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Epidemiology and Medical Service Use for Spontaneous Pneumothorax: A 12-year Longitudinal Study Using Nationwide Cohort Data

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Abstract

Objectives: To analyze the prevalence rate and treatment of spontaneous pneumothorax according to sociodemographic characteristics, in order to obtain detailed and objective information about spontaneous pneumothorax.

Design: A 12-year longitudinal nationwide cohort study.

Setting: Data obtained from the Korean National Health Insurance Service Sharing Service.

Participants: A total of 4658 participants who used medical services due to spontaneous pneumothorax between 2002 and 2013.

Outcome measures: For those diagnosed with spontaneous pneumothorax, the use of medical services, hospitalization data, sociodemographics, co-morbidity, treatment administered, and medication prescribed were recorded.

Results: The annual prevalence of spontaneous pneumothorax ranged from 39 to 66 per 100,000, while the rate of hospitalization due to spontaneous pneumothorax ranged from 18 to 36 per 100,000. The prevalence rate of spontaneous pneumothorax in Korea has increased since 2002. The male-to-female ratio was approximately 4–10:1, with a higher prevalence rate in males. By age, the 15–34-year-old group, and particularly 15–19-year-olds, showed the highest prevalence rate; the rate then declined before increasing again for those 65 years old or older. In total, 47–57% of spontaneous pneumothorax patients underwent hospitalization. The average number of rehospitalizations due to pneumothorax was 1.56 per person, and more than 70% of recurrences occurred within 1 year. Chronic obstructive pulmonary disease was the most common comorbidity. The average treatment period was 11 days as an outpatient and 14 days in-hospital. The average medical costs were $94.50 for outpatients and $2523 for hospital admissions. The most common treatment for spontaneous pneumothorax was oxygen inhalation and thoracostomy, and the most commonly prescribed medications were analgesics, antitussives, and antibiotics.

Conclusions: We here detailed the epidemiology and treatments for spontaneous pneumothorax in Korea. This information can contribute to the understanding of spontaneous pneumothorax.

Keywords: Epidemiology, Longitudinal cohort, National Health Insurance Service-Sample Cohort Database (NHIS-SCD); Prevalence; Primary Spontaneous Pneumothorax

Strengths and limitations of this study

- Large-scale, long-term (12 year) follow-up data sets, representing the Korean population, were analyzed. The inpatient and outpatient costs of spontaneous pneumothorax treatment were calculated.
- Data on detailed medical-service use were recorded and analyzed, such as medication, procedures, surgery undertaken due to spontaneous pneumothorax.
- Due to a lack of relevant information in the claims data, for example, medical treatments are not necessarily covered by insurance, not all relevant treatments data could be considered.
- This study could not distinguish whether medical service use was due to new occurrences or follow-up of existing spontaneous pneumothorax.

Introduction

The pulmonary system is important because it plays a crucial role in oxygenation of the blood.[1] In pneumothorax, air or gas pools in the inter-pleural cavity,[2] leading to lung collapse and impaired pulmonary function.[3] Pneumothorax is categorized into spontaneous pneumothorax (SP) or traumatic pneumothorax, depending on etiology, and SP is subcategorized into primary spontaneous pneumothorax (PSP), occurring in the absence of underlying lung-related comorbidities, and secondary spontaneous pneumothorax (SSP), occurring in the presence of underlying lung-related comorbidities.[4]

The prevalence rate of SP reportedly ranges from 1.2 to 9.8/100,000 in women to 7.4 to 24/100,000 in men; the prevalence rate of hospitalized SP is about 17 to 22/100,000 in men, 6 to 7/100,000 in women, and 14 to 23/100,000 overall.[5-9] Although SP has a relatively low prevalence rate, it is clinically important,[10] as relapse rates are high (20–40%, depending on duration)[7, 11, 12] and hospitalization is often required, influencing the work productivity of patients.

However, there is a paucity of research on SP.[13] Given its low prevalence rate, large-scale research at a national scale is needed to evaluate the epidemiology of SP. Although large-scale studies have been performed in the UK, France, and Germany, these have provided limited epidemiological information.[6-8]

Thus, we aimed to determine the prevalence rate of SP and medical service use by the affected patients, according to sociodemographic characteristics, by implementing the National Sample Cohort data from the National Health Insurance Service (NHIS) of Korea, to gain a more accurate understanding of the prevalence, treatment and management of SP in Korea.

Methods

Patient and Public Involvement

The National Health Insurance (NHI) system in Korea is a single-payer system to which 98% of citizens belong. Under this system, a medical provider requests reimbursement from a third-person payer (the NHIS) when a patient uses a medical service.[14] [15] The NHIS-NSC is a population-based cohort built by the NHIS. In 2002, a cohort was extracted by systematic stratified random sampling from a pool of 47,851,928 individuals, excluding those who were not enrolled in the NHI (income level of 0) and foreigners.[16] The cohort comprises 1,476 levels, based on sex, age, and income. Finally, 2.2% of this pool (1,025,340 individuals) were extracted and data from newborns were added each year to maintain the sample size[16]. Based on NHIS Sample Cohort (NHIS-NSC) data (for the period 2002–2013), we included only 4,658 patients diagnosed with SP in the 12 years between January 2002 and December 2013. SP patients were defined as those who used a medical service at least once for main or secondary diseases of ICD-10 J93.0 (Spontaneous tension pneumothorax), J93.1 (Other spontaneous pneumothorax), J93.8 (Other pneumothorax), or J93.9 (Pneumothorax, unspecified).

Main descriptive variables

Prevalence rate of SP

For each year, the frequency per 100,000 and the frequency of patients who used medical services at least once for SP as the major or secondary diagnosis were determined. Sociodemographic characteristics are shown by sex, age, income level, and insurance type. Based on previous studies,[6, 8] age was subdivided as follows: < 15, 15–34, 35–64, and ≥ 65 years. Income level was divided into low (0, 1, 2, or 3 out of 0–10), medium (4, 5, 6, or 7), or high (8, 9, or 10). Insurance type was divided into region-based enrollee, job-based enrollee, and medical assistance recipient. For each year, the prevalence of SP per 100,000 and the frequency of patients who were hospitalized due to SP were analyzed. Patients who used hospitalization services at least once were counted; two or more hospitalizations were not counted more than once. The hospitalization rate among pneumothorax patients was

calculated using the same standards: the denominator was the number of patients who used medical services at least once due to SP in a given year, by sex and age, and the numerator was the number of patients who used hospitalization services at least once.

Hospitalization of SP patients by year

Frequency of rehospitalization due to SP is shown by time period. The ratios of the total rehospitalization number to rehospitalization in a specific time period are also shown. The number of rehospitalizations counted all hospitalizations (other than the first-time) and allowed for duplication within each patient. To calculate the number of hospitalizations per person, the average, standard deviation (SD), minimum and maximum number of hospitalizations per time period were calculated. For the number of hospitalizations per person, first-time hospitalizations were also included. The interval between hospitalizations was calculated as the interval between the dates of two admissions.

Comorbidities in SP patients

Diseases were counted as comorbidities if they were diagnosed as the major or secondary disease within 1 year of the first date of SP onset. The number of patients who were given codes for frequent comorbidities, i.e., chronic obstructive pulmonary disease (COPD), pneumonia, interstitial lung disease, lung cancer, asthma and lung abscess, were counted; patients with multiple comorbid conditions were counted more than once.[8, 17] The Charlson Comorbidity Index (CCI) was categorized into normal and CCI 0, 1, 2, and ≥ 3[18-20] The International Statistical Classification of Disease and Related Health Problems, 10th revision(ICD-10) codes of comorbidities are shown in Supplemental Table 1.

Treatment period and medical costs of SP patients

The total number of follow-ups within 60 days after medical service use due to new SP onset, the number of follow-ups that occurred within a specified duration, and the comparative ratio of follow-ups within 60 days were analyzed. The mean, minimum, and maximum number of follow-ups, including the first medical service use, were analyzed. For hospitalization service users, the follow-up duration was calculated based on the date of discharge. The number of follow-ups in a specified period after discharge and the average number of follow-ups are

shown. Additionally, the average follow-up duration and average medical costs for each new SP onset were also calculated, as was the average length of hospitalization for patients. Given that we analyzed administrative data, it was necessary to distinguish between medical service use due to new SP onset and that due to follow-up. Based on previous research indicating that air leaks from SP generally stop within approximately 15 days and that X-ray follow-up is recommended 2–4 weeks after discharge,[7, 21] we set the SP follow-up duration as 60 days and defined new SP onset as cases in which no medical service use (due to SP) was recorded in the previous 60 days. When one patient experienced multiple new occurrences of SP, repeated counting was allowed.

The medical costs of SP patients included the average medical cost per person. Medical costs determined to be eligible for reimbursement by HIRA out of treatment costs were indicated in the submitted insurance claim statement. Medical costs are the sum of benefits reimbursed by the insurer (Korean National Health Insurance Service) to the medical care institutions and self-payment costs paid by the beneficiary (patient). Each patient's medical costs were calculated as the sum of costs listed on their claims. The average medical costs were the amount of total medical expenses for one year divided by the number of patients. Due to a lack of relevant information in the claims data, the costs did not uncover items non-reimbursable items such as traditional drugs and indirect medical costs such as transportation costs and lost productivity. If uncovered items or indirect medical costs which did not contain medical services provided under the NHI were included, the medical costs of SP patients might be higher than that of this study.

Treatment and medication for SP patients

In terms of treatment for SP patients, the most frequent treatment of the code that corresponds to the "Procedure/surgery" category in the statement listing SP as the major or secondary diagnosis was given. All statements prescribing the corresponding treatment were counted and duplication of treatments and patients were allowed. Treatments were categorized as non-surgical treatments and surgical treatments. Percentages were calculated by having the denominator as codes that correspond to the "Procedure/surgery" category, excluding costs of materials, drugs used during treatment and list of tests. For medication, the most frequent

treatment of the code that corresponds to the "Medication" category in the diagnostic statement was given. Among frequently prescribed drugs, digestants were excluded. Similar to "Procedure/surgery", all statements that prescribe the corresponding drug were counted and drug and patient duplication was allowed. Medication data were limited to cases of inpatient prescription, while outpatient prescriptions were excluded. Based on the 5th Anatomical Therapeutic Chemical (ATC) Classification System level,[22-24] notation of the medication taken was indicated by the 5-step code of the chemical name and the three drugs that did not undergo the 5-step classification were indicated by their ingredients.

Statistical analysis

The total annual prevalence rate of SP and that of hospitalization due to SP are shown in frequency and frequency per 100,000 people. It was calculated by dividing the corresponding frequency by the total population that fits in the corresponding range and multiplying by 100,000. Categorical variables, such as the sociodemographic characteristics, number of rehospitalizations per period, comorbidities, CCI level, and follow-up frequency per period, treatment and drugs for the total number of SP patients for 12 years, are shown as frequencies and percentages. Continuous variables, such as number of hospitalizations, CCI value, total follow-up frequency, length of hospitalization in days and medical costs, are reflected by calculating the average, SD, minimum, and maximum values. Analyses were conducted using the statistical package SAS version 9.4 (SAS Institute Inc., Cary, NC).

Results

Sociodemographic characteristics of SP patients

The sociodemographic characteristics of SP patients are shown in Table 1. During 2002 to 2013, 4,658 patients used medical services for SP as their major or secondary diagnosis, at least once. The male-to-female ratio was about 4.4:1. Most patients were 15–34-year-olds, while those below 15-years old were least affected. Most were in the high-income group, while the low-income group utilized medical services the least. Job-based enrollees were the most common category.

Table 1. Sociodemographic characteristics of spontaneous pneumothorax patients

		N	%*
Total number of pneumothorax patients		4,658	
Sex			
	Male	3,796	81.5
	Female	862	18.5
Age (years)	< 15	123	2.6
	15–34	2,407	51.7
	35–64	1,374	29.5
	≥ 65	754	16.2
Income range			
	Low (0–3)	1,037	22.3
	Medium (4–7)	1,725	37.0
	High (8–10)	1,896	40.7
Insurance type			
	Region	1,741	37.4
	Job	2,804	60.2

Medical Assistance	113	2.4

*% = N / 4,658 × 100

Prevalence rate of SP

The annual prevalence rate of SP (SP patients per 100,000 people) by sex ranged from 39 to 66 per 100,000, depending on the year (Fig. 1). The prevalence rate of SP consistently increased from 2002 to 2011 and decreased slightly thereafter. Among males, the rate was 63 per 100,000 in 2002, and then increased consistently to 109 per 100,000 in 2011. Thereafter, it decreased slightly, but the rate still exceeded 100 per 100,000 in 2012 and 2013. Among females, the rate was 15 per 100,000 in 2002, and remained essentially constant at 15–18 per 100,000, except for an increase to 23 per 100,000 in 2011. The male-to-female ratio slowly increased from 4.2:1 in 2002, to a ratio of 6.5:1 in 2010.

In all years, except 2002, the SP prevalence rate was the highest in the 15–34-year-old group, followed by the ≥ 65-year-old, 34–64-year-old, and < 15-year-old groups (Fig. 2). The prevalence rate for those in the 15–34-year-old group was 64.8 per 100,000 in 2002, which then increased to 133.2 per 100,000 in 2009. The rate in the ≥ 65-year-olds also increased, from 69.1 per 100,000 in 2002 to 93.5 per 100,000 in 2013.

The prevalence rate of SP by sex, age, income level, and insurance type are summarized in Supplementary Table 2. To examine the detailed distribution by age, age groups were further subdivided into 5-year increments. The prevalence rate tended to be the highest at 15–19 years, decreased to 40–49 years, and then peaked again at 65–74 years before decreasing again. The prevalence rate was slightly higher in the high-income group, but remained low among medical-assistance recipients, although this rate increased after 2011 to a rate higher than that of health insurance enrollees.

The prevalence rates of SP patients who were hospitalized are shown in Figs. 3 and 4. The rate of hospitalization was 18.3 per 100,000 individuals in 2002, increasing to 36.2 per 100,000 at 2011 before decreasing in 2012. The rate of hospitalization in men was 31.4 per 100,000 in 2002, which increased to 61.0 per 100,000 in 2011. Among women, the

hospitalization rate was 5.3 per 100,000 in 2002, and 11.3 per 100,000 in 2011. This rate decreased for both sexes in 2012. The rate tended to increase up to 2012 for men, but there was no consistent trend for females. The male-to-female ratio of hospitalization was 6:1 on average. By age, hospitalization in the 15–34-year age group was the highest at 33–75 per 100,000, followed by the ≥ 65-year-old group and the 35–64-year-old group. The rate was the lowest for the < 15-year-old group, at 1–3 per 100,000. The prevalence of hospitalized SP patients among the total population, by age and sex, are shown in Supplementary Table 3.

Hospitalization of SP patients by year

Within the SP patient sample, the proportion of those receiving hospital treatment was defined as the hospitalization treatment rate. The number of patients who used the hospitalization service for SP in 2002 was 188(47.2%) (Table 2). The rate of hospitalization treatment slowly increased thereafter up to 2010 and then decreased slightly. No sex-related differences in hospitalization treatment rates were observed. However, for age-related differences, the ≥ 65-year-old group had the highest hospitalization treatment rate, while the < 15-year-old group had the lowest rate.

The frequency and proportion of rehospitalization of SP patients is shown in Supplementary Table 4. In total, 3,005 patients used hospital services at least once due to SP between 2002 and 2013. Among these, 1,683 were rehospitalized, with 60.7% of all rehospitalizations occurring within 6 months and 71.4% within 1 year. The average number of hospitalizations per person overall was 1.56, at an average interval of 223.07 days.

Table 2. Rate of hospitalization treatment for spontaneous pneumothorax patients

	Total number of pneumothorax patients	Total number of hospitalized patients		Sex				Age (years)							
				Male		Female		< 15		15–34		35–64		≥ 65	
		N	Hospitalization rate (%)*	N	Hospitalization rate (%)*	N	Hospitalization rate (%)*	N	Hospitalization rate (%)*	N	Hospitalization rate (%)*	N	Hospitalization rate (%)*	N	Hospitalization rate (%)*
2002	398	188	47.2	161	50.0	27	35.5	4	36.4	111	53.1	43	35.0	30	54.5
2003	490	236	48.2	202	50.0	34	39.5	2	33.3	135	49.1	62	42.2	37	59.7
2004	504	262	52.0	217	52.7	45	48.9	9	40.9	151	54.7	56	42.7	46	61.3

2005	514	276	53.7	235	55.7	41	44.6	3	33.3	161	59.2	74	45.7	38	53.5
2006	518	281	54.2	241	56.8	40	42.6	2	16.7	156	54.7	66	47.5	57	69.5
2007	555	286	51.5	244	51.8	42	50.0	4	36.4	169	56.3	73	44.2	40	50.6
2008	557	296	53.1	270	57.0	26	31.3	3	27.3	183	57.7	62	39.7	48	65.8
2009	610	327	53.6	279	53.8	48	52.7	4	36.4	215	58.0	59	41.3	49	57.6
2010	598	342	57.2	306	59.1	36	45.0	3	21.4	196	59.4	89	50.6	54	69.2
2011	661	364	55.1	307	56.1	57	50.0	3	25.0	208	57.1	82	45.8	71	67.0
2012	623	338	54.3	285	53.6	53	58.2	4	36.4	184	52.9	83	50.3	67	67.7
2013	616	338	54.9	291	55.5	47	51.1	4	30.8	175	55.4	86	51.5	73	60.8

* Hospitalization rate (%) = N / total number of spontaneous pneumothorax patients × 100

Comorbidities in SP patients

Lung-related comorbidities in SP patients by age are shown in Table 3. For the < 15-year-old group, there were no particular comorbidities. COPD was the most common comorbidity, followed by pneumonia and asthma.

Table 3. Comorbidities of spontaneous pneumothorax patients

	15–34 years		35–64 years		≥ 65 years		Total	
	N	%*	N	%†	N	%‡	N	%§
Total	**2,407**		**1,374**		**497**		**4,658**	
COPD	273	11.3	277	20.2	287	57.7	837	18.0
Pneumonia	102	4.2	109	7.9	150	30.2	361	7.8
Interstitial	4	0.2	17	1.2	13	2.6	34	0.7
Lung cancer	11	0.5	72	5.2	67	13.5	150	3.2
Asthma	63	2.6	111	8.1	174	35.0	348	7.5
Lung abscess	1	0.0	8	0.6	0	0.0	9	0.2
CCI								
Mean	0.25		0.69		1.31		0.47	
0	1,823	75.7	708	51.5	173	34.8	2,704	58.1
1	468	19.4	420	30.6	305	61.4	1,193	25.6
2	45	1.9	165	12.0	166	33.4	376	8.1
3 or more	5	0.2	65	4.7	99	19.9	159	3.4

* % = N / 2,407 × 100

†% = N / 1,374 × 100

‡% = N / 496 × 100

§% = N / 4658 × 100

COPD, Chronic Obstructive Pulmonary Disease; CCI, Charlson Comorbidity Index

COPD was more common in the ≥ 65-year-old group than in the younger age groups. Fewer patients among the 15–34-year-old group had asthma than pneumonia. The prevalence of all comorbidities other than lung abscess was the highest in the ≥ 65-year-old group. The lung cancer rate was lower in the 15–34-year-old and 35–64-year-old groups than in the ≥ 65-year-old group.

The average CCI value of SP patients was 0.47 and increased with increasing age. The number of patients with a CCI value of 0 decreased with increasing age, while that of patients with a CCI value of ≥ 3 increased with increasing age.

Treatment period and medical costs of SP patients

There were 4,157 outpatient service users among patients with first-time SP (no use of medical service for SP for 60 days prior) from 2002 to 2013 (Table 4). Among these, 3,035 required follow-up within 60 days of the first onset of SP. Most follow-ups occurred within 30 days. The average number of follow-ups in each time period including the first-time visit was found to be 1.14 days within 7 days, 1.33 days within 14 days, 1.54 days within 30 days, and 1.73 days within 60 days. The average length of time between follow-ups was 11.07 days and the average medical cost per person was $94.5 (106,766 KRW).

Table 4. Outpatient or inpatient treatment period and medical costs of spontaneous pneumothorax

		Follow-up frequency during period	Total follow-up frequency (Including first visit)				
		Cumulative frequency	Total follow-up frequency (Within 60 days) Comparative ratio	Mean	SD	min	max
Outpatient and follow-up							
First-time outpatient use	4,157						
Within 7 days		582	19.2	1.14	0.42	1	6
Within 14 days		1,372	45.2	1.33	0.63	1	8
Within 30 days		2,245	74.0	1.54	0.84	1	13
Within 60 days		3,035	100.0	1.73	1.07	1	13
Average follow-up period				11.07	16.55	0	60
Average medical costs (US $)*				94.5	141.5	0.9	2,673.6

Hospitalization and follow-up							
First-time hospitalization use	3,005						
Within 7 days		180	30.0	1.06	0.24	1	3
Within 14 days		301	50.1	1.10	0.31	1	3
Within 30 days		451	75.0	1.15	0.40	1	5
Within 60 days		601	100.0	1.20	0.48	1	7
Average number of days of hospitalization				14.19	18.25	0	601
Average follow-up period				3.67	10.67	0	60
Average medical costs (US $)*				2,523.0	2,692.2	45.9	48,967.3

*The cost of items determined to be eligible for reimbursement by the HIRA (Health Insurance Review and Assessment Service) out of the total treatment amount were indicated in the submitted insurance claim statement. It was converted from Korean Won to US dollar, according to the exchange rate on October 12, 2018 (US $1.00 = Korean 1,130 Won).

The number of hospitalizations for first cases of SP was 3,005, of which 601 required follow-up within 60 days of discharge. Most follow-ups occurred within 30 days and the proportion of follow-ups occurring in the first week was higher for in-patients than for outpatient service users. The average number of follow-ups was lower for inpatients than for outpatient service users. The average length of hospitalization was 14.19 days. The average follow-up period after discharge was 3.67 days and the average medical costs for each hospitalization was markedly higher than those of outpatients.

Treatment and medication for SP patients

Treatment and medication details are shown in Table 5. The most commonly received non-surgical treatment for SP patients was oxygen inhalation, followed by suction drainage or tracheostomy suction. Thoracostomy was the most common surgical treatment, followed by lung wedge resection. The frequency of other surgical treatments was low.

Medication commonly prescribed for SP could be categorized into analgesics, antitussives, and antibiotics, when excluding digestives. Among analgesics, paracetamol, codeine combinations, excluding psycholeptics and tramadol and paracetamol combinations were prescribed at similar rates. Among antitussives, most were prescribed bromhexine. Among antibiotics, cefixime was the most frequently prescribed.

