

RESEARCH COMMUNICATION

Health and Economic Burden of Major Cancers Due to Smoking in Korea

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Abstract

Cigarette smoking is one of the most important public health concerns in Korea and worldwide. A number of studies have been conducted to measure the health and economic burden of smoking, but these did not reflect recent changes such as the decrease in smoking rate and the increase in the incidence of cancer. The purpose of this study was to provide up-to-date estimates of the health and economic burden of cancer caused by smoking and to compare the results with those of previous studies. Cancer-related burden was assessed with nationally representative data such as claims data from the National Health Insurance Corporation, and cause of death records from the National Statistical Office and the Korea Health Panel. We determined the smoking-attributable burden by multiplying the smoking-attributable fraction by the total burden. As a result, the burden of major cancers due to smoking was found to be substantial despite a recent sharp decrease in smoking by the Korean population. The total economic cost reaches \$2,234.0 million in males and \$870.0 million in females. Also, the health burden of cancers due to smoking is 2,038.9 disability adjusted life years (DALYs) per 100,000 individuals in men and 732.2 DALYs per 100,000 individuals in women. Among all cancers, cancers of the trachea, lungs and bronchus are the leading causes of health and economic burden. The huge burden caused by cancers linked to smoking makes it imperative that adequate policies to decrease the prevalence of smoking be developed, particularly considering the recent increase in smoking rate among women.

Key words : Cost of illness - DALY - cancer - smoking - Korea

Asian Pacific J Cancer Prev, **13**, 1525-1531

Introduction

Cigarette smoking is one of major public health concern due to its prevalence and preventable characteristics. The use of tobacco is a major cause of preventable death worldwide (World Health Organization [WHO] and Research for International Tobacco Control, 2010). It affects the incidence and prognosis of various illnesses such as cancer, respiratory diseases and cardiovascular diseases. For this reason, smoking imposes severe health and economic burden on society. Smoking occupies 3.9% of total disability adjusted life years (DALYs) in low and middle income countries and 12.7% of DALYs in high-income countries. Also, it ranks fourth among global health risk factors, behind underweight conditions in children, high blood pressure and unsafe sex (Lopez

et al., 2006). If this trend persists, the use of tobacco will cause more than eight million deaths per year by 2030 (WHO and Research for International Tobacco Control, 2010).

Smoking is also an important component of health care costs. In a study from the United States, the smoking-attributable cost was found to be 6.54% of total medical care costs, which include costs associated with ambulatory and inpatient care and prescription drugs (Miller et al., 1999). In another study conducted in Taiwan, the smoking-attributable expenditure amounted to \$397.6 million and 6.8% of total medical expenditures (Yang et al., 2005).

Among all smoking-related diseases, cancer is most closely tied to smoking (Ezzati and Lopez, 2003; Danaei et al., 2005). Lung cancer alone causes 0.85

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million smoking-related deaths annually and follows only cardiovascular disease and chronic obstructive pulmonary disease as the most common cause of smoking-related death in the world in 2000 (Ezzati, Lopez, 2003). Also Smoking alone causes 1.5 million cancer deaths, which account for 21% of all cancer deaths (seven million) globally (Danaei et al., 2005). In Korea, premature cancer death due to smoking accounts for 61.9% and 15.8% of total cancer-related premature death in men and women, respectively (Ha et al., 2003). Other studies conducted in Korea found that the burden of major smoking-related cancers (measured in DALYs) was 1,930.1 person years per 100,000 men in 2001 (Lee et al., 2006). Furthermore, in another study from Korea, which determined the expenditure of the National Health Insurance Corporation (NHIC) for smoking-related care, the cancer-related cost due to smoking was found to be \$190.9 million, comprising 46.1% of the total smoking-related medical expenditure of the NHIC in 2003 (Lee et al., 2007).

