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Nationwide epidemiology and healthcare utilization of spine tumor patients in the adult Korean population, 2009–2012

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Background. The aim of this nationwide study was to describe the incidence and health care utilization of adult Korean patients with primary malignant, primary nonmalignant, and metastatic spine tumors between 2009 and 2012.

Methods. Patients with primary and metastatic spine tumors were identified from the Korean Health Insurance Review and Assessment Service database between January 1, 2009, and December 31, 2012. Demographics, incidence rate, annual medical cost, and annual hospital stay of each new patient were reviewed.

Results. Of 1600 primary spine tumors diagnosed from 2009 to 2012, 373 (23.3%) were malignant, and 1227 (76.7%) were nonmalignant. The most common tumor type was neoplasm of spinal cord among primary malignant (C72.0, 51.5%) and primary nonmalignant (D33.4, 66.2%) spine tumors. Differences in primary malignant, primary nonmalignant, and metastatic spine tumor incidence by sex were significant ($P = .004$, $<.001$, and $<.001$, respectively). The annual incidence rate of primary nonmalignant and metastatic spine tumors increased significantly over the study period ($P = .005$ and $<.001$, respectively). Lung, liver/biliary, and breast were the most prevalent original tumor sites for metastatic spine tumors. In 2011, average annual medical costs associated with treatment of primary malignant, primary nonmalignant, and metastatic tumors were US $15 223, $6502, and $16 038, respectively. Average annual hospital stay durations for primary malignant, primary nonmalignant, and metastatic spine tumors in 2011 were 103.4, 61.7, and 79.6 days, respectively.

Conclusions. This is the first nationwide analysis of spine tumors, including metastatic spine tumors, in Asia.

Keywords: epidemiology, metastasis, neoplasm, population, spinal cord, spine.

The relative rarity of primary malignant and nonmalignant spine tumors limits research, treatment decisions, and health care planning.[1–4] Several population-based incidence rates have been reported in Western countries.[2,4–7] Such efforts can provide information to health care agencies and stimulate research on primary spine tumors. As the cancer incidence rate and survival of cancer patients increase,[8] the incidence of spinal metastases is also expected to rise.[9]

Despite the high morbidity and mortality associated with metastatic spine tumors, the health care burden to the general population has not been studied extensively, and there is a paucity of studies describing the frequency of their occurrence in the community.[10–12] Only one report has described its epidemiology, including that for metastatic spine tumors without spinal cord compression.[10]

Population-based studies are less subject to selection or nonresponse biases than case series studies. Thus, they have greater statistical power,[13] and we undertook a population-based study. Korea has a compulsory health insurance system, and all medical reimbursement records for the entire Korean population are

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maintained in a single database that can be used to assess the nationwide effects of illnesses and consequent health care use.[14,15]

The aim of our nationwide study was to describe the epidemiology of spine tumors and determine the health care utilization associated with primary malignant, primary nonmalignant, and metastatic spine tumors in the adult Korean population during 2009–2012.

Materials and Methods

Data Source

All nationwide inpatient and outpatient data on diseases and services (procedures and operations) are coded and registered in the Korean National Health Insurance (NHI) Corporation's database, thus enabling the undertaking of population-based studies.[16] Disease codes are standardized according to the Korean Classification of Disease, Version 4, which follows the International Classification of Disease, Tenth Revision (ICD-10).[16] In Korea, the NHI database is a fee-for-service system. All health care organizations in Korea use these standardized codes for diseases and procedures.

Patient Population and Study Design

Patients with primary and metastatic spine tumors were identified from the Korean Health Insurance Review and Assessment Service (HIRA) database between January 1, 2008, and December 31, 2012. Every primary and metastatic tumor occurring within the spine is included in this nationwide study. A multidisciplinary panel consisting of spine surgeons (S.S., C.K.C, U.K.C, and M.J.S.), epidemiologists (J.H.K. and E.J.P.), and a radiation oncologist (S.H.K) defined the primary and metastatic spine tumors. Disagreements were resolved by consensus after discussion.

