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Analysis of Long-Term Medical Expenses in Vertebral Fracture Patients

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Background: The objective of this study was to analyze the direct medical expenses of a vertebral fracture cohort (VC) and a matched cohort (MC) over 5 years preceding and following the fracture, analyze the duration of the rise in medical expenses due to the fracture, and examine whether the expenses vary with age group, utilizing a national claims database.

Methods: Subjects with vertebral fractures and matched subjects were chosen from the National Health Insurance Service Sample cohort (NHIS-Sample) of South Korea. Patients with vertebral fractures were either primarily admitted to acute care hospitals (index admissions) or those who received kyphoplasty or vertebroplasty during the follow-up period (2002–2015). A risk-set matching was performed using 1 : 5 random sampling to simulate a real-world situation. Individual-level direct medical expenses per quarter were calculated for 5 years prior and subsequent to the vertebral fracture. In this analysis using a comparative interrupted time series design, we examined the direct medical expenses of a VC and an MC.

Results: A total of 3,923 incident vertebral fracture patients and 19,615 matched subjects were included in this study. The mean age was 75.5 ± 7.4 years, and 69.5% were women. The mean difference in medical expenses between the two groups increased steadily before the fracture. The medical expenses of the VC peaked in the first quarter following the fracture. The cost changes were 1.82 times higher for the VC than for the MC (95% confidence interval, 1.62–2.04; $p < 0.001$) in the first year. Subsequently, there were no differential changes in medical expenses between the two groups ($p > 0.05$). In the < 70-year subgroup, there were no differential changes in medical expenses between the two groups ($p > 0.05$). However, in the ≥ 80-year subgroup, the cost changes for the VC were higher than those for the MC up to 5 years after time zero.

Conclusions: Based on our study results, we suggest that health and medical policies for vertebral fractures should be designed to last up to approximately 1 year after the fracture. Health policies should be differentiated according to age group.

Keywords: *Spine fracture, Vertebral fracture, Health care costs, Interrupted time series analysis*

As the number of elderly population has grown, the occurrence of osteoporotic fractures has also increased.[1] As a result, there has been an increase in the need for medical resources and medical expenses, leading to a socioeconomic burden not only for the families of patients but also for the healthcare system.[2] Various efforts are being made to reduce healthcare expenses for managing osteoporotic fractures. One approach is to select a less expensive treatment method by comparing and analyzing the cost-effectiveness of treatments.[3] Another approach is to employ a method to prevent future medical expenses, such as using a fracture liaison service to prevent refractures.[4] However, while these approaches still hold potential for cost savings within the healthcare system, they seem unlikely to provide direct economic assistance to patients and families

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who have experienced fractures.

Among the major osteoporotic fractures, vertebral fracture is the most common type of fracture and a major risk factor for subsequent fractures in untreated patients.[5] It has been reported that over half of patients who suffer from hip fractures have also experienced a previous vertebral fracture, and 14% of patients who have had a vertebral fracture have suffered at least one severe vertebral fracture.[6] Patients who have experienced a vertebral fracture are reported to have up to a five-fold higher risk of experiencing another vertebral fracture within 1 year compared to patients who have not experienced a vertebral fracture.[7] Women with osteoporosis who have had two or more vertebral fractures are reported to have a risk of refracture up to 75 times higher compared to women without osteoporosis and a history of vertebral fractures.[8] Therefore, the medical expenses incurred in the treatment of patients with vertebral fractures can increase if they experience subsequent fractures, which can create a significant financial burden for their families.

In the United States, the cost of osteoporotic vertebral fractures has been estimated to be 746 million U.S. dollars (USD) annually and is projected to increase to 25 billion USD by 2025.[9] Lindsay et al.[10] conducted a study on the direct medical expenses incurred by vertebral fracture patients aged 65 to 74 years over the course of 1 year. They found that inpatient care cost 488 USD and outpatient care cost 156 USD. Other previous studies also reported that vertebral fractures account for only 6% of total fracture expenses, making it seem like a less important consideration for healthcare payers and providers when compared to the higher expenses associated with hip fractures.[9,11] However, it should be noted that the study only took into account the expenses of symptomatic vertebral fracture patients, who represent 35%–50% of all vertebral fracture patients, and did not investigate complications that may arise after asymptomatic vertebral fractures or the medical expenses incurred by subsequent fractures.[11] Therefore, medical expenses may have been underestimated. Additionally, previous studies only analyzed yearly expenses and did not examine long-term cost increases.

