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ORIGINAL ARTICLE

Risk factors for subsequent hip fractures and fatality after an initial hip fracture in Korea: using nationwide claims data

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Abstract

Summary In this study, the risk of fatality after hip fracture but not the risk of subsequent hip fractures was higher among men.

Introduction The purpose of this study was to analyze the risk factors for subsequent hip fractures and fatality after an initial hip fracture among Koreans older than 50 years of age using information in the national claims database.

Methods Our study was conducted using data from the Korean National Health Insurance Service database from 2007 to 2016. A total of 16,915 Korean patients aged ≥ 50 years with a first hip fracture in 2012 were followed for 4 years. Data on fracture, comorbidity, and prescription variables were retrieved from the national registry. The Cox proportional hazards model was used to identify the risk factors affecting subsequent hip fractures and fatality after the initial hip fracture.

Results A total of 952 patients had subsequent hip fractures, and 6793 patients died. The cumulative incidence rates were 1.3% after 1 year and 5.6% after 4 years. Old age, renal disease, dementia, and Parkinson's disease were associated with a higher risk of subsequent hip fractures. The fatality rate after the initial hip fracture was 1.6 times higher among men than among women. Certain risk factors for fatality, such as pneumonia after fracture, cerebrovascular disease, mild liver disease, renal disease, and malignancy, were more prevalent among men.

Conclusion During the study period, the risk of fatality after hip fracture but not the risk of subsequent hip fractures was higher among men. The gender difference in fatality might be explained by the larger burden of comorbid diseases among men.

Keywords Incidence · Fatality · Nationwide claims data · Subsequent hip fracture · Gender

Introduction

The global population is aging, and the increased life expectancy of the elderly population is considered the most important reason underlying the increased incidence of osteoporotic fractures [1–4]. Osteoporotic fractures in the elderly population result in high mortality and morbidity, greatly reducing the quality of life for the remaining years [5, 6].

Subsequent osteoporotic fractures have increased concerns among patients who failed to manage their osteoporosis after an initial fracture [7, 8]. Among cases of osteoporotic fractures, hip fractures have the worst prognosis because of high mortality and the loss of independence. However, studies on the incidence and risk factors for subsequent hip fractures are limited by the lower incidence of subsequent hip fractures compared with that of the initial hip fracture and the need for a large sample size.

The purpose of this study was to analyze the risk factors for subsequent hip fractures and fatality after an initial hip fracture among Koreans older than 50 years of age using information

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in the national claims database of the Korean National Health Insurance Service (KNHIS) from 2007 to 2016.

Materials and methods

Ethics statement

The study protocol was approved by the institutional review board (IRB) of Wonkwang University Sanbon Hospital (IRB No. WMCSB 201706-64). The requirement for informed consent was waived because the study was based on routinely collected administrative and claims data.

Data source

This study used data derived from the Korean National Health Insurance (KNHI) claims database from 1 January 2007 to 31 December 2016. The KNHIS guarantees health services to the Korean population, except for cosmetic surgery and services related to traffic or industrial accidents. All clinics and hospitals submit patient information, such as patient diagnoses (International Classification of Diseases, 10th Revision [ICD-10]), prescriptions, and procedures, to the KNHIS for claims. Therefore, the database comprises complete paid claims data including patient diagnoses, prescriptions, procedures, surgeries, outpatient physician encounters, and hospitalizations. All personal identification numbers were converted to anonymous codes so that they could not be tracked. The KNHIS claims database has the medical information of every Korean (~ 50 million) who has used medical services [9]. The database includes information pertaining to the reimbursement for each medical service, such as basic patient demographics, clinic or hospital identifiers, disease codes, costs incurred, the results of health screening, individual/family health history, health behavior, and information related to the cause of death [10].

Study population and follow-up

To analyze the incidence and risk factors for subsequent hip fractures, we conducted a population-based, retrospective cohort study. First, we identified subjects who experienced hip fractures in a cohort of Koreans aged 50 or older between 1 January and 31 December 2012 (n = 30,313). We excluded subjects who experienced any osteoporotic fracture including fractures of the hip, vertebra, distal radius, and humerus between 2007 and 2011 (n = 22,254). In addition, we excluded subjects with conditions resulting from high-impact traumas (multiple fractures) (n = 16,971). Ultimately, 16,915 participants were selected in the initial hip fracture group. Follow-up lasted from the date of the initial hip fracture diagnosis (index date) to the subsequent hip fracture, death, or 4 years.