Table 5. Treatments and drugs used for spontaneous pneumothorax patients

	Treatment			Drugs	
	N	%*		N	%†
Total count of prescription statements	**21,107**			**37,488**	
Non-surgical treatments			**Analgesics**		
Oxygen Inhalation	4,351	20.6	Paracetamol	1,039	2.8
Nebulizer Treatment Of Lower Airway	534	2.5	Codeine, combinations excluding psycholeptics	878	2.3
Suction Drainage Or Tracheostomy Suction, Etc.	2,481	11.8	Tramadol and paracetamol	832	2.2
Tracheal Intubation	81	0.4	Propionic acid-derivatives	784	2.1
Surgical treatments			Aceclofenac	455	1.2
Thoracostomy	3,132	14.8	**Antitussives**		
Wedge Resection Of Lung	1,304	6.2	Acetylcysteine	672	1.8
Resection Of Bullae	125	0.6	Xanthines	635	1.7
Pleurodesis	27	0.1	Bromhexine	789	2.1
Apicolysis, Pleurolysis	15	0.1	Ambroxol	553	1.5
Lobectomy Of Lung	13	0.1	**Antibiotics**		
Pleurectomy	12	0.1	Cefixime	374	1.0
Segmentectomy Of Lung	10	0.0	Third-generation cephalosporins	305	0.8
Pleural Decortication	8	0.0			
Primary Thoracoplasty	4	0.0			

*% = N / 21,107

†% = N / 37,488

Discussion

In this large cohort study in Korea, the annual prevalence rate of spontaneous pneumothorax (SP) was 39–66 per 100,000. These numbers are slightly higher than those previously reported: 1.2–7.4 per 100,000 in Minnesota [5] and 9.8–24 per 100,000 in United Kingdom.[6] The reason for these differences may be because SP was defined as cases in which medical service was used for SP, which could include follow-up appointments, rather than counting the strict number of incidents. In contrast, the prevalence rate of hospitalization due to SP was 18–36 per 100,000 overall. These rates were previously reported as 14.3–22.7 per 100,000 overall [7, 8], which are similar to those found in our study. It may because of hospitalization being a result of new incidents only.

The prevalence rate was much higher for males than in previous studies. The male-to-female ratio for all SP and for hospitalized SP were higher than that reported previously (2.4:1–3.3:1) [6, 8, 9]. In terms of age, the prevalence rate was the highest for the 15–34-year-old group, particularly for the 15–19-year-old group, followed by the ≥ 65-year-old, 35–64-year-old, and < 15-year-old group, respectively. Previous studies showed a peak-age for SP at 20, followed by a later peak at 70 [8, 25]. Overall, the incidence of SP is higher in Korea, particularly in males and at a slightly earlier age (15–19 years) than in other countries: e.g., 20–25 years in France [7] and Germany,[8] and 20–24 years or 30–34 years in England.[6] The prevalence of SP in males increased until 2012, while there was no clear trend in females. As there have been no previous large-scale research in Eastern countries, we cannot conclude whether these results are due to ethnicity or environment.

SP has a high rate of hospitalization;[26] 47–57% of SP patients in our study received hospital treatment. There were no marked differences due to sex, although the female hospitalization rate was slightly lower. The hospitalization rate was highest in the ≥ 65-year-old group and lowest in the < 15-year-old group. The necessity of hospitalization for SP is debated. Hallifax and Rahman stated in 2015 that outpatient treatment is sufficient for patients who are young, have no comorbidities and have stable vital signs; however, the evidence of outpatient treatment stability is lacking.[10]

SP has a high rate of relapse;[22, 27, 28] with 1,683 of 3,003 first-time hospitalization cases requiring rehospitalization in our study. Although previous studies have shown that the relapse rate of SP is 15–40%,[7, 11, 12, 29] these studies were based on small sample sizes (82–273 subjects). The risk factors for SP relapse are controversial; some studies indicate that elderly people and women are at higher risk,[7, 30] while other studies indicate that age and sex have no significant effect.[31] Furthermore, low BMI [12, 32], non-surgical treatment and smoking habits [12, 31] have been implicated in SP, yet further study is required to delineate the risk factors.

SP can involve lung-related comorbidities.[33, 34] To distinguish between PSP and SSP, it is important to evaluate comorbidities. This distinction is important, as these conditions have different characteristics and prognoses;[21, 35] however, categorizing these conditions based on administrative data remains challenging,[17] because there are no codes to differentiate between PSP and SSP in the ICD categorizations. Nevertheless, our objective was describe details related to SP; thus, we examined the current comorbidity status, rather than attempting to categorize SP patients. Among comorbidities, COPD was the most common in all age groups. With increasing age, the proportion of patients with comorbidities increased; thus, with increasing age, SSP was more common than PSP. Therefore, the decrease in SP risk with age, followed by an increase, may be due to an increase in SSP in particular.

The approximate treatment period for SP was 11 days for outpatients and 17.7 days for hospitalized patients. The average number of follow-ups within 60 days was 1.73. Thus, many cases of SP are minor and a single outpatient visit is necessary to complete the treatment. For both hospitalization and outpatient service users, 75% of total follow-ups occurred within 1 month; hence, the follow-up duration for SP is short. Few studies have assessed the treatment or follow-up duration for SP, yet our results are similar to a previous study reporting a remission period of 7–15 days for SP,[21, 36]. X-ray follow-up is recommended within 2–4 weeks of discharge [35] and the median value of length of stay (LOS) is 6–7 days.[7, 30] No previous studies have reported the socioeconomic costs due to SP; in our study, we found an average medical cost of $94.50 per person for outpatient services and of $2,523.00 per person for hospitalization. The maximum costs were $2,673.60 per person for outpatient and $48,967.30 per person for hospitalization.

For treatment, surgery, and medication for SP patients, we reported the frequency of prescriptions rather than the number of people. Oxygen inhalation among non-surgical treatments and thoracostomy among surgical treatments were the most common procedures. A previous study has also shown that the most common treatment for SP patients is thoracostomy (92% of patients).[29] The surgery most commonly performed after thoracostomy is lung wedge resection; this involves removing a portion of the lung and is less invasive, preserves more lung function, and has fewer side-effects than lobar resection.[38, 39] For medication; analgesics, antitussives, and antibiotics were the most frequently prescribed, after excluding digestants. For convenience of analysis, we excluded outpatient prescriptions. Considering that the rate of hospitalization exceeded 60% for SP patients, prescription patterns are not likely to differ markedly between hospitalized and overall cases.

This study has several limitations. First, we could not distinguish between PSP, SSP, and iatrogenic pneumothorax; further research is needed on the epidemiology and medical service use of each SP category. Second, our results should be interpreted with caution, as we could not ascertain whether medical service use was due to new incidents of SP or to follow-up. Although we attempted to select medical service use due to new incidents of SP by using an operational definition, based on previous reports, this may not be accurate. Third, our study may be limited by the lack of data on uncovered items and general medicinal products in the treatment history records of SP patients. Lastly, as the diagnosis codes in claim data that was the basis for identifying the patients may not completely accurate[40], it is not sure that all patients with SP were listed under the corresponding diagnosis codes. However, despite these limitations, this study provided a detailed record of the epidemiology and treatment of SP. Our study is significant in that it provides novel information, contributing to an understanding of SP, a little-understood condition with an increasing prevalence in Korea.

Conclusion

This study demonstrated the increasing prevalence of SP, higher prevalence of SP in men, and earlier peak age of SP patients in Korea, and defined the medical service use characteristics of patients with SP in Korea. These findings can contribute to the understanding of SP.

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Author contributions

IHH and BYJ contributed to the overall conception and design of the study protocol. BJ and DK contributed to the specific study design and data analysis. DK wrote the first draft of the manuscript. All authors contributed to interpretation of the analyses and revisions of the final manuscript. All authors gave final approval of the version to be submitted.

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Competing interest

No competing interests to declare.

Ethics approval

The study was approved by the Institutional Review Board of Jaseng Hospital of Korean Medicine in Seoul, Korea (JASENG 2018-09-007).

Data sharing statement

The datasets generated and analyzed during the current study are available on the National Health Insurance Sharing Service. NHIS provides support to research activities in various sectors of society, the economy, environment, industry, etc., as well as policy and academic research on the health sector by providing sample cohort databases. The research database consists of five types of databases: a sample cohort database, medical check-up cohort database, elderly cohort database, working women cohort database, and infant medical check-up cohort database. Each

cohort database consists of the following four detailed data-sets: qualification database, treatment database, medical check-up database, and clinic database.

The present study utilized the sample cohort database, which is third-party data not owned by the authors. The sample cohort database is available upon approval for data sharing, from the health insurance corporation. For the purpose of policy and academic research a fee is paid to obtain data from the NHIS website [https://nhiss.nhis.or.kr/bd/ab/bdaba022eng.do].

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Figure legends

Fig. 1. Annual prevalence rate of spontaneous pneumothorax, by sex (per 100,000 people).

Fig. 2. Annual prevalence rate of spontaneous pneumothorax, by age (per 100,000 people).

Fig. 3. Annual prevalence rate of hospitalization due to spontaneous pneumothorax, by sex (per 100,000 people).

Fig. 4. Annual prevalence rate of hospitalization due to spontaneous pneumothorax, by age (per 100,000 people).

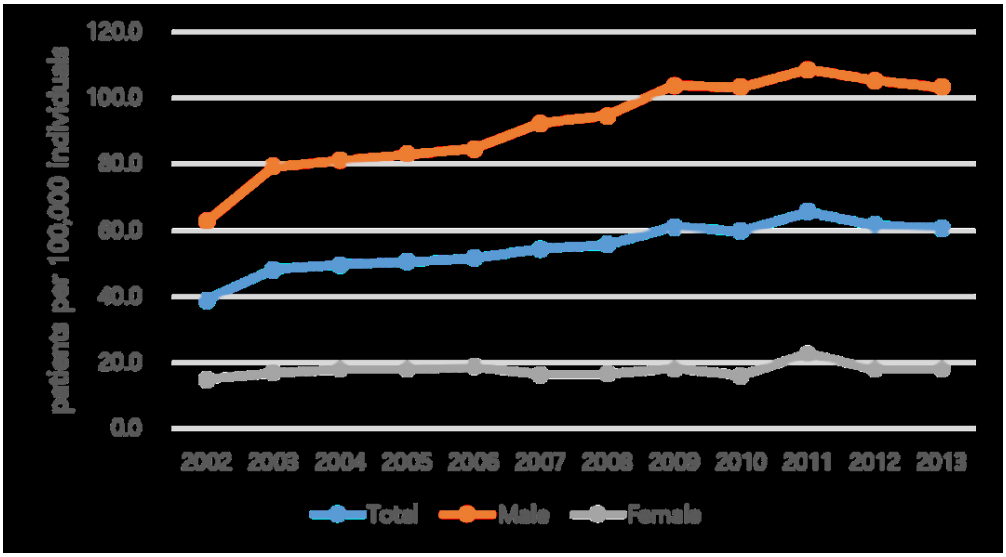

Fig.1

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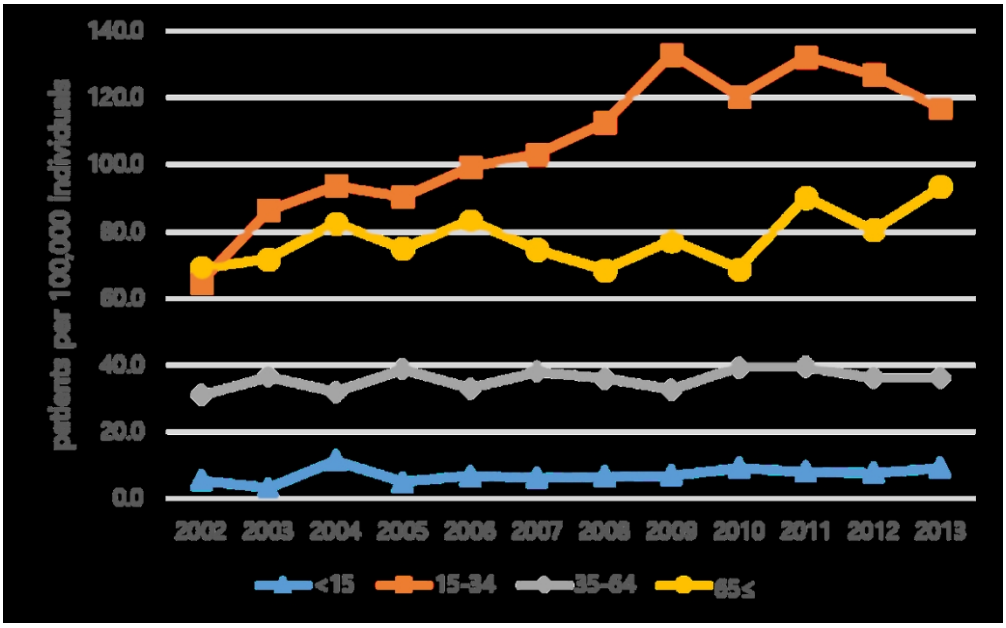

Fig.2

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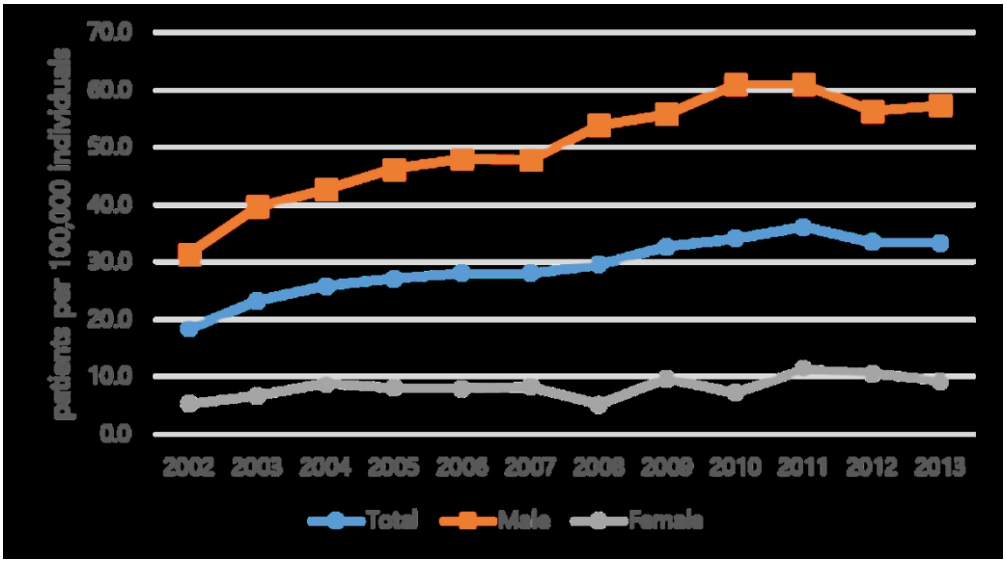

Fig.3

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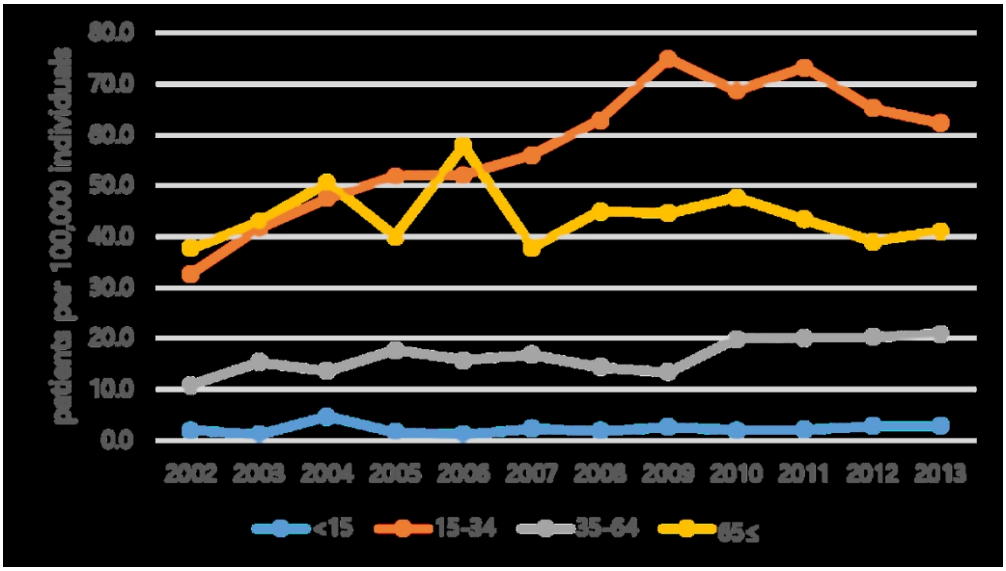

Fig.4

99x56mm (300 x 300 DPI)

Supplementary Table 1. ICD-10 codes of comorbidities in spontaneous pneumothorax

Disease	Code
COPD	J40*, J41*, J42*, J43*, J44*, J961, J982
Pneumonia	J12*, J13*, J14*, J15*, J16*, J18*
Interstitial lung disease	J84*
Lung cancer	C34*, C780*, C783, D022-D024, D143*, D174, D381
Asthma	J45*
Lung abscess	J850, J851, J852

COPD, Chronic Obstructive Pulmonary Disease

Supplementary Table 2. Prevalence rate of spontaneous pneumothorax per 100,000 individuals and sociodemographic characteristics

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.
Total SP Patients	398	38.8	490	48.2	504	49.6	514	50.5	518	51.7	555	54.4	557	55.7	610	61.1	598	59.7	661	65.7	623	61.6	616	60.7
Sex																								
Male	322	62.7	404	79.3	412	81.1	422	83.0	424	84.7	471	92.4	474	94.6	519	103.9	518	103.3	547	108.7	532	105.2	524	103.3
Female	76	14.8	86	16.9	92	18.1	92	18.1	94	18.8	84	16.4	83	16.6	91	18.2	80	16.0	114	22.7	91	18.0	92	18.1
Age																								
< 15	11	5.3	6	3.0	22	11.2	9	4.7	12	6.6	11	6.2	11	6.5	11	6.8	14	9.0	12	7.9	11	7.5	13	9.1
15–34	220	64.8	281	86.3	298	93.9	281	90.4	297	99.3	311	103.2	328	112.6	382	133.2	344	120.6	376	132.4	359	127.2	329	117.1
35–64	123	30.9	147	36.4	131	31.8	162	38.6	139	32.9	165	37.9	156	35.9	143	32.5	176	39.3	179	39.4	165	36.0	167	36.1
≥ 65	55	69.1	62	71.7	75	82.6	71	74.8	82	83.2	79	74.6	73	68.4	85	77.3	78	68.8	106	90.3	99	80.5	120	93.5
Sub-divided Age																								
< 15	11	5.3	6	3.0	22	11.2	9	4.7	12	6.6	11	6.2	11	6.5	11	6.8	14	9.0	12	7.9	11	7.5	13	9.1
15–19	81	114.7	96	143.2	110	165.5	106	160.4	111	166.2	140	200.4	162	231.4	193	270.2	179	245.2	184	254.0	156	218.9	153	220.2
20–24	54	63.7	91	109.1	71	89.2	66	86.9	73	104.6	71	104.9	58	91.3	77	122.8	77	123.2	92	142.8	105	156.8	93	134.6
25–29	41	47.6	50	62.6	55	70.0	55	69.6	66	84.0	63	77.6	58	72.1	60	78.0	45	61.3	46	66.4	50	76.5	44	70.1
30–34	33	33.6	38	39.9	40	43.1	45	50.2	35	41.6	26	31.4	39	50.5	41	54.1	29	38.0	42	53.9	37	47.1	26	32.7
35–39	23	25.7	30	33.1	28	30.5	39	42.1	32	34.4	34	35.9	30	32.7	26	29.0	41	47.3	31	37.3	34	42.4	33	43.2
40–44	19	20.0	23	24.6	21	22.9	26	28.9	18	20.9	23	26.6	21	24.2	28	31.7	24	26.8	30	32.9	26	28.3	25	27.5
45–49	26	35.4	22	28.4	21	25.7	26	30.5	20	22.7	30	32.9	32	35.8	24	27.3	24	27.8	29	34.5	15	18.0	28	32.6
50–54	13	24.2	23	42.4	22	38.8	19	30.8	21	31.7	26	36.9	26	35.5	23	29.6	26	32.0	33	38.6	35	40.0	25	28.4
55–59	21	48.4	25	55.9	18	38.9	25	51.5	26	53.7	23	44.8	26	50.9	21	39.3	32	54.6	29	45.4	27	40.2	31	43.3
60–64	21	48.7	24	55.1	21	48.8	27	64.2	22	54.0	29	70.6	21	50.3	21	48.5	29	63.5	27	58.4	28	57.8	25	50.5
65–69	23	71.1	22	64.3	30	84.4	34	93.9	30	80.6	32	79.4	25	62.9	24	61.2	26	67.3	32	83.8	28	73.3	30	75.4
70–74	16	74.4	19	82.4	21	85.7	15	57.0	25	90.1	25	85.1	24	80.2	33	105.6	14	43.6	22	65.5	12	33.2	27	73.2

≥ 75	16	62.1	21	72.0	24	78.1	22	68.0	27	80.4	22	60.8	24	64.9	28	70.9	38	89.1	52	114.0	59	121.2	63	121.8
Income																								
Low (0–3)	71	31.1	99	43.9	116	51.3	129	54.8	92	39.7	125	52.0	116	48.4	127	54.4	117	48.8	163	67.3	150	68.1	170	70.3
Medium (4–7)	164	40.9	194	49.3	188	48.2	190	49.4	212	56.0	206	53.8	213	57.3	229	61.8	213	58.0	237	64.7	190	54.2	196	53.3
High (8–10)	163	41.1	197	49.5	200	50.0	195	49.2	214	54.6	224	56.3	228	58.5	254	64.4	268	67.8	261	65.5	283	64.2	250	61.7
Insurance type																								
Region	200	40.2	236	49.8	206	45.8	221	52.5	201	52.0	214	56.4	203	56.2	213	61.3	200	59.8	207	64.4	179	57.4	161	53.8
Employment	195	39.3	252	49.2	292	54.7	285	51.1	315	54.6	336	55.8	346	57.6	390	63.3	396	62.6	419	64.4	414	62.0	415	60.5
Medical Assistance	3	9.8	2	6.3	6	18.1	8	21.1	2	5.1	5	12.7	8	20.5	7	19.8	2	5.7	35	103.7	30	95.8	40	132.9

Prev., Prevalence Rate

Supplementary Table 3. Annual prevalence rate of hospitalization due to spontaneous pneumothorax (per 100,000 individuals)

Hospitalization				Sex						Age (years)											
				Male			Female			< 15			15–34			35–64			≥ 65		
Year	N	Prev.*	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†
2002	188	18.3		161	31.4		27	5.3		4	1.9		111	32.7		43	10.8		30	37.7	
2003	236	23.2	26.5	202	39.7	26.5	34	6.7	26.9	2	1.0	-48.4	135	41.5	26.9	62	15.3	42.0	37	42.8	13.7
2004	262	25.8	11.1	217	42.7	7.6	45	8.9	32.3	9	4.6	360.9	151	47.6	14.7	56	13.6	-11.3	46	50.7	18.3
2005	276	27.1	5.3	235	46.2	8.3	41	8.1	-8.9	3	1.6	-65.7	161	51.8	8.9	74	17.6	29.6	38	40.1	-20.9
2006	281	28.0	3.3	241	48.1	4.1	40	8.0	-1.0	2	1.1	-29.8	156	52.1	0.6	66	15.6	-11.3	57	57.8	44.4
2007	286	28.0	-0.1	244	47.8	-0.6	42	8.2	3.0	4	2.2	103.9	169	56.1	7.5	73	16.8	7.4	40	37.8	-34.7
2008	296	29.6	5.6	270	53.9	12.6	26	5.2	-36.7	3	1.8	-20.7	183	62.8	12.1	62	14.3	-14.9	48	45.0	19.1
2009	327	32.7	10.7	279	55.8	3.6	48	9.6	85.0	4	2.5	39.3	215	74.9	19.3	59	13.4	-6.1	49	44.5	-1.0
2010	342	34.1	4.2	306	61.0	9.3	36	7.2	-25.3	3	1.9	-22.0	196	68.7	-8.3	89	19.9	48.2	54	47.6	6.9
2011	364	36.2	6.0	307	61.0	-0.1	57	11.3	57.6	3	2.0	2.7	208	73.3	6.6	82	20.1	1.2	71	43.4	-8.9
2012	338	33.4	-7.6	285	56.4	-7.6	53	10.5	-7.5	4	2.7	36.7	184	65.2	-11.0	83	20.2	0.7	67	39.1	-9.9

2013	338	33.3	-0.4	291	57.4	1.8	47	9.3	-11.7	4	2.8	2.8	175	62.3	-4.5	86	20.8	3.0	73	41.0	5.0

Prev., *Prevalence rate: rate of prevalence per 100,000 individuals.