Therefore, the objective of this study was to analyze the direct medical cost of a vertebral fracture cohort (VC) and a matched cohort (MC) for 5 years before and after the fracture to evaluate the duration for which the increase in medical cost due to vertebral fracture persists and to study whether disparities exist in medical expenses depending on the age group utilizing a Korean national claims database.

METHODS

The study design and protocol were authorized by the Institutional Review Board of Daejeon Eulji Medical Center (EMC-IRB No. 2022-07-009). The requirement for written informed consent was exempted for those enrolled in this study.

Database

Patients with vertebral fractures and matched subjects were chosen from the National Health Insurance Service Sample cohort (NHIS-Sample) of South Korea. The NHIS created the National Health Information Database (NHID), which serves as a repository for healthcare and long-term care service records, specifically designed for research purposes.[12,13] Using the NHID, the NHIS constructed and provided researchers with the NHIS-Sample, a comprehensive set of administrative data that serves as a representative resource for health policy and biomedical research. The NHIS-Sample consists of a million people selected by a systematic stratified random sampling method from a total of 48,222,537 subjects on December 31, 2006.[13] Under a social insurance system mandated by the National Health Insurance Act, excluding those who passed or emigrated, all subjects could be followed up until 2015. The NHIS manages all personal, demographic, and healthcare data of the entire South Korean population. The NHIS-Sample cohort includes comprehensive data on medical claims for both inpatient and outpatient care. This information consists of codes for treatment procedures, prescriptions, and diagnoses.

Incident VC

Based on a previous study,[14] the inclusion criteria for the incident VC consisted the following diagnosis codes as suggested by the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10): S22.0 (fracture of the thoracic spine), S22.1 (multiple fractures of the thoracic spine), S32.0 (fracture of the lumbar spine), M48.4 (fatigue fracture of vertebra), and M48.5 (collapsed vertebra, not elsewhere classified). Subjects were either admitted to acute care hospitals (time zero) for the first time or those who had received kyphoplasty or vertebroplasty during the follow-up period (2002–2015).[15]

The following patients were excluded to maintain the reliability of the study design. Subjects with vertebral fractures before January 1, 2007, were removed to assure a vertebral fracture-free period. Due to the potential of incomplete information, patients enrolled in the Medical

Aid program were excluded. Finally, patients aged < 60 years were excluded. The onset date (time zero) of a vertebral fracture was referred as when the patient was admitted to an acute care hospital or the date of kyphoplasty or vertebroplasty that met the inclusion criteria.

Risk-Set Matching

Despite the NHIS-Sample cohort being constructed retrospectively, this study's design closely emulated a prospective study. First, a risk-set matching was performed with randomized sampling to simulate a real-world situation.[16,17] Subjects with vertebral fractures were paired to subjects of the same age and sex at time zero. Should subjects passed during the follow-up period, we matched subjects whose difference from the time of death was within 1 month to increase the comparability of medical expenses between the two cohorts. This method of risk-set matching was repeated for subsequent vertebral patients.[16,18] A 1 : 5 random sampling was done for each risk set. To enable matching independent of future events, the matched subjects could either be those who never had or were yet to develop vertebral fractures. Thus, a patient with vertebral fracture in the incident VC could be introduced to the study as a patient with vertebral fracture or as a matched subject.[19] Furthermore, to prevent overlapping samples, paired subjects were discarded in following risk sets.

Direct Medical Cost Calculations

For a period of 5 years prior and subsequent to time zero, the individual-level direct medical expenses per quarter were computed. The patients' quarterly medical expenses were reconstructed from medical statements. The insurer's payment and patient's copayment (excluding uncovered payments) were calculated from the medical statement table of the NHIS-Sample. The medical expenses include all expenses of outpatient and inpatient department, prescriptions, oriental medical services, medications, dental services, and all aspects covered by NHIS services. Expenses of long-term care hospitals were included; however, expenses of long-term care services, such as long-term care facilities, were not included. Medical expenses were inflated to values in Korean won in 2023 using the 2023 conversion index.[20] The values were expressed in USD by applying an exchange rate of 1,307 won per dollar (as on March 21, 2023).