Primary spine tumor was defined by the following criteria; (i) ICD-10 codes for primary malignant or primary nonmalignant spine tumor, (ii) spine MRI within 1 year after initial ICD-10 code assignment, (iii) no previous same-tumor code history within 1 year, and (iv) hospital visit within 3 months after diagnosis (Table 1). The ICD-10 codes for primary malignant spine tumors were C41.2 (malignant neoplasm of vertebral column), C41.4 (malignant neoplasm of pelvic bones, sacrum, and coccyx), C70.1 (malignant neoplasm of spinal meninges), and C72.0 (malignant neoplasm of spinal cord). The ICD-10 codes for primary nonmalignant spine tumor were D16.6 (benign neoplasm of vertebral column), D16.8 (benign neoplasm of pelvic bones, sacrum, and coccyx), D32.1 (benign neoplasm of spinal meninges), D33.4 (benign neoplasm of spinal cord), and D42.1 (neoplasm of uncertain or unknown behavior of spinal meninges). In order to verify these definitions, our data were compared with recently reported data from the Korea Central Cancer Registry (KCCR).[17]

The presence of a metastatic spine tumor was defined by the following criteria; (i) ICD-10 codes for metastatic spine tumor, (ii) spinal MRI within 1 year after ICD-10 code assignment, and (iii) no previous same-tumor code history within 1 year. The ICD-10 codes for metastatic spine tumor were C79.5 (secondary malignant neoplasm of bone and marrow) and M49.50 (metastatic fracture of vertebra, multiple sites in spine). The KCCR database could not provide metastatic spine tumor data. Therefore, we compared the data extracted by the same search criteria from a single tertiary hospital (Seoul National University Hospital) to verify the definitions of metastatic spine tumor.

The original tumor site in metastatic spine tumors was determined by the presence of an ICD-10 "C" code (indicative of a malignant neoplasm) before or simultaneously with metastatic spine tumor diagnosis.

Data regarding age, sex, health insurance type, comorbidity, medical cost, and hospital stay duration were obtained from the NHI database. Comorbidities were classified using the Charlson Comorbidity Index.[18,19]

For newly diagnosed spine tumor patients, the hospital stay duration and medical costs per person occurring in a single calendar year following diagnosis were included in our analysis. The total medical cost is composed of cost covered by the NHI (benefits paid by NHI plus own health insurance burden), and cost not covered by the NHI. The medical cost in this study was cost covered by the NHI (benefits paid by NHI plus own health insurance burden).

Table 1. ICD-10 codes and additional conditions used to define the incidence of primary and metastatic spine tumors

Tumor Type (ICD-10 Code)	Additional Conditions
Primary malignant spine tumor	
Malignant neoplasm of vertebral column (C41.2)	Spine MRI within 1 year after diagnosis, no previous same tumor history within 1 year, and hospital visit within 3 months after diagnosis
Malignant neoplasm of pelvic bones, sacrum and coccyx (C41.4)	
Malignant neoplasm of spinal meninges (C70.1)	
Malignant neoplasm of spinal cord (C72.0)	
Primary nonmalignant spine tumor	
Benign neoplasm of vertebral column (D16.6)	
Benign neoplasm of pelvic bones, sacrum and coccyx (D16.8)	
Benign neoplasm of spinal meninges (D32.1)	
Benign neoplasm of spinal cord (D33.4)	
Neoplasm of uncertain or unknown behavior of spinal meninges (D42.1)	
Metastatic spine tumor	
Secondary malignant neoplasm of bone and marrow (C79.5)	Spine MRI within 1 year after diagnosis and no previous same tumor history within 1 year
Metastatic fracture of vertebra, multiple sites in spine (M49.50)	

Abbreviations: ICD-10, International Classification of Disease, Tenth Revision; MRI, magnetic resonance imaging.