Operational definition of hip fractures

Hip fractures were identified by using an algorithm based on selected ICD-10 codes and procedure codes used to search the claims database (Supplementary Table 1). First, fracture codes with procedure codes, including open reduction of a fractured extremity (femur), closed pinning (femur), external fixation (pelvis/femur), closed reduction of a fractured extremity (pelvis/femur), bone traction, skin traction, hemiarthroplasty, and total hip arthroplasty (hip), were regarded as hip fractures. Second, based on the last claim date, subsequent hip fractures were defined as fractures for which recurrent inpatient or outpatient treatment claims were made with a hip fracture diagnosis after the index date and an interval of at least 6 months between the claims [11].

Statistical analysis

Statistical comparison between groups was performed by using the t test or chi-square test. When appropriate, the Kaplan–Meier method was used to illustrate the estimated cumulative incidence of subsequent hip fractures and fatality after an initial hip fracture. The log-rank test was used to compare the incidence and fatality rate according to sex and age. The Cox proportional hazards model was used to evaluate the effect of clinical characteristics on the risk of subsequent hip fractures and fatality after the initial hip fracture. To eliminate the risk of immortal time bias, we performed the landmark analyses at 1, 2, and 3 years after the initial hip fracture. In the landmark method, a fixed time point during the follow-up period was selected as a landmark for conducting the analysis of survival. Only those subjects who had survived until the landmark time were included in the analysis [12].

Covariates included age, sex, fracture subtype, comorbidities before or after the index date, and the use of bisphosphonate (BP) and anticoagulants after the index date. Among the comorbidities, pneumonia, sepsis, and venous thromboembolism were evaluated for 6 months after the index date, and other comorbidities were evaluated for 1 year before the index date. The use of BP and anticoagulants was assessed from the index date to the end of the study. The use of BP is presented as the proportion of the follow-up period in which BP was used.

Effect sizes are presented as hazard ratios (HRs) and 95% confidence intervals (CIs). Database management and all analyses were performed using the SAS statistical package version 9.3 (SAS Institute, Cary, NC, USA).

Results

Incidence of subsequent hip fractures

Of the 30,313 subjects with hip fractures in 2012, 16,915 subjects with an initial hip fracture were followed for 4 years. Among them, women accounted for 68.5%. Men were significantly younger than women (73.7 versus 78.9 years). At the time of the initial fracture, the rates of congestive heart failure, dementia, rheumatic disease, and diabetes mellitus (DM) without complications were significantly higher among women than among men. However, the rates of myocardial infarction, peripheral vascular disease, cerebrovascular disease, chronic obstructive pulmonary disease (COPD), mild liver disease, hemiplegia, renal disease, and any malignancy were significantly higher among men. After initial hip fracture, the rate of pneumonia was significantly higher among men, and that of venous thromboembolism was significantly higher among women. The use of BP was significantly higher among women (Table 1).