Statistical Analyses

In analysis of comparative interrupted time series, we examined the direct medical expenses between the VC and MC.[21,22] Time series were established using the time unit of a quarter over 5 years prior and subsequent to time zero and were divided into six divisions before and every year after time zero. Changes in the baseline trend and intercept were considered before time zero; however, only intercept changes were considered for the segments after time zero. The equation for analysis is included in the Supplementary Material 1.

A generalized linear model with a gamma distribution and logarithmic link function was used for a segmented regression. A generalized estimating equation using a robust standard error was employed to deter overestimating standard errors in parameter estimates.[23] Statistical analyses were conducted using SAS Enterprise Guide version 7.1 software (SAS Institute, Cary, NC, USA) with a statistical significance set at $p < 0.05$.

Baseline characteristics, such as age, household income level, sex, residential area, calendar month and year of the vertebral fracture, Charlson Comorbidity Index (CCI) score, registered disability, medication history, number of hospital admissions, and medical history, were investigated. Each subject's number of comorbidities was evaluated by diagnosis codes using the Quan ICD-10 coding algorithm for the CCI score.[24] Prescription of antihypertensive, lipid-lowering agents, and antidiabetic for > 28 days was examined for those taking the medications. Medical history included hospital admission within 3 years before the vertebral fracture and the number of outpatient visits. Among the baseline characteristics, residential area, household income level, calendar month and year of the vertebral fracture, and CCI score were adjusted as categorical variables. For the subgroup analysis, the subjects were grouped into three categories (< 70, 70–80, and ≥ 80).

RESULTS

From January 1, 2002, to December 31, 2015, 5,570 subjects with vertebral fractures were admitted to hospitals and received operation. A total of 883 subjects who first developed a vertebral fracture before January 1, 2007, were excluded. Additionally, 220 patients aged < 60 years at the time of the incidence and 107 patients under the Medical Aid program were omitted. Four hundred and thirty seven subjects with vertebral fractures were designated as control subjects for another patient with vertebral fracture during risk-set matching. The final number of incident vertebral fracture patients was 3,923 and that of matched subjects was 19,615. The mean age was 75.5 ± 7.4 years, and 69.5% were female (Table 1).

Direct medical expenses for the VC were higher

Table 1. Baseline Characteristics of the Study Subjects at Time Zero

Characteristics	Vertebral fractures (n = 3,923)	Matched cohort (n = 19,615)	*p*-value
Age (yr)	75.5 ± 7.4	75.5 ± 7.4	1.000
Age group (yr)			1.000
≥ 60 to ≤ 69	864 (22.0)	4,320 (22.0)	
≥ 70 to ≤ 79	1,772 (45.2)	8,860 (45.2)	
≥ 80	1,287 (32.8)	6,435 (32.8)	
Female sex	3,143 (80.1)	15,715 (80.1)	1.000
Household income level			0.067
Low	1,003 (25.6)	4,640 (23.7)	
Mid–low	604 (15.4)	3,084 (15.8)	
Mid–high	980 (25.0)	5,144 (26.3)	
High	1,336 (34.1)	6,711 (34.3)	
Residential district			< 0.001
Metropolitan	1,403 (35.8)	7,998 (40.8)	
Non-metropolitan	2,520 (64.2)	11,617 (59.2)	
Month at the time of risk-set matching*			1.000
Jan–Mar	977 (24.9)	4,885 (24.9)	
Apr–Jun	1,031 (26.3)	5,155 (26.3)	
Jul–Sep	938 (23.9)	4,690 (23.9)	
Oct–Dec	977 (24.9)	4,885 (24.9)	
Calendar year			1.000
2007	334 (8.5)	1,670 (8.5)	
2008	325 (8.3)	1,625 (8.3)	
2009	363 (9.3)	1,815 (9.3)	
2010	416 (10.6)	2,080 (10.6)	
2011	477 (12.2)	2,385 (12.2)	
2012	510 (13.0)	2,550 (13.0)	
2013	482 (12.3)	2,410 (12.3)	
2014	486 (12.4)	2,430 (12.4)	
2015	530 (23.5)	2,650 (23.5)	
Registered disability	751 (19.1)	2,928 (14.9)	< 0.001
Charlson Comorbidity Index score			< 0.001
0	1,013 (25.8)	6,705 (34.2)	
1	1,087 (27.7)	5,471 (27.9)	
2	774 (19.7)	3,266 (16.7)	
3 or more	1,049 (26.7)	4,173 (21.3)	