Because of the public health implications of smoking, some studies investigating the health and economic burden of smoking have been conducted in Korea (Ha et al., 2003; Kang et al., 2003; Lee et al., 2006; Lee et al., 2007). However, these studies do not reflect recent rapid changes in the prevalence of smoking in Korea. The prevalence of smoking in men aged 20 years and older dropped from 73.2% in 1992 to 52.2% in 2006 (Park et al., 2009). In 2007, the prevalence of smoking declined to 45% among men aged 19 years and older (Korea Centers for Disease Control and Prevention [KCDC] and Ministry of Health & Welfare [MOHW], 2011), though in 2008, the prevalence of smoking in men increased to 47.7%. Therefore the proportion of current smoker, former smoker and non-smoker in Korea population was changed.

This steep and abrupt decrease is hard to find in the history. For example, in Japan and the United States, changes of a similar nature have taken more than 20 years to occur (Park et al., 2009). This abrupt change in Korea is mainly attributed to the Korean government's tobacco control policy, which was launched in 1995 (Park et al., 2009; Levy et al., 2010).

However, when considering the epidemiologic transition of cancer, estimating the burden of cancer due to smoking becomes more complex. The incidence rate of cancer in Korea is increasing due to the rapid aging of the population and changes in lifestyle (Shin et al., 2007; National Cancer Information Center, 2011).

Considering the huge burden smoking and cancer impose on health and economic resources, providing up-to-date information on this burden and analyzing patterns of changes are important. Therefore, in this study we attempted to measure the health and economic burden of cancer due to smoking in Korea in the point of 2008 by analyzing recent and nationally representative data such as claims data from the NHIC, cause-of-death records from the National Statistical Office (NSO) and

data from the Korea Health Panel. We also compared our results with those of similar studies previously conducted in Korea.

Materials and Methods

The following eleven major smoking-related cancers were included in this analysis based on previous studies (Ha et al., 2003; Lee et al., 2006): cancer of the lip, oral cavity, and pharynx (C00-C14); esophagus (C15), pancreas (C25), larynx (C32), and trachea, lung and bronchus cancer (C33, C34); cancer of the cervix uteri (C53), urinary bladder (C67), kidney and other urinary (C64, C65, C66, C68); stomach (C16), liver (C22) and colorectal (C18-C21) cancer. Also, this analysis limited its scope to those 35 years old and older, as most of the cumulative hazardous effects of smoking-related cancers are unlikely to manifest in individuals younger than middle age (Ha et al., 2003; Kang et al., 2003; Lee et al., 2006).

The smoking-attributable fraction (SAF) was calculated using the prevalence rate of current smoking, the prevalence rate of former smokers and the non-smoking rate (Levin, 1953; Yang et al., 2005) according to the following formula:

$$\text{SAF} = [P_0 + P_1 \times (\text{RR}_1) + P_2 (\text{RR}_2) - 1] / [P_0 + P_1 \times (\text{RR}_1) + P_2 (\text{RR}_2)]$$

Where P_0 is the non-smoking rate, P_1 is the prevalence rate of former smokers and P_2 is the prevalence rate of current smokers among individuals aged 35 years and older in 2008. The current smoker rate, former smoker rate and non-smoker rate was obtained from the raw data of the 2008 Korean National Health and Nutrition Examination Survey (KNHANES) (KCDC and MOHW, 2011). RR_1 is the relative mortality rate of current smokers compared to non-smokers, and RR_2 is the relative mortality rate of former smokers compared to non-smokers. Relative risk values from Japan were used to estimate the relative risk of selected cancers (Katanoda et al., 2008).

Calculation of the economic cost of major cancers due to smoking

This study estimated the economic burden of the eleven major smoking-related cancers using the prevalence approach, and the economic cost of all cases in 2008 was measured. The economic costs in this study consisted of direct costs and indirect costs (Kim et al., 2010). Direct costs are costs paid as a direct result of disease, and include direct medical costs and direct non-medical care costs such as transportation and caregivers' costs. Indirect costs include loss of productivity costs associated with admissions and outpatient visits in addition to costs related to premature death.

We used claim records from the NHIC to estimate the direct costs of the major cancers. The NHIC is the exclusive insurer of the Korean social health insurance system, and NHIC claims records represent medical care

covered by the Korean insurance program (Kang et al., 2010). Claims records from 2008 associated with the major cancers due to smoking were obtained. The data was collected by using the major claim International Classification of Diseases (ICD)-10 code of claims record. And total claimed costs and admission days were computed by each major cancer. In the case of inpatients, all cases claimed as major cancers were included in the total cost. Outpatients who used outpatient services more than twice for each major cancer were defined as cancer patients and their costs were summed and included in the total cost (Lee et al., 2006; Kim et al., 2010).