Table 1 Clinical characteristics of initial hip fracture patient at 2012

	Total		Men		Women		*P* value
	N 16,915	%	*N* 5333	%	*N* 11,582	%	
Age groups (years)							
Mean (std)	77.3 (9.82)		73.7 (10.46)		78.9 (9.06)		< 0.001
50–65	1919	11.3	1030	19.3	889	7.7	< 0.001
65–80	7312	43.2	2658	49.8	4654	40.2	
≥ 80	7684	45.4	1645	30.8	6039	52.1	
Fracture subtype							
Femur neck fx	10,314	61.0	3130	58.7	7184	62.0	< 0.0001
Intertrochanteric fx	8741	51.7	2817	52.8	5924	51.1	0.043
Pre-index—comorbidity*							
Myocardial infarction	185	1.1	73	1.4	112	1.0	0.02
Congestive heart failure	685	4.0	149	2.8	536	4.6	< 0.001
Peripheral vascular disease	340	2.0	132	2.5	208	1.8	0.003
Cerebrovascular ds	2480	14.7	879	16.5	1601	13.8	< 0.001
Dementia	2335	13.8	540	10.1	1795	15.5	< 0.001
Chronic pulmonary disease	2432	14.4	828	15.5	1604	13.8	0.004
Rheumatic disease	350	2.1	61	1.1	289	2.5	< 0.001
Mild liver disease	387	2.3	204	3.8	183	1.6	< 0.001
DM without complication	2391	14.1	670	12.6	1721	14.9	< 0.001
DM with chronic complication	1297	7.7	415	7.8	882	7.6	0.705
Hemiplegia or paraplegia	305	1.8	141	2.6	164	1.4	< 0.001
Renal disease	504	3.0	231	4.3	273	2.4	< 0.001
Any malignancy, including leukemia	952	5.6	466	8.7	486	4.2	< 0.001
Moderate or severe liver disease	24	0.1	12	0.2	12	0.1	0.051
Metastatic solid tumor	48	0.3	18	0.3	30	0.3	0.373
Parkinson's disease	506	3.0	154	2.9	352	3.0	0.591
Post-index—comorbidity†							
Pneumonia	1369	8.1	576	10.8	793	6.8	< 0.001
Sepsis	427	2.5	150	2.8	277	2.4	0.105
Venous thromboembolism	336	2.0	70	1.3	266	2.3	< 0.001
Post-index—medication‡							
Bisphosphonate use (≥ 50%)	1727	10.2	153	2.9	1574	13.6	< 0.001
Anticoagulant	580	3.4	167	3.1	413	3.6	0.149

*Comorbidities were assessed for 1 year before the index date

† Comorbidities were assessed for 6 month after the index date

‡ The use of medication was assessed from the index date to the end of the study

Over 4 years, 952 patients had subsequent hip fractures, including 710 (74.6%) women and 242 (25.4%) men. Supplementary Table 2 shows the age- and gender-stratified incidence of subsequent hip fractures. The incidence rates of subsequent hip fractures were 1.5%, 2.1%, 2.2%, and 2.0% in the first, second, third, and fourth year, respectively. The cumulative incidence of subsequent hip fractures was higher among women (Fig. 1a) and was increased with age (Fig. 1b).

To identify the risk factors for subsequent hip fractures, Cox proportional hazards regression analyses were performed (Table 2). According to the results of multivariate analysis, there were no significant differences between men and women in the occurrence of subsequent fractures. Age was a significant risk factor; the adjusted HRs for subsequent fractures were 1.25 (95% CI 1.0–1.57) for patients aged 65–80 years and 1.38 (95% CI, 1.09–1.74) for patients older than 80 years compared with patients aged 50–65 years. In comparison with femur neck fracture, intertrochanteric fracture had a lower risk of subsequent fractures (HR 0.88, 95% CI 0.77–1.0). Dementia (HR 2.13, 95% CI 1.82–2.5), renal disease (HR 2.33, 95% CI 1.7–3.2), metastatic solid cancer (HR 3.15, 95% CI 1.0–9.99), and Parkinson's disease (HR 1.58, 95% CI 1.14–2.17) were identified as significant risk factors for subsequent hip fractures. Interestingly, cerebrovascular disease (HR 0.76, 95% CI 0.62–0.93) was associated with a reduced risk of subsequent fractures. The use of BP (≥ 50%) after the initial fracture was not associated with subsequent fracture reduction.

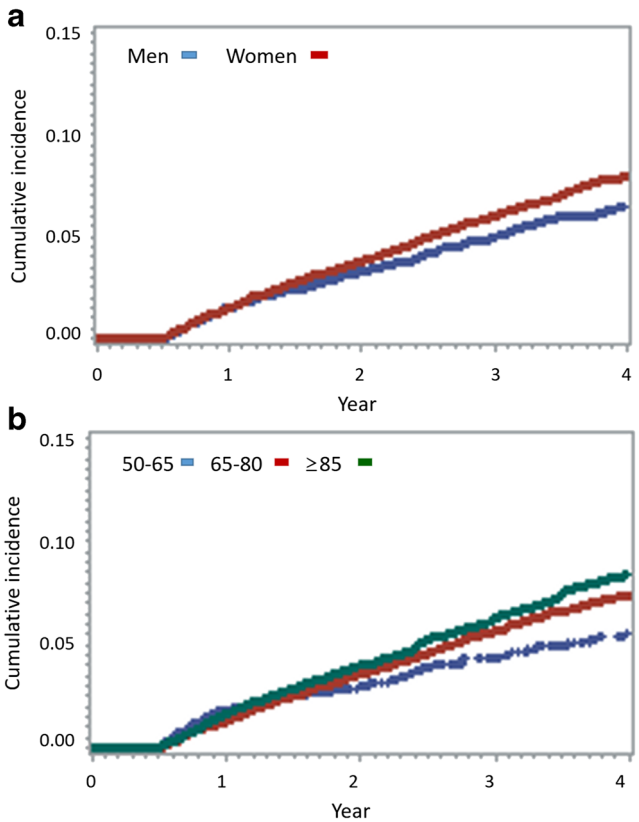

Fig. 1 Cumulative incidence of subsequent hip fractures according to gender and age

