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Trend of lung cancer surgery, hospital selection, and survival between 2005 and 2016 in South Korea

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Abstract

Background: Studies on the clinical implication of hospital selection for patients with lung cancer are few. Therefore, this study aimed to analyze 2005–2016 data from the Korean national database to assess annual trends of lung cancer surgery and clinical outcomes according to hospital selection.

Methods: Data of 212 554 patients with lung cancer who underwent upfront surgery were screened. Trends according to sex, age, residence, and income were examined. Descriptive statistics were performed, and p_{trend} values were estimated. The association between survival and hospital selection was assessed using the log-rank test. A multivariate Cox regression analysis was also performed.

Results: A total of 49 021 patients were included in this study. Surgery was prevalent among men, patients aged 61–75 years, capital area residents, and high-income patients. However, with the increasing rate of surgery among women, patients aged ≥76 years, city residents, and middle-income patients, the current distribution of lung cancer surgery could change. The rate of lobectomy among these groups increased. All patients, except those in capital areas, preferred a hospital outside their area of residence (HOR); the number of patients with this tendency also increased. However, this trend was not observed among low-income patients and those aged ≥76 years. There were significant differences in survival according to hospital selection.

Conclusions: The trend of lung cancer surgery is changing. The current medical system is effective in providing lobectomy for patients including women, aged ≥76 years, city residents, and middle-income. Increasing tendency to choose an HOR requires further study.

KEYWORDS
hazard analysis, hospitals, lung cancer, survival

INTRODUCTION

Despite advances in medicine, lung cancer remains a fatal disease worldwide.[1–4] In Korea, pulmonary malignancies are the leading cause of cancer-related deaths, and the prevalence of lung cancer continues to increase among patients aged ≥65 years.[5] Factors affecting the clinical outcomes of lung cancer include smoking behavior, timing of diagnosis, and surgical technique.[6–9] Additionally, the implementation of public health policies can help improve cancer survival. To implement such policies, the findings of a large well-designed study are required; however, such studies are few. We previously analyzed trends in lung cancer using data of 1 million individuals registered in the Korean National Health Insurance (KNHI) database (2003–2013).[10] We observed an increasing rate of lung cancer surgery over time. Furthermore, the accessibility to surgery was limited among low-income patients and those who lived outside large cities.

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However, we included several treatment options such as surgery; therefore, the available surgery-related data (e.g., type of surgery, hospital selection, and trend of surgery according to socioeconomic groups) were limited.

Hospital selection is determined based on various factors; hospital reputation and distance from home are key factors in decision-making.[11–13] Similar factors were found in Korea, but hospital reputation seemed to be more important than distance. A recent study on lung cancer surgery using data from the KNHI database found that more than 60% of surgeries were performed in Seoul, revealing a pattern of centralized treatment.[14] However, the study did not analyze in detail whether the centralized treatment pattern was common among various social classes and whether such a treatment choice positively influenced survival.

Therefore, this study aimed to analyze trends in lung cancer surgery and assess the clinical implication of hospital selection among patients with lung cancer using 2005–2016 data from the national database.

METHODS

Data sources and subjects

The KNHI provides universal health insurance and comprehensive medical care coverage to all residents in South Korea. Data for the period between 2005 and 2016 were obtained from the Sharing Service of the KNHI Corporation. The raw data from KNHI is close to the registry one, but the study population defined in the study is a closed cohort because once defined according to the criteria, they are fixed and cannot be added. The database provides the following detailed sociodemographic information: sex, age, health insurance premiums, residential area, comorbid diseases, treatment information, imaging and laboratory test results, prescribed procedures, and mortality. The study protocol was approved by the Institutional Review Board of Chungbuk National University (2018-04-022). The informed consent to participate had been waived by the Ethics Committee.

Patients with International Classification of Diseases (10th edition) clinical modification code C34, which is indicative of lung cancer, were screened for eligibility. Pathological data were not registered in the KNHI database; hence, pathology-confirmed diagnoses were not possible. To overcome this limitation, patients who were not treated under the "exempted calculation of health insurance," which is a reduced coinsurance rate offered to eligible patients to help pay for medical expenses, were excluded. To avoid financial burdens associated with misdiagnoses, exempted calculation is allowed only after rigorous patient screening performed by the government. As such, to ensure that all study participants had confirmed lung cancer, only patients registered in the exempted calculation system were included in the study.

To ensure homogeneity, only patients who underwent upfront surgery were included. Patients who received adjuvant treatment were excluded from the study (Figure 1a). According to the national comprehensive cancer network (NCCN) guidelines, upfront surgery is recommended for patients with stage I lung cancer as this supports participant homogeneity in this study.