Although the NHIC claims data is nationally representative of insured medical costs, it does not provide information about the cost of care that is not covered by insurance, such as elective services. In order to estimate the cost of those services not covered by insurance, data from a survey of non-covered services in 2008 was used (Choi et al., 2009). The proportion of non-covered service costs among total medical costs was 0.17-0.30 in inpatients and 0.11-0.20 in outpatients by each disease. The disease-specific non-covered cost rate was multiplied by the total cost in order to determine the non-covered cost of each disease.

The direct non-medical cost was composed of caregivers' cost and transportation cost related to the treatment of major cancers. The average cost of transportation was estimated using the first round of the 2008 Korea Health Panel Survey (Korea Institute for Health and Social Affairs and NHIC, 2011). The average cost of transportation for a cancer patient was estimated at \$10.7 per one-way trip for inpatients and \$5.0 per one-way trip for outpatients. The frequency of inpatient and outpatient service use was acquired from NHIC claims data.

The Korean Health Panel Survey was also used to estimate average caregivers' costs. According to this survey, the overall mean daily caregivers' pay was estimated to be \$48.1, and 73% of cancer patients were estimated to have utilized a caregiver. The total admission days of cancer patients was estimated from NHIC claims data, and the following equation was used to calculate caregivers' cost:

Caregivers' cost = (days of hospitalization due to major cancer × average caregivers' cost per day in 2008 [\$48.1]) × (the percentage of caregiver utilization in cancer patients)

Indirect costs were classified as costs associated with premature death and productivity loss due to hospitalization or outpatient service use. The loss of productivity was calculated for individuals between the ages of 35 and 65. The average daily wage by each age group was estimated using Ministry of Labor statistics (Ministry of Labor, 2009). The total number of hospitalization days and the frequency of outpatient visits were estimated from NHIC data. The productivity loss due to outpatient visits was determined to be one-third

of inpatients' loss per day (Kim et al., 2010).

The loss due to premature death was measured using the cause of death report generated by the NSO (2009). The number of deaths due to major cancers in people aged 35 and older was determined by age group and sex. Total lost income of the deceased up to age 65 was calculated using the average wage of the age group (Ministry of Labor, 2009). And future income was discounted by 3% per year to obtain the present value (Kim et al., 2010). Age and sex specific costs were calculated (Korea Exchange Bank, 2011), and all costs measured in local currency were converted to US dollars (\$1 = 1,104.7 won). The smoking-attributable cost was estimated using the total cost and SAF in the following equation:

Smoking-attributable cost = total cost of major cancers × SAF

Calculation of the health burden of major cancers due to smoking

Population figures and cause of death data from the NSO were used to calculate cause-specific mortality rates in 2008 (NSO, 2009). Standard expected years of life lost (YLL) was used to measure disease-specific YLL, and the YLL function was applied to estimate the burden of major cancers due to premature death. Also, in order to estimate years lived with disability (YLD), the incidence rate of each major smoking-related cancer was estimated using NHIC data from 2005-2008, except for cases of laryngeal, urinary bladder, and kidney and other urinary cancers. Patients who did not use health care for a specific cancer during 2005-2007 but used health care in 2008 were defined as incident cases. Incidence rate was computed as the number of incident cases per total population (Ha et al., 2003; Lee et al., 2006), except in the case of larynx, urinary bladder, and kidney and other urinary cancers for which the number of incident cases and the incidence rate were determined according to 2007 registry data from the National Cancer Information Center. The number of incident cases according to NHIC claims data was used in conjunction with the number of deaths determined from NSO data in order to estimate the case fatality rate for each cancer. DISMOD II software was employed in the estimation of the disability duration and the age at disease onset (WHO, 2011). The burden of the cancers was computed by summing YLL and YLD to yield DALYs, and DALYs per 100,000 people were estimated by dividing the total DALYs by the total number of individuals aged 35 and older. Finally, the DALYs due to smoking were calculated using SAF in the following equation:

Smoking-attributable DALYs = total DALYs of major cancers × SAF

This study complied with local legislation and the Declaration of Helsinki. Additionally, since this study used public data from the Korea Health Panel, NHIC and NSO, which do not have personal identifiers, it did not require institutional review board approval.