Grow., †Growth rate (%) = (Current Year *100) / Previous Year) - 100

Supplementary Table 4. Rehospitalization of spontaneous pneumothorax patients

Rehospitalization (within)	Number of rehospitalizations		Number of hospitalizations per person			
	N*	Cumulative %	Mean	SD	Minimum	Maximum
6 months	1,022	60.7	1.34	0.70	1	10
1 year	1,202	71.4	1.40	0.80	1	12
2 years	1,412	83.9	1.47	0.94	1	19
Total	1,683	100.0	1.56	1.07	1	19
Interval between hospitalizations			223.07	445.3	0	3,989

*N = Cumulative frequency

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Epidemiology and Medical Service Use for Spontaneous Pneumothorax: A 12-year Study Using Nationwide Cohort Data in Korea

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ABSTRACT

Objectives: This study aimed to promote an understanding of spontaneous pneumothorax by analyzing the prevalence rate and medical service use by patients with spontaneous pneumothorax according to sociodemographic characteristics.

Design: A 12-year nationwide study.

Setting: Data obtained from the Korean National Health Insurance Service Sharing Service.

Participants*:* A total of 4658 participants who used medical services due to spontaneous pneumothorax between 2002 and 2013 in Korea.

Outcome measures: For those diagnosed with spontaneous pneumothorax, the use of medical services, hospitalization data, sociodemographics, co-morbidity, treatment administered, and medication prescribed were recorded.

Results: The annual prevalence of spontaneous pneumothorax ranged from 39 to 66 per 100,000 individuals, while the prevalence of hospitalization due to spontaneous pneumothorax ranged from 18 to 36 per 100,000 individuals. The prevalence rate of spontaneous pneumothorax in Korea has increased since 2002. The male-to-female ratio was approximately 4–10:1, with a higher prevalence rate in males. By age, the 15–34-year-old group, and particularly 15–19-year-olds, showed the highest prevalence rate; the rate then declined before increasing again for those aged 65 years or older. In total, 47–57% of spontaneous pneumothorax patients underwent hospitalization. The average number of rehospitalizations due to pneumothorax was 1.56 per person, and more than 70% of recurrences occurred within 1 year. Chronic obstructive pulmonary disease (COPD) was the most common comorbidity. The average treatment period was 11 days as an outpatient and 14 days in-hospital. The average medical costs were $94.50 for outpatients and $2523 for hospital admissions. The most common treatment for spontaneous pneumothorax was oxygen inhalation and thoracostomy, and the most commonly prescribed medications were analgesics, antitussives, and antibiotics.

Conclusions: We here detailed the epidemiology and treatments for spontaneous

pneumothorax in Korea. This information can contribute to the understanding of spontaneous pneumothorax.

Keywords: Epidemiology, Longitudinal cohort, National Health Insurance Service-Sample Cohort Database (NHIS-SCD); Prevalence; Primary Spontaneous Pneumothorax

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Large-scale, long-term (12 years) follow-up data sets, representing the Korean population, were analyzed.
- Not only the inpatient costs but also the outpatient costs of spontaneous pneumothorax treatment were calculated.
- Data on detailed medical-service use, such as medication, procedures, surgery undertaken due to spontaneous pneumothorax, were recorded and analyzed.
- Due to a lack of relevant information in the claims data (for example, medical treatments are not necessarily covered by insurance), not all relevant treatments data could be considered.
- This study could not distinguish whether medical service use was due to new occurrences or follow-up of existing spontaneous pneumothorax.

INTRODUCTION

The pulmonary system is important because it plays a crucial role in the oxygenation of the blood.[1] In pneumothorax, air or gas pools in the inter-pleural cavity,[2] leading to lung collapse and impaired pulmonary function.[3] Pneumothorax is categorized into spontaneous pneumothorax (SP) or traumatic pneumothorax, depending on etiology, and SP is subcategorized into primary spontaneous pneumothorax (PSP), occurring in the absence of underlying lung-related comorbidities, and secondary spontaneous pneumothorax (SSP), occurring in the presence of underlying lung-related comorbidities.[4]

The prevalence rate of SP per 100,000 individuals reportedly ranges from 1.2 to 9.8 in women to 7.4 to 24.0 in men; the prevalence rate of hospitalized SP per 100,000 individuals is about 17 to 22 in men, 6 to 7 in women, and 14 to 23 overall.[5-9] Although SP has a relatively low prevalence rate, it is clinically important,[10] as relapse rates are high (20–40%, depending on duration);[7, 11, 12] hospitalization is often required influencing work productivity. Furthermore, pneumothorax patients may be at high risk of stress.[13]

However, there is a paucity of research on SP.[14] There is a lack of knowledge about the modalities of management and the treatments of SP.[15] Given its low prevalence rate, large-scale research at a national scale is needed to evaluate the epidemiology of SP. Although large-scale studies have been performed in the UK, France, and Germany, these have provided limited epidemiological information.[6-8]

Thus, we aimed to determine the prevalence rate of SP and medical service use of patients treated for SP, according to sociodemographic characteristics, by implementing the National Sample Cohort (NSC) data from the National Health Insurance Service (NHIS) of Korea, to reformulate a more accurate understanding of the prevalence, treatment, and management of SP in Korea.

METHODS

Database

Twelve years of NHIS-NSC data (for the period 2002–2013) were analyzed. The National Health Insurance (NHI) system in Korea is a single-payer system to which 98% of citizens belong. Under this system, a medical provider requests reimbursement from a third-person payer (the NHIS) when a patient uses a medical service.[16, 17] The NHIS-NSC is a population-based cohort built by the NHIS. In 2002, a cohort was extracted by systematic stratified random sampling from a pool of 47,851,928 individuals, excluding those who were not enrolled in the NHI (income level of 0) and foreigners.[18] The cohort comprised of 1,476 levels, based on sex, age, and income. Finally, 2.2% of this pool (1,025,340 individuals) were extracted and data from newborns were added each year to maintain the sample size.[18]

Study population and sampling

Our study was performed on 4,658 patients diagnosed with SP in the 12 years between January 2002 and December 2013 in Korea. SP patients were defined as those who used a medical service at least once for main or secondary diseases with the International Statistical Classification of Disease and Related Health Problems, 10th revision (ICD-10) J93.0 (Spontaneous tension pneumothorax), J93.1 (Other spontaneous pneumothorax), J93.8 (Other pneumothorax), or J93.9 (Pneumothorax, unspecified). S27 (Injury of other and unspecified intrathoracic organs) and S27.0X (Traumatic pneumothorax) were excluded because this analysis was only for SP patients.

Main descriptive variables

Prevalence rate of SP

For each year, the frequency per 100,000 individuals and the frequency of patients who used medical services at least once for SP as the major or secondary diagnosis were determined. Sociodemographic characteristics are shown by sex, age, income level, and insurance type. Based on previous studies,[6, 8] age was subdivided as follows: < 15, 15–34, 35–64, and ≥

65 years. Income level was divided into low (0, 1, 2, or 3 out of 0–10), medium (4, 5, 6, or 7), or high (8, 9, or 10). Insurance type was divided into region-based enrollee, job-based enrollee, and medical assistance recipient.

For each year, the prevalence of SP per 100,000 individuals and the frequency of patients who were hospitalized due to SP were analyzed. In addition, prevalence rate of SSP was analyzed. SSP was operationally defined as SP patients with a diagnosis of underlying lung disease such as COPD, pneumonia, interstitial lung disease, lung cancer, asthma, and lung abscess within a year before the first date of SP onset. Patients who used hospitalization services at least once were counted; two or more hospitalizations were not counted more than once. The hospitalization rate among pneumothorax patients was calculated using the same standards: the denominator was the number of patients who used medical services at least once due to SP in a given year, by sex and age, and the numerator was the number of patients who used hospitalization services at least once.

Hospitalization of SP patients by year

Frequency of rehospitalization due to SP is shown by time period. The ratios of the total rehospitalization number to rehospitalization in a specific time period are also shown. The number of rehospitalizations counted all hospitalizations (other than the first-time) and allowed for duplication for each patient. To calculate the number of hospitalizations per person, the average, standard deviation (SD), minimum and maximum number of hospitalizations per time period were calculated. For the number of hospitalizations per person, first-time hospitalizations were also included. The interval between hospitalizations was calculated as the interval between the dates of two admissions.

Comorbidities in SP patients

Diseases were counted as comorbidities if they were diagnosed as the major or secondary disease within 1 year before the first date of SP onset. The number of patients who were given codes for frequent comorbidities, i.e., COPD, pneumonia, interstitial lung disease, lung cancer, asthma, and lung abscess, were counted; patients with multiple comorbid conditions were counted more than once.[8, 19] The Charlson Comorbidity Index (CCI) was categorized

into normal and CCI 0, 1, 2, and ≥ 3.[20-22] ICD-10 codes of comorbidities are shown in Supplement Table 1.

Treatment period and medical costs of SP patients

The total number of follow-ups within 60 days after medical service use due to new SP onset, the number of follow-ups that occurred within a specified duration, and the comparative ratio of follow-ups within 60 days was analyzed. The mean, minimum, and maximum number of follow-ups, including the first medical service use, were analyzed. For hospitalization service users, the follow-up duration was calculated based on the date of discharge. The number of follow-ups in a specified period after discharge and the average number of follow-ups are shown.

Additionally, the average follow-up duration and average medical costs for each new SP onset were also calculated, as was the average length of hospitalization for patients. Given that we analyzed administrative data, it was necessary to distinguish between medical service use due to new SP onset and that due to follow-up. Based on previous research indicating that air leaks from SP generally stops within approximately 15 days and that X-ray follow-up is recommended 2–4 weeks after discharge,[7, 23] screening analysis results and discussions with medical experts in Korea, SP follow-up duration was determined as 60 days. New SP onset was defined as cases in which no medical service use (due to SP) was recorded in the previous 60 days. When one patient experienced multiple new occurrences of SP, repeated counting was allowed.

The medical costs of SP patients included the average medical cost per person. Medical costs determined to be eligible for reimbursement by Health Insurance Review and Assessment Service (HIRA) out of treatment costs were indicated in the submitted insurance claim statement. Medical costs are the sum of benefits reimbursed by the insurer (NHIS) to the medical care institutions and self-payment costs paid by the beneficiary (patient). Each patient's medical costs were calculated as the sum of costs listed on their claims. The average medical costs were the amount of total medical expenses for one year divided by the number of patients.

Treatment and medication for SP patients

In terms of treatment of SP patients, the most frequent treatment with a code that corresponds to the "Procedure/surgery" category in the statement listing SP as the major or secondary diagnosis was given. All statements prescribing the corresponding treatment were counted and duplication of treatments and patients were allowed. Treatments were categorized as non-surgical treatments and surgical treatments. Non-surgical treatment included oxygen inhalation, nebulizer treatment of the lower airway, suction drainage or tracheostomy suction and tracheal intubation, and surgical treatment included thoracostomy, wedge resection of the lung, resection of bullae, and pleurodesis. The criteria distinguishing between surgical and non-surgical treatments were in accordance with the classification of the claims data. Percentages were calculated by having the denominator as codes that correspond to the "Procedure/surgery" category, excluding costs of materials, drugs used during treatment and list of tests. For medications, the most frequent treatment belonging to the code that corresponds to the "Medication" category in the diagnostic statement was given. Among frequently prescribed drugs, digestants were excluded. Similar to "Procedure/surgery", all statements that prescribed the corresponding drug were counted; and drug and patient duplication was allowed. Medication data were limited to cases of inpatient prescription, while outpatient prescriptions were excluded. Based on the 5th Anatomical Therapeutic Chemical (ATC) Classification System level,[11, 12, 24] notation of the medication taken was indicated by the 5-step code of the chemical name; and the three drugs that did not undergo the 5-step classification were indicated by their ingredients.

Statistical analysis

The total annual prevalence rate of SP and that of hospitalization due to SP are shown in frequency and frequency per 100,000 individuals. It was calculated by dividing the corresponding frequency by the total population that fits in the corresponding range and multiplying by 100,000. Categorical variables, such as the sociodemographic characteristics, number of rehospitalizations per period, comorbidities, CCI level, and follow-up frequency per period, treatment and drugs for the total number of SP patients for 12 years, are shown as frequencies and percentages. Continuous variables, such as number of hospitalizations, CCI

value, total follow-up frequency, length of hospitalization in days and medical costs, are reflected by calculating the average, SD, minimum, and maximum values. Logistic regression analysis was performed including age, sex, income, type of insurance and comorbidity to identify factors influencing hospitalization rate. Data cleaning and analyses were conducted using the statistical package SAS version 9.4 (SAS Institute Inc., Cary, NC).

The patient and public involvement statement

Encrypted and published data was used in this study. Thus, there were no patients' involvement in this study.

RESULTS

Sociodemographic characteristics of SP patients

The sociodemographic characteristics of SP patients are shown in Table 1. During 2002 to 2013, 4,658 patients used medical services for SP as their major or secondary diagnosis, at least once. The male-to-female ratio was about 4.4:1. Most patients were 15–34-year-olds, while those below 15-years were least affected. Most were in the high-income group, while the low-income group utilized medical services the least. Job-based enrollees were the most common category.

Table 1. Sociodemographic characteristics of spontaneous pneumothorax patients

		All SP (n=4,658)	%*
Sex			
	Male	3,796	81.5
	Female	862	18.5
Age (years)			
	< 15	123	2.6
	15–34	2,407	51.7
	35–64	1,374	29.5

	≥ 65	754	16.2
Income range			
	Low (0–3)	1,037	22.3
	Medium (4–7)	1,725	37.0
	High (8–10)	1,896	40.7
Insurance type			
	Region	1,741	37.4
	Job	2,804	60.2
	Medical Assistance	113	2.4

*% = N / 4,658 × 100, SP: spontaneous pneumothorax

Prevalence rate of SP

The annual prevalence rate of SP (SP patients per 100,000 individuals) by sex ranged from 39 to 66 per 100,000 individuals, depending on the year (Fig. 1). The prevalence rate of SP consistently increased from 2002 to 2011 and decreased slightly thereafter. Among males, the rate was 63 per 100,000 individuals in 2002, and then increased consistently to 109 per 100,000 individuals in 2011. Thereafter, it decreased slightly, but the rate still exceeded 100 per 100,000 individuals in 2012 and 2013. Among females, the rate was 15 per 100,000 individuals in 2002, and remained essentially constant at 15–18 per 100,000 individuals, except for an increase to 23 per 100,000 individuals in 2011. The male-to-female ratio slowly increased from 4.2:1 in 2002, to a ratio of 6.5:1 in 2010.

In all years, except 2002, the SP prevalence rate was the highest in the 15–34-year-old group, followed by the ≥ 65-year-old, 34–64-year-old, and < 15-year-old groups (Fig. 2). The prevalence rate for those in the 15–34-year-old group was 64.8 per 100,000 individuals in 2002, which then increased to 133.2 per 100,000 individuals in 2009. The rate in the ≥ 65-year-olds also increased, from 69.1 per 100,000 individuals in 2002 to 93.5 per 100,000 individuals in 2013.

The prevalence rate of SP by sex, age, income level, and insurance type are summarized in

Supplement Table 2. To examine the detailed distribution by age, age groups were further subdivided into 5-year increments. The prevalence rate tended to be the highest at 15–19 years, decreased to 40–49 years, and then peaked again at 65–74 years before decreasing again (Supplement fig.1). The prevalence rate was slightly higher in the high-income group, but remained low among medical-assistance recipients, although this rate increased after 2011 to a rate higher than that of health insurance enrollees.

The prevalence rates of SP patients who were hospitalized are shown in Figs. 3 and 4. The rate of hospitalization was 18.3 per 100,000 individuals in 2002, increasing to 36.2 per 100,000 individuals in 2011 before decreasing in 2012. The rate of hospitalization in men was 31.4 per 100,000 individuals in 2002, which increased to 61.0 per 100,000 individuals in 2011. Among women, the hospitalization rate was 5.3 per 100,000 individuals in 2002 and 11.3 per 100,000 in 2011. This rate decreased for both sexes in 2012. The rate tended to increase up to 2012 for men, but there was no consistent trend for females. The male-to-female ratio of hospitalization was 6:1 on average. By age, hospitalization in the 15–34-year age group was the highest at 33–75 per 100,000 individuals, followed by the ≥ 65-year-old group and the 35–64-year-old group. The rate was the lowest for the < 15-year-old group, at 1–3 per 100,000 individuals. The prevalence of hospitalized SP patients among the total population, by age and sex, are shown in Supplement Table 3.

The prevalence rates of SSP ranged from 10.5 to 12.1 per 100,000 individuals, from 8.5 to 9.6 in male and 1.4 to 2.7 in female (Supplement fig. 2).

Hospitalization of SP patients by year

Within the SP patient sample, the proportion of those receiving hospital treatments was defined as the hospitalization treatment rate. The number of patients who used the hospitalization service for SP in 2002 was 188 (47.2%) (Table 2). The rate of hospitalization treatment slowly increased thereafter up to 2010 and then decreased slightly. No sex-related differences in hospitalization treatment rates were observed. However, for age-related differences, the ≥ 65-year-old group had the highest hospitalization treatment rate, while the < 15-year-old group had the lowest rate. In addition, as a result of the logistic regression

analysis model, the hospitalization rate was influenced by sex, age and underlying lung disease (Supplement Table 4).

The frequency and proportion of rehospitalization of SP patients is shown in Supplement Table 5. In total, 3,005 patients used hospital services at least once due to SP between 2002 and 2013. Among these, 1,683 were rehospitalized, with 60.7% of all rehospitalizations occurring within 6 months and 71.4% within 1 year. The average number of hospitalizations per person overall was 1.56, at an average interval of 223.07 days.

Table 2. Rate of hospitalization treatment for spontaneous pneumothorax patients

	Total SP (N)	Total HP (N)	HR (%)*	Sex				Age (years)							
				Male		Female		< 15		15–34		35–64		≥ 65	
				N	HR*	N	HR*	N	HR*	N	HR*	N	HR*	N	HR*
2002	398	188	47.2	161	50.0	27	35.5	4	36.4	111	53.1	43	35.0	30	54.5
2003	490	236	48.2	202	50.0	34	39.5	2	33.3	135	49.1	62	42.2	37	59.7
2004	504	262	52.0	217	52.7	45	48.9	9	40.9	151	54.7	56	42.7	46	61.3
2005	514	276	53.7	235	55.7	41	44.6	3	33.3	161	59.2	74	45.7	38	53.5
2006	518	281	54.2	241	56.8	40	42.6	2	16.7	156	54.7	66	47.5	57	69.5
2007	555	286	51.5	244	51.8	42	50.0	4	36.4	169	56.3	73	44.2	40	50.6
2008	557	296	53.1	270	57.0	26	31.3	3	27.3	183	57.7	62	39.7	48	65.8
2009	610	327	53.6	279	53.8	48	52.7	4	36.4	215	58.0	59	41.3	49	57.6
2010	598	342	57.2	306	59.1	36	45.0	3	21.4	196	59.4	89	50.6	54	69.2
2011	661	364	55.1	307	56.1	57	50.0	3	25.0	208	57.1	82	45.8	71	67.0
2012	623	338	54.3	285	53.6	53	58.2	4	36.4	184	52.9	83	50.3	67	67.7
2013	616	338	54.9	291	55.5	47	51.1	4	30.8	175	55.4	86	51.5	73	60.8

* Hospitalization rate (%) = N / total number of spontaneous pneumothorax patients × 100
SP : spontaneous pneumothorax, HR : Hospitalization rate, HP : Hospitalized patients

Comorbidities in SP patients

Lung-related comorbidities in SP patients by age are shown in Table 3. For the < 15-year-old group, there were no particular comorbidities. COPD was the most common comorbidity, followed by pneumonia and asthma.