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Statistical Analysis

Frequency of occurrence by demographic characteristics and tumor types for all primary spine and metastatic spine tumors were determined. Overall incidence rates for primary malignant, primary nonmalignant, and metastatic spine tumors were calculated. Incidence rates by age at diagnosis, sex, ICD-10 codes, diagnosis year, health insurance type (Medicare or Medicaid), and number of comorbidities were calculated. All incidence rates were expressed as incidence per 100 000 persons. Age-adjusted rates were standardized to "Age Structure of Population in Korea 2009" as provided by Statistics Korea. Logistic regression analysis was performed to determine the association between age and incidence rate. Male-to-female rate ratios were calculated by dividing the incidence rate for males by that for females. Rates were compared using the chi-square test or Fisher exact test. The relationships of incidence rate with diagnosis year and the numbers of comorbidities were compared by using logistic regression analysis. A 2-tailed P value of <.05 was considered indicative of a significant difference. SAS software (version 9.1.3; SAS Institute, Inc.) was used for statistical analysis. Statistical testing applied in this study was counseled by the Seoul National University Medical Research Collaborating Center (2013–0167). This study was approved by the institutional review boards of the National Evidence-based Healthcare Collaborating Agency, Seoul National University Hospital, Korea Cancer Center Hospital, Ilsan Paik Hospital, and St. Vincent's Hospital.

Results

Primary Spine Tumors

Of 1600 primary spine tumors diagnosed from 2009 to 2012, 373 (23.3%) were malignant, and 1227 (76.7%) were nonmalignant. The most frequent tumor type was neoplasm of the spinal cord in both primary malignant (C72.0, 51.5%) and primary nonmalignant (D33.4, 66.2%) spine tumors. Overall incidence rates for C72.0 and D33.4 neoplasms during the study period were 0.99 and 3.24 per 100 000 persons, respectively. The second most common tumor types were neoplasm of the vertebral column (C41.2, 39.1%) in primary malignant spine tumor and neoplasm of meninges (D32.1, 17.7%) in primary nonmalignant spine tumor (Table 2).

The incidence rates among our 7 patient age groups ranged from 0.38 to 3.08 per 100 000 persons for primary malignant spine tumors and from 1.04 to 6.04 per 100 000 persons for primary nonmalignant spine tumors. The ≥80 year age group had the highest incidence rate of primary malignant spine tumors, and the 60–69 year age group had the highest incidence rate of primary nonmalignant spine tumors. The incidence rate increased with age in both primary malignant and primary nonmalignant spine tumors (P = <.001 and <.001, respectively; Table 2).

Differences in primary spine tumor incidence by sex were also noted. The overall primary malignant spine tumor incidence rate for males was 1.14 per 100 000 persons, while females had an incidence rate of 0.84 per 100 000 persons (P = .004). In primary nonmalignant spine tumor, the overall incidence rate for males was 2.91 per 100 000 persons, while females had an incidence rate of 3.57 per 100 000 persons (P = <.001, Table 2).

Among the types of primary malignant spine tumor, neoplasm of vertebral column (C41.2) and neoplasm of spinal cord (C72.0) were significantly higher in males than in females (P = .013 and .028, respectively). In primary nonmalignant spine tumors, neoplasm of spinal meninges (D32.1) was significantly higher in females than in males (P = <.0001). In metastatic spine tumors, secondary malignant neoplasm (C79.5) was significantly higher in males than in females (P = <.0001, Table 3).

The annual incidence rate of primary nonmalignant spine tumors increased significantly (P = .005, Table 2). The most prevalent number of comorbidities was 3–6 for primary malignant spine tumors and 0–2 for primary nonmalignant spine tumors (Table 2).

Metastatic Spine Tumors

The overall incidence rate of metastatic spine tumors was 35.13 per 100 000 persons during the study period. Incidence rates among the study's 7 patient age groups ranged from 2.16 to 142.65 per 100 000 persons. The incidence rate increased with age (P = <.001, Table 2), and the 70–79 year age group had the highest incidence rate of metastatic spine tumors.

The overall metastatic spine tumor incidence rate for males was 41.52 per 100 000 persons, which was significantly higher than that for females (28.90 per 100 000 persons; P = <.001, Table 2).

Among metastatic spine tumors over the study period, 28.1% of all primary sites were in lung, 12.9% in liver/biliary, 10.2% in breast, 9.1% in colon, 8.9% in stomach, 5.8% in prostate, 4.0% in rectum, 3.8% in pancreas, 2.0% in plasma cell, and 2.0% in kidney locations (Table 4). Over the study period, the annual incidence rate of metastatic spine tumors increased significantly (P = <.001, Table 2).

The most common number of comorbidities was ≥8 in metastatic spine tumors (Table 2).