Table 1. Continued

Characteristics	Vertebral fractures (n = 3,923)	Matched cohort (n = 19,615)	*p*-value
Past medication history			
Anti-hypertensive agents	2,585 (65.9)	12,469 (63.6)	0.006
Anti-diabetic agents	754 (19.2)	3,952 (20.1)	0.185
Lipid-lowering agents	1,256 (32.0)	6,068 (30.9)	0.182
Past medical history			
Admission within 3 years before vertebral fracture	2,687 (68.5)	8,549 (43.6)	< 0.001
Number of outpatient visits			< 0.001
0 to < 21	271 (6.9)	2,785 (14.2)	
≥ 21 to < 47	653 (16.6)	4,485 (22.9)	
≥ 47 to < 85	981 (25.0)	5,620 (28.7)	
≥ 85	2,018 (51.4)	6,725 (34.3)	
Death during follow-up period (5 yr)	1,789 (45.6)	8,945 (45.6)	1.000

Values are presented as mean ± standard deviation or number (%) of subjects.
*Risk-set matching was done at the time of vertebral fracture of each subject in the vertebral fracture cohort.

Table 2. Total Medical Expenses in Vertebral Fracture and Matched Cohorts, and Mean Differences of Medical Expenses between Vertebral Fracture and Matched Cohorts Before and after Time Zero

		Matched cohort			Vertebral fracture cohort			Mean difference*	95% CI
		n	Mean cost per subject (USD)	95% CI	n	Mean cost per patient (USD)	95% CI		
Total cost before time zero	5 yr	19,615	847	831–862	3,923	977	945–1,009	131	94–167
	4 yr	19,615	1,956	1,934–1,978	3,923	2,276	2,230–2,322	320	267–374
	3 yr	19,615	2,177	2,152–2,202	3,923	2,569	2,518–2,619	392	332–452
	2 yr	19,615	2,445	2,417–2,474	3,923	3,016	2,954–3,078	570	500–641
	1 yr	19,615	2,819	2,785–2,853	3,923	3,969	3,888–4,050	1,150	1,066–1,234
Total cost after time zero	1 yr	19,615	2,885	2,849–2,921	3,923	6,531	6,432–6,629	3,646	3,554–3,737
	2 yr	18,678	2,587	2,552–2,623	3,672	3,633	3,539–3,726	1,045	955–1,136
	3 yr	17,739	2,269	2,234–2,305	3,484	3,218	3,125–3,312	949	859–1040
	4 yr	16,840	1,983	1,947–2,018	3,301	2,804	2,708–2,900	821	731–912
	5 yr	13,887	1,873	1,835–1,912	2,708	2,429	2,326–2,533	556	457–654

USD: U.S. dollar, CI: confidence interval.
*$p < 0.001$, Mean difference: the difference in mean cost between the vertebral fracture and matched cohorts.

than those for the MC in each year during the entire observation period ($p < 0.001$ in each year) (Table 2, Fig. 1). The mean difference in medical expenses of the two cohorts increased steadily before the fracture. The medical expenses of the VC peaked in the first quarter following the fracture. The medical expenses in the VC and MC within the first year subsequent to time zero were 6,531 USD per subject and 2,885 USD per subject, respectively.