Table 3. Comorbidities of spontaneous pneumothorax patients

	15–34 years		35–64 years		≥ 65 years		Total	
	N	%*	N	%†	N	%‡	N	%§
Total	**2,407**		**1,374**		**497**		**4,658**	
COPD	273	11.3	277	20.2	287	57.7	837	18.0
Pneumonia	102	4.2	109	7.9	150	30.2	361	7.8
Interstitial	4	0.2	17	1.2	13	2.6	34	0.7
Lung cancer	11	0.5	72	5.2	67	13.5	150	3.2
Asthma	63	2.6	111	8.1	174	35.0	348	7.5
Lung abscess	1	0.0	8	0.6	0	0.0	9	0.2
CCI								
Mean	0.25		0.69		1.31		0.47	
0	1,823	75.7	708	51.5	173	34.8	2,704	58.1
1	468	19.4	420	30.6	305	61.4	1,193	25.6
2	45	1.9	165	12.0	166	33.4	376	8.1
3 or more	5	0.2	65	4.7	99	19.9	159	3.4

* % = N / 2,407 × 100

†% = N / 1,374 × 100

‡% = N / 496 × 100

§% = N / 4658 × 100

COPD, Chronic Obstructive Pulmonary Disease; CCI, Charlson Comorbidity Index

COPD was more common in the ≥ 65-year-old group than in the younger age groups. Fewer patients among the 15–34-year-old group had asthma than pneumonia. The prevalence of all comorbidities other than lung abscess was the highest in the ≥ 65-year-old group. The lung cancer rate was lower in the 15–34-year-old and 35–64-year-old groups than in the ≥ 65-year-old group.

The average CCI value of SP patients was 0.47 and increased with increasing age. The number of patients with a CCI value of 0 decreased with increasing age, while that of patients with a CCI value of ≥ 3 increased with increasing age.

Treatment period and medical costs of SP patients

There were 4,157 outpatient service users among patients with first-time SP (no use of medical service for SP for 60 days prior) from 2002 to 2013 (Table 4). Among these, 3,035 required follow-up within 60 days of the first onset of SP. Most follow-ups occurred within 30 days. The average number of follow-ups in each time period including the first-time visit was found to be 1.14 days within 7 days, 1.33 days within 14 days, 1.54 days within 30 days, and 1.73 days within 60 days. The average length of time between follow-ups was 11.07 days and the average medical cost per person was $94.5 (106,766 KRW).

Table 4. Outpatient or inpatient treatment period and medical costs of spontaneous pneumothorax

		FU frequency during period		Total FU frequency (Including first visit)			
		Cumulative frequency	Total FU frequency (Within 60 days) Comparative ratio	Mean	SD	min	max
Outpatient FU							
First-time outpatient use	4,157						
Within 7 days		582	19.2	1.14	0.42	1	6
Within 14 days		1,372	45.2	1.33	0.63	1	8
Within 30 days		2,245	74.0	1.54	0.84	1	13
Within 60 days		3,035	100.0	1.73	1.07	1	13
Average follow-up period				11.07	16.55	0	60
Average medical costs (US $)*				94.5	141.5	0.9	2,673.6
Hospitalization FU							
First-time	3,005						

hospitalization use						
Within 7 days	180	30.0	1.06	0.24	1	3
Within 14 days	301	50.1	1.10	0.31	1	3
Within 30 days	451	75.0	1.15	0.40	1	5
Within 60 days	601	100.0	1.20	0.48	1	7
Average number of days of hospitalization			14.19	18.25	0	601
Average follow-up period			3.67	10.67	0	60
Average medical costs (US $)*			2,523.0	2,692.2	45.9	48,967.3

*The cost of items determined to be eligible for reimbursement by the HIRA (Health Insurance Review and Assessment Service) out of the total treatment amount were indicated in the submitted insurance claim statement. It was converted from Korean Won to US dollar, according to the exchange rate on October 12, 2018 (US $1.00 = Korean 1,130 Won).

FU : follow-up; SD: standard deviation; min: minimum; max: maximum

The number of hospitalizations for first cases of SP was 3,005, of which 601 required follow-up within 60 days of discharge. Most follow-ups occurred within 30 days and the proportion of follow-ups occurring in the first week was higher for in-patients than for outpatient service users. The average number of follow-ups was lower for inpatients than for outpatient service users. The average length of hospitalization was 14.19 days. The average follow-up period after discharge was 3.67 days and the average medical costs for each hospitalization were markedly higher than those of outpatients.

Treatment and medication for SP patients

Treatment and medication details are shown in Table 5. The most commonly received non-surgical treatment for SP patients was oxygen inhalation, followed by suction drainage or tracheostomy suction. Thoracostomy was the most common surgical treatment, followed by lung wedge resection. The frequency of other surgical treatments was low. The rate of surgery for SP varied by year, but was estimated at about 40%. It was highest at 47.5% in 2010 and slightly decreased thereafter. By sex, the rate of surgery was higher in males than females (Supplement fig. 3).

Medication commonly prescribed for SP could be categorized into analgesics, antitussives, and antibiotics, when excluding digestants. Among analgesics, paracetamol, codeine combinations, excluding psycholeptics and tramadol as well as paracetamol combinations were prescribed at similar rates. Among antitussives, most prescribed was bromhexine. Among antibiotics, cefixime was the most frequently prescribed.

Table 5. Treatments and drugs used for spontaneous pneumothorax patients

Treatment			Drugs		
	N	%*		N	%†
Total count of prescription statements	**21,107**			**37,488**	
Non-surgical treatments			**Analgesics**		
Oxygen Inhalation	4,351	20.6	Paracetamol	1,039	2.8
Nebulizer Treatment Of Lower Airway	534	2.5	Codeine, combinations excluding psycholeptics	878	2.3
Suction Drainage Or Tracheostomy Suction, Etc.	2,481	11.8	Tramadol and paracetamol	832	2.2
Tracheal Intubation	81	0.4	Propionic acid-derivatives	784	2.1
Surgical treatments			Aceclofenac	455	1.2
Thoracostomy	3,132	14.8	**Antitussives**		
Wedge Resection Of Lung	1,304	6.2	Acetylcysteine	672	1.8
Resection Of Bullae	125	0.6	Xanthines	635	1.7
Pleurodesis	27	0.1	Bromhexine	789	2.1
Apicolysis, Pleurolysis	15	0.1	Ambroxol	553	1.5
Lobectomy Of Lung	13	0.1	**Antibiotics**		
Pleurectomy	12	0.1	Cefixime	374	1.0
Segmentectomy Of Lung	10	0.0	Third-generation cephalosporins	305	0.8

Pleural Decortication	8	0.0
Primary Thoracoplasty	4	0.0

*% = N / 21,107

†% = N / 37,488

DISCUSSION

In this large study in Korea, the annual prevalence rate of SP was 39–66 per 100,000 individuals. These numbers were slightly higher than those previously reported: 1.2–7.4 per 100,000 individuals in Minnesota [5] and 9.8–24 per 100,000 individuals in the United Kingdom.[6] The reason for these differences may be because SP was defined as cases in which medical service was used, which could include follow-up appointments, rather than the strict number of incidents. In contrast, the prevalence rate of hospitalization due to SP was 18–36 per 100,000 individuals overall. These rates were previously reported as 14.3–22.7 per 100,000 individuals overall,[7, 8] and are similar to those found in our study. The similarity may be because hospitalization was as a result of new SP incidents only. In addition, the prevalence rate of SP consistently increased from 2002 to 2011 and decreased slightly thereafter. This is consistent with previous a study that showed increased prevalence of SP.[25] Though the cause of increased SP can be presumed to be atmospheric conditions; however, the increase in other underlying lung diseases such as COPD or lung cancer still remains controversial. In this study, there was no significant change in the prevalence rate of SSP by year, which implies that PSP was increased. Further study is therefore needed.[26-28]

The prevalence rate was much higher for males than in previous studies. The male-to-female ratio for all SP and for hospitalized SP was higher than that reported previously (2.4:1–3.3:1).[6, 8, 9] In terms of age, the prevalence rate was the highest for the 15–34-year-old group, particularly for the 15–19-year-old group, followed by the ≥ 65-year-old, 35–64-year-old, and < 15-year-old group, respectively. Previous studies showed a peak-age for SP at 20, followed by a later peak at 70.[8, 29] Overall, the incidence of SP was higher in Korea, particularly in males and at a slightly earlier age (15–19 years) than in other countries: e.g., 20–25 years in France [7] and Germany,[8] and 20–24 years or 30–34 years in England.[6] The prevalence of SP in males increased until 2012, while there was no clear trend in females. Since there was no previous large-scale research in Eastern countries, we cannot conclude whether these results are due to ethnicity or environment. In addition, the choice of terms between ‘prevalence’ and ‘incidence’ was one of the challenges of this study. It was determined to use ‘prevalence’ because there were several previous studies that reported ‘prevalence’ and this study was based on the occurrence of

within the period of a year.

SP has a high rate of hospitalization;[30] 47–57% of SP patients in our study received hospital treatment. There were no marked differences due to sex, although the female hospitalization rate was slightly lower. The hospitalization rate was highest in the ≥ 65-year-old group and lowest in the < 15-year-old group. The necessity of hospitalization for SP is debated. Hallifax and Rahman stated in 2015 that outpatient treatment is sufficient for patients who are young, have no comorbidities, and have stable vital signs; however, the evidence of outpatient treatment stability is lacking.[10]

SP has a high rate of relapse;[24, 25, 31] with 1,683 of 3,003 first-time hospitalization cases requiring rehospitalization in our study. Although previous studies have shown that the relapse rate of SP is 15–40%,[7, 11, 12, 25, 32] these studies were based on small sample sizes (82–273 subjects). [7, 11, 12, 25, 32] Though there was a large-scale study, only hospitalized patients were analyzed.[25] The risk factors for SP relapse are controversial; some studies indicate that elderly people and women are at higher risk,[7, 33] while other studies indicate that age and sex have no significant effect.[34] Furthermore, low BMI [12, 35], non-surgical treatment and smoking habits [12, 34] have been implicated in SP, yet further study is required to delineate the risk factors.

SP can involve lung-related comorbidities.[36, 37] To distinguish between PSP and SSP, it is important to evaluate comorbidities. This distinction is important, as these conditions have different characteristics and prognoses;[23, 38] however, categorizing these conditions based on administrative data remains challenging.[19] This is because there are no codes to differentiate between PSP and SSP in the ICD categorizations. Nevertheless, our objective was to describe details related to SP; thus, we examined the current comorbidity status, rather than attempting to categorize SP patients. Among comorbidities, COPD was the most common in all age groups. With increasing age, the proportion of patients with comorbidities increased; thus, with increasing age, SSP was more common than PSP. Therefore, the decrease in SP risk with age, followed by an increase, may be due to an increase in SSP in particular.

The approximate treatment period for SP was 11 days for outpatients and 17.7 days for

hospitalized patients. The average number of follow-ups within 60 days was 1.73. Thus, many cases of SP were minor and a single outpatient visit is necessary to complete the treatment. For both hospitalization and outpatient service users, 75% of total follow-ups occurred within 1 month; hence, the follow-up duration for SP is short. Few studies have assessed the treatment or follow-up duration for SP, yet our results are similar to a previous study reporting a remission period of 7–15 days for SP,[23, 39]. X-ray follow-up is recommended within 2–4 weeks of discharge [35] and the median value of length of stay (LOS) is 6–7 days.[7, 33] No previous study has reported the socioeconomic costs due to SP; in our study, we found an average medical cost of $94.50 per person for outpatient services and of $2,523.00 per person for hospitalization. The maximum costs were $2,673.60 per person for outpatient and $48,967.30 per person for hospitalization.

For treatment, surgery, and medication for SP patients, we reported the frequency of prescriptions rather than the number of people. Oxygen inhalation among non-surgical treatments and thoracostomy among surgical treatments were the most common procedures. A previous study has also shown that the most common treatment for SP patients is thoracostomy (92% of patients).[32] The surgery most commonly performed after thoracostomy is lung wedge resection; this involves removing a portion of the lung and is less invasive, preserves more lung function, and has fewer side-effects than lobar resection.[40, 41] The rate of surgery showed a mild tendency to increase until 2010 and then decreased slightly thereafter. It was not possible to confirm whether this was due to the severity of SP or the medical practice tendency in Korea. For medication; analgesics, antitussives, and antibiotics were the most frequently prescribed, after excluding digestants. For convenience of analysis, we excluded outpatient prescriptions. Considering that the rate of hospitalization exceeded 60% for SP patients, prescription patterns are not likely to differ markedly between hospitalized and overall cases.

This study has several limitations. First, we could not distinguish between PSP and SSP because of the limitations of the data. Accordingly, it was also impossible to present each treatment methods. According to a study analyzing the first line treatment and management of PSPs and SPSs, there are differences with PSPs and SSPs in management methods[15]. Further research is needed on the epidemiology and medical service use of each SP category. Secondly, our results should be interpreted with caution, as we could not ascertain whether medical service use was

due to new incidents of SP or to follow-up. That is, rehospitalizations with the same episodes and recurrence 60 days before the last treatment were not detected. Although we attempted to select medical service use due to new incidents of SP by using an operational definition, this may not have been accurate. Thirdly, our study may be limited by the lack of data on uncovered items and from patients who were not covered by health insurance. However, in Korea, because 98% of the total population is covered by health insurance, it seems to be the entire population data. Existence of uncovered items or indirect medical costs was a limitation in this study. In addition, as the diagnosis codes in the claim's data that was the basis for identifying the patients may not be completely accurate [42], it is not clear whether all patients with SP were listed under the appropriate corresponding diagnosis codes. Lastly, since analysis was performed using NHI data from 2002, there is a possibility of misclassification of new-onset SP due to SP patients who ever suffered from SP before 2012.

However, despite these limitations, this study provided a detailed record of the epidemiology and treatment of SP. Our study is significant in that it provides novel information, contributing to an understanding of SP, a little-understood condition with an increasing prevalence in Korea.

CONCLUSION

This study demonstrated the increasing prevalence of SP, higher prevalence of SP in men, and earlier peak age of SP patients in Korea, and also defined the medical service use characteristics of patients with SP in Korea. These findings can contribute to the understanding of SP.

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Author contributions

IHH and YJL contributed to the overall conception and design of the study protocol. BJ and DK contributed to the specific study design and data analysis. DK wrote the first draft of the manuscript. BHJ and SHC contributed to interpretation of the analyses and revisions of the final manuscript. All authors gave final approval of the version to be submitted.

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Competing interest

No competing interests to declare.

Ethics approval

The study was approved by the Institutional Review Board of Jaseng Hospital of Korean Medicine in Seoul, Korea (JASENG 2018-09-007).

Data sharing statement

The datasets generated and analyzed during the current study are available on the National Health Insurance Sharing Service. NHIS provides support to research activities in various sectors of society, the economy, environment, industry, etc., as well as policy and academic research on the health sector by providing sample cohort databases. The research database consists of five types of databases: a sample cohort database, medical check-up cohort database, elderly cohort database, working women cohort database, and infant medical check-up cohort database. Each

cohort database consists of the following four detailed data-sets: qualification database, treatment database, medical check-up database, and clinic database.

The present study utilized the sample cohort database, which is a third-party data not owned by the authors. The sample cohort database is available upon approval for data sharing, from the health insurance corporation. For the purpose of policy and academic research a fee is paid to obtain data from the NHIS website [https://nhiss.nhis.or.kr/bd/ab/bdaba022eng.do].

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Figure legends

Fig. 1. Annual prevalence rate of spontaneous pneumothorax, by sex (per 100,000 individuals).

Fig. 2. Annual prevalence rate of spontaneous pneumothorax, by age (per 100,000 individuals).

Fig. 3. Annual prevalence rate of hospitalization due to spontaneous pneumothorax, by sex (per 100,000 individuals).

Fig. 4. Annual prevalence rate of hospitalization due to spontaneous pneumothorax, by age (per 100,000 individuals).

Supplement fig. 1. Prevalence rate of spontaneous pneumothorax by age (per 100,000 individuals).

Supplement fig. 2. Annual prevalence rate of secondary spontaneous pneumothorax, by sex (per 100,000 individuals)

Supplement fig. 3. Annual rate of surgery due to spontaneous pneumothorax, by sex (per 100,000 individuals)

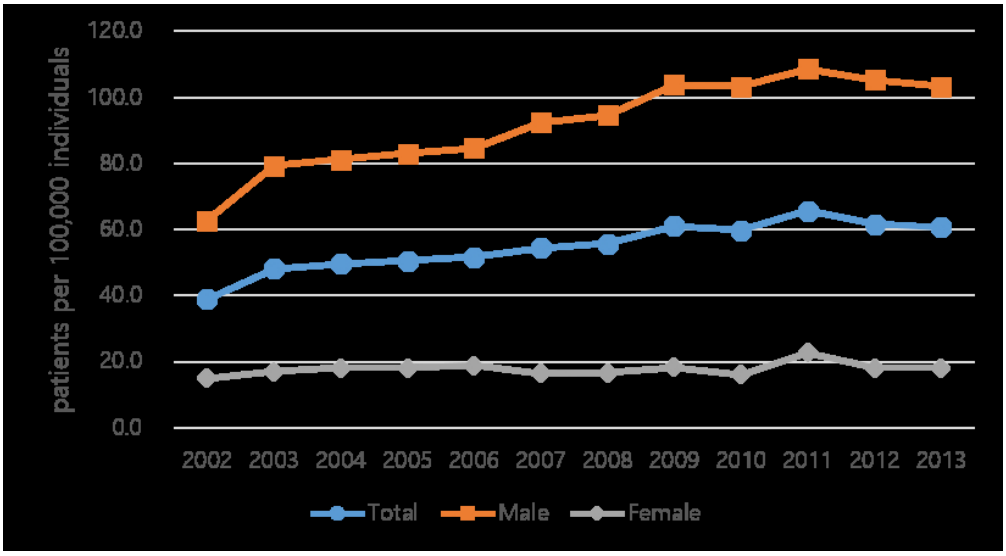

fig1

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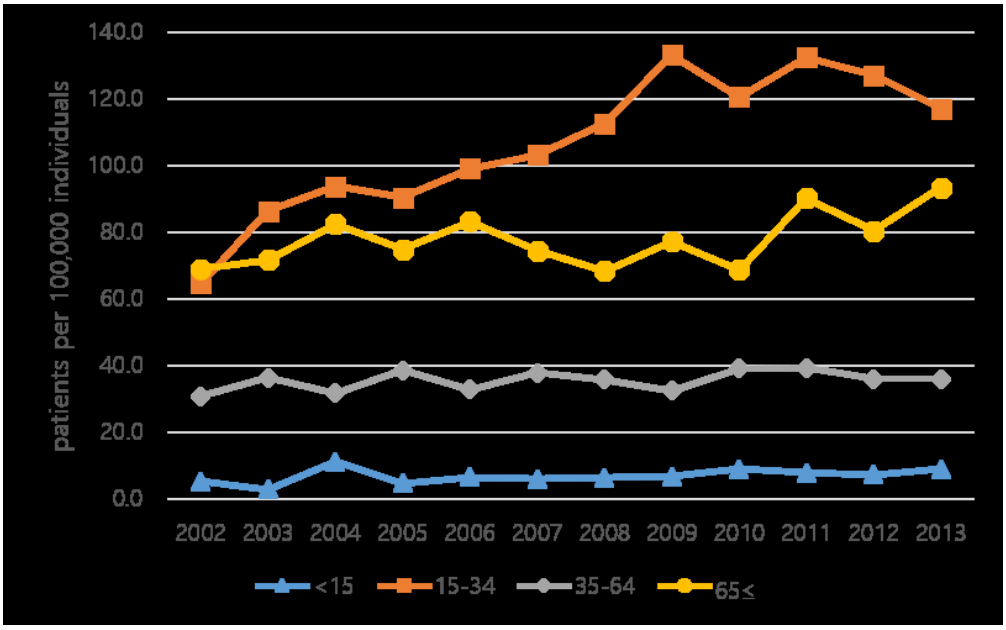

fig2

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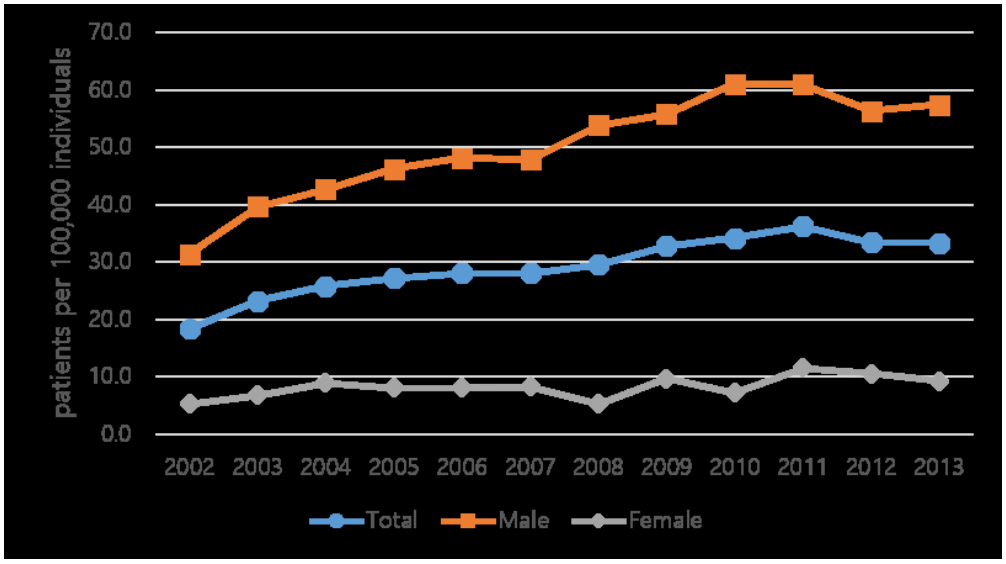

fig3

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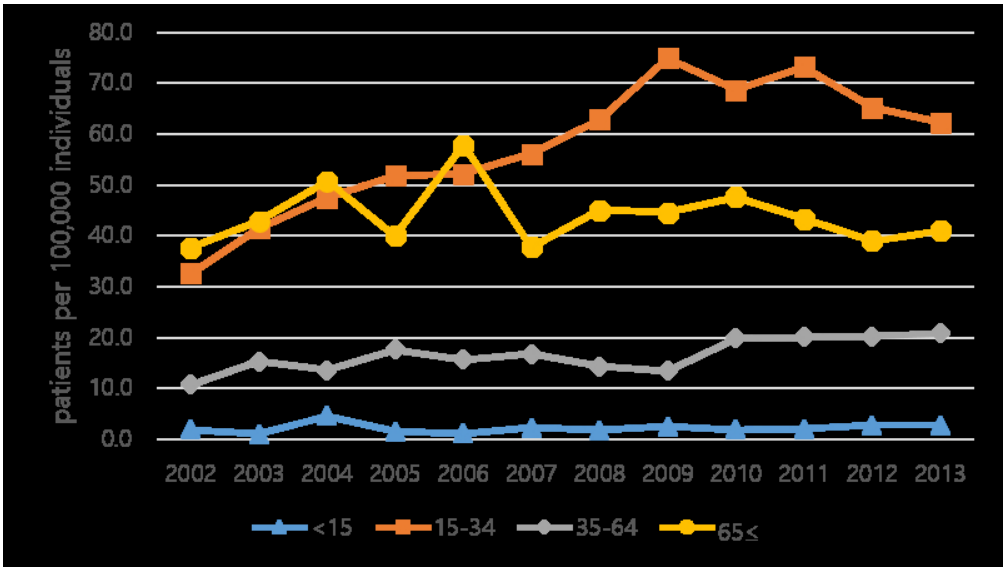


fig4

67x38mm (300 x 300 DPI)