Table 2 Risk factors for subsequent hip fracture

	HR*	95% CI	*P* value
Gender			
Men	ref		
Women	1.05	(0.9, 1.23)	0.541
Age groups (years)			
50–65	ref		
65–80	1.25	(1.0, 1.57)	0.054
≥ 80	1.38	(1.09, 1.74)	0.009
Fracture subtype			
Femur neck fracture	ref		
Intertrochanteric fracture	0.88	(0.77, 1.0)	0.043
Pre-index—comorbidity			
Myocardial infarction	1.09	(0.59, 2.04)	0.789
Congestive heart failure	0.88	(0.61, 1.27)	0.485
Peripheral vascular disease	0.95	(0.59, 1.53)	0.822
Cerebrovascular ds	0.76	(0.62, 0.93)	0.007
Dementia	2.13	(1.82, 2.5)	< 0.001
Chronic pulmonary disease	1.01	(0.84, 1.21)	0.955
Rheumatic disease	1.32	(0.91, 1.93)	0.154
Mild liver disease	1.08	(0.69, 1.68)	0.752
DM without complication	1.04	(0.87, 1.26)	0.695
DM with chronic complication	0.83	(0.64, 1.09)	0.175
Hemiplegia or paraplegia	1.18	(0.72, 1.94)	0.517
Renal disease	2.33	(1.7, 3.2)	< 0.001
Any malignancy, including leukemia	1.11	(0.82, 1.51)	0.518
Moderate or severe liver disease	2.21	(0.54, 9.09)	0.275
Metastatic solid tumor	3.15	(1, 9.99)	0.052
Parkinson's disease	1.58	(1.14, 2.17)	0.006
Post-index—comorbidity			
Pneumonia	1.16	(0.88, 1.53)	0.318
Sepsis	0.71	(0.32, 1.59)	0.402
Venous thromboembolism	0.89	(0.51, 1.56)	0.681
Post-index—medication			
BP use ≥ 50%	1.61	(1.34, 1.92)	< 0.001
Anticoagulant	0.68	(0.44, 1.05)	0.081

CI, confidence interval; *HR*, hazard ratio; *BP*, bisphosphonate

All covariates were included for adjustment in multivariate Cox regression analysis

Fatality rate after an initial hip fracture

A total of 6793 patients died after an initial hip fracture by the end of the follow-up period. Women accounted for 63.9% (n = 4343) of the deaths and were older than men at death (82.6 versus 77.8 years). The fatality rate of men was significantly

higher than that of women during the follow-up period after the initial hip fracture ($P < 0.001$, Fig. 2a). The fatality rate was also significantly increased with increasing age ($P < 0.001$, Fig 2b).

We further examined the risk factors for fatality after an initial hip fracture. The results of multivariate analysis showed that male gender, old age, intertrochanteric fracture type, congestive heart failure, cerebrovascular disease, dementia, mild liver disease, DM with chronic complications, renal disease, any malignancy, moderate to severe liver disease, metastatic solid tumor, Parkinson's disease, pneumonia, and sepsis were statistically significant risk factors (Table 3). The risk of death among women was decreased compared with that among men during the follow-up period (HR 0.63, 95% CI 059–0.66, $P < 0.001$). Age was a significant risk factor for death; the adjusted HRs for death were 2.07 (95% CI 1.83–2.34) for patients aged 65–80 years and 4.4 (95% CI, 3.91–4.97) for patients older than 80 years compared with patients aged 50–65 years. Intertrochanteric fracture, cerebrovascular disease, mild liver disease, renal disease, any malignancy, and pneumonia were significantly more prevalent among men than among women (Table 1). In the subgroup analysis according to gender, cerebrovascular disease and moderate to severe liver disease were significant risk factors for fatality only among men, and mild liver disease was a significant risk factor for fatality only among women. The use of BP (≥ 50%) was associated with a significant decrease in fatality after hip fracture only among women. Supplementary Table 3 shows the results of the landmark analysis. The adjusted HRs of pneumonia were 2.12 (95% CI, 1.97–2.27) at 1 year but gradually decreased to 1.61(95% CI, 1.43–1.8) at 2 years and 1.52 (95% CI, 1.3–1.77) at 3 years. At 3 years, sepsis was not significantly associated with fatality. The adjusted HRs of BP use (≥ 50%) were similar at all landmark points.