Definitions

Surgery included open or thoracoscopic resection of the trachea or lungs (KNHI reimbursement codes O1311–O1316, O1341–O1345, and O1401–O1432 for pneumonectomy [removal of the entire right or left lung], lobectomy (lobe removal), and sublobectomy [including segmentectomy and wedge resection], respectively). Patients who underwent exploratory thoracotomies (KNHI reimbursement codes O1360) were not included (Figure 1a).

Income was divided into three categories: low = lower 30th percentile, middle-level = 30th–70th percentile, and high = top 30th percentile. Area of residence was divided into capital area (Seoul and Kyunggi province: >25 million residents), city (six cities with 1.1–3.4 million residents), and rural (all other areas: <1 million residents).

Hospital selection was divided into two groups according to the place of surgery: hospital in the patient's area of residence (HIR) and hospital outside the patient's area of residence (HOR). For example, if a patient living in a city chose a hospital in a capital area or a patient living in a rural area chose a hospital in the city, these choices were considered as HOR. Although it was possible that a patient living in a capital area may have chosen a rural hospital, this was unlikely because first, all large hospitals are located within cities and capital areas, with the top five hospitals that treat 30% of all patients with lung cancer located in Seoul,[15] and second, all patients are guaranteed equal coverage by the single health insurance system.

Statistical analyses

Trends in surgery were analyzed by patient sex, age (20–60, 61–75, and ≥ 76 years), income category, and residential area; hospital choice was analyzed using the same factors. The intergroup analysis was performed with chi-square test and the annual p_{trend} was determined using a Wilcoxon-type test for trend across ordered groups. Survival was defined as the period between the date of surgical resection and the date of death from any cause. Survival curves were plotted using the Kaplan–Meier method. The log-rank test was used to compare survival data. To determine prognostic factors, a multivariate analysis was performed using a Cox proportional hazards model. All statistical tests were two-sided, with a significance level set at $p < 0.05$. Analyses were performed using Stata software version 12.1 (Stata).