Supplement Table 1. ICD-10 codes of comorbidities in spontaneous pneumothorax

Disease	Code
COPD	J40*, J41*, J42*, J43*, J44*, J961, J982
Pneumonia	J12*, J13*, J14*, J15*, J16*, J18*
Interstitial lung disease	J84*
Lung cancer	C34*, C780*, C783, D022-D024, D143*, D174, D381
Asthma	J45*
Lung abscess	J850, J851, J852

ICD-10, International Statistical Classification of Disease and Related Health Problems, 10th revision; COPD, Chronic Obstructive Pulmonary Disease

Supplement Table 2. Prevalence rate of spontaneous pneumothorax per 100,000 individuals and sociodemographic characteristics

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.
Total SP Patients	398	38.8	490	48.2	504	49.6	514	50.5	518	51.7	555	54.4	557	55.7	610	61.1	598	59.7	661	65.7	623	61.6	616	60.7
Sex																								
Male	322	62.7	404	79.3	412	81.1	422	83.0	424	84.7	471	92.4	474	94.6	519	103.9	518	103.3	547	108.7	532	105.2	524	103.3
Female	76	14.8	86	16.9	92	18.1	92	18.1	94	18.8	84	16.4	83	16.6	91	18.2	80	16.0	114	22.7	91	18.0	92	18.1
Age																								
< 15	11	5.3	6	3.0	22	11.2	9	4.7	12	6.6	11	6.2	11	6.5	11	6.8	14	9.0	12	7.9	11	7.5	13	9.1
15–34	220	64.8	281	86.3	298	93.9	281	90.4	297	99.3	311	103.2	328	112.6	382	133.2	344	120.6	376	132.4	359	127.2	329	117.1
35–64	123	30.9	147	36.4	131	31.8	162	38.6	139	32.9	165	37.9	156	35.9	143	32.5	176	39.3	179	39.4	165	36.0	167	36.1
≥ 65	55	69.1	62	71.7	75	82.6	71	74.8	82	83.2	79	74.6	73	68.4	85	77.3	78	68.8	106	90.3	99	80.5	120	93.5
Sub-divided Age																								
< 15	11	5.3	6	3.0	22	11.2	9	4.7	12	6.6	11	6.2	11	6.5	11	6.8	14	9.0	12	7.9	11	7.5	13	9.1
15–19	81	114.7	96	143.2	110	165.5	106	160.4	111	166.2	140	200.4	162	231.4	193	270.2	179	245.2	184	254.0	156	218.9	153	220.2
20–24	54	63.7	91	109.1	71	89.2	66	86.9	73	104.6	71	104.9	58	91.3	77	122.8	77	123.2	92	142.8	105	156.8	93	134.6
25–29	41	47.6	50	62.6	55	70.0	55	69.6	66	84.0	63	77.6	58	72.1	60	78.0	45	61.3	46	66.4	50	76.5	44	70.1
30–34	33	33.6	38	39.9	40	43.1	45	50.2	35	41.6	26	31.4	39	50.5	41	54.1	29	38.0	42	53.9	37	47.1	26	32.7
35–39	23	25.7	30	33.1	28	30.5	39	42.1	32	34.4	34	35.9	30	32.7	26	29.0	41	47.3	31	37.3	34	42.4	33	43.2
40–44	19	20.0	23	24.6	21	22.9	26	28.9	18	20.9	23	26.6	21	24.2	28	31.7	24	26.8	30	32.9	26	28.3	25	27.5
45–49	26	35.4	22	28.4	21	25.7	26	30.5	20	22.7	30	32.9	32	35.8	24	27.3	24	27.8	29	34.5	15	18.0	28	32.6
50–54	13	24.2	23	42.4	22	38.8	19	30.8	21	31.7	26	36.9	26	35.5	23	29.6	26	32.0	33	38.6	35	40.0	25	28.4
55–59	21	48.4	25	55.9	18	38.9	25	51.5	26	53.7	23	44.8	26	50.9	21	39.3	32	54.6	29	45.4	27	40.2	31	43.3
60–64	21	48.7	24	55.1	21	48.8	27	64.2	22	54.0	29	70.6	21	50.3	21	48.5	29	63.5	27	58.4	28	57.8	25	50.5
65–69	23	71.1	22	64.3	30	84.4	34	93.9	30	80.6	32	79.4	25	62.9	24	61.2	26	67.3	32	83.8	28	73.3	30	75.4
70–74	16	74.4	19	82.4	21	85.7	15	57.0	25	90.1	25	85.1	24	80.2	33	105.6	14	43.6	22	65.5	12	33.2	27	73.2
≥ 75	16	62.1	21	72.0	24	78.1	22	68.0	27	80.4	22	60.8	24	64.9	28	70.9	38	89.1	52	114.0	59	121.2	63	121.8
Income																								
Low (0–3)	71	31.1	99	43.9	116	51.3	129	54.8	92	39.7	125	52.0	116	48.4	127	54.4	117	48.8	163	67.3	150	68.1	170	70.3
Medium (4–7)	164	40.9	194	49.3	188	48.2	190	49.4	212	56.0	206	53.8	213	57.3	229	61.8	213	58.0	237	64.7	190	54.2	196	53.3

High (8–10)	163	41.1	197	49.5	200	50.0	195	49.2	214	54.6	224	56.3	228	58.5	254	64.4	268	67.8	261	65.5	283	64.2	250	61.7
Insurance type																								
Region	200	40.2	236	49.8	206	45.8	221	52.5	201	52.0	214	56.4	203	56.2	213	61.3	200	59.8	207	64.4	179	57.4	161	53.8
Employment	195	39.3	252	49.2	292	54.7	285	51.1	315	54.6	336	55.8	346	57.6	390	63.3	396	62.6	419	64.4	414	62.0	415	60.5
Medical Assistance	3	9.8	2	6.3	6	18.1	8	21.1	2	5.1	5	12.7	8	20.5	7	19.8	2	5.7	35	103.7	30	95.8	40	132.9

Prev., Prevalence Rate

Supplement Table 3. Annual prevalence rate of hospitalization due to spontaneous pneumothorax (per 100,000 individuals)

Hospitalization				Sex						Age (years)											
				Male			Female			< 15			15–34			35–64			≥ 65		
Year	N	Prev.*	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†
2002	188	18.3		161	31.4		27	5.3		4	1.9		111	32.7		43	10.8		30	37.7	
2003	236	23.2	26.5	202	39.7	26.5	34	6.7	26.9	2	1.0	-48.4	135	41.5	26.9	62	15.3	42.0	37	42.8	13.7
2004	262	25.8	11.1	217	42.7	7.6	45	8.9	32.3	9	4.6	360.9	151	47.6	14.7	56	13.6	-11.3	46	50.7	18.3
2005	276	27.1	5.3	235	46.2	8.3	41	8.1	-8.9	3	1.6	-65.7	161	51.8	8.9	74	17.6	29.6	38	40.1	-20.9
2006	281	28.0	3.3	241	48.1	4.1	40	8.0	-1.0	2	1.1	-29.8	156	52.1	0.6	66	15.6	-11.3	57	57.8	44.4
2007	286	28.0	-0.1	244	47.8	-0.6	42	8.2	3.0	4	2.2	103.9	169	56.1	7.5	73	16.8	7.4	40	37.8	-34.7
2008	296	29.6	5.6	270	53.9	12.6	26	5.2	-36.7	3	1.8	-20.7	183	62.8	12.1	62	14.3	-14.9	48	45.0	19.1
2009	327	32.7	10.7	279	55.8	3.6	48	9.6	85.0	4	2.5	39.3	215	74.9	19.3	59	13.4	-6.1	49	44.5	-1.0
2010	342	34.1	4.2	306	61.0	9.3	36	7.2	-25.3	3	1.9	-22.0	196	68.7	-8.3	89	19.9	48.2	54	47.6	6.9
2011	364	36.2	6.0	307	61.0	-0.1	57	11.3	57.6	3	2.0	2.7	208	73.3	6.6	82	20.1	1.2	71	43.4	-8.9
2012	338	33.4	-7.6	285	56.4	-7.6	53	10.5	-7.5	4	2.7	36.7	184	65.2	-11.0	83	20.2	0.7	67	39.1	-9.9
2013	338	33.3	-0.4	291	57.4	1.8	47	9.3	-11.7	4	2.8	2.8	175	62.3	-4.5	86	20.8	3.0	73	41.0	5.0

Prev., *Prevalence rate: rate of prevalence per 100,000 individuals.

Grow., †Growth rate (%) = (Current Year *100) / Previous Year) - 100

Supplement Table 4. Logistic regression analysis of factors affecting hospitalization rate in spontaneous pneumothorax patients

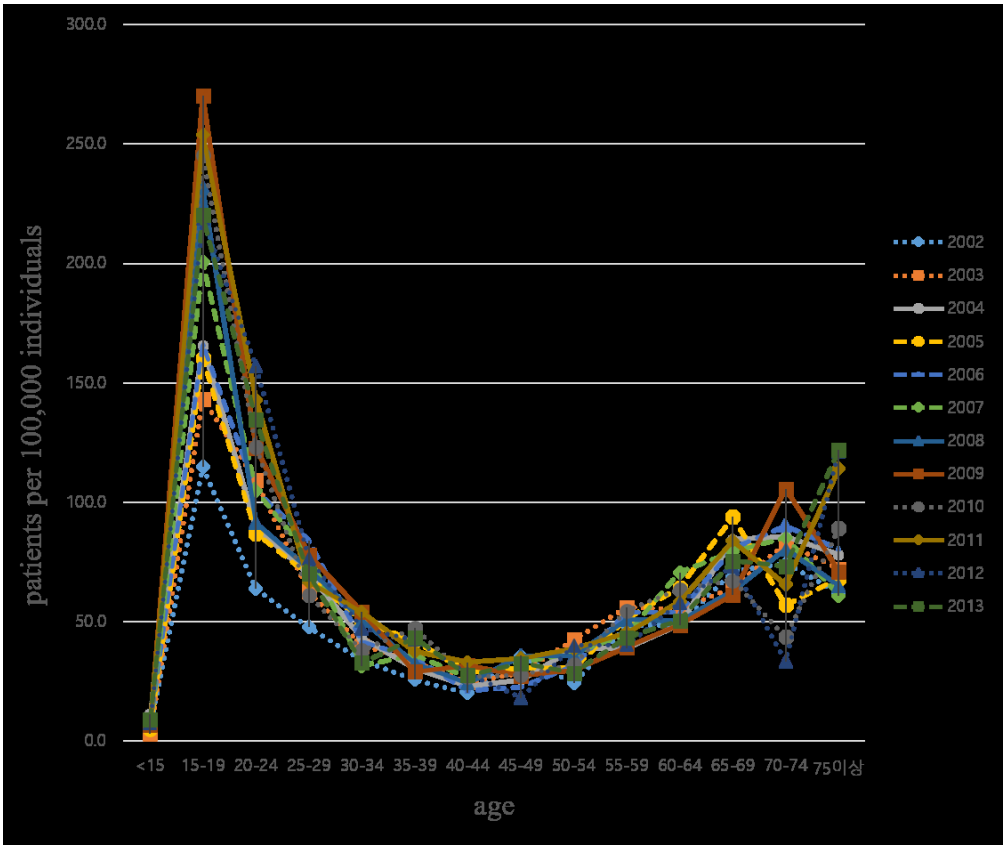
	Hospitalization			
Characteristics	Unadjusted OR	95% CI	Adjusted OR[b]	95% CI
Sex				
M	1.39	(1.23, 1.57)	1.40	(1.24, 1.59)
F	1.0[a]	-	1.0[a]	-
Age				
< 15	0.19	(0.10, 0.38)	0.20	(0.10, 0.40)
15–34	1.52	(1.37, 1.69)	1.48	(1.32, 1.64)
35–64	1.0[a]	-	1.0[a]	-
≥ 65	1.74	(1.52, 1.99)	1.73	(1.51, 1.98)
Income range				
Low (0–3)	1.0[a]	-	1.0[a]	-
Medium (4–7)	0.98	(0.86, 1.11)	0.97	(0.86, 1.10)
High (8–10)	0.97	(0.86, 1.09)	0.95	(0.84, 1.07)
Insurance Type				
Region	1.0[a]	-	1.0[a]	-
Job	1.00	(0.91, 1.10)	0.99	(0.90, 1.09)
Medical	1.60	(1.17, 2.19)	1.57	(1.15, 2.15)
Assistance				
Comorbidities				
(ref. none)				
COPD	2.34	(2.02, 2.72)	2.38	(2.04, 2.77)
Pneumonia	2.05	(1.66, 2.55)	2.08	(1.67, 2.59)
Interstitial	3.77	(1.66, 8.59)	3.87	(1.69, 8.84)
Lung cancer	2.14	(1.53, 2.99)	2.16	(1.54, 3.04)
Asthma	2.03	(1.63, 2.52)	2.08	(1.67, 2.60)
Lung abscess	1.09	(0.29, 4.07)	1.02	(0.27, 3.79)

OR; odds raio, CI; confidence intervals; M, male; F, female; COPD, chronic obstructive pulmonary disease
a; reference group, b: adjusted for age and sex

Supplement Table 5. Rehospitalization of spontaneous pneumothorax patients

Rehospitalization (within)	Number of rehospitalizations		Number of hospitalizations per person			
	N*	Cumulative %	Mean	SD	Minimum	Maximum
6 months	1,022	60.7	1.34	0.70	1	10
1 year	1,202	71.4	1.40	0.80	1	12
2 years	1,412	83.9	1.47	0.94	1	19
Total	1,683	100.0	1.56	1.07	1	19
Interval between hospitalizations			223.07	445.3	0	3,989

*N = Cumulative frequency; SD, standard deviation



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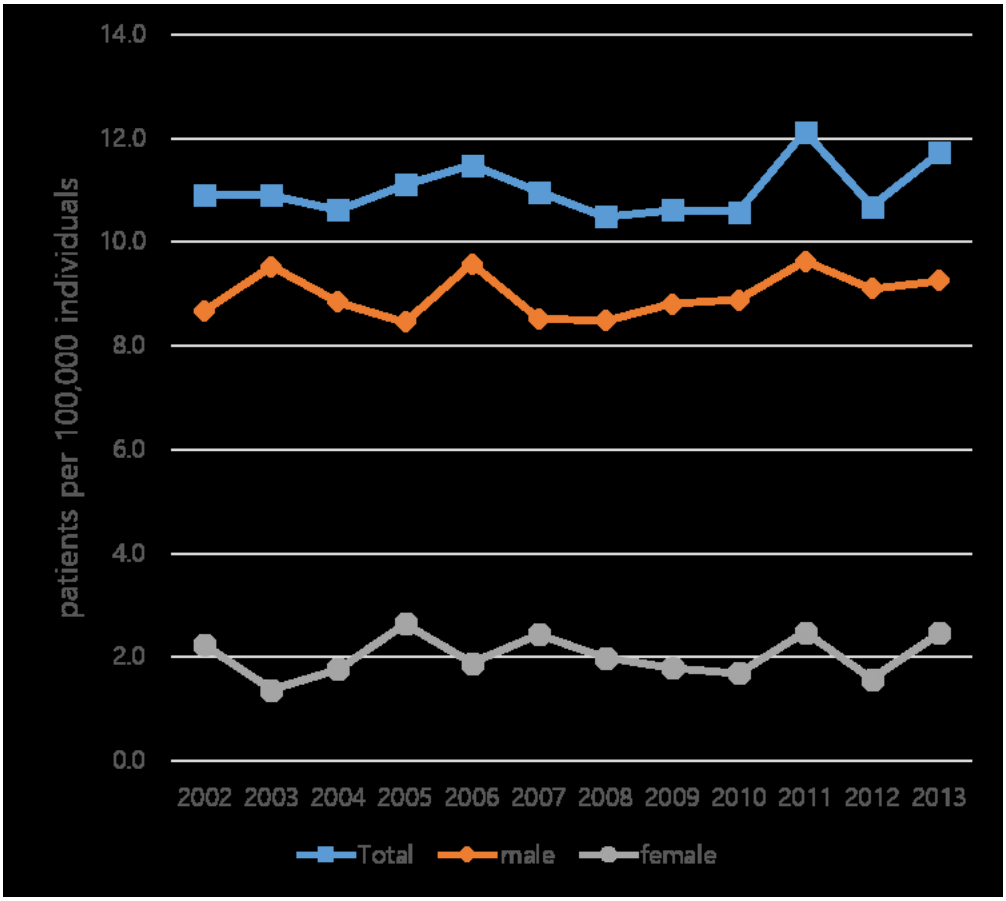

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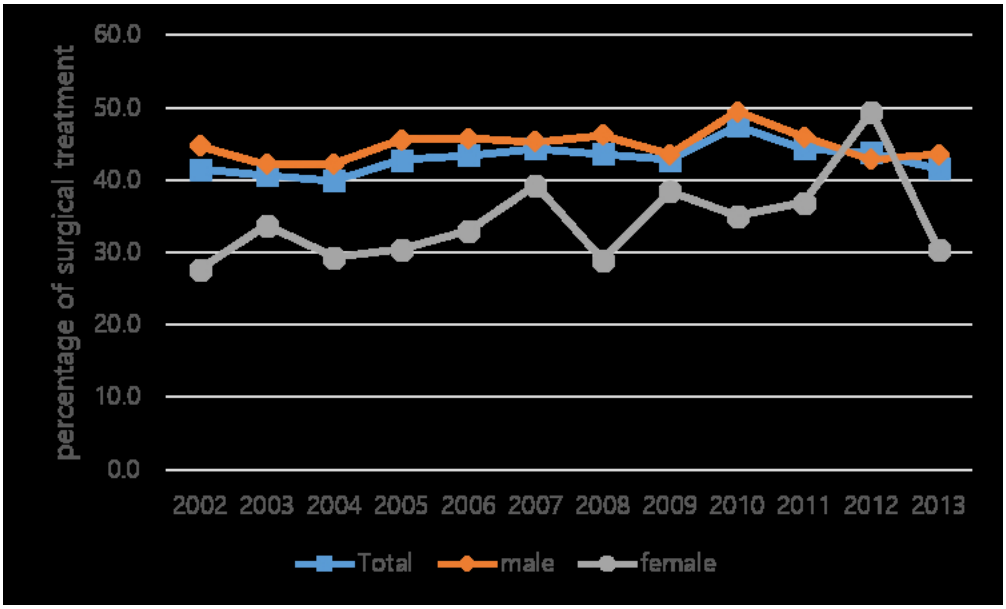

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63x38mm (300 x 300 DPI)

The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	(a) P1L1(title), P2L5(abstract) (b) P2L1-P2L1	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	1.1 P1L2(title), P2L6(abstract) 1.2 P1L2(title), P2L8(abstract) 1.3 There is no linkage between databases
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	P4L9-L19		
Objectives	3	State specific objectives, including any prespecified hypotheses	P4L20-L24		
Methods					
Study Design	4	Present key elements of study design early in the paper	P5L2-L11		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5L12-L20		

Participants	6	*(a) Cohort study* - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	(a)P5L12-L20 (b)This is no matched studies	RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	6.1 P5L2-L11, P5L12-17 6.2 P5L2-L11, P5L12-17 6.3 There is no linkage between databases
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	P5L21-P9L3	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	In this study, only J93 patients were considered out of the data of the entire population from the start, and no confounders. Explanations of other outcomes are in P5L21-P9L3.
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement).	P5L21-P9L3		

		Describe comparability of assessment methods if there is more than one group			
Bias	9	Describe any efforts to address potential sources of bias	P5L7-L11		
Study size	10	Explain how the study size was arrived at	P5L2-L11		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	P5L25-P6L2 P6L27-L28		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses	P8L21-P9L3		
Data access and cleaning methods		..		RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population.	12.1 P5L2-L11 12.2 P9L2

				RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	none
Results					
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	P9L9, Table 1 In this study, only J93 patients were considered out of the data of the entire population from the start, Thus, it was quite difficult for us to draw a flowchart.	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	In this study, only J93 patients were considered out of the data of the entire population from the start, Thus, it was quite difficult for us to draw a flowchart.
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)	(a)P9L10 (b)none missing data		
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time	P10L2-P19L3		

		Case-control study - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures			
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	This is descriptive study, so it is not applicable		
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses			
Discussion					
Key results	18	Summarise key results with reference to study objectives	P21L2, P22L1, P22L8, P22L26,		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P23L21-P24L8	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Not applicable

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P23L25-L30		
Generalisability	21	Discuss the generalisability (external validity) of the study results	P24L9-L11		
Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P25L8-L10		
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	P25L16-P26L6

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

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Epidemiology and Medical Service Use for Spontaneous Pneumothorax: A 12-year Study Using Nationwide Cohort Data in Korea

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Epidemiology and Medical Service Use for Spontaneous Pneumothorax: A 12-year Study Using Nationwide Cohort Data in Korea

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ABSTRACT

Objectives: This study aimed to promote an understanding of spontaneous pneumothorax by analyzing the prevalence rate and medical service use by patients with spontaneous pneumothorax according to sociodemographic characteristics.

Design: A 12-year nationwide study.

Setting: Data obtained from the Korean National Health Insurance Service Sharing Service.

Participants*:* A total of 4658 participants who used medical services due to spontaneous pneumothorax between 2002 and 2013 in Korea.

Outcome measures: For those diagnosed with spontaneous pneumothorax, the use of medical services, hospitalization data, sociodemographics, co-morbidity, treatment administered, and medication prescribed were recorded.