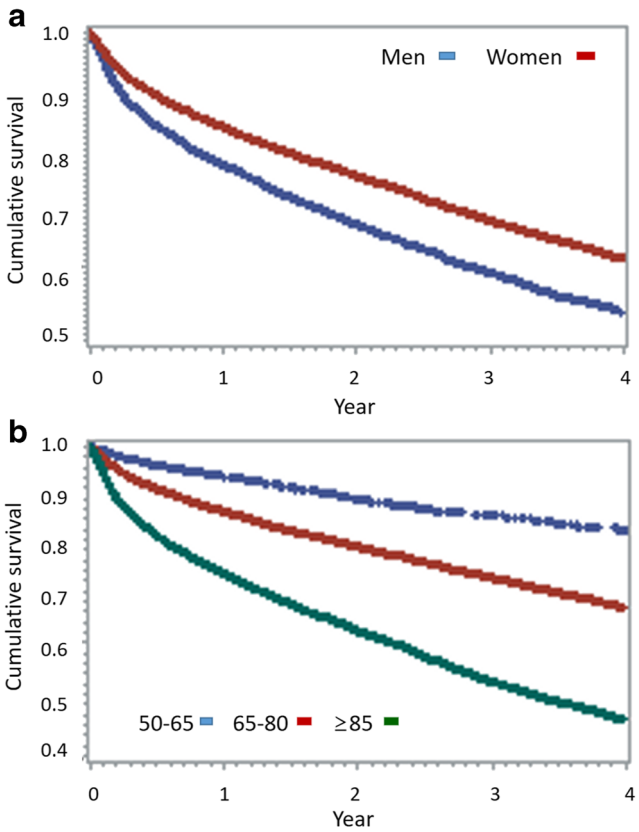

Fig. 2 Cumulative survival after an initial hip fracture according to gender and age

Discussion

The present study examined the incidence of subsequent hip fractures in a population-based cohort of subjects aged ≥ 50 years who sustained an initial hip fracture in 2012. The incidence of subsequent hip fractures was lower in our study than in other studies using claims data. Ryg et al. reported that the cumulative incidence rates of subsequent hip fractures were 9% after 1 year and 20% after 5 years in a cohort study in Denmark (1977–2001) [13]. In a study in Austria (2008–2010), the cumulative incidence rates of subsequent hip fractures after 1, 2, and 3 years were reported as 2.97%, 5.28%, and 7.19%, respectively [14]. In Taiwan, the incidence of subsequent hip fractures was determined by analyzing information in the Taiwan National Health Insurance Research Database (2001–2011) for 95,484 hip fracture patients [15]. The cumulative incidence rates of subsequent hip fractures within 1 year and 4 years were 2.2% and 6.3%, respectively, for women and 1.8% and 4.7%, respectively, for men. In particular, subsequent fractures occurred most frequently in the first year. Hip fracture rates are higher in Denmark, Austria, and Taiwan than in Korea; thus, the incidence of subsequent fractures may also be higher [16]. However, as we did not include fractures that occurred in the 6 months after the initial fracture, the 1-year incidence rates in this study might be underestimated. In addition, we excluded subjects who experienced osteoporotic fractures (hip, spine, distal radius, and humerus) before the initial hip fracture; thus, the incidence of subsequent hip fractures may be lower than that in other studies. Nevertheless, in a previous study in Korea, Lee et al. reported that the cumulative 1-year, 2-year, and 3-year incidence rates of subsequent hip fractures were 1.0%, 1.9%, and 2.2%, respectively, using claims data between 2007 and 2011 [17]. In Korea, the number of hip fractures has increased until recently; thus, it is thought that the incidence of subsequent fractures has also increased.