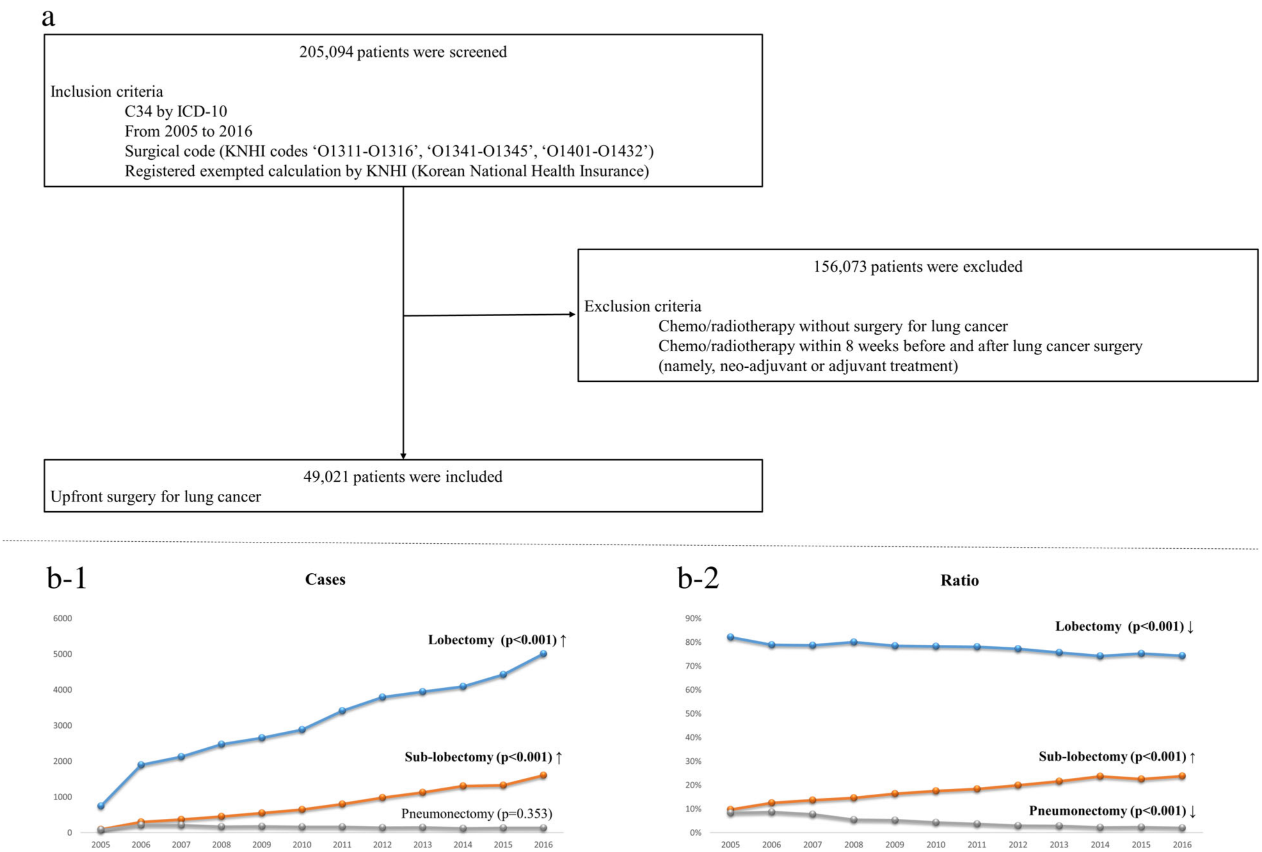

FIGURE 1 Study participants and trends of lung cancer surgery. Patients with lung cancer and C34 code (a) were screened between 2005 and 2016. Registered patients with exempted calculation were included to overcome the unavailability of pathological data in the database. To ensure homogeneity, only patients who underwent upfront surgery were included. The overall number of lobectomy and sublobectomy cases (b-1) increased, but that of pneumonectomy did not. The rate (b-2) of sublobectomy increased, but the rate of lobectomy and pneumonectomy decreased

TABLE 1 Demographic characteristics of patients in the screened and study groups

		All patients	Excluded patients	Study group		Study group		
						HIR[a]	HOR[b]	
Total		n = 205 094	n = 156 073	n = 49 021	p-value	n = 29 399	n = 19 622	p-value
Sex					<0.001			<0.001
	Male	145 070 (71%)	114 132 (73%)	30 938 (63%)		18 766 (64%)	12 172 (62%)	
	Female	60 024 (29%)	41 941 (27%)	18 083 (37%)		10 633 (36%)	7450 (38%)	
Age (years)					<0.001			<0.001
	20–60	47 221 (23%)	30 934 (20%)	16 287 (33%)		9672 (33%)	6615 (34%)	
	61–75	102 247 (50%)	74 885 (48%)	27 362 (56%)		16 387 (56%)	10 975 (56%)	
	≥76	55 626 (27%)	50 254 (32%)	5372 (11%)		3340 (11%)	2032 (10%)	
Residence					<0.001			<0.001
	Capital area	75 796 (37%)	54 614 (35%)	21 182 (43%)		15 398 (52%)	5784 (29%)	
	City	47 606 (23%)	36 420 (23%)	11 186 (23%)		7320 (25%)	3866 (20%)	
	Rural	81 692 (40%)	65 039 (42%)	16 653 (34%)		6681 (23%)	9972 (51%)	
Income					<0.001			<0.001
	High	85 384 (42%)	62 719 (40%)	22 665 (46%)		12 903 (44%)	9762 (50%)	
	Middle	62 905 (31%)	48 246 (31%)	14 659 (30%)		8899 (30%)	5760 (29%)	
	Low	56 805 (27%)	45 108 (29%)	11 697 (24%)		7597 (26%)	4100 (21%)	
Choice of hospital					<0.001			
	HIR	133 578 (65%)	104 179 (67%)	29 399 (60%)				
	HOR	71 516 (35%)	51 894 (33%)	19 622 (40%)				

[a]HIR, hospital in the area of residence.
[b]HOR, hospital outside the area of residence.

RESULTS

Characteristics of the study population

A total of 205 094 patients with confirmed lung cancer, 71% of whom were men (Table 1), were eligible. Patients aged 61–75 years comprised 50% of this cohort, while those aged ≥76 years accounted for 27%. Most patients resided in either rural (40%) or capital (37%) areas. Nearly half of the eligible patients (42%) had high incomes, and 35% of patients chose an HOR. Area of residence was divided into capital area (Seoul and Kyunggi province: >25 million residents), city (six cities with 1.1–3.4 million residents), and rural (all other areas: <1 million residents) areas. Income was divided into high = top 30th percentile, middle-level = 30th–70th percentile, and low = lower 30th percentile.

A total of 49 021 patients (23%) met the inclusion criteria (Figure 1a and Table 1). Most of the patients were male (63%), aged 61–75 years (56%), capital area residents (43%), and had a high income (46%) and chose an HIR (n = 29 399; 60%). In addition, the difference between the study group and excluded patients was significant: the proportion of patients who were female, younger, lived in a capital area, had a high income, and chose an HOR were higher in the study group (Table 1; all p-values <0.001). In the study group, a greater proportion of patients chose an HOR, were female, were younger, lived in a rural area, and had a high income (Table 1; all p-values <0.000).