Results: The annual prevalence of spontaneous pneumothorax ranged from 39 to 66 per 100,000 individuals, while the prevalence of hospitalization due to spontaneous pneumothorax ranged from 18 to 36 per 100,000 individuals. The prevalence rate of spontaneous pneumothorax in Korea has increased since 2002. The male-to-female ratio was approximately 4–10:1, with a higher prevalence rate in males. By age, the 15–34-year-old group, and particularly 15–19-year-olds, showed the highest prevalence rate; the rate then declined before increasing again for those aged 65 years or older. In total, 47–57% of spontaneous pneumothorax patients underwent hospitalization. The average number of rehospitalizations due to pneumothorax was 1.56 per person, and more than 70% of recurrences occurred within 1 year. Chronic obstructive pulmonary disease (COPD) was the most common comorbidity. The average treatment period was 11 days as an outpatient and 14 days in-hospital. The average medical costs were $94.50 for outpatients and $2523 for hospital admissions. The most common treatment for spontaneous pneumothorax was oxygen inhalation and thoracostomy, and the most commonly prescribed medications were analgesics, antitussives, and antibiotics.

Conclusions: We here detailed the epidemiology and treatments for spontaneous

pneumothorax in Korea. This information can contribute to the understanding of spontaneous pneumothorax.

Keywords: Epidemiology, Longitudinal cohort, National Health Insurance Service-Sample Cohort Database (NHIS-SCD); Prevalence; Primary Spontaneous Pneumothorax

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Large-scale, long-term (12 years) follow-up data sets, representing the Korean population, were analyzed.
- Not only the inpatient costs but also the outpatient costs of spontaneous pneumothorax treatment were calculated.
- Data on detailed medical-service use, such as medication, procedures, surgery undertaken due to spontaneous pneumothorax, were recorded and analyzed.
- Due to a lack of relevant information in the claims data (for example, medical treatments are not necessarily covered by insurance), not all relevant treatments data could be considered.
- This study could not distinguish whether medical service use was due to new occurrences or follow-up of existing spontaneous pneumothorax.

INTRODUCTION

The pulmonary system is important because it plays a crucial role in the oxygenation of the blood.[1] In pneumothorax, air or gas pools in the inter-pleural cavity,[2] leading to lung collapse and impaired pulmonary function.[3] Pneumothorax is categorized into spontaneous pneumothorax (SP) or traumatic pneumothorax, depending on etiology, and SP is subcategorized into primary spontaneous pneumothorax (PSP), occurring in the absence of underlying lung-related comorbidities, and secondary spontaneous pneumothorax (SSP), occurring in the presence of underlying lung-related comorbidities.[4]

The prevalence rate of SP per 100,000 individuals reportedly ranges from 1.2 to 9.8 in women to 7.4 to 24.0 in men; the prevalence rate of hospitalized SP per 100,000 individuals is about 17 to 22 in men, 6 to 7 in women, and 14 to 23 overall.[5-9] Although SP has a relatively low prevalence rate, it is clinically important,[10] as relapse rates are high (20–40%, depending on duration);[7, 11, 12] hospitalization is often required influencing work productivity. Furthermore, pneumothorax patients may be at high risk of stress.[13]

However, there is a paucity of research on SP.[14] There is a lack of knowledge about the modalities of management and the treatments of SP.[15] Given its low prevalence rate, large-scale research at a national scale is needed to evaluate the epidemiology of SP. Although large-scale studies have been performed in the UK, France, and Germany, these have provided limited epidemiological information.[6-8]

Thus, we aimed to determine the prevalence rate of SP and medical service use of patients treated for SP, according to sociodemographic characteristics, by implementing the National Sample Cohort (NSC) data from the National Health Insurance Service (NHIS) of Korea, to reformulate a more accurate understanding of the prevalence, treatment, and management of SP in Korea.

METHODS

Database

Twelve years of NHIS-NSC data (for the period 2002–2013) were analyzed. The National Health Insurance (NHI) system in Korea is a single-payer system to which 98% of citizens belong. Under this system, a medical provider requests reimbursement from a third-person payer (the NHIS) when a patient uses a medical service.[16, 17] The NHIS-NSC is a population-based cohort built by the NHIS. In 2002, a cohort was extracted by systematic stratified random sampling from a pool of 47,851,928 individuals, excluding those who were not enrolled in the NHI (income level of 0) and foreigners.[18] The cohort comprised of 1,476 levels, based on sex, age, and income. Finally, 2.2% of this pool (1,025,340 individuals) were extracted and data from newborns were added each year to maintain the sample size.[18]

Study population and sampling

Our study was performed on 4,658 patients diagnosed with SP in the 12 years between January 2002 and December 2013 in Korea. SP patients were defined as those who used a medical service at least once for main or secondary diseases with the International Statistical Classification of Disease and Related Health Problems, 10th revision (ICD-10) J93.0 (Spontaneous tension pneumothorax), J93.1 (Other spontaneous pneumothorax), J93.8 (Other pneumothorax), or J93.9 (Pneumothorax, unspecified). S27 (Injury of other and unspecified intrathoracic organs) and S27.0X (Traumatic pneumothorax) were excluded because this analysis was only for SP patients.

Main descriptive variables

Prevalence rate of SP

For each year, the frequency per 100,000 individuals and the frequency of patients who used medical services at least once for SP as the major or secondary diagnosis were determined. Sociodemographic characteristics are shown by sex, age, income level, and insurance type. Based on previous studies,[6, 8] age was subdivided as follows: < 15, 15–34, 35–64, and ≥

65 years. Income level was divided into low (0, 1, 2, or 3 out of 0–10), medium (4, 5, 6, or 7), or high (8, 9, or 10). Insurance type was divided into region-based enrollee, job-based enrollee, and medical assistance recipient.

For each year, the prevalence of SP per 100,000 individuals and the frequency of patients who were hospitalized due to SP were analyzed. In addition, prevalence rate of SSP was analyzed. SSP was operationally defined as SP patients with a diagnosis of underlying lung disease such as COPD, pneumonia, interstitial lung disease, lung cancer, asthma, and lung abscess within a year before the first date of SP onset. Patients who used hospitalization services at least once were counted; two or more hospitalizations were not counted more than once. The hospitalization rate among pneumothorax patients was calculated using the same standards: the denominator was the number of patients who used medical services at least once due to SP in a given year, by sex and age, and the numerator was the number of patients who used hospitalization services at least once.

Hospitalization of SP patients by year

Frequency of rehospitalization due to SP is shown by time period. The ratios of the total rehospitalization number to rehospitalization in a specific time period are also shown. The number of rehospitalizations counted all hospitalizations (other than the first-time) and allowed for duplication for each patient. To calculate the number of hospitalizations per person, the average, standard deviation (SD), minimum and maximum number of hospitalizations per time period were calculated. For the number of hospitalizations per person, first-time hospitalizations were also included. The interval between hospitalizations was calculated as the interval between the dates of two admissions.

Comorbidities in SP patients

Diseases were counted as comorbidities if they were diagnosed as the major or secondary disease within 1 year before the first date of SP onset. The number of patients who were given codes for frequent comorbidities, i.e., COPD, pneumonia, interstitial lung disease, lung cancer, asthma, and lung abscess, were counted; patients with multiple comorbid conditions were counted more than once.[8, 19] The Charlson Comorbidity Index (CCI) was categorized

into normal and CCI 0, 1, 2, and ≥ 3.[20-22] ICD-10 codes of comorbidities are shown in Supplement Table 1.

Treatment period and medical costs of SP patients

The total number of follow-ups within 60 days after medical service use due to new SP onset, the number of follow-ups that occurred within a specified duration, and the comparative ratio of follow-ups within 60 days was analyzed. The mean, minimum, and maximum number of follow-ups, including the first medical service use, were analyzed. For hospitalization service users, the follow-up duration was calculated based on the date of discharge. The number of follow-ups in a specified period after discharge and the average number of follow-ups are shown.

Additionally, the average follow-up duration and average medical costs for each new SP onset were also calculated, as was the average length of hospitalization for patients. Given that we analyzed administrative data, it was necessary to distinguish between medical service use due to new SP onset and that due to follow-up. Based on previous research indicating that air leaks from SP generally stops within approximately 15 days and that X-ray follow-up is recommended 2–4 weeks after discharge,[7, 23] screening analysis results and discussions with medical experts in Korea, SP follow-up duration was determined as 60 days. New SP onset was defined as cases in which no medical service use (due to SP) was recorded in the previous 60 days. When one patient experienced multiple new occurrences of SP, repeated counting was allowed.

The medical costs of SP patients included the average medical cost per person. Medical costs determined to be eligible for reimbursement by Health Insurance Review and Assessment Service (HIRA) out of treatment costs were indicated in the submitted insurance claim statement. Medical costs are the sum of benefits reimbursed by the insurer (NHIS) to the medical care institutions and self-payment costs paid by the beneficiary (patient). Each patient's medical costs were calculated as the sum of costs listed on their claims. The average medical costs were the amount of total medical expenses for one year divided by the number of patients.

Treatment and medication for SP patients

In terms of treatment of SP patients, the most frequent treatment with a code that corresponds to the "Procedure/surgery" category in the statement listing SP as the major or secondary diagnosis was given. All statements prescribing the corresponding treatment were counted and duplication of treatments and patients were allowed. Treatments were categorized as non-surgical treatments and surgical treatments. Non-surgical treatment included oxygen inhalation, nebulizer treatment of the lower airway, suction drainage or tracheostomy suction and tracheal intubation, and surgical treatment included thoracostomy, wedge resection of the lung, resection of bullae, and pleurodesis. The criteria distinguishing between surgical and non-surgical treatments were in accordance with the classification of the claims data. Percentages were calculated by having the denominator as codes that correspond to the "Procedure/surgery" category, excluding costs of materials, drugs used during treatment and list of tests. For medications, the most frequent treatment belonging to the code that corresponds to the "Medication" category in the diagnostic statement was given. Among frequently prescribed drugs, digestants were excluded. Similar to "Procedure/surgery", all statements that prescribed the corresponding drug were counted; and drug and patient duplication was allowed. Medication data were limited to cases of inpatient prescription, while outpatient prescriptions were excluded. Based on the 5th Anatomical Therapeutic Chemical (ATC) Classification System level,[11, 12, 24] notation of the medication taken was indicated by the 5-step code of the chemical name; and the three drugs that did not undergo the 5-step classification were indicated by their ingredients.

Statistical analysis

The total annual prevalence rate of SP and that of hospitalization due to SP are shown in frequency and frequency per 100,000 individuals. It was calculated by dividing the corresponding frequency by the total population that fits in the corresponding range and multiplying by 100,000. Categorical variables, such as the sociodemographic characteristics, number of rehospitalizations per period, comorbidities, CCI level, and follow-up frequency per period, treatment and drugs for the total number of SP patients for 12 years, are shown as frequencies and percentages. Continuous variables, such as number of hospitalizations, CCI

value, total follow-up frequency, length of hospitalization in days and medical costs, are reflected by calculating the average, SD, minimum, and maximum values. Logistic regression analysis was performed including age, sex, income, type of insurance and comorbidity to identify factors influencing hospitalization rate. Data cleaning and analyses were conducted using the statistical package SAS version 9.4 (SAS Institute Inc., Cary, NC).

The patient and public involvement statement

Patients and the public were not involved in the design. Encrypted and published data was used in this study. Thus, there were no patients' involvement in this study.

RESULTS

Sociodemographic characteristics of SP patients

Flow chart that summarizes the selection of patients is shown Supplement fig.1. It shows that 4,658 patients used medical services for SP as their major or secondary diagnosis, at least once during 2002 to 2013. The sociodemographic characteristics of SP patients are shown in Table 1.. The male-to-female ratio was about 4.4:1. Most patients were 15–34-year-olds, while those below 15-years were least affected. Most were in the high-income group, while the low-income group utilized medical services the least. Job-based enrollees were the most common category.

Table 1. Sociodemographic characteristics of spontaneous pneumothorax patients

		All SP (n=4,658)	%*
Sex			
	Male	3,796	81.5
	Female	862	18.5
Age (years)			
	< 15	123	2.6
	15–34	2,407	51.7

	35–64	1,374	29.5
	≥ 65	754	16.2
Income range			
	Low (0–3)	1,037	22.3
	Medium (4–7)	1,725	37.0
	High (8–10)	1,896	40.7
Insurance type			
	Region	1,741	37.4
	Job	2,804	60.2
	Medical Assistance	113	2.4

*% = N / 4,658 × 100, SP: spontaneous pneumothorax

Prevalence rate of SP

The annual prevalence rate of SP (SP patients per 100,000 individuals) by sex ranged from 39 to 66 per 100,000 individuals, depending on the year (Fig. 1). The prevalence rate of SP consistently increased from 2002 to 2011 and decreased slightly thereafter. Among males, the rate was 63 per 100,000 individuals in 2002, and then increased consistently to 109 per 100,000 individuals in 2011. Thereafter, it decreased slightly, but the rate still exceeded 100 per 100,000 individuals in 2012 and 2013. Among females, the rate was 15 per 100,000 individuals in 2002, and remained essentially constant at 15–18 per 100,000 individuals, except for an increase to 23 per 100,000 individuals in 2011. The male-to-female ratio slowly increased from 4.2:1 in 2002, to a ratio of 6.5:1 in 2010.

In all years, except 2002, the SP prevalence rate was the highest in the 15–34-year-old group, followed by the ≥ 65-year-old, 34–64-year-old, and < 15-year-old groups (Fig. 2). The prevalence rate for those in the 15–34-year-old group was 64.8 per 100,000 individuals in 2002, which then increased to 133.2 per 100,000 individuals in 2009. The rate in the ≥ 65-year-olds also increased, from 69.1 per 100,000 individuals in 2002 to 93.5 per 100,000 individuals in 2013.

The prevalence rate of SP by sex, age, income level, and insurance type are summarized in Supplement Table 2. To examine the detailed distribution by age, age groups were further subdivided into 5-year increments. The prevalence rate tended to be the highest at 15–19 years, decreased to 40–49 years, and then peaked again at 65–74 years before decreasing again (Supplement fig.2). The prevalence rate was slightly higher in the high-income group, but remained low among medical-assistance recipients, although this rate increased after 2011 to a rate higher than that of health insurance enrollees.

The prevalence rates of SP patients who were hospitalized are shown in Figs. 3 and 4. The rate of hospitalization was 18.3 per 100,000 individuals in 2002, increasing to 36.2 per 100,000 individuals in 2011 before decreasing in 2012. The rate of hospitalization in men was 31.4 per 100,000 individuals in 2002, which increased to 61.0 per 100,000 individuals in 2011. Among women, the hospitalization rate was 5.3 per 100,000 individuals in 2002 and 11.3 per 100,000 in 2011. This rate decreased for both sexes in 2012. The rate tended to increase up to 2012 for men, but there was no consistent trend for females. The male-to-female ratio of hospitalization was 6:1 on average. By age, hospitalization in the 15–34-year age group was the highest at 33–75 per 100,000 individuals, followed by the ≥ 65-year-old group and the 35–64-year-old group. The rate was the lowest for the < 15-year-old group, at 1–3 per 100,000 individuals. The prevalence of hospitalized SP patients among the total population, by age and sex, are shown in Supplement Table 3.

The prevalence rates of SSP ranged from 10.5 to 12.1 per 100,000 individuals, from 8.5 to 9.6 in male and 1.4 to 2.7 in female (Supplement fig. 3).

Hospitalization of SP patients by year

Within the SP patient sample, the proportion of those receiving hospital treatments was defined as the hospitalization treatment rate. The number of patients who used the hospitalization service for SP in 2002 was 188 (47.2%) (Table 2). The rate of hospitalization treatment slowly increased thereafter up to 2010 and then decreased slightly. No sex-related differences in hospitalization treatment rates were observed. However, for age-related differences, the ≥ 65-year-old group had the highest hospitalization treatment rate, while the

< 15-year-old group had the lowest rate. In addition, as a result of the logistic regression analysis model, the hospitalization rate was influenced by sex, age and underlying lung disease (Supplement Table 4).

The frequency and proportion of rehospitalization of SP patients is shown in Supplement Table 5. In total, 3,005 patients used hospital services at least once due to SP between 2002 and 2013. Among these, 1,683 were rehospitalized, with 60.7% of all rehospitalizations occurring within 6 months and 71.4% within 1 year. The average number of hospitalizations per person overall was 1.56, at an average interval of 223.07 days.

Table 2. Rate of hospitalization treatment for spontaneous pneumothorax patients

	Total SP (N)	Total HP (N)	HR (%)*	Sex				Age (years)							
				Male		Female		< 15		15–34		35–64		≥ 65	
				N	HR*	N	HR*	N	HR*	N	HR*	N	HR*	N	HR*
2002	398	188	47.2	161	50.0	27	35.5	4	36.4	111	53.1	43	35.0	30	54.5
2003	490	236	48.2	202	50.0	34	39.5	2	33.3	135	49.1	62	42.2	37	59.7
2004	504	262	52.0	217	52.7	45	48.9	9	40.9	151	54.7	56	42.7	46	61.3
2005	514	276	53.7	235	55.7	41	44.6	3	33.3	161	59.2	74	45.7	38	53.5
2006	518	281	54.2	241	56.8	40	42.6	2	16.7	156	54.7	66	47.5	57	69.5
2007	555	286	51.5	244	51.8	42	50.0	4	36.4	169	56.3	73	44.2	40	50.6
2008	557	296	53.1	270	57.0	26	31.3	3	27.3	183	57.7	62	39.7	48	65.8
2009	610	327	53.6	279	53.8	48	52.7	4	36.4	215	58.0	59	41.3	49	57.6
2010	598	342	57.2	306	59.1	36	45.0	3	21.4	196	59.4	89	50.6	54	69.2
2011	661	364	55.1	307	56.1	57	50.0	3	25.0	208	57.1	82	45.8	71	67.0
2012	623	338	54.3	285	53.6	53	58.2	4	36.4	184	52.9	83	50.3	67	67.7
2013	616	338	54.9	291	55.5	47	51.1	4	30.8	175	55.4	86	51.5	73	60.8

* Hospitalization rate (%) = N / total number of spontaneous pneumothorax patients × 100
SP : spontaneous pneumothorax, HR : Hospitalization rate, HP : Hospitalized patients

Comorbidities in SP patients

Lung-related comorbidities in SP patients by age are shown in Table 3. For the < 15-year-old group, there were no particular comorbidities. COPD was the most common comorbidity, followed by pneumonia and asthma.

Table 3. Comorbidities of spontaneous pneumothorax patients

	15–34 years		35–64 years		≥ 65 years		Total	
	N	%*	N	%†	N	%‡	N	%§
Total	**2,407**		**1,374**		**497**		**4,658**	
COPD	273	11.3	277	20.2	287	57.7	837	18.0
Pneumonia	102	4.2	109	7.9	150	30.2	361	7.8
Interstitial	4	0.2	17	1.2	13	2.6	34	0.7
Lung cancer	11	0.5	72	5.2	67	13.5	150	3.2
Asthma	63	2.6	111	8.1	174	35.0	348	7.5
Lung abscess	1	0.0	8	0.6	0	0.0	9	0.2
CCI								
Mean	0.25		0.69		1.31		0.47	
0	1,823	75.7	708	51.5	173	34.8	2,704	58.1
1	468	19.4	420	30.6	305	61.4	1,193	25.6
2	45	1.9	165	12.0	166	33.4	376	8.1
3 or more	5	0.2	65	4.7	99	19.9	159	3.4

* % = N / 2,407 × 100

†% = N / 1,374 × 100

‡% = N / 496 × 100

§% = N / 4658 × 100

COPD, Chronic Obstructive Pulmonary Disease; CCI, Charlson Comorbidity Index

COPD was more common in the ≥ 65-year-old group than in the younger age groups. Fewer patients among the 15–34-year-old group had asthma than pneumonia. The prevalence of all comorbidities other than lung abscess was the highest in the ≥ 65-year-old group. The lung cancer rate was lower in the 15–34-year-old and 35–64-year-old groups than in the ≥ 65-year-old group.

The average CCI value of SP patients was 0.47 and increased with increasing age. The number of patients with a CCI value of 0 decreased with increasing age, while that of patients with a CCI value of ≥ 3 increased with increasing age.

Treatment period and medical costs of SP patients

There were 4,157 outpatient service users among patients with first-time SP (no use of medical service for SP for 60 days prior) from 2002 to 2013 (Table 4). Among these, 3,035 required follow-up within 60 days of the first onset of SP. Most follow-ups occurred within 30 days. The average number of follow-ups in each time period including the first-time visit was found to be 1.14 days within 7 days, 1.33 days within 14 days, 1.54 days within 30 days, and 1.73 days within 60 days. The average length of time between follow-ups was 11.07 days and the average medical cost per person was $94.5 (106,766 KRW).

Table 4. Outpatient or inpatient treatment period and medical costs of spontaneous pneumothorax

		FU frequency during period		Total FU frequency (Including first visit)			
		Cumulative frequency	Total FU frequency (Within 60 days) Comparative ratio	Mean	SD	min	max
Outpatient FU							
First-time outpatient use	4,157						
Within 7 days		582	19.2	1.14	0.42	1	6
Within 14 days		1,372	45.2	1.33	0.63	1	8
Within 30 days		2,245	74.0	1.54	0.84	1	13
Within 60 days		3,035	100.0	1.73	1.07	1	13
Average follow-up period				11.07	16.55	0	60
Average medical costs (US $)*				94.5	141.5	0.9	2,673.6
Hospitalization FU							
First-time	3,005						

hospitalization use						
Within 7 days	180	30.0	1.06	0.24	1	3
Within 14 days	301	50.1	1.10	0.31	1	3
Within 30 days	451	75.0	1.15	0.40	1	5
Within 60 days	601	100.0	1.20	0.48	1	7
Average number of days of hospitalization			14.19	18.25	0	601
Average follow-up period			3.67	10.67	0	60
Average medical costs (US $)*			2,523.0	2,692.2	45.9	48,967.3

*The cost of items determined to be eligible for reimbursement by the HIRA (Health Insurance Review and Assessment Service) out of the total treatment amount were indicated in the submitted insurance claim statement. It was converted from Korean Won to US dollar, according to the exchange rate on October 12, 2018 (US $1.00 = Korean 1,130 Won).

FU : follow-up; SD: standard deviation; min: minimum; max: maximum

The number of hospitalizations for first cases of SP was 3,005, of which 601 required follow-up within 60 days of discharge. Most follow-ups occurred within 30 days and the proportion of follow-ups occurring in the first week was higher for in-patients than for outpatient service users. The average number of follow-ups was lower for inpatients than for outpatient service users. The average length of hospitalization was 14.19 days. The average follow-up period after discharge was 3.67 days and the average medical costs for each hospitalization were markedly higher than those of outpatients.