Annual Medical Cost and Hospital Stay

In 2011, average annual medical costs, including inpatient and outpatient treatments, for primary malignant, primary nonmalignant, and metastatic spine tumors included in this study were US $15 223, $6502, and $16 038, respectively. The average annual medical cost for primary malignant spine tumors increased from US $10 051 in 2009 to $15 223 in 2011, whereas the average annual cost for primary nonmalignant spine tumors decreased from US $6849 in 2009 to $6502 in 2011. The average annual medical cost for metastatic spine tumor treatment increased from US $15 223 in 2009 to $16 038 in 2011 (Table 5).

In 2011, average annual hospital stay durations for primary malignant, primary nonmalignant, and metastatic spine tumors were 103.4, 61.7, and 79.6 days, respectively. The average annual hospital stay duration for primary malignant spine tumor increased from 76.9 days in 2009 to 103.4 days in 2011, whereas the average annual hospital stay duration for primary nonmalignant spine tumor decreased from 64.1 days in 2009 to 61.7 days in 2011. The average annual hospital stay duration for metastatic spine tumor patients increased from 78.9 days in 2009 to 79.6 days in 2011 (Table 6).

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Table 2. Description of primary and metastatic spine tumor incidence by selected characteristics, South Korea, 2009–2012

Characteristics	Primary Malignant Spine Tumor			Primary Nonmalignant Spine Tumor			Metastatic Spine Tumor		
	Count (%)	Rate (95% CI)	*P*	Count (%)	Rate (95% CI)	*P*	Count (%)	Rate (95% CI)	*P*
Total	373 (100.0)	0.99 (0.89–1.09)		1227 (100.0)	3.24 (3.06–3.43)		13 288 (100.0)	35.13 (34.53–35.72)	
Age at diagnosis, years									
20–29	27 (7.2)	0.38 (0.24–0.52)	**<.001**†	74 (6.0)	1.04 (0.80–1.27)	**<.001**†	154 (1.2)	2.16 (1.82–2.50)	**<.001**†
30–39	46 (12.3)	0.55 (0.39–0.70)		157 (12.8)	1.86 (1.57–2.16)		462 (3.5)	5.49 (4.99–5.99)	
40–49	58 (15.5)	0.67 (0.50–0.84)		263 (21.4)	3.02 (2.66–3.39)		1611 (12.1)	18.52 (17.61–19.42)	
50–59	91 (24.4)	1.44 (1.14–1.73)		325 (26.5)	5.14 (4.58–5.70)		2957 (22.3)	46.76 (45.07–48.44)	
60–69	64 (17.2)	1.60 (1.21–1.99)		242 (19.7)	6.04 (5.28–6.80)		3787 (28.5)	94.53 (91.52–97.54)	
70–79	61 (16.4)	2.54 (1.90–3.17)		137 (11.2)	5.70 (4.74–6.65)		3431 (25.8)	142.65 (137.87–147.42)	
≥80	26 (7.0)	3.08 (1.90–4.26)		29 (2.4)	3.43 (2.18–4.68)		886 (6.6)	104.94 (98.03–111.85)	
Sex									
Male	212 (56.8)	1.14 (0.98–1.29)	**.004**†	543 (44.3)	2.91 (2.66–3.15)	**<.001**†	7752 (58.3)	41.52 (40.59–42.44)	**<.001**†
Female	161 (43.2)	0.84 (0.71–0.97)		684 (55.7)	3.57 (3.30–3.84)		5536 (41.7)	28.90 (28.14–29.66)	
Categories									
Vertebral column (C41.2, D16.6)	146 (39.1)	0.39 (0.32–0.45)		126 (10.3)	0.33 (0.27–0.39)				
Pelvic bone, sacrum, coccyx (C41.4, D16.8)	25 (6.7)	0.07 (0.04–0.09)		4 (0.3)	0.01 (0.00–0.02)				
Meninges (C70.1, D32.1)	10 (2.7)	0.03 (0.01–0.04)		217 (17.7)	0.57 (0.50–0.65)				
Spinal cord (C72.0, D33.4)	192 (51.5)	0.51 (0.44–0.58)		812 (66.2)	2.15 (2.00–2.29)				
Uncertain (D42.1)				68 (5.5)	0.18 (0.14–0.22)				
Secondary malignancy (C79.5, M4950)							13 288 (100.0)	35.13 (34.53–35.72)	
Diagnosis year									
2009	85 (22.8)	0.17 (0.13–0.21)	0.215*	261 (21.3)	0.53 (0.46–0.59)	**.005***	3000 (22.6)	6.04 (5.83–6.26)	**<.001***
2010	81 (21.7)	0.16 (0.13–0.20)		290 (23.6)	0.58 (0.51–0.65)		3372 (25.4)	6.76 (6.53–6.99)	
2011	100 (26.8)	0.20 (0.16–0.24)		339 (27.6)	0.68 (0.60–0.75)		3478 (26.2)	6.94 (6.71–7.17)	
2012	107 (28.7)	0.21 [0.17–0.25)		337 (27.5)	0.67 (0.60–0.74)		3438 (25.9)	6.83 (6.60–7.06)	
Health insurance type									
Medicare	348 (93.3)	0.92 (0.82–1.02)	**<.001**†	1171 (95.4)	3.10 (2.92–3.27)	**<.001**†	12 252 (92.2)	32.39 (31.81–32.96)	**<.001**†
Medicaid	25 (6.7)	0.07 (0.04–0.09)		56 (4.6)	0.15 (0.11–0.19)		1036 (7.8)	2.74 (2.57–2.91)	
CCI									
0–2	94 (25.2)	0.25 (0.20–0.30)	**<.001***	931 (75.9)	2.46 (2.30–2.62)	**<.001***	5 (0.0)	0.01 (0.00–0.02)	**<.001***
3–5	185 (49.6)	0.49 (0.42–0.56)		253 (20.6)	0.67 (0.59–0.75)		2372 (17.9)	6.27 (6.02–6.52)	
6–7	56 (15.0)	0.15 (0.11–0.19)		31 (2.5)	0.08 (0.05–0.11)		5446 (41.0)	14.40 (14.01–14.78)	
≥8	38 (10.2)	0.10 (0.07–0.13)		12 (1.0)	0.03 (0.01–0.05)		5465 (41.1)	14.45 (14.06–14.83)	