Trend of lung cancer surgery

The rates of performed overall lobectomy ($p < 0.001$) and sublobectomy ($p < 0.001$) increased over time (Figure 1b-1); however, the rate of pneumonectomy did not ($p = 0.353$). The magnitude of increase was the highest for sublobectomy

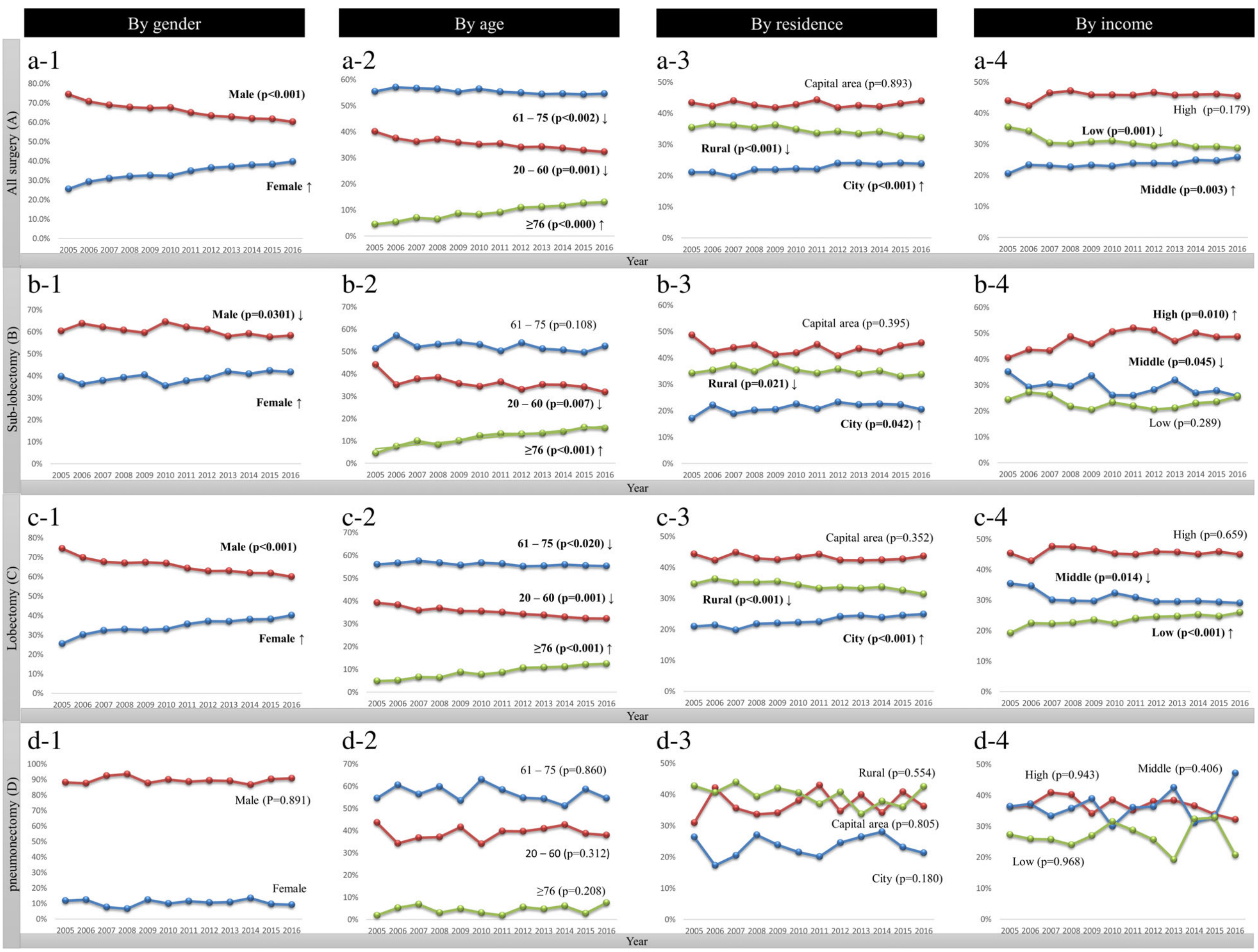

FIGURE 2 Annual trends of lung cancer surgery in South Korea from 2005 to 2016. Trends of lung cancer surgery are depicted by sex, age, residence, and income. The trends of overall (a) surgery, (b) sublobectomy, and (c) lobectomy were similar; they increased over time, particularly among female patients, patients aged ≥76 years, and city dwellers. However, these trends differed with socioeconomic class: the rate of surgery increased among middle-income patients (a-4). The rate of sublobectomy (b-4) and lobectomy (c-4) increased among high- and low-income patients, respectively. The rate of pneumonectomy (d) increased among male patients (d-1), although the change was not significant (d). The p-values are the significance probability of the regression coefficient for the change by year. $p < 0.05$ means that the trends are changing