Table 1 Direct and Indirect Cost of Major Cancers Due to Smoking in Korea (2008)^a

Cancer	Men			Women		
	Direct cost	Indirect cost	Total cost	Direct cost	Indirect cost	Total cost
Lip, oral cavity, pharynx	\$21.1	\$49.6	\$70.7	\$5.8	\$8.5	\$14.4
Esophagus	\$28.5	\$64.2	\$92.7	\$1.1	\$2.4	\$3.5
Pancreas	\$11.2	\$58.5	\$69.7	\$13.8	\$46.2	\$60.0
Larynx	\$11.7	\$16.0	\$27.7	\$0.4	\$0.3	\$0.7
Trachea, lung, bronchus	\$184.7	\$534.5	\$719.2	\$67.8	\$182.3	\$250.2
Cervix uteri		Not applicable		\$30.3	\$64.5	\$94.8
Urinary bladder	\$17.9	\$17.8	\$35.7	\$2.9	\$2.5	\$5.4
Kidney, other urinary	\$14.1	\$10.4	\$24.5	\$4.3	\$7.0	\$11.3
Stomach	\$68.3	\$186.2	\$254.5	\$41.7	\$123.2	\$164.9
Liver	\$101.9	\$544.2	\$646.2	\$27.7	\$95.5	\$123.2
Colorectal	\$119.9	\$173.3	\$293.1	\$56.4	\$85.2	\$141.6
Total	\$579.3	\$1,654.7	\$2,234.0	\$252.3	\$617.6	\$870.0

^aUnits are millions of dollars

Table 2 DALYs of Major Cancers Due to Smoking in Korea (2008)^a

Cancer	Men			Women		
	YLL	YLD	DALY	YLL	YLD	DALY
Lip, oral cavity, pharynx	31.3	54.3	85.6	5.1	5.7	10.7
Esophagus	56.9	7.7	64.7	2.5	1.3	3.8
Pancreas	37.9	4.8	42.6	46.7	8.3	55.0
Larynx	18.8	23.8	42.6	0.7	0.5	1.2
Trachea, lung, bronchus	488.9	67	555.9	159.8	31.6	191.4
Cervix uteri	Not applicable			39.4	40.1	79.5
Urinary bladder	20.1	28.1	48.2	3.6	6.0	9.6
Kidney, other urinary	20.6	36.5	57.1	5.5	13.1	18.6
Stomach	132.1	108.4	240.5	85.9	33.3	119.2
Liver	306.8	304.5	611.3	74.0	19.6	93.7
Colorectal	126.5	163.9	290.4	61.6	87.9	149.5
Total	1,239.8	799.1	2,038.9	484.6	247.5	732.2

DALYs disability adjusted life years, YLL years of life lost, YLD years lived with disability; ^aUnits are person-years per 100,000 people

Results

The direct and indirect costs of major cancers due to smoking are shown in Table 1. In males, the leading cancers due to smoking in terms of cost were trachea, lung and bronchus (\$719.2 million), which accounted for 32.1% of the total cancer cost in males, followed by liver (\$646.2 million), colorectal (\$293.1 million), stomach (\$254.5 million) and esophagus (\$92.7 million) cancer. In females, cancers of the trachea, lung and bronchus were also the most costly (\$250.2 million), followed by cancers of the stomach (\$164.9 million), colorectal (\$141.6 million), liver (\$123.2 million) and cervix uteri (\$92.7 million). The total cost for males (\$2,234.0 million) was higher than the costs for females (\$870.0 million). Furthermore, in all cancers except those affecting the cervix uteri the economic burden of cancer was found to be higher in males than in females. However, the cost proportion of females suffering from pancreatic and gastric cancers was higher than the cost