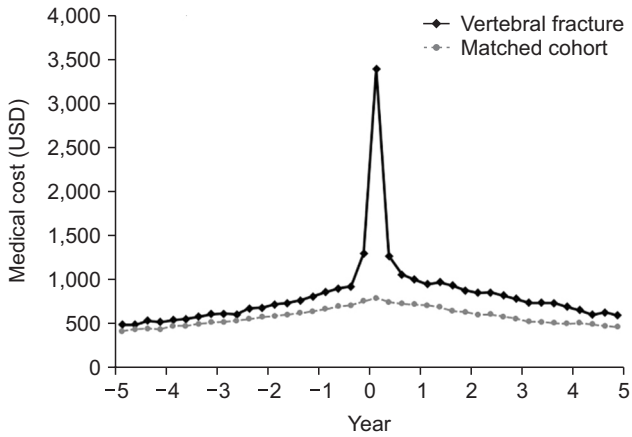

Fig. 1. This graph shows direct medical cost utilization per quarter for 5 years before and after time zero of spine fracture cohort and matched cohort. USD: U.S. dollar.

The mean difference in medical expenses before and after time zero between the VC and MC was 3,645 USD (95% confidence interval [CI], 3,554–3,737; $p < 0.001$) in the first year and 1,045 USD (95% CI, 955–1,136; $p < 0.001$) in the second year. The mean difference in medical expenses between the two cohorts decreased steadily after the fracture.

Direct medical expenses of the VC in the fifth year prior to time zero were 1.08 times greater than those of the MC ($p < 0.001$) (Table 3). Preceding time zero, the medical expenses of the VC and MC increased by 2% per quarter. The cost changes were 1.82 times higher for the VC than for the MC (95% CI, 1.62–2.04; $p < 0.001$) in the first year. Subsequently, there were no disparities in medical expenses between the two cohorts ($p > 0.05$).

As noted in Fig. 2, medical expenses increased steadily before the fracture in the < 70-year subgroup and 70- to 79-year subgroup of the VC compared to expenses in the MC subgroups (Fig. 2). However, there was no marked increase in medical expenses before the fracture in the ≥ 80-year subgroup of the VC compared to the expenses for the same subgroup of the MC. In the < 70-year subgroup, there were no significant differences in medical expenses between the two groups ($p > 0.05$). In the ≥ 80-year subgroup, the cost changes for the VC were higher than those for the MC over 5 years after time zero (Table 3).

DISCUSSION

Previous studies on medical expenses associated with vertebral fractures have primarily emphasized annual medical expenses accrued following a vertebral fracture, with a particular emphasis on osteoporotic fractures and their impact on the healthcare system.[1,9] Some studies have also reported on medical expenses incurred after a vertebral fracture by dividing them into hospitalization expenses and post-care expenses, but even these have only reported on short-term medical expenses.[11] Other studies have focused on cost-effective analysis of treatment methods or specific management.[3] However, these studies have not been able to analyze how much medical expenses increase for how long due to vertebral fractures. Moreover, the results of past studies on annual healthcare expenses have been overestimated. This is because medical expenses for comorbidities occurring before the fracture would have been included in the analysis after the fracture occurred. Taking into account the limitations of previous studies, our research designed a study to analyze the long-term medical expenses of subjects with vertebral fractures and analyzed the following main results. The direct medical expenses for VC were higher compared to MC across the entire observation period. The mean difference in medical expenses between both groups increased steadily prior to the fracture. The highest medical expenses for VC were observed in the first quarter following the fracture, and the direct medical expenses related to vertebral fracture continued to increase for up to 1 year after the injury. In the age < 70-year subgroup, no significant increase was observed in direct medical expenses ascribable to vertebral fracture. However, for age ≥ 80-year subgroup, the rise in direct medical expenses was continued for up to 5 years. Notably, unlike other subgroups, the age ≥ 80-year subgroup of VC showed no significant increase in medical expenses before the fracture when compared to the age ≥ 80-year subgroup of MC.

We noticed that direct medical expenses were noticeably higher among those experiencing vertebral fractures compared to matched patients over the entire 10-year observation period. Furthermore, a steady increase in direct medical expenses prior to fracture was observed in patients with vertebral fractures, which could imply exacerbation of comorbidities that can increase the vertebral fracture risk. It is well known that vertebral fractures are associated with low bone mass and other causes of skeletal fragility, such as chronic glucocorticoid therapy, rheumatoid arthritis, Crohn disease, chronic obstructive pulmonary disease, advanced age, low body weight, and ankylosing spondylitis.[25] Therefore, we believe that increased direct medical expenses could mean an escalated risk for vertebral fractures. Additionally, it seems that monitoring worsening comorbidities and increased direct medical expenses for managing underlying diseases can be helpful in predicting and preventing vertebral fracture occurrence.