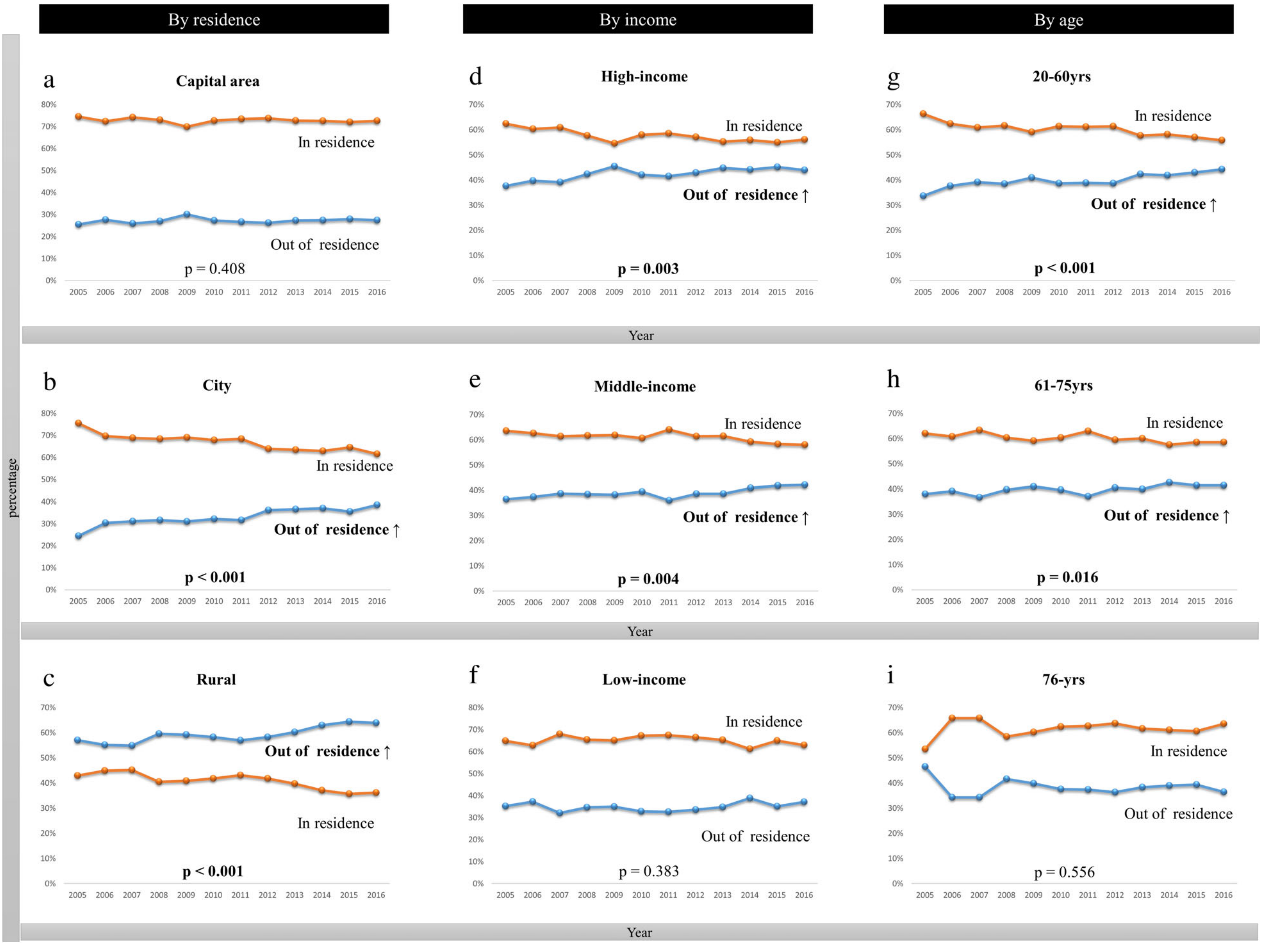

FIGURE 3 Hospital selection according to residence, income, and age. Hospital selection was divided into two groups: hospital in the patient's area of residence (HIR) and hospital outside the patient's area of residence (HOR). (a) Patients in capital areas preferred HIRs; this remained unchanged. (b) A larger proportion of patients in cities chose an HIR; this proportion decreased significantly. (c) Patients in rural areas were more likely to choose an HOR; this tendency increased. The tendency to choose an HOR increased among (d) high- and (e) middle-income patients. (f) Meanwhile, no significant trend was observed among low-income patients. (g and h) The preference for HOR increased among patients aged ≤75 years, but no trend was observed among those (i) aged ≥76 years. The p-values are the significance probability of the regression coefficient for the change by year. $p < 0.05$ means that the trends are changing

(Figure 1b-2, $p < 0.000$). While the absolute numbers of patients who underwent lobectomy and pneumonectomy did not decrease, the proportions of patients who underwent lobectomy and pneumonectomy compared with those of patients who underwent sublobectomy ($p < 0.001$ for both) decreased (Figure 1b).