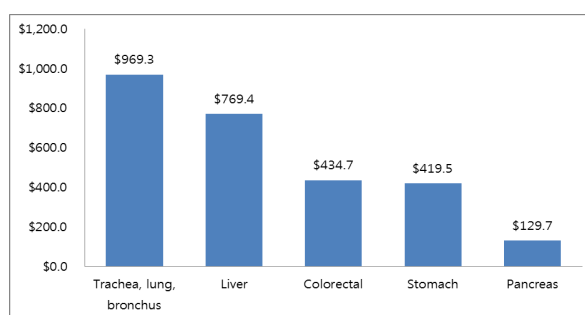


Figure 1. Economic Cost of the Five Most Costly Major Cancers Due to Smoking (unit: millions of dollars)

proportion suffering from other cancers (46.3% in pancreatic cancer and 39.3% in stomach cancer).

In terms of cost classification, the burden due to indirect costs (\$2,272.3 million) was higher than the burden of direct costs (\$831.6 million). As a result, the total cost of major cancers due to smoking amounted to \$3,104.0 million. The cost of cancer due to smoking reached 43.8% of cancer related cost in males, 41.0% of cancer related cost in females and 43.0% of cancer related cost in total, respectively.

Table 2 shows the estimated DALYs due to smoking-related cancer per 100,000 people in Korea. In males, liver cancer had the highest burden (611.3 person years), followed by trachea, lung and bronchus cancer (555.9 person years), colorectal (290.4 person years) cancer, stomach cancer (240.5 person years), and lip, oral cavity and pharynx cancers (85.6 person years).

In females, the leading cause of DALYs was trachea, lung and bronchus cancer (191.4 person years), followed by colorectal (149.5 person years), stomach (119.2 person years), liver (93.7 person years) and cervix uteri (79.5 person years) cancers. The total DALYs in males was 2.7 times higher than that of females, and among the components of DALYs, YLL was higher than YLD in both men and women. The total DALYs of major cancer due to smoking reached 1,358.1 person years per 100,000 people. Also, the DALYs of smoking-attributable cancers reached 43.3% and 40.3% of the total DALYs for all cancers in males and females, respectively.

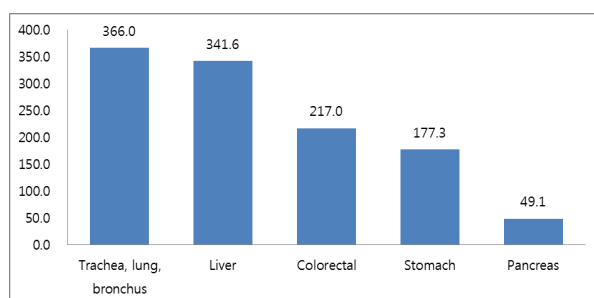


Figure 2. Disability Adjusted Life Years of the Five Most Costly Major Cancers Due to Smoking (units: person years per 100,000 people)

The five leading smoking-attributable cancers in terms of socioeconomic costs are presented in Figure 1. The most costly were trachea, lung and bronchus (\$969.3 million), followed by liver (\$769.4 million), colorectal (\$434.7 million), stomach (\$419.5 million) and pancreas (\$129.7 million) cancers.

Figure 2 shows the burden of major smoking-attributable cancers in terms of DALYs per 100,000 people. The cancers with the highest burden were those of the trachea, lung and bronchus (366.0 person years), liver (341.6 person years), colorectal (217.0 person years), stomach (177.3 person years) and pancreas (49.1 person years).

Discussion

We found that in 2008, the cost of cancer due to smoking was \$2,234.0 million in males and \$870.0 million in females, for a total of \$3,104.0 million. The cost of cancer due to smoking was estimated to be 43% of total cancer costs. Also, the health burden of smoking-attributable cancer due to smoking was 2,038.9 DALYs per 100,000 people in men and 732.2 DALYs per 100,000 people in women, accounting for 41.7% of the total cancer DALYs in Korea. Among the major smoking-related cancers in men, economic cost of tracheal, lung and bronchial cancers is highest (\$719.2 million) and health burden of liver cancer was highest (611.3 person years per 100,000 people) respectively. In women, tracheal, lung and bronchial cancers were the leading cause of economic costs (\$250.2 million) and DALYs (191.4 person years per 100,000 people). When the economic and health burden of men and women are considered together, tracheal, lung and bronchus cancers were the leading cause of economic cost and health burden.