In this study, old age, renal disease, dementia, and Parkinson's disease were significant predictors for subsequent hip fractures. The results are in agreement with the findings of a previous study [18]. Dementia and Parkinson's disease may be related to the risk of second hip fractures

Table 3 Risk factors for fatality after an initial hip fracture

Women	Total			Men			Women		
	HR 0.63	95% CI (0.59, 0.66)	*P* value < 0.001	HR	95% CI	*P* value	HR	95% CI	*P* value
Age groups (years)									
50–65	ref			ref			ref		
65–80	2.07	(1.83, 2.34)	< 0.001	2.19	(1.88, 2.55)	< 0.001	1.97	(1.62, 2.41)	< 0.001
≥ 80	4.4	(3.91, 4.97)	< 0.001	4.18	(3.58, 4.89)	< 0.001	4.53	(3.72, 5.51)	< 0.001
Fracture subtype									
Femur neck fracture	ref			ref			ref		
Intertrochanteric fracture	1.08	(1.03, 1.13)	0.005	1.05	(0.97, 1.14)	0.262	1.08	(1.02, 1.15)	0.015
Pre-index—comorbidity									
Myocardial infarction	1.05	(0.86, 1.29)	0.678	1.14	(0.84, 1.54)	0.427	1	(0.76, 1.32)	0.99
Congestive heart failure	1.43	(1.29, 1.6)	< 0.001	1.54	(1.25, 1.89)	< 0.001	1.39	(1.23, 1.57)	< 0.001
Peripheral vascular disease	1.12	(0.95, 1.32)	0.181	1.03	(0.81, 1.32)	0.822	1.22	(0.98, 1.51)	0.082
Cerebrovascular ds	1.11	(1.04, 1.19)	0.004	1.15	(1.03, 1.28)	0.014	1.09	(1, 1.19)	0.062
Dementia	1.57	(1.48, 1.67)	< 0.001	1.72	(1.53, 1.92)	< 0.001	1.51	(1.4, 1.62)	< 0.001
Chronic pulmonary disease	1.02	(0.95, 1.09)	0.713	1.08	(0.97, 1.2)	0.184	0.98	(0.89, 1.07)	0.536
Rheumatic disease	1.02	(0.85, 1.23)	0.841	0.89	(0.6, 1.32)	0.545	1.09	(0.88, 1.34)	0.463
Mild liver disease	1.36	(1.16, 1.59)	0.001	1.19	(0.96, 1.49)	0.127	1.54	(1.22, 1.95)	0.001
DM without complication	1.06	(0.99, 1.14)	0.12	1.09	(0.97, 1.24)	0.168	1.05	(0.96, 1.15)	0.301
DM with chronic complication	1.22	(1.12, 1.33)	< 0.001	1.33	(1.15, 1.54)	0.001	1.17	(1.04, 1.31)	0.009
Hemiplegia or paraplegia	0.87	(0.71, 1.07)	0.175	1	(0.76, 1.31)	0.972	0.73	(0.52, 1.02)	0.061
Renal disease	2.03	(1.81, 2.28)	< 0.001	1.73	(1.46, 2.05)	< 0.001	2.47	(2.11, 2.89)	< 0.001
Any malignancy, including leukemia	1.89	(1.73, 2.07)	< 0.001	1.66	(1.46, 1.88)	< 0.001	2.14	(1.88, 2.44)	< 0.001
Moderate or severe liver disease	2.62	(1.59, 4.34)	0.001	3.29	(1.69, 6.42)	0.001	1.82	(0.85, 3.92)	0.126
Metastatic solid tumor	3.12	(2.27, 4.3)	< 0.001	2.25	(1.35, 3.76)	0.002	4.34	(2.85, 6.59)	< 0.001
Parkinson's disease	1.48	(1.31, 1.67)	< 0.001	1.5	(1.22, 1.84)	0.001	1.45	(1.25, 1.69)	< 0.001
Post-index—comorbidity									
Pneumonia	2.14	(1.99, 2.29)	< 0.001	2.11	(1.88, 2.35)	< 0.001	2.19	(1.99, 2.4)	< 0.001
Sepsis	3.3	(2.96, 3.69)	< 0.001	2.63	(2.18, 3.17)	< 0.001	3.9	(3.4, 4.47)	< 0.001
Venous thromboembolism	1.04	(0.87, 1.24)	0.709	0.94	(0.67, 1.32)	0.686	1.1	(0.89, 1.35)	0.405
Post-index—medication									
BP use ≥ 50%	0.87	(0.79, 0.95)	0.002	1.18	(0.94, 1.47)	0.162	0.83	(0.75, 0.91)	< 0.001
Anticoagulant	0.87	(0.76, 1.01)	0.062	0.79	(0.62, 1.02)	0.066	0.9	(0.75, 1.08)	0.245