The rate of surgery increased over time, particularly among females, patients aged ≥76 years, city dwellers, and middle-income patients (Figure 2a). This rate decreased significantly among patients living in rural areas and those with a low income (Figure 2a-3, a-4). The trend for sublobectomy (including segmentectomy, an advanced technique) was similar to that for overall surgery, although the increasing trend was observed only among high-income patients (Figure 2b-4). Compared to the rate of other surgery types, the rate of lobectomy (the standard surgery option for lung cancer) increased among patients aged ≥76 years, city dwellers, and low income patients only (Figure 2c). Pneumonectomy was performed mostly in male patients; no trend or difference was observed in each socioeconomic class (Figure 2d).

Trend of hospital selection

Most patients chose an HIR; however, there was a likelihood of change to an HOR, except for patients in capital areas, with a low income, and aged ≥76 years (Figure 3). Patients in capital areas preferred an HIR, and the trend did not change over time (Figure 3a, $p = 0.408$). Although most patients in cities chose an HIR, the number of patients who chose an HIR decreased significantly over time (Figure 3b, $p < 0.001$). Patients in rural areas (Figure 3c) were more likely to choose an HOR; the number of patients who chose an HOR increased over time ($p < 0.001$). The number of patients who chose an HOR increased among high- (Figure 3d; $p = 0.003$) and middle- income patients (Figure 3e; $p = 0.004$), while it did not increase among low-

