriousness and importance of hip fractures. Moreover, the findings may provide evidence for public health policy makers to establish effective policies to prevent the incidence of hip fracture and to reduce mortality after hip fracture based on sex characteristics.

3. Limitations

The present study had the following limitations with respect to the study population and the data. First, the data used in the present study consisted of health insurance claims data, which is a limitation in that some claims data listed diseases that did not match the actual disease. However, the present study attempted to minimize the possibility of disease input error through establishing an operational definition of hip fracture using a combination of disease and procedure codes.

Second, the NHIS-SC data used in the present study uses ‘city’ as the basic unit of residential area, and because of this limitation, the study could not analyze more detailed residential area characteristics.

Third, hospital location information was also provided in city units; therefore, the study could not analyze more detailed hospital location characteristics.

Fourth, since the multilevel analysis according to the regional level was not performed, the random effects according to regions could not be considered.

Moreover, the present study also had limitations with respect to the variables used. First, the national health screening participation rate among the study patients was low, which presented a limitation in using the health screening data. As a result, health behavior variables could not be accounted for in detail in the analysis.

Second, the long-term care eligibility rate among the study patients was low, which presented a limitation in using long-term care data. As a result, some variables could not be accounted for in the analysis.

Third, since claims data were used, other potential covariates, such as marital status, living arrangements, occupation, educational level, social network, and genetics could not be controlled.

Fourth, due to limitations in the data available, treatment-related variables used in previous studies, such as the type of anesthesia, use of steroids, the cause of fracture, and the severity of fracture could not be adjusted.

Ⅵ. Conclusion

The present study was the first study to use NHIS-SC data to conduct sex-stratified analysis on the risk of mortality after hip fracture in elderly Koreans. The results showed that men and women had different factors associated with the risk of mortality. Here, factors associated with a higher risk of mortality in elderly men were identified as being of older age, being a medical-care aid beneficiary, not participating in national health screening, being a long-term care beneficiary, having ≤16 days of hospital stay, having a higher CCI score, and being treated at a general hospital. Meanwhile, factors associated with a higher risk of mortality after hip fracture in elderly women were identified as being of older age, residing in Seoul, belonging to the quintile 3 self-employed group, not participating in national health screening, having ≤16 days of hospital stay, having undergone a hip replacement, not having osteoporosis, having a higher CCI score, being treated at a hospital located in a non-metropolitan area, and being treated at a hospital with less than one form of medical imaging equipment available for use.

By identifying factors associated with the risk of post-hip fracture mortality in Korean elderly patients, the present study may provide basic data for raising awareness of the seriousness and importance of hip fracture. Moreover, the findings may provide evidence for public health policy makers to establish effective policies to prevent the incidence of hip fracture and to reduce mortality after hip fracture based on sex characteristics. Follow-up studies that consider factors not included in the present study, such as health behavior and disease severity, are required.

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Korean abstract

우리나라 노인의 고관절 골절 후 사망률과 사망 결정요인 연구: 국민건강보험공단 노인코호트 자료(2002-2013)를 사용하여

평균 수명이 증가하면서 전세계적으로 고령인구가 늘어감에 따라 고관절 골절이 주요한 보건의료문제로 대두되고 있다. 우리나라의 경우, 출산률이 감소하면서 인구구조가 급속도로 고령화되어 65 세 이상 노인 인구의 비율이 빠르게 증가하고 있어 고관절 골절의 발생 건수가 증가할 것으로 예측됨에도 불구하고 국내에서는 고관절 골절 후 사망에 대한 연구가 거의 보고된 바가 없다.

따라서, 본 연구는 국내 최초로 국민건강보험공단의 노인코호트 자료를 이용하여 우리나라 65 세 이상 노인의 고관절 골절 후 사망 위험에 대한 관련 요인을 다각적인 측면에서 성별로 층화하여 분석하고자 한다.

본 연구에서는 고관절 골절로 진단 받고 수술받은 65 세 이상 노인 14,273 명을 대상으로 분석하였으며, 고관절 골절 후 1 년내 사망 위험과 관련 요인을 규명하기 위해 콕스 회귀분석(Cox proportional hazard model)을 사용하였다.

연구 결과, 남성과 여성의 사망 위험에 대한 관련 요인은 각각 다르게 나타났다. 남성 노인은 연령이 높아질수록, 의료급여 수급자일수록, 국가건강검진을 안 할수록, 장기요양보험을 수급할수록, 재원일수가 16 일 이하일수록, CCI score 가 높아질수록, 종합병원에서 진료를 할수록 고관절 골절 후 사망 위험이 증가했으며, 여성 노인은 연령이 높아질수록, 서울에 거주할수록, 지역보험이면서 소득 3 분위일수록, 국가건강검진을 안 할수록, 재원일수가 16 일 이하일수록, 고관절 치환술을 실시할수록, 골다공증이 없을수록, CCI score 가 높아질수록, 소도시에 위치한 병원일수록, 고가의료장비를 한 종류 이하 소유한 병원에서 진료를 받을수록 고관절 골절 후 사망 위험이 증가하였다.

본 연구는 우리나라 노인의 고관절 골절 후 사망 위험에 대한 관련 요인들을 규명함으로써 고관절 골절의 심각성과 중요성을 경각시킬 수 있는 기초 자료로써 활용될 수 있을 것이다. 나아가 보건의료정책 입안자들에게 고관절 골절 발생을 예방하고 골절 후 사망을 줄일 수 있는 효율적인 정책을 성별 특성에 맞게 펼칠 수 있도록 근거 자료로 제공 될 수 있을 것이다. 또한, 본 연구에서 다루지 못했던 건강행태와 중증도를 고려한 후속 연구도 필요할 것이다.

핵심어: 사망률, 고관절 골절, 결정요인, 노인, 한국