Table 3. Differences in Differential Changes of Medical Expenses between Vertebral Fracture and Matched Cohorts during Before and after Time Zero

		All vertebral fractures			Age < 70 yr			Age ≥ 70 to < 80 yr			Age ≥ 80 yr		
		Ratio	95% CI	*p*-value	Ratio	95% CI	*p*-value	Ratio	95% CI	*p*-value	Ratio	95% CI	*p*-value
Indication of predicted graph*	Baseline cost difference (USD)†	3,995	3,134–5,093	< 0.001	4,767	2796–8126	< 0.001	4,943	3,327–7,343	< 0.001	3,080	2,221–4,270	< 0.001
	Baseline cost difference	1.08	0.98–1.20	0.139	0.92	0.76–1.12	0.412	1.08	0.93–1.26	0.306	1.21	1.00–1.45	0.046
	Cost increase per quarter	1.02	1.01–1.02	< 0.001	1.02	1.01–1.03	0.001	1.02	1.01–1.03	< 0.001	1.02	1.02–1.03	< 0.001
	Difference of slop of cost increase‡	1.00	0.99–1.01	0.670	1.02	1.00–1.04	0.028	1.00	0.99–.01	0.520	0.99	0.97–1.00	0.033
DID estimate ratio§	1 yr	1.82	1.62–2.04	< 0.001	1.13	0.80–1.61	0.484	1.83	1.55–2.16	< 0.001	2.35	1.96–2.82	<.0001
	2 yr	1.14	0.96–1.35	0.123	0.83	0.50–1.36	0.454	1.09	0.86–1.39	0.463	1.53	1.17–1.99	0.002
	3 yr	1.16	0.95–1.43	0.154	0.78	0.43–1.44	0.431	0.95	0.71–1.27	0.738	1.84	1.33–2.54	0.000
	4 yr	1.15	0.91–1.45	0.252	0.64	0.32–1.28	0.209	0.86	0.61–1.22	0.397	2.05	1.42–2.97	0.000
	5 yr	1.06	0.79–1.43	0.696	1.05	0.47–2.35	0.906	0.95	0.63–1.44	0.812	1.76	1.12–2.78	0.015

CI: confidence interval, USD: U.S. dollar, DID: difference in difference.
*Indication of predicted graph: indicators of the predicted graph for medical cost utilization considering the increase in medical cost of both groups before matching. †Baseline cost difference: difference in medical cost between vertebral fracture and matched cohorts at 5 years before time zero. ‡Cost slope difference: difference in slope of medical cost increase in vertebral fracture and matched cohorts. §DID estimate ratio: the ratios of medical expenses at each time considering the difference between the difference in medical cost before and after time zero in the vertebral fracture cohort and the difference in medical cost before and after time zero in matched cohort.