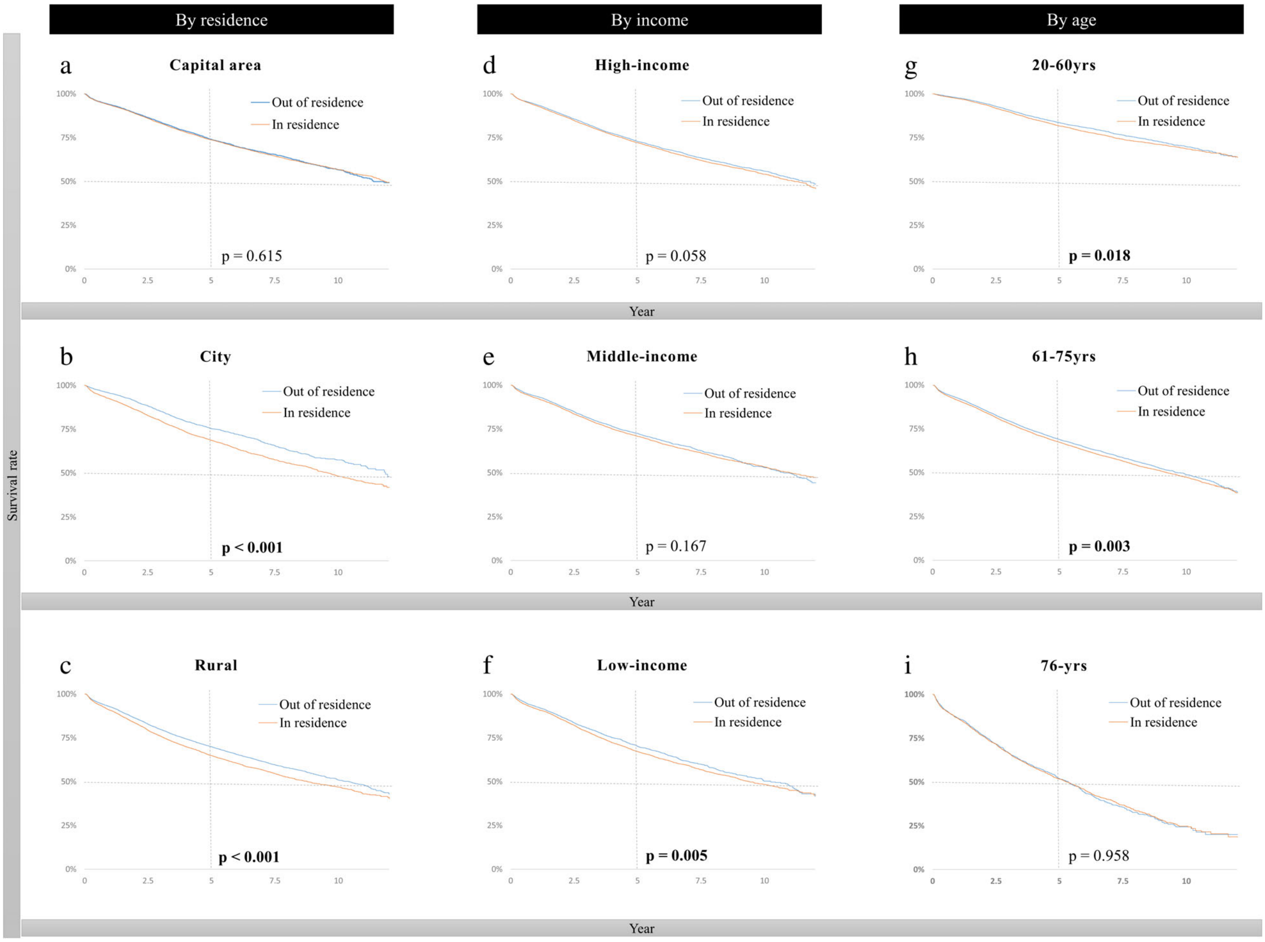

FIGURE 4 Survival analysis between hospital in the area of residence (HIR) and hospital outside the area of residence (HOR). (a) Survival was not associated with hospital selection among patients in capital areas. However, patients in (b) cities and (c) rural areas had better survival when they chose an HOR. There were no survival differences among (d) high- (e) and middle-income patients; (f) however, choosing an HOR was associated with better survival among low-income patients. (g and h) Patients aged <76 years had better survival when they chose an HOR; (i) however, hospital selection had no impact among patients aged ≥76 years

income patients (Figure 3f; $p = 0.383$). Finally, the number of patients who chose an HOR increased among patients aged ≤75 years (Figure 3g, h, 20–60 years: $p < 0.001$; 60–75 years: $p = 0.016$). Meanwhile, this was not the case among patients aged ≥76 years (Figure 3i; $p = 0.556$).

Hospital selection and survival analysis

Patients who chose an HOR had an improved or unchanged survival in all groups. There was no difference in survival among patients in capital areas when classified according to hospital selection (Figure 4a; $p = 0.615$). Survival was improved among patients in the city (Figure 4b; $p < 0.001$) or rural areas (Figure 4c; $p < 0.001$) who chose an HOR. When classified according to income level, hospital selection did not influence the survival of high- (Figure 4d; $p = 0.058$) and middle-income patients (Figure 4e; $p = 0.167$); however, choosing an HOR was associated with better survival among low-income patients (Figure 4f; $p = 0.005$). The survival of patients aged <76 years (20–60 years: $p < 0.018$; 61–75 years: $p < 0.003$) (Figure 4g, h) improved when they chose an HOR; however, hospital location had no impact on survival among patients aged ≥76 years (Figure 4i; $p = 0.958$).

Multivariate analysis of survival outcomes

Considering the median and 5-year survival rates, larger city, higher income, and younger age were favorable factors for survival (Figure 4). Multivariate analyses were performed using sex, age, residence, income, hospital selection, type of surgery, and Charlson comorbidity index as covariates (Table 2). HOR, capital area, higher income, lobectomy, female sex, and younger age were significant factors for improved survival; ($p < 0.001$ in all variables). The hazard ratios (HRs) are shown in Table 2.

TABLE 2 Factors associated with survival in patients with lung cancer

Factor		Hazard ratio	95% confidence interval		*p*-value
Sex	Male	1			
	Female	0.548	0.527	0.570	<0.001
Age (years)	20–60	1			
	61–75	1.824	1.747	1.903	<0.001
	≥76	3.162	2.988	3.346	<0.001
Choice of hospital	HIR[a]	1			
	HOR[b]	0.912	0.881	0.945	<0.001
Residence	Capital area[c]	1			
	City[d]	1.141	1.093	1.191	<0.001
	Rural[e]	1.203	1.157	1.251	<0.001
Income	High[f]	1			
	Middle[g]	1.098	1.056	1.141	<0.001
	Low[h]	1.197	1.149	1.247	<0.001
Type of surgery	Sublobectomy	1			
	Lobectomy	0.738	0.708	0.769	<0.001
	Pneumonectomy	1.485	1.381	1.597	<0.001
Charlson comorbidity index score	1–3	1			
	4–6	1.247	1.200	1.297	<0.001
	7–9	1.686	1.564	1.816	<0.001
	≥10	2.663	1.982	3.577	<0.001

[a]HIR, hospital in the area of residence.
[b]HOR, hospital outside the area of residence Area of residence was divided into.
[c]Capital (Seoul and Kyunggi province: >25 million residents).
[d]City (six cities with 1.1–3.4 million residents), and.
[e]Rural (all other areas: <1 million residents) areas. Income was divided into.
[f]High = top 30th percentile.
[g]Middle-level = 30th–70th percentile, and.
[h]Low = lower 30th percentile.