Bold style indicates statistical significance.
Abbreviations: CCI, Charlson Comorbidity Index; CI, confidence interval.
†Chi-square test.
*Logistic regression analysis.

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Table 3. Primary and metastatic spine tumor male-to-female incidence ratio in South Korea, 2009–2012

Tumor Type (ICD-10 code)	Total		Male		Female		Male-Female Rate Ratio	P
	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)		
Primary malignant spine tumor								
Vertebral column (C41.2)	146	0.39 (0.32–0.45)	87	0.47 (0.37–0.56)	59	0.31 (0.23–0.39)	1.51	**.013**†
Pelvic bones, sacrum and coccyx (C41.4)	25	0.07 (0.04–0.09)	11	0.06 (0.02–0.09)	14	0.07 (0.03–0.11)	0.81	.592†
Spinal meninges (C70.1)	10	0.03 (0.01–0.04)	4	0.02 (0.00–0.04)	6	0.03 (0.01–0.06)	0.68	.554*
Spinal cord (C72.0)	192	0.51 (0.44–0.58)	110	0.59 (0.48–0.70)	82	0.43 (0.34–0.52)	1.38	**.028**†
Primary nonmalignant spine tumor								
Vertebral column (D16.6)	126	0.33 (0.27–0.39)	57	0.31 (0.23–0.38)	69	0.36 (0.28–0.45)	0.85	.355†
Pelvic bones, sacrum and coccyx (D16.8)	4	0.01 (0.00–0.02)	1	0.01 (-0.01–0.02)	3	0.02 (-0.00–0.03)	0.34	0.330*
Spinal meninges (D32.1)	217	0.57 (0.50–0.65)	73	0.39 (0.30–0.48)	144	0.75 (0.63–0.87)	0.52	**<.0001**
Spinal cord (D33.4)	812	2.15 (2.00–2.29)	377	2.02 (1.82–2.22)	435	2.27 (2.06–2.48)	0.89	.095†
Uncertain (D42.1)	68	0.18 (0.14–0.22)	35	0.19 (0.13–0.25)	33	0.17 (0.11–0.23)	1.09	.728†
Metastatic spine tumor								
Secondary malignant neoplasm (C79.5)	13242	35.01 (34.41–35.60)	7726	41.38 (40.45–42.30)	5516	28.79 (28.03–29.55)	1.44	**<.0001**†
Metastatic fracture (M49.50)	46	0.12 (0.09–0.16)	26	0.14 (0.09,0.19)	20	0.10 (0.06–0.15)	1.33	.331†

Abbreviations: CI, confidence interval.
Bold style indicates statistical significance.
Male-to-female rate ratio = male rate/ female rate.
†Chi-square test.
*Fisher exact test.