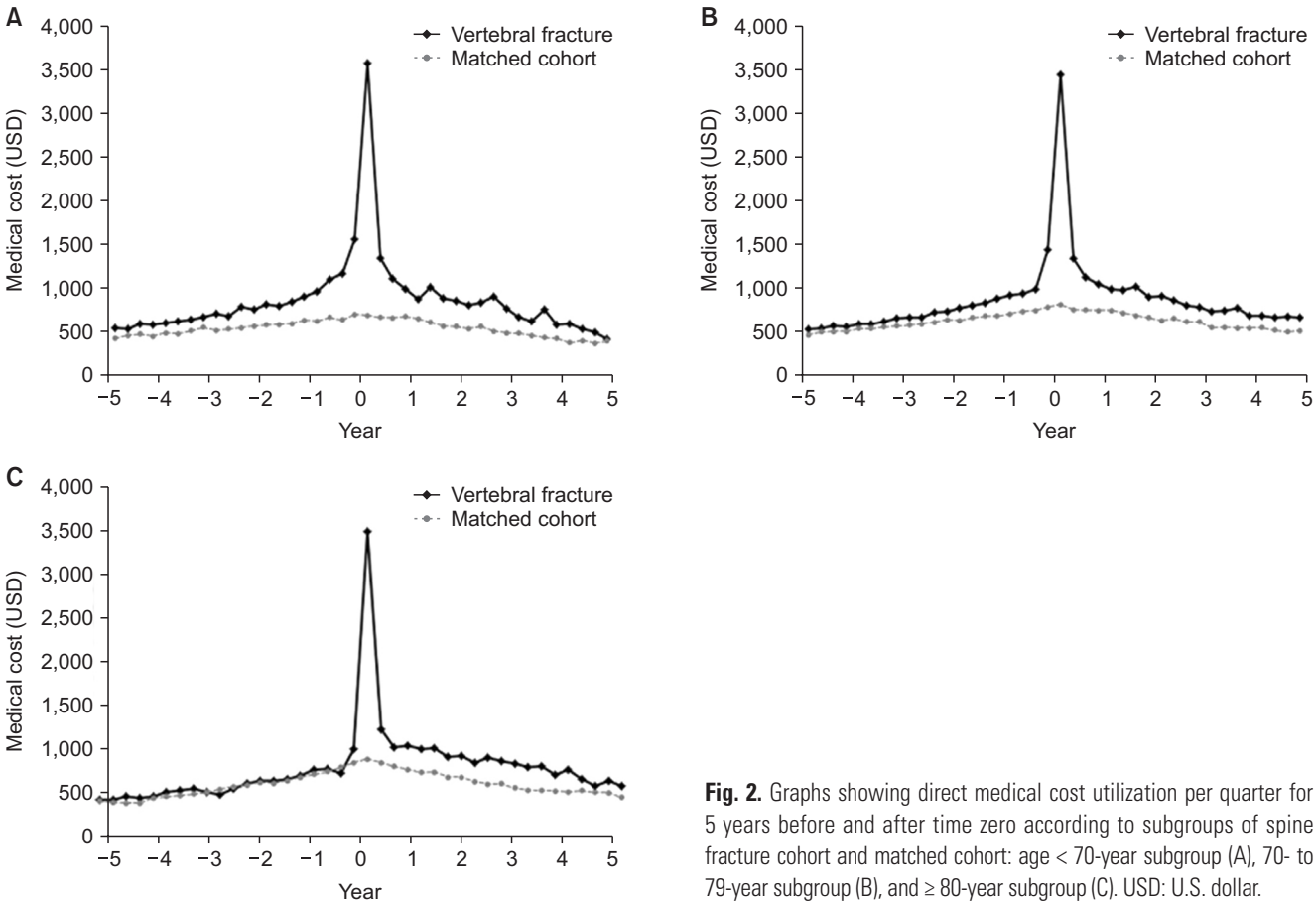

Fig. 2. Graphs showing direct medical cost utilization per quarter for 5 years before and after time zero according to subgroups of spine fracture cohort and matched cohort: age < 70-year subgroup (A), 70- to 79-year subgroup (B), and ≥ 80-year subgroup (C). USD: U.S. dollar.

However, in our study, there was no significant increase in pre-fracture medical expenses observed in elderly patients aged 80 years and older. This is likely due to the fact that these patients already have severe osteoporosis and many comorbidities, resulting in a very high risk of vertebral fracture. Therefore, as the effectiveness of monitoring worsening comorbidities and increased direct medical expenses is reduced in the ≥ 80-year subgroup, it is important to recognize the constant high risk of vertebral fractures in this age group when designing fracture prevention services and to ensure that the service is applied strictly.