Treatment and medication for SP patients

Treatment and medication details are shown in Table 5. The most commonly received non-surgical treatment for SP patients was oxygen inhalation, followed by suction drainage or tracheostomy suction. Thoracostomy was the most common surgical treatment, followed by lung wedge resection. The frequency of other surgical treatments was low. The rate of surgery for SP varied by year, but was estimated at about 40%. It was highest at 47.5% in 2010 and slightly decreased thereafter. By sex, the rate of surgery was higher in males than females (Supplement fig. 4).

Medication commonly prescribed for SP could be categorized into analgesics, antitussives, and antibiotics, when excluding digestants. Among analgesics, paracetamol, codeine combinations, excluding psycholeptics and tramadol as well as paracetamol combinations were prescribed at similar rates. Among antitussives, most prescribed was bromhexine. Among antibiotics, cefixime was the most frequently prescribed.

Table 5. Treatments and drugs used for spontaneous pneumothorax patients

	Treatment			Drugs	
	N	%*		N	%†
Total count of prescription statements	**21,107**			**37,488**	
Non-surgical treatments			**Analgesics**		
Oxygen Inhalation	4,351	20.6	Paracetamol	1,039	2.8
Nebulizer Treatment Of Lower Airway	534	2.5	Codeine, combinations excluding psycholeptics	878	2.3
Suction Drainage Or Tracheostomy Suction, Etc.	2,481	11.8	Tramadol and paracetamol	832	2.2
Tracheal Intubation	81	0.4	Propionic acid-derivatives	784	2.1
Surgical treatments			Aceclofenac	455	1.2
Thoracostomy	3,132	14.8	**Antitussives**		
Wedge Resection Of Lung	1,304	6.2	Acetylcysteine	672	1.8
Resection Of Bullae	125	0.6	Xanthines	635	1.7
Pleurodesis	27	0.1	Bromhexine	789	2.1
Apicolysis, Pleurolysis	15	0.1	Ambroxol	553	1.5
Lobectomy Of Lung	13	0.1	**Antibiotics**		
Pleurectomy	12	0.1	Cefixime	374	1.0
Segmentectomy Of Lung	10	0.0	Third-generation cephalosporins	305	0.8

Pleural Decortication	8	0.0
Primary Thoracoplasty	4	0.0

*% = N / 21,107

†% = N / 37,488

DISCUSSION

The annual prevalence of SP ranged from 39 to 66 per 100,000 individuals. The male-to-female ratio was approximately 4–10:1, and the 15–34-year-old group, particularly 15–19-year-olds, showed the highest prevalence rate. About 47–57% SP patients underwent hospitalization. COPD was the most common comorbidity. The average treatment period was 11 days as an outpatient and 14 days in-hospital. The average medical costs were $94.50 for outpatients and $2523 for hospital admissions. The most common treatment for SP was oxygen inhalation and thoracostomy, and operation rate was about 40%. The most commonly prescribed medications were analgesics, antitussives, and antibiotics.

In this large study in Korea, the annual prevalence rate of SP was 39–66 per 100,000 individuals. These numbers were slightly higher than those previously reported: 1.2–7.4 per 100,000 individuals in Minnesota [5] and 9.8–24 per 100,000 individuals in the United Kingdom.[6] The reason for these differences may be because SP was defined as cases in which medical service was used, which could include follow-up appointments, rather than the strict number of incidents. In contrast, the prevalence rate of hospitalization due to SP was 18–36 per 100,000 individuals overall. These rates were previously reported as 14.3–22.7 per 100,000 individuals overall,[7, 8] and are similar to those found in our study. The similarity may be because hospitalization was as a result of new SP incidents only. In addition, the prevalence rate of SP consistently increased from 2002 to 2011. This is consistent with previous a study that showed increased prevalence of SP.[25] The cause of this problem is still controversial. Though deteriorated atmosphere condition is presumed to be the cause,[26-28] the increase underlying lung diseases such as COPD or lung cancer could be another cause. In this study, there was no significant change in the prevalence rate of SSP by year, which implies that PSP was increased, not by increasing of underlying lung disease. To solve the problem of increasing SP prevalence, further study which can determine the exact cause is needed

The prevalence rate was much higher for males than in previous studies. The male-to-female ratio for all SP and for hospitalized SP was higher than that reported previously (2.4:1–3.3:1).[6, 8, 9] In terms of age, the prevalence rate was the highest for the 15–34-year-old group, particularly for the 15–19-year-old group, followed by the ≥ 65-year-old, 35–64-year-old, and

< 15-year-old group, respectively. Previous studies showed a peak-age for SP at 20, followed by a later peak at 70.[8, 29] Overall, the incidence of SP was higher in Korea, particularly in males and at a slightly earlier age (15–19 years) than in other countries: e.g., 20–25 years in France [7] and Germany,[8] and 20–24 years or 30–34 years in England.[6] The prevalence of SP in males increased until 2012, while there was no clear trend in females. Since there was no previous large-scale research in Eastern countries, we cannot conclude whether these results are due to ethnicity or environment. In addition, the choice of terms between 'prevalence' and 'incidence' was one of the challenges of this study. It was determined to use 'prevalence' because there were several previous studies that reported 'prevalence' and this study was based on the occurrence of within the period of a year.

SP has a high rate of hospitalization;[30] 47–57% of SP patients in our study received hospital treatment. There were no marked differences due to sex, although the female hospitalization rate was slightly lower. The hospitalization rate was highest in the ≥ 65-year-old group and lowest in the < 15-year-old group. The necessity of hospitalization for SP is debated. Hallifax and Rahman stated in 2015 that outpatient treatment is sufficient for patients who are young, have no comorbidities, and have stable vital signs; however, the evidence of outpatient treatment stability is lacking.[10]

SP has a high rate of relapse;[24, 25, 31] with 1,683 of 3,003 first-time hospitalization cases requiring rehospitalization in our study. Although previous studies have shown that the relapse rate of SP is 15–40%,[7, 11, 12, 25, 32] these studies were based on small sample sizes (82–273 subjects). [7, 11, 12, 25, 32] Though there was a large-scale study, only hospitalized patients were analyzed.[25] The risk factors for SP relapse are controversial; some studies indicate that elderly people and women are at higher risk,[7, 33] while other studies indicate that age and sex have no significant effect.[34] Furthermore, low BMI [12, 35], non-surgical treatment and smoking habits [12, 34] have been implicated in SP, yet further study is required to delineate the risk factors.

SP can involve lung-related comorbidities.[36, 37] To distinguish between PSP and SSP, it is important to evaluate comorbidities. This distinction is important, as these conditions have different characteristics and prognoses;[23, 38] however, categorizing these conditions based on

administrative data remains challenging.[19] This is because there are no codes to differentiate between PSP and SSP in the ICD categorizations. Nevertheless, our objective was to describe details related to SP; thus, we examined the current comorbidity status, rather than attempting to categorize SP patients. Among comorbidities, COPD was the most common in all age groups. With increasing age, the proportion of patients with comorbidities increased; thus, with increasing age, SSP was more common than PSP. Therefore, the decrease in SP risk with age, followed by an increase, may be due to an increase in SSP in particular.

The approximate treatment period for SP was 11 days for outpatients and 17.7 days for hospitalized patients. The average number of follow-ups within 60 days was 1.73. Thus, many cases of SP were minor and a single outpatient visit is necessary to complete the treatment. For both hospitalization and outpatient service users, 75% of total follow-ups occurred within 1 month; hence, the follow-up duration for SP is short. Few studies have assessed the treatment or follow-up duration for SP, yet our results are similar to a previous study reporting a remission period of 7–15 days for SP,[23, 39]. X-ray follow-up is recommended within 2–4 weeks of discharge [35] and the median value of length of stay (LOS) is 6–7 days.[7, 33] No previous study has reported the socioeconomic costs due to SP; in our study, we found an average medical cost of $94.50 per person for outpatient services and of $2,523.00 per person for hospitalization. The maximum costs were $2,673.60 per person for outpatient and $48,967.30 per person for hospitalization.

For treatment, surgery, and medication for SP patients, we reported the frequency of prescriptions rather than the number of people. Oxygen inhalation among non-surgical treatments and thoracostomy among surgical treatments were the most common procedures. A previous study has also shown that the most common treatment for SP patients is thoracostomy (92% of patients).[32] The surgery most commonly performed after thoracostomy is lung wedge resection; this involves removing a portion of the lung and is less invasive, preserves more lung function, and has fewer side-effects than lobar resection.[40, 41] The rate of surgery showed a mild tendency to increase until 2010 and then decreased slightly thereafter. It was not possible to confirm whether this was due to the severity of SP or the medical practice tendency in Korea. For medication; analgesics, antitussives, and antibiotics were the most frequently prescribed, after excluding digestants. For convenience of analysis, we excluded outpatient prescriptions.

Considering that the rate of hospitalization exceeded 60% for SP patients, prescription patterns are not likely to differ markedly between hospitalized and overall cases.

This study has several limitations. First, we could not distinguish between PSP and SSP because of the limitations of the data. Accordingly, it was also impossible to present each treatment methods. According to a study analyzing the first line treatment and management of PSPs and SPSs, there are differences with PSPs and SSPs in management methods[15]. Further research is needed on the epidemiology and medical service use of each SP category. Secondly, our results should be interpreted with caution, as we could not ascertain whether medical service use was due to new incidents of SP or to follow-up. That is, rehospitalizations with the same episodes and recurrence 60 days before the last treatment were not detected. Although we attempted to select medical service use due to new incidents of SP by using an operational definition, this may not have been accurate. Thirdly, our study may be limited by the lack of data on uncovered items and from patients who were not covered by health insurance. However, in Korea, because 98% of the total population is covered by health insurance, it seems to be the entire population data. Existence of uncovered items or indirect medical costs was a limitation in this study. In addition, as the diagnosis codes in the claim's data that was the basis for identifying the patients may not be completely accurate [42], it is not clear whether all patients with SP were listed under the appropriate corresponding diagnosis codes. Lastly, since analysis was performed using NHI data from 2002, there is a possibility of misclassification of new-onset SP due to SP patients who ever suffered from SP before 2012.

However, despite these limitations, this study provided a detailed record of the epidemiology and treatment of SP. Our study is significant in that it provides novel information, contributing to an understanding of SP, a little-understood condition with an increasing prevalence in Korea.

CONCLUSION

This study investigated the epidemiology and medical treatment of SP in Korea, which was not studied before. As a result, the incidence of SP in Korea is increasing, incidence in men is higher than women. It also showed a high rate of SP recurrence within a year, how treatment of pneumothorax in Korea is being done. However, this study not identify the specific cause of the increase in SP. Therefore, future research is needed to identify the cause of increased SP in

1 Korea and find ways to prevent the increase in SP

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Author contributions

IHH, LYJ and BJ contributed to the overall conception and design of the study protocol. BJ and DK contributed to the specific study design and data analysis. DK wrote the first draft of the manuscript. DK, BJ, SHC, BHJ, YJL and IHH contributed to interpretation of the analyses and revisions of the final manuscript. All authors gave final approval of the version to be submitted.

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Competing interest

No competing interests to declare.

Ethics approval

The study was approved by the Institutional Review Board of Jaseng Hospital of Korean Medicine in Seoul, Korea (JASENG 2018-09-007).

Data sharing statement

The datasets generated and analyzed during the current study are available on the National Health Insurance Sharing Service. NHIS provides support to research activities in various sectors of society, the economy, environment, industry, etc., as well as policy and academic research on the health sector by providing sample cohort databases. The research database consists of five types of databases: a sample cohort database, medical check-up cohort database, elderly cohort database, working women cohort database, and infant medical check-up cohort database. Each

cohort database consists of the following four detailed data-sets: qualification database, treatment database, medical check-up database, and clinic database.

The present study utilized the sample cohort database, which is a third-party data not owned by the authors. The sample cohort database is available upon approval for data sharing, from the health insurance corporation. For the purpose of policy and academic research a fee is paid to obtain data from the NHIS website [https://nhiss.nhis.or.kr/bd/ab/bdaba022eng.do].

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Figure legends

Fig. 1. Annual prevalence rate of spontaneous pneumothorax, by sex (per 100,000 individuals).

Fig. 2. Annual prevalence rate of spontaneous pneumothorax, by age (per 100,000 individuals).

Fig. 3. Annual prevalence rate of hospitalization due to spontaneous pneumothorax, by sex (per 100,000 individuals).

Fig. 4. Annual prevalence rate of hospitalization due to spontaneous pneumothorax, by age (per 100,000 individuals).

Supplement fig.1. Flow chart of selection patients.

Supplement fig. 2. Prevalence rate of spontaneous pneumothorax by age (per 100,000 individuals).

Supplement fig. 3. Annual prevalence rate of secondary spontaneous pneumothorax, by sex (per 100,000 individuals)

Supplement fig. 4. Annual rate of surgery due to spontaneous pneumothorax, by sex (per 100,000 individuals)

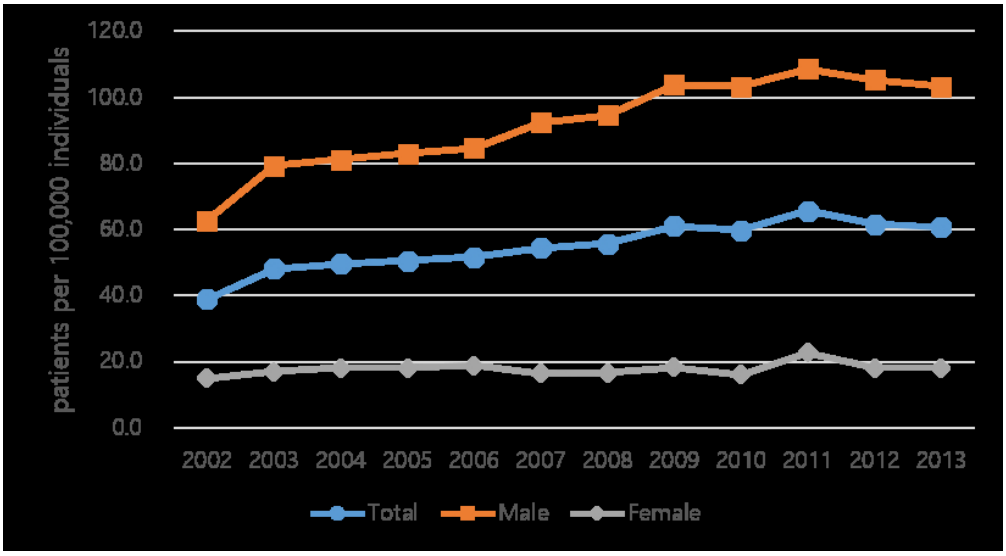

fig1

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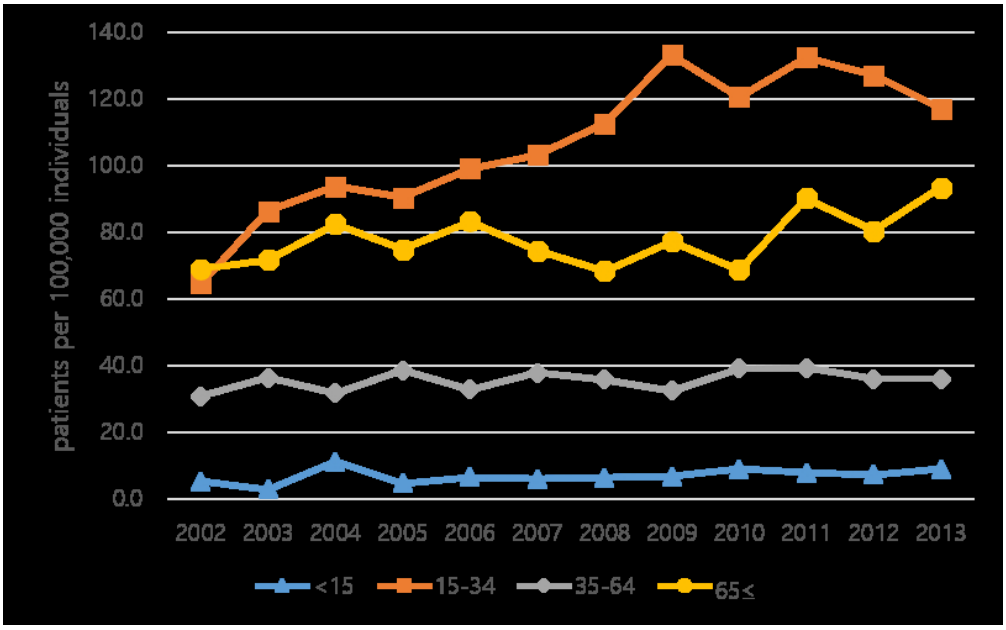

fig2

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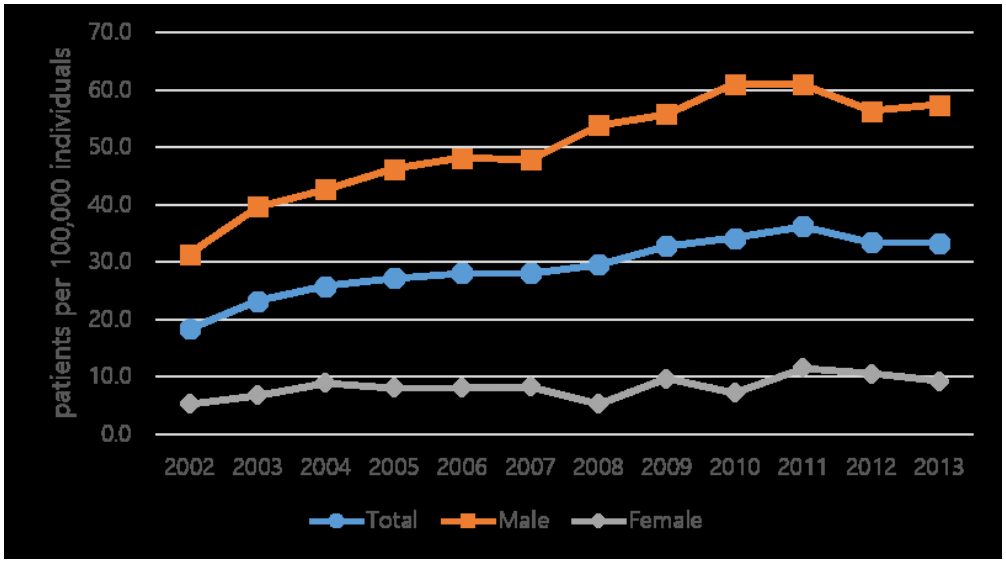

fig3

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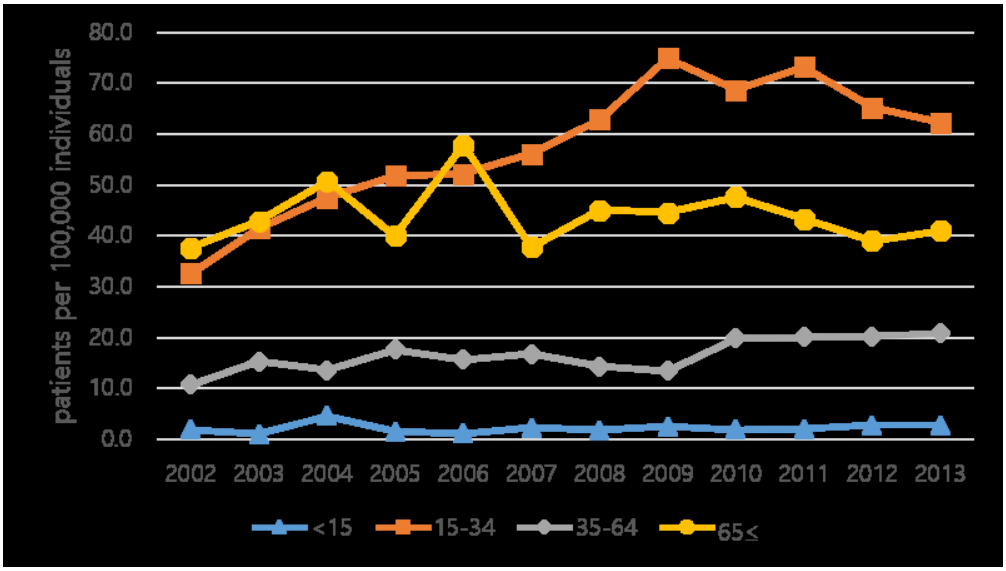

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Supplement Table 1. ICD-10 codes of comorbidities in spontaneous pneumothorax

Disease	Code
COPD	J40*, J41*, J42*, J43*, J44*, J961, J982
Pneumonia	J12*, J13*, J14*, J15*, J16*, J18*
Interstitial lung disease	J84*
Lung cancer	C34*, C780*, C783, D022-D024, D143*, D174, D381
Asthma	J45*
Lung abscess	J850, J851, J852

ICD-10, International Statistical Classification of Disease and Related Health Problems, 10th revision; COPD, Chronic Obstructive Pulmonary Disease

Supplement Table 2. Prevalence rate of spontaneous pneumothorax per 100,000 individuals and sociodemographic characteristics