Discussion

Primary Spine Tumors

In this study, the most common type of primary malignant and primary nonmalignant spine tumor was neoplasm of the spinal cord (C72.0 and D33.4, respectively). The second most common tumor type was neoplasm of the vertebral column (C41.2) among primary malignant tumors and neoplasm of the spinal meninges (D32.1) among primary nonmalignant spine tumors. This tendency agreed with recent reports that spinal cord tumors were the most common, followed by spinal meninges tumors.[5,6] However, our study disagrees with those older studies in which spinal meninges tumors were as prevalent as or more prevalent than spinal cord tumors.[7,20] This difference may be attributed to small sample sizes in previous studies or to population differences in the Norwegian and Croatian data, as previously described.[5,6]

In our primary malignant spine tumor group, patients aged ≥80 years were the most prevalent, and patients aged 60–69 years were the most prevalent in the primary nonmalignant spine tumor group. In a previous study, patients aged 70–79 years were more prevalent among those with primary nonmalignant tumor.[5]

With regard to sex-based differences, the overall incidence rate among males was significantly higher than that for females in the primary malignant spine tumor group (1.14 vs 0.84 per 100 000 persons, $P = .004$). In contrast, the overall incidence rate for males was significantly lower than that for females in the primary nonmalignant spine tumor group (2.91 vs 3.57 per 100 000 persons, $P = <.001$). Both results are consistent with a recent report from the United States.[5]

In this study, the incidence rates of both primary malignant and nonmalignant spine tumors have increased significantly during the period 2009–2012, more so than those reported from a recent study in which the incidence rates increased gradually (but not significantly) during 2004–2007.[5] Although this observation is hard to explain, it may be due to an increase in diagnostic rates, which might be partly attributable to an increase in willingness to be examined as a result of the decrease in the patients' burden of medical cost from 10% to 5%, which has been in effect since 2010. Further studies are warranted to clarify the reasons for the increased incidence of primary nonmalignant spine tumors.

Metastatic Spine Tumors

The metastatic spine tumor incidence rates increased with age in this study. Peak incidence was in the 70–79 year age group (Table 2). These results support a previous study in southeast Norway in which the incidence increased with age and peaked in the 70–79 years age group.[10]

The incidence rate of metastatic spine tumors in male patients was significantly higher than that of female patients in this study (Tables 2 and 4). This tendency is similar to the results reported in previous studies.[10–12]

With regard to the original tumor site, lung, liver/biliary, and breast locations were most prevalent and comprised 51.2% of the metastatic spine tumor locations in this study (Table 3). The top 3 original tumor sites in our study differed from those

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Table 4. Incidence according to original tumor site in spine metastasis, South Korea, 2009–2012

Original Tumor Site	Total	Year			
		2009	2010	2011	2012
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Lung	3737 (28.1)	899 (30.0)	935 (27.7)	957 (27.5)	946 (27.5)
Liver/biliary	1708 (12.9)	330 (11.0)	429 (12.7)	505 (14.5)	444 (12.9)
Breast	1350 (10.2)	305 (10.2)	330 (9.8)	345 (9.9)	370 (10.8)
Prostate	1210 (9.1)	270 (9.0)	284 (8.4)	325 (9.3)	331 (9.6)
Colon	1209 (9.1)	272 (9.1)	330 (9.8)	299 (8.6)	308 (9.0)
Stomach	1189 (8.9)	282 (9.4)	323 (9.6)	288 (8.3)	296 (8.6)
Rectum	591 (4.4)	146 (4.9)	157 (4.7)	151 (4.3)	137 (4.0)
Pancreas	631 (4.7)	150 (5.0)	160 (4.7)	170 (4.9)	151 (4.4)
Plasma cell	551 (4.1)	129 (4.3)	124 (3.7)	140 (4.0)	158 (4.6)
Kidney	372 (2.8)	74 (2.5)	94 (2.8)	98 (2.8)	106 (3.1)
Others	4727 (35.6)	1070 (35.7)	1227 (36.4)	1172 (33.7)	1258 (36.6)
Total	13 288 (100)	3000 (100)	3372 (100)	3478 (100)	3438 (100)