A study on the medical expenses of patients over 50 years of age with vertebral fractures found that hospitalization rates were higher among older patients.[11] Additionally, a study on the expenses of treating osteoporotic vertebral fracture found that hospitalization expenses were the highest among the medical expenses incurred over the course of a year.[26] Furthermore, it was reported that hospitalization via the emergency room was more expensive than regular hospitalization.[11] We found that direct medical expenses in subjects with vertebral fractures peaked in the first quarter following the fracture. This phenomenon is believed to be due not only to the cost of the surgical procedure itself, but also to increased hospitalization-related expenses as previously found in other studies. We also found that direct medical costs were markedly increased in those with vertebral fractures in the first year following the fracture. Leslie et al. analyzed direct healthcare expenses over a 5-year period for fracture patients in Canada.[27] In their study, they found that healthcare expenses for vertebral fracture patients, as well as other types of fractures, were highest in the first year following the fracture and that by the fourth year after the vertebral fracture, healthcare expenses had returned to a level similar to before the fracture occurred. It is not surprising that the most significant healthcare expenses occur within the first year after a fracture. However, this study was not focused on elderly patients, did not account for the increase in healthcare expenses prior to the fracture, and did not have a control group of individuals of the same age and sex, so there are limitations to considering this period as the period of increased healthcare expenses due to the vertebral fracture. Therefore, based on our study findings, we believe that economic and healthcare policy support for patients with

vertebral fracture should be focused within the first year following the fractures.

The Increase in direct medical expenses was attributable to vertebral fracture up to 5 years in patients older than 80 years from time zero. Elderly patients with severe osteoporosis or sagittal imbalance are prone to repeated vertebral fractures and have a higher rate of complications after fractures. In addition, disability and pain symptoms can persist even after discharge from the hospital.[28,29] These characteristics of elderly patients with vertebral fractures appear to lead to a rise in long-term medical expenses. In contrast, our study did not observe an increase in medical expenses within 1 year after fracture among individuals under 70 years of age. It appears that the mild osteoporosis likely resulted in minor fractures and was resolved with few complications, leading to these results. Therefore, policies on medical cost reductions or medical welfare for clinical domains that are part of longer-term treatment of these patients, such as chronic pain and rehabilitation, should be implemented to support older patients for a longer time.

Our study has several limitations. The first is that direct comparisons between medical expense differences reported in this study and those in other countries are challenging owing to the differences in healthcare systems across countries. However, patients with vertebral fractures have similar clinical characteristics across countries, such as comorbidities, postoperative mortality rates, treatment options, time to bone union, and complications following the fracture.[30-32] Therefore, we believe that the ratios of differential changes in patients in the VC and MC in our study can be generalized to medical systems in other countries. Another limitation is that our study did not include in the direct medical cost analysis the out-of-pocket expenses for services not covered by the NHIS. This was because information on such expenses is not available in the NHIS database. However, we designed the study as a comparative interrupted time series to analyze the proportions of direct medical expenses between subjects with vertebral fractures and the MC. We believe that this study design will thus minimize the impact of out-of-pocket expenses for uncovered services. Third, when analyzing patients younger than 70 years and those over 80 years, caution is necessary interpreting the differences in changes between the groups because of differences in the slopes of cost increases. For example, it may appear that the direct medical expenses for vertebral fracture subjects younger than 70 years were lower than those of the MC each year from the second to the fifth, following time zero. However, this was because the rise in direct medical expenses for vertebral fracture subjects prior to time zero affected the analysis. Similarly, for subjects 80 years and older, the slope for vertebral fracture subjects prior to time zero was smaller than that of the MC. Therefore, the differential changes in direct medical expenses may have been lower than the actual differential changes. Fourth, diagnosis codes may not accurately capture the actual status of the subject's disease, which is a limitation of insurance databases. Nonetheless, the incidence of vertebral fractures was well ascertained, as almost all hospitals follow a fee-for-service system, and all treatment procedures are claimed. Despite these limitations, we believe that a larger sample size and a more complete follow-up of the NHIS cohort, as well as the fact that it portrays the South Korean population, help offset some of these drawbacks.

The increase in direct medical expenses due to vertebral fractures was sustained for 1 year. However, there was no increase in direct medical expenses that was attributable to vertebral fractures in patients younger than 70 years. For those over 80 years, expenses increased from time zero to 5 years. Based on this, we suggest that health and medical policies for vertebral fractures should be designed to last up to approximately a year after the fracture. Health policies should be organized according to age group.

CONFLICT OF INTEREST

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

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SUPPLEMENTARY MATERIAL

Supplementary material is available in the electronic version of this paper at the CiOS website, www.ecios.org

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