DISCUSSION

In this retrospective study, data of patients who underwent lung cancer surgery and were registered under a single insurance system from the national database were analyzed. The rate of surgery increased among women, patients aged ≥76 years, city dwellers, and middle-income patients, resulting in varying lung cancer surgery trends. The number of patients who preferred an HOR continued to increase, which led to better survival. However, this trend was not observed among patients aged ≥76 years or low-income patients; their survival did not improve compared with the survival of patients in other social classes. Furthermore, patients in rural areas had poorer survival.

The characteristics of patients and types of lung cancer surgery changed continuously between 2005 and 2016 in South Korea. Although surgery was common among males, patients aged 61–75 years, those living in a capital area, and high-income patients during the study period, the rate of surgery increased steadily among women, city dwellers, and middle-income patients. It is expected that these trends will result in changes in patient characteristics in the future. Regarding the type of surgery, two facts should be noted. First, the rate of lobectomy, which is a standard surgery for lung cancer, is increasing among female patients, low-income patients, and patients aged ≥76 years (these patient groups are considered vulnerable).[16–18] Compared to the rate of pneumonectomy (HR = 1.5, $p < 0.001$), the rate of lobectomy increased: this was noted because of lobectomy-associated increased survival (HR = 0.7, $p < 0.001$). In addition, pneumonectomy is associated with a high rate of complications.[18] Second, surgery type differed with income. The rate of sublobectomy (including segmentectomy), which may help preserve lung function,[19,20] increased only among high-income patients, despite associated technical difficulties.[21,22]

Among patients who chose an HOR, the trends were unchanged, except for those in capital areas, aged ≥76 years, or with a low income. This was not appropriate for three reasons. First, patients in cities and urban areas waste resources by choosing an HOR. This leads to an increase in the social cost of lung cancer surgery. Second, this trend was not observed among vulnerable patients, that is, those with a low income or aged ≥76 years. At a glance, it gives an impression that all patients have an equal opportunity of selecting medical resources under a single health insurance system. However, this is not the case among vulnerable patients. Similar problems can be found in other countries with a single insurance system.[23] Third, such a trend can disrupt the local medical system. A certain rate of performed surgeries is required to maintain surgeons' skills.[24,25] However, if the trend in this study continues, the number of surgeries performed by surgeons in noncapital areas would be insufficient, which could decrease the surgery quality. This vicious cycle can accelerate the centralized phenomenon and hence disrupt the local medical system.

Regarding survival, the relevance of choosing an HOR may be controversial. First, there was an association between HOR and better survival (Figure 4b, c, f, g, h), suggesting the benefit of choosing an HOR (Table 2). Meanwhile, the tendency of choosing an HOR increased among high- and middle-income patients without any differences in survival (Figure 4d, e). However, despite the associated better survival, patients in other groups did not follow the trend (Figure 4f). Choosing an HOR meant resource wastage and inequality of opportunities. Second, older adults tend to be more frail postoperatively;[26–29] however, hospital selection had no impact on the survival of patients aged ≥76 years in our study (Figure 4i). Therefore, performing surgery in an HOR may be a better prognostic factor, and not the act of choosing an HOR itself. Third, although HOR was a positive prognostic factor in the multivariate analysis (Table 2), its effect was not as significant as those of other factors. Rather, it was confirmed that surgery type and effective management of comorbidities were more important for survival. Finally, it is anticipated that neglecting the surgery trend will strengthen the centralized phenomenon, which can lead to other problems in this era of new infectious diseases such as coronavirus disease.[30]

This study had some limitations. First, pathological data were unavailable. As a result, there was a risk of misdiagnosis in some patients. Additionally, patients with different disease stages may have been considered in the survival analysis. To address these limitations, only patients who were registered for the exempted health insurance calculation were selected because these exemptions are issued based on pathological data or strong radiological evidence. Moreover, because patients' pathological stages were unknown, those who underwent nonsurgical treatments for lung cancer were excluded from this study. The log-rank test was performed only for covariates expected to be influenced least by the lung cancer stage, such as sex, income level, and residence area, because some patients may not have undergone adjuvant treatment despite advanced-stage disease; understanding these factors is important for interpreting the multivariate analysis results. Further comparisons might be possible in the future if additional information, including pathological data, is permitted legally to be included in databases.

In conclusion, the rate of lung cancer surgery increased among women, patients aged ≥76 years, city dwellers, and middle-income patients. It is expected that these trends would change the lung cancer surgery distribution in the future. The increase in the rate of surgery, especially lobectomy, among vulnerable patients may ensure improved survival. According to hospital selection, the tendency of choosing an HOR increased. However, further research is required to discover effective coping mechanisms for this trend.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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