reported in Western countries. Prostate, breast, and lung were the most prevalent original tumor sites in reports from Norway and Ontario (Canada),[10,11] while lung, prostate, and multiple myeloma were the most prevalent original tumor sites in a report from the United States.[12] According to the national cancer registry, thyroid, stomach, colon, lung, liver, breast, prostate, biliary, pancreas, and non-Hodgkin lymphoma were the 10 most prevalent cancers in Korea.[21] Liver and biliary tumors, when calculated independently, are the fifth and eighth most prevalent cancer sites in Korea. Because thyroid, stomach, and colon cancers are not usually metastasized to spine, liver/biliary cancers, taken as a single entity, might well be among the 3 most frequent sites.

The average annual incidence rate of metastatic spine tumors increased gradually and significantly ($P = <.001$, Table 2) from 2009 to 2012. This tendency concurs with results reported previously in the United States.[9,12]

Annual Medical Cost

In primary malignant and nonmalignant spine tumors, the annual medical costs were US $15 223 and $6502, respectively. A recent nationwide US study reported a mean hospital charge of US $61 157 for primary intramedullary spine tumor treatment.[20] In that study, the medical costs included only treatments over a period of 4–5 days, which is markedly shorter than the days of inpatient service in Korea (see Table 6), indicating that medical costs in Korea are much lower than those in the United States.

In this study's metastatic spine tumor group, the average annual medical cost was US $16 038. The mean cost per spinal cord compression event was reported to be €4884 to €12 082 in a recent European cohort study.[22] Even though the cost of a single treatment event cannot be compared with an average annual total medical cost, these results indicate that medical costs in Korea are relatively inexpensive. In Korea, the cost not covered for neoplastic disease by the NHI was 16.4% (in 2010), 17.3% (in 2011), and 16.0% (in 2012). Even though we consider these rates high, medical costs for spine tumors are not as high as in Europe or the United States.

Limitations

Several limitations of this study should be noted. First, there may be undetected variation in diagnosis, coding, and reporting of spine neoplasms because the NHI database is based on claims for medical fees. The NHI database does not include histology information. Therefore, there may be a difference between the data in the NHI database and the data in a histology-based cancer registry. Other detailed conditions (eg, the presence of spinal cord compression or neoplastic meningitis) could not be analyzed in this study due to lack of information in the study's database. Second, the presence of additional conditions is inevitable when defining primary and metastatic spine tumors. The ICD-10 codes inadequately identify the complete details for primary or metastatic spine tumors. For example, an ICD-10 code identifies just all metastatic bone tumors, but for clarity we added other limiting conditions (eg, spinal MRI within 1 year after diagnosis and no previous same-tumor history within 1 year) to clearly define a newly detected metastatic spine tumor. In this study, a multidisciplinary panel comprising spine surgeons, epidemiologists, and a radiation oncologist defined primary and metastatic spine tumors. In addition, we tried to verify these definitions to compare our data with the data from KCCR and the hospital record data of a tertiary hospital. Third, the included medical costs were only those covered by NHI. Regardless of those limitations, to the best of our knowledge, this is the first population-based, nationwide study in Asia that has analyzed epidemiology and costs of spine tumors, including metastatic spine tumors.