CI, confidence interval; *HR*, hazard ratio; *BP*, bisphosphonate

All covariates were included for adjustment in multivariate Cox regression analysis

through possible falls associated with cognitive impairment or medication [19, 20]. In univariate analysis, the incidence of subsequent hip fractures was higher among women than among men; however, there was no significant gender difference in multivariate analysis. Several previous studies reported that women gender was a strong predictor for subsequent hip fractures [14, 15]. However, a study of a UK population by Sheikh et al. reported results similar to our findings [19]. The use of BP after fractures has been proven beneficial in reducing the risk of subsequent fractures [17, 18]. However, in this study, the use of BP after the initial fracture was not meaningful for the prevention of subsequent fractures, which may be explained by the use of BP in a high-risk group. Importantly, the number of people who have been prescribed with BP for 50% or more of the follow-up period after hip fracture was too small (10.2%); thus, further strategies need to be developed to improve drug persistence for subsequent fracture prevention.

Hip fractures occur frequently among women; however, the fatality rate after hip fracture has been reported to be higher among men than among women [15, 21]. Similar results were obtained in this study; the fatality rate after hip fracture was

1.6 times higher among men than among women, and this difference persisted for 4 years. In a previous study that analyzed the cause of death among men and women after hip fracture, Wehren et al. found that deaths caused by infection were more common among men than among women [22]. In addition, baseline comorbidities, fracture type, and postoperative complications did not explain the gender difference. They estimated that the increased rate of deaths caused by infection could be responsible for the gender difference [22]. However, in our study, individual comorbidities such as congestive heart failure, cerebrovascular disease, dementia, renal disease, any malignancy, metastatic solid cancer, Parkinson's disease, pneumonia, and sepsis after fracture were independent predictors for fatality after hip fracture. In agreement with previous findings, pneumonia after fracture was more common among men in our study. Moreover, several baseline comorbidities identified as risk factors were more prevalent among men. In addition, the use of BP, a protective factor against fatality, was significantly lower among men. Therefore, the burden of baseline comorbid diseases and post-fracture pneumonia may be responsible for the gender difference.

This study had several limitations. First, due to database limitations, we could not consider bone mineral density (BMD), laboratory data such as vitamin D and calcium, body mass index, and smoking or alcohol status. Second, although the operative definition of the study excluded pathologic fractures or high-energy trauma, it was not possible to clinically diagnose disease-associated fractures. Therefore, the data on fracture incidence may have been overestimated. Nevertheless, to distinguish it as much as possible, we only included patients older than 50 years who fulfilled specific inclusion criteria that had been used in previous studies. Third, as there was no information on the direct cause of death after hip fracture, only the accompanying diseases were analyzed to explain gender differences. Finally, we did not have information on postoperative functional recovery. Previously, Berry et al. reported that age and functional status were the most significant risk factors for subsequent hip fractures in a US population [23]. In the future, if a database of hospital records linked to claims data is established, more in-depth research may be conducted.

In conclusion, the risk of subsequent hip fracture was increased continuously in 4 years from the initial hip fracture. The factors affecting the occurrence of subsequent fractures were old age, renal disease, dementia, and Parkinson's disease. There was no gender difference in the risk of subsequent hip fractures. The fatality rate after hip fracture was 1.6 times higher among men than among women. Several risk factors for fatality including pneumonia after fracture, cerebrovascular disease, mild liver disease, renal disease, and malignancy were more prevalent among men. Therefore, the gender difference in fatality might be explained by the larger burden of comorbid diseases among men.

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Compliance with ethical standards

The study protocol was approved by the institutional review board (IRB) of Wonkwang University Sanbon Hospital (IRB No. WMCSB 201706-64). The requirement for informed consent was waived because the study was based on routinely collected administrative and claims data.

Conflict of interest None.

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