In this study, among the major cancers, the costs of cancers of the trachea, lung and bronchus were highest, followed by liver, colorectal and stomach cancers. In earlier studies of the cost of smoking in 2003, lung, stomach and liver cancers led the list of cancers in terms of costs (Lee et al., 2007). However, those studies only measured the medical expenditure of NHIC, and therefore it was difficult to directly compare the results of our study. Despite this, the increase in the cost of

colorectal cancers was remarkable. From 1999 to 2008, the annual percentage increase of the age-adjusted incidence rate of colon cancer (C18-C20) was 6.9% in males and 5.2% in females, which is the third highest total increase rate next to thyroid and prostate cancers (National Cancer Information Center, 2011).

In previous studies measuring the health burden of cancers in 2001 (Lee et al., 2006), the DALYs of major cancer due to smoking measured 1,930.1 person years and 352.6 person years per 100,000 people in men and women, respectively. Our study found that since 2001, the health burden in women had increased while the burden in men remained relatively stable. Aside from methodological differences between studies, several factors could have resulted in this change. For example, the prevalence of smoking in females increased slightly between 2001 and 2008. In 2001, the prevalence of smoking among females 19 years of age and older was 5.2%, but in 2008 the prevalence increased to 7.4%. Meanwhile, the prevalence of smoking among males decreased from 60.9% in 2001 to 47.7% in 2008 (KCDC and MOHW, 2011). Also, the incidence of cancer in Korea increased during the same time period. The crude incidence of cancer per 100,000 people increased from 261.5 in males and 203.0 in females in 2001 to 375.7 in males and 348.1 in females in 2008 (National Cancer Information Center, 2011). The increase in the smoking-attributable burden of cancer among women and the relative stability of this rate among men could be affected by the increase in the health burden of cancer and the increase in the prevalence of smoking among females and the decrease in the prevalence of smoking among males.

The economic cost of major cancers due to smoking in individuals 35 and older is \$3,104.0 million in this study, which is equivalent to approximately 0.33% of Korea's global domestic product (GDP) (The Bank of Korea, 2009). Furthermore, among all diseases, cancer was the leading cause of DALYs, which is 1,525 person years per 100,000 people (Yoon et al., 2007). Consequently, cancers due to smoking impose a substantial health and economic burden on Korea. Also, smoking could impose additional burden on Korean society when other smoking-attributable diseases are taken into account. For example, in a study on smoking-attributable costs, the cost of cancer due to smoking was estimated to be 46.1% of total smoking-attributable costs in Korea (Lee et al., 2007). The smoking-attributable economic burden could therefore be estimated at \$6,733.1 million and 0.72% of the total GDP (The Bank of Korea, 2009). The DALYs of cancers due to smoking is estimated at about 41.5% of total DALYs due to smoking in men (Allender et al., 2009), and smoking-attributable DALYs could be extended to 5,378.5 person years per 100,000 people in men.

Though it is difficult to draw direct comparisons of the burden of smoking among studies due to differences in study methods and epidemiological characteristics, other studies of smoking have also reported the substantial

effect of smoking on the society. In studies conducted in the United Kingdom, smoking is responsible for 12.1% of total DALYs and 24.12% of National Health Service costs (Allender et al., 2009). Also, the smoking-attributable cost was shown to be 6.8% and 6.54% of total medical expenditures in Taiwan and the United States, respectively (Miller et al., 1999; Yang et al., 2005).

Some limitations of this study should be considered. First, the SAF of this study is established on the formula of Levin (1953). Though this is one of most widely used method to estimate burden of smoking, this method does not consider latency period which disease occur (Gallus et al., 2011; Ginsberg et al., 2010). Because the smoking prevalence of Korea is decreased these decades, these estimates of smoking attributable burden are possibly underestimated and the smoking attributable burden could be greater. In addition, the relative risk of this study is based on Japanese one instead of Cancer Prevention Study II of American Cancer Society to reflect the characteristics of cancer among Asian. But there is a possible limitation to use a Japanese relative risk