Conclusions

This is the first nationwide epidemiological analysis of spine tumors, including metastatic tumors, in Asia. The results of our analyses contribute to the development of a more detailed description of age and sex differences, annual incidence rates, original tumor sites, medical costs, and durations of hospital stays related to spine tumors at a national level in Korea. Our study provides insight into the epidemiology of spine tumors

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Table 5. Annual medical cost of a new patient with spine tumor in South Korea, 2009–2011

Characteristics	2009 Primary Malignant N (%)	2009 Primary Malignant US $	2009 Primary Nonmalignant N (%)	2009 Primary Nonmalignant US $	2009 Metastatic N (%)	2009 Metastatic US $	2010 Primary Malignant N (%)	2010 Primary Malignant US $	2010 Primary Nonmalignant N (%)	2010 Primary Nonmalignant US $	2010 Metastatic N (%)	2010 Metastatic US $	2011 Primary Malignant N (%)	2011 Primary Malignant US $	2011 Primary Nonmalignant N (%)	2011 Primary Nonmalignant US $	2011 Metastatic N (%)	2011 Metastatic US $
Total (mean ± SD)	85 (100.0)	10 051 ± 9,660	261 (100.0)	6849 ± 7050	3,000 (100.0)	15 223 ± 13 478	81 (100.0)	16 853 ± 16 761	290 (100.0)	5890 ± 6817	3,372 (100.0)	15 554 ± 13 198	100 (100.0)	15 223 ± 16 430	339 (100.0)	6502 ± 8771	3,478 (100.0)	16 038 ± 15 292
Outpatient service (mean ± SD)	84 (98.8)	1509 ± 1529	260 (99.6)	1397 ± 2204	2,591 (86.4)	3356 ± 4710	79 (97.5)	2892 ± 5174	288 (99.3)	1077 ± 907	2,887 (85.6)	3599 ± 4851	97 (97.0)	2819 ± 4426	339 (100.0)	1054 ± 1059	3,001 (86.3)	3681 ± 4988
Inpatient service (mean ± SD)	77 (90.6)	9449 ± 9247	225 (86.2)	6330 ± 6568	2,805 (93.5)	13 181 ± 12 245	73 (90.1)	15 570 ± 14 353	239 (82.4)	5849 ± 6985	3,118 (92.5)	13 489 ± 12 048	87 (87.0)	14 355 ± 15 874	275 (81.1)	6716 ± 9023	3,242 (93.2)	13 798 ± 14 526

Abbreviation: US $, United States dollars.

Table 6. Annual hospital stay (days) of a new patient with spine tumor in South Korea, 2009–2011

Characteristics	2009 Primary Malignant N (%)	2009 Primary Malignant days	2009 Primary Nonmalignant N (%)	2009 Primary Nonmalignant days	2009 Metastatic N (%)	2009 Metastatic days	2010 Primary Malignant N (%)	2010 Primary Malignant days	2010 Primary Nonmalignant N (%)	2010 Primary Nonmalignant days	2010 Metastatic N (%)	2010 Metastatic days	2011 Primary Malignant N (%)	2011 Primary Malignant days	2011 Primary Nonmalignant N (%)	2011 Primary Nonmalignant days	2011 Metastatic N (%)	2011 Metastatic days
Total (mean ± SD)	85 (100.0)	76.9 ± 65.8	261 (100.0)	64.1 ± 62.1	3,000 (100.0)	78.9 ± 59.9	81 (100.0)	100.2 ± 82.4	290 (100.0)	56.7 ± 55.7	3,372 (100.0)	76.5 ± 57.2	100 (100.0)	103.4 ± 97.9	339 (100.0)	61.7 ± 69.7	3,478 (100.0)	79.6 ± 60.4
Outpatient service (mean ± SD)	84 (98.8)	26.7 ± 21.9	260 (99.6)	32.1 ± 33.5	2,591 (86.4)	29.1 ± 32.1	79 (97.5)	29.9 ± 21.9	288 (99.3)	28.6 ± 25.5	2,887 (85.6)	29.0 ± 29.4	97 (97.0)	38.2 ± 47.9	339 (100.0)	30.0 ± 27.2	3,001 (86.3)	30.2 ± 30.6
Inpatient service (mean ± SD)	77 (90.6)	55.7 ± 62.8	225 (86.2)	37.3 ± 56.2	2,805 (93.5)	57.4 ± 52.6	73 (90.1)	78.8 ± 84.4	239 (82.4)	34.3 ± 54.5	3,118 (92.5)	55.9 ± 51.2	87 (87.0)	76.3 ± 88.8	275 (81.1)	39.1 ± 66.4	3,242 (93.2)	57.4 ± 54.0

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and health care utilization in primary and metastatic spine tumor patients in Korea.

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