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.	N	Prev.
Total SP Patients	398	38.8	490	48.2	504	49.6	514	50.5	518	51.7	555	54.4	557	55.7	610	61.1	598	59.7	661	65.7	623	61.6	616	60.7
Sex																								
Male	322	62.7	404	79.3	412	81.1	422	83.0	424	84.7	471	92.4	474	94.6	519	103.9	518	103.3	547	108.7	532	105.2	524	103.3
Female	76	14.8	86	16.9	92	18.1	92	18.1	94	18.8	84	16.4	83	16.6	91	18.2	80	16.0	114	22.7	91	18.0	92	18.1
Age																								
< 15	11	5.3	6	3.0	22	11.2	9	4.7	12	6.6	11	6.2	11	6.5	11	6.8	14	9.0	12	7.9	11	7.5	13	9.1
15–34	220	64.8	281	86.3	298	93.9	281	90.4	297	99.3	311	103.2	328	112.6	382	133.2	344	120.6	376	132.4	359	127.2	329	117.1
35–64	123	30.9	147	36.4	131	31.8	162	38.6	139	32.9	165	37.9	156	35.9	143	32.5	176	39.3	179	39.4	165	36.0	167	36.1
≥ 65	55	69.1	62	71.7	75	82.6	71	74.8	82	83.2	79	74.6	73	68.4	85	77.3	78	68.8	106	90.3	99	80.5	120	93.5
Sub-divided Age																								
< 15	11	5.3	6	3.0	22	11.2	9	4.7	12	6.6	11	6.2	11	6.5	11	6.8	14	9.0	12	7.9	11	7.5	13	9.1
15–19	81	114.7	96	143.2	110	165.5	106	160.4	111	166.2	140	200.4	162	231.4	193	270.2	179	245.2	184	254.0	156	218.9	153	220.2
20–24	54	63.7	91	109.1	71	89.2	66	86.9	73	104.6	71	104.9	58	91.3	77	122.8	77	123.2	92	142.8	105	156.8	93	134.6
25–29	41	47.6	50	62.6	55	70.0	55	69.6	66	84.0	63	77.6	58	72.1	60	78.0	45	61.3	46	66.4	50	76.5	44	70.1
30–34	33	33.6	38	39.9	40	43.1	45	50.2	35	41.6	26	31.4	39	50.5	41	54.1	29	38.0	42	53.9	37	47.1	26	32.7
35–39	23	25.7	30	33.1	28	30.5	39	42.1	32	34.4	34	35.9	30	32.7	26	29.0	41	47.3	31	37.3	34	42.4	33	43.2
40–44	19	20.0	23	24.6	21	22.9	26	28.9	18	20.9	23	26.6	21	24.2	28	31.7	24	26.8	30	32.9	26	28.3	25	27.5
45–49	26	35.4	22	28.4	21	25.7	26	30.5	20	22.7	30	32.9	32	35.8	24	27.3	24	27.8	29	34.5	15	18.0	28	32.6
50–54	13	24.2	23	42.4	22	38.8	19	30.8	21	31.7	26	36.9	26	35.5	23	29.6	26	32.0	33	38.6	35	40.0	25	28.4
55–59	21	48.4	25	55.9	18	38.9	25	51.5	26	53.7	23	44.8	26	50.9	21	39.3	32	54.6	29	45.4	27	40.2	31	43.3
60–64	21	48.7	24	55.1	21	48.8	27	64.2	22	54.0	29	70.6	21	50.3	21	48.5	29	63.5	27	58.4	28	57.8	25	50.5
65–69	23	71.1	22	64.3	30	84.4	34	93.9	30	80.6	32	79.4	25	62.9	24	61.2	26	67.3	32	83.8	28	73.3	30	75.4
70–74	16	74.4	19	82.4	21	85.7	15	57.0	25	90.1	25	85.1	24	80.2	33	105.6	14	43.6	22	65.5	12	33.2	27	73.2
≥ 75	16	62.1	21	72.0	24	78.1	22	68.0	27	80.4	22	60.8	24	64.9	28	70.9	38	89.1	52	114.0	59	121.2	63	121.8
Income																								
Low (0–3)	71	31.1	99	43.9	116	51.3	129	54.8	92	39.7	125	52.0	116	48.4	127	54.4	117	48.8	163	67.3	150	68.1	170	70.3
Medium (4–7)	164	40.9	194	49.3	188	48.2	190	49.4	212	56.0	206	53.8	213	57.3	229	61.8	213	58.0	237	64.7	190	54.2	196	53.3

High (8–10)	163	41.1	197	49.5	200	50.0	195	49.2	214	54.6	224	56.3	228	58.5	254	64.4	268	67.8	261	65.5	283	64.2	250	61.7
Insurance type																								
Region	200	40.2	236	49.8	206	45.8	221	52.5	201	52.0	214	56.4	203	56.2	213	61.3	200	59.8	207	64.4	179	57.4	161	53.8
Employment	195	39.3	252	49.2	292	54.7	285	51.1	315	54.6	336	55.8	346	57.6	390	63.3	396	62.6	419	64.4	414	62.0	415	60.5
Medical Assistance	3	9.8	2	6.3	6	18.1	8	21.1	2	5.1	5	12.7	8	20.5	7	19.8	2	5.7	35	103.7	30	95.8	40	132.9

Prev., Prevalence Rate

Supplement Table 3. Annual prevalence rate of hospitalization due to spontaneous pneumothorax (per 100,000 individuals)

Hospitalization				Sex						Age (years)										
				Male			Female			< 15			15–34			35–64			≥ 65		
Year	N	Prev.*	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†	N	Prev.	Grow. (%)†
2002	188	18.3		161	31.4		27	5.3		4	1.9		111	32.7		43	10.8		30	37.7	
2003	236	23.2	26.5	202	39.7	26.5	34	6.7	26.9	2	1.0	-48.4	135	41.5	26.9	62	15.3	42.0	37	42.8	13.7
2004	262	25.8	11.1	217	42.7	7.6	45	8.9	32.3	9	4.6	360.9	151	47.6	14.7	56	13.6	-11.3	46	50.7	18.3
2005	276	27.1	5.3	235	46.2	8.3	41	8.1	-8.9	3	1.6	-65.7	161	51.8	8.9	74	17.6	29.6	38	40.1	-20.9
2006	281	28.0	3.3	241	48.1	4.1	40	8.0	-1.0	2	1.1	-29.8	156	52.1	0.6	66	15.6	-11.3	57	57.8	44.4
2007	286	28.0	-0.1	244	47.8	-0.6	42	8.2	3.0	4	2.2	103.9	169	56.1	7.5	73	16.8	7.4	40	37.8	-34.7
2008	296	29.6	5.6	270	53.9	12.6	26	5.2	-36.7	3	1.8	-20.7	183	62.8	12.1	62	14.3	-14.9	48	45.0	19.1
2009	327	32.7	10.7	279	55.8	3.6	48	9.6	85.0	4	2.5	39.3	215	74.9	19.3	59	13.4	-6.1	49	44.5	-1.0
2010	342	34.1	4.2	306	61.0	9.3	36	7.2	-25.3	3	1.9	-22.0	196	68.7	-8.3	89	19.9	48.2	54	47.6	6.9
2011	364	36.2	6.0	307	61.0	-0.1	57	11.3	57.6	3	2.0	2.7	208	73.3	6.6	82	20.1	1.2	71	43.4	-8.9
2012	338	33.4	-7.6	285	56.4	-7.6	53	10.5	-7.5	4	2.7	36.7	184	65.2	-11.0	83	20.2	0.7	67	39.1	-9.9
2013	338	33.3	-0.4	291	57.4	1.8	47	9.3	-11.7	4	2.8	2.8	175	62.3	-4.5	86	20.8	3.0	73	41.0	5.0

Prev., *Prevalence rate: rate of prevalence per 100,000 individuals.

Grow., †Growth rate (%) = (Current Year *100) / Previous Year) - 100

Supplement Table 4. Logistic regression analysis of factors affecting hospitalization rate in spontaneous pneumothorax patients

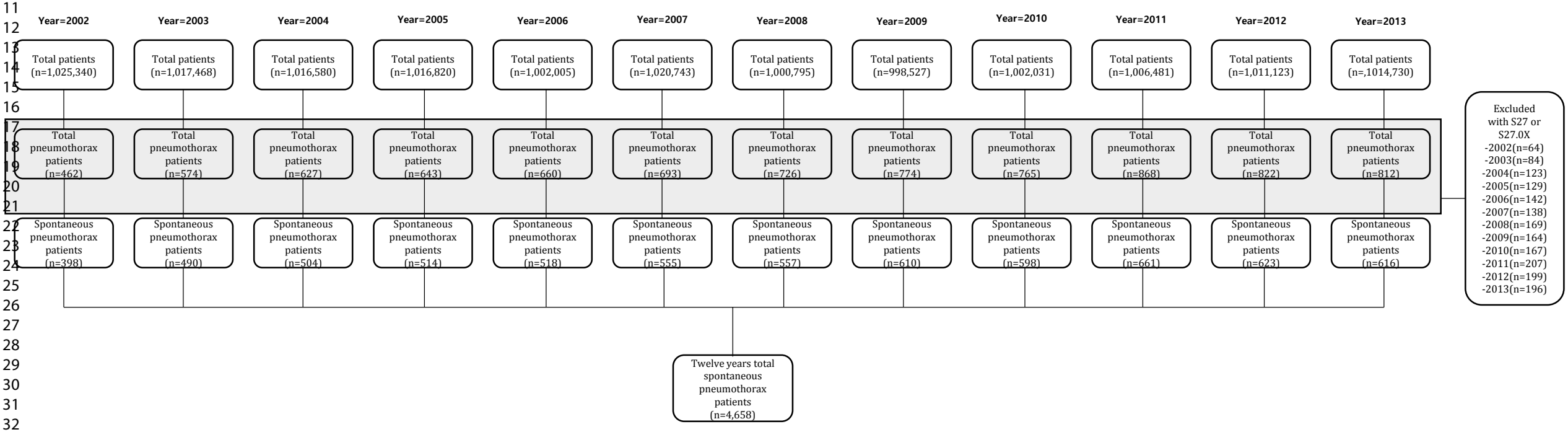
	Hospitalization			
Characteristics	Unadjusted OR	95% CI	Adjusted OR[b]	95% CI
Sex				
M	1.39	(1.23, 1.57)	1.40	(1.24, 1.59)
F	1.0[a]	-	1.0[a]	-
Age				
< 15	0.19	(0.10, 0.38)	0.20	(0.10, 0.40)
15–34	1.52	(1.37, 1.69)	1.48	(1.32, 1.64)
35–64	1.0[a]	-	1.0[a]	-
≥ 65	1.74	(1.52, 1.99)	1.73	(1.51, 1.98)
Income range				
Low (0–3)	1.0[a]	-	1.0[a]	-
Medium (4–7)	0.98	(0.86, 1.11)	0.97	(0.86, 1.10)
High (8–10)	0.97	(0.86, 1.09)	0.95	(0.84, 1.07)
Insurance Type				
Region	1.0[a]	-	1.0[a]	-
Job	1.00	(0.91, 1.10)	0.99	(0.90, 1.09)
Medical	1.60	(1.17, 2.19)	1.57	(1.15, 2.15)
Assistance				
Comorbidities				
(ref. none)				
COPD	2.34	(2.02, 2.72)	2.38	(2.04, 2.77)
Pneumonia	2.05	(1.66, 2.55)	2.08	(1.67, 2.59)
Interstitial	3.77	(1.66, 8.59)	3.87	(1.69, 8.84)
Lung cancer	2.14	(1.53, 2.99)	2.16	(1.54, 3.04)
Asthma	2.03	(1.63, 2.52)	2.08	(1.67, 2.60)
Lung abscess	1.09	(0.29, 4.07)	1.02	(0.27, 3.79)

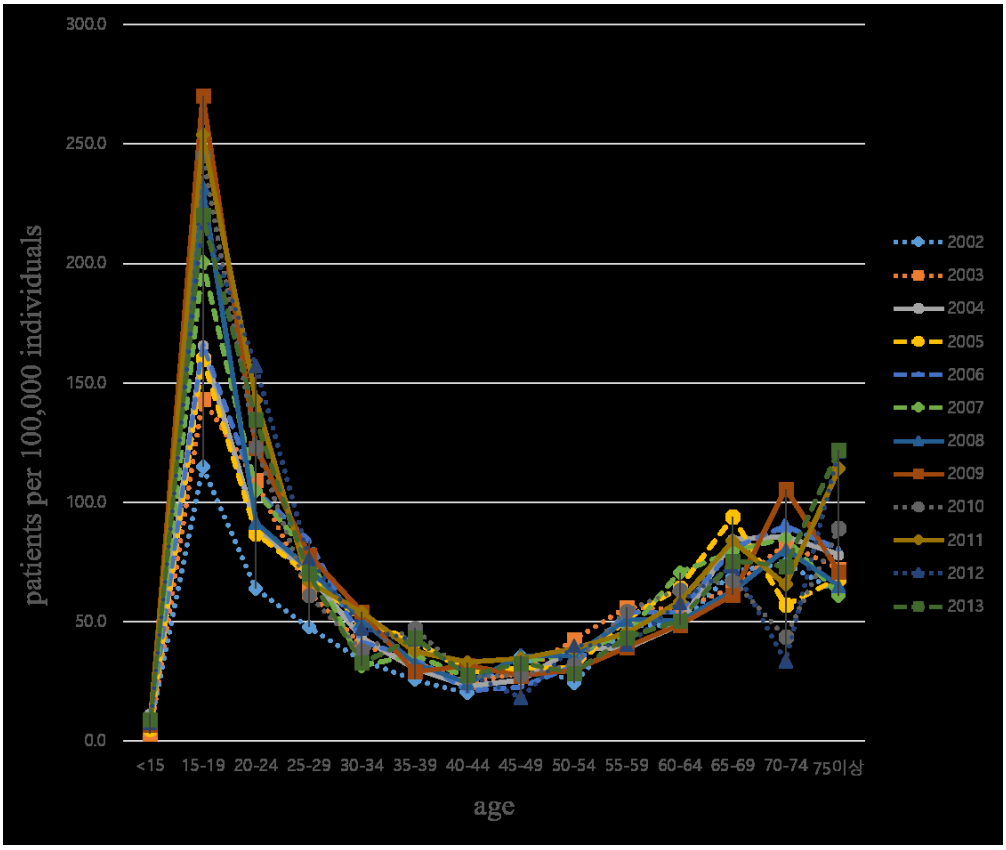
OR; odds raio, CI; confidence intervals; M, male; F, female; COPD, chronic obstructive pulmonary disease
a; reference group, b: adjusted for age and sex

Supplement Table 5. Rehospitalization of spontaneous pneumothorax patients

Rehospitalization (within)	Number of rehospitalizations		Number of hospitalizations per person			
	N*	Cumulative %	Mean	SD	Minimum	Maximum
6 months	1,022	60.7	1.34	0.70	1	10
1 year	1,202	71.4	1.40	0.80	1	12
2 years	1,412	83.9	1.47	0.94	1	19
Total	1,683	100.0	1.56	1.07	1	19
Interval between hospitalizations			223.07	445.3	0	3,989

*N = Cumulative frequency; SD, standard deviation


Year=2002
Year=2003
Year=2004
Year=2005
Year=2006
Year=2007
Year=2008
Year=2009
Year=2010
Year=2011
Year=2012
Year=2013
Total patients (n=1,025,340)
Total patients (n=1,017,468)
Total patients (n=1,016,580)
Total patients (n=1,016,820)
Total patients (n=1,002,005)
Total patients (n=1,020,743)
Total patients (n=1,000,795)
Total patients (n=998,527)
Total patients (n=1,002,031)
Total patients (n=1,006,481)
Total patients (n=1,011,123)
Total patients (n=,1014,730)
Total pneumothorax patients (n=462)
Total pneumothorax patients (n=574)
Total pneumothorax patients (n=627)
Total pneumothorax patients (n=643)
Total pneumothorax patients (n=660)
Total pneumothorax patients (n=693)
Total pneumothorax patients (n=726)
Total pneumothorax patients (n=774)
Total pneumothorax patients (n=765)
Total pneumothorax patients (n=868)
Total pneumothorax patients (n=822)
Total pneumothorax patients (n=812)
Spontaneous pneumothorax patients (n=398)
Spontaneous pneumothorax patients (n=490)
Spontaneous pneumothorax patients (n=504)
Spontaneous pneumothorax patients (n=514)
Spontaneous pneumothorax patients (n=518)
Spontaneous pneumothorax patients (n=555)
Spontaneous pneumothorax patients (n=557)
Spontaneous pneumothorax patients (n=610)
Spontaneous pneumothorax patients (n=598)
Spontaneous pneumothorax patients (n=661)
Spontaneous pneumothorax patients (n=623)
Spontaneous pneumothorax patients (n=616)
Excluded with S27 or S27.0X
-2002(n=64)
-2003(n=84)
-2004(n=123)
-2005(n=129)
-2006(n=142)
-2007(n=138)
-2008(n=169)
-2009(n=164)
-2010(n=167)
-2011(n=207)
-2012(n=199)
-2013(n=196)
Twelve years total spontaneous pneumothorax patients (n=4,658)



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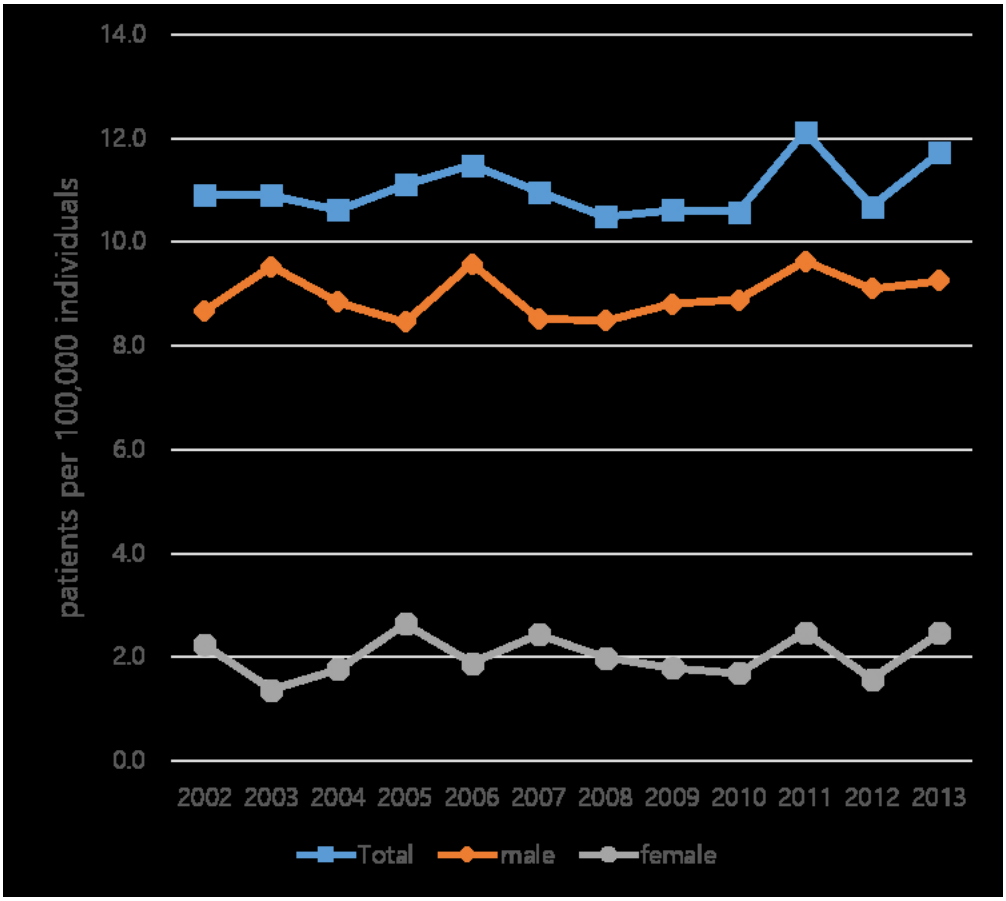

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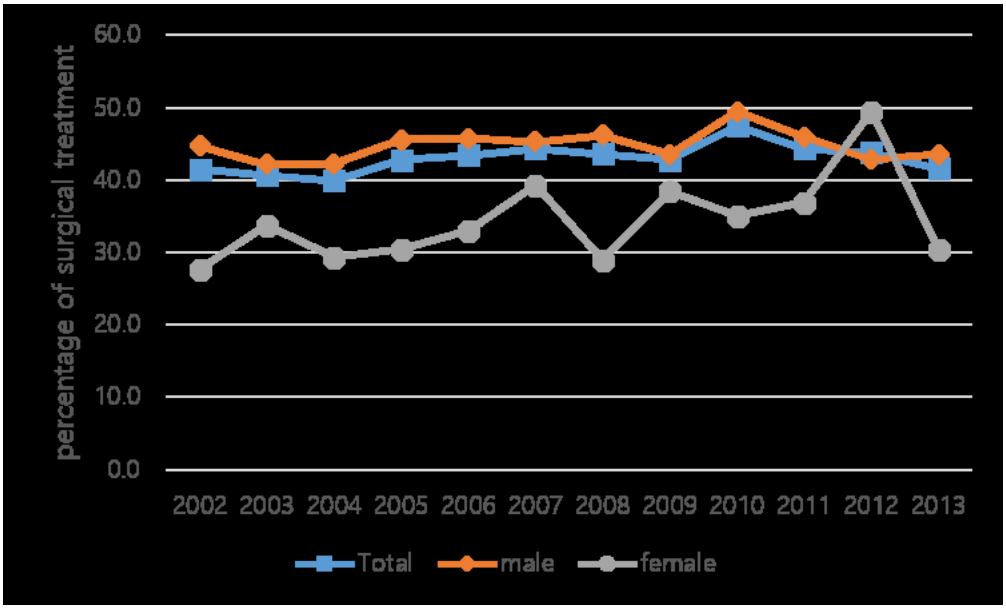

63x38mm (300 x 300 DPI)

The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	(a) P1L1(title), P2L5(abstract) (b) P2L1-P2L1	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	1.1 P1L2(title), P2L6(abstract) 1.2 P1L2(title), P2L8(abstract) 1.3 There is no linkage between databases
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	P4L9-L19		
Objectives	3	State specific objectives, including any prespecified hypotheses	P4L20-L24		
Methods					
Study Design	4	Present key elements of study design early in the paper	P5L2-L11		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	P5L12-L20		

Participants	6	*(a) Cohort study* - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case	(a)P5L12-L20 (b)This is no matched studies	RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	6.1 P5L2-L11, P5L12-17 6.2 P5L2-L11, P5L12-17 6.3 There is no linkage between databases
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	P5L21-P9L3	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	In this study, only J93 patients were considered out of the data of the entire population from the start, and no confounders. Explanations of other outcomes are in P5L21-P9L3.
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement).	P5L21-P9L3		

		Describe comparability of assessment methods if there is more than one group			
Bias	9	Describe any efforts to address potential sources of bias	P5L7-L11		
Study size	10	Explain how the study size was arrived at	P5L2-L11		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	P5L25-P6L2 P6L27-L28		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses	P8L21-P9L3		
Data access and cleaning methods		..		RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population.	12.1 P5L2-L11 12.2 P9L2

				RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	none
Results					
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	P9L9, Table 1 In this study, only J93 patients were considered out of the data of the entire population from the start, Thus, it was quite difficult for us to draw a flowchart.	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	In this study, only J93 patients were considered out of the data of the entire population from the start, Thus, it was quite difficult for us to draw a flowchart.
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)	(a)P9L10 (b)none missing data		
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time	P10L2-P19L3		

		Case-control study - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or summary measures			
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	This is descriptive study, so it is not applicable		
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses			
Discussion					
Key results	18	Summarise key results with reference to study objectives	P21L2, P22L1, P22L8, P22L26,		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	P23L21-P24L8	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Not applicable

Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	P23L25-L30		
Generalisability	21	Discuss the generalisability (external validity) of the study results	P24L9-L11		
Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	P25L8-L10		
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	P25L16-P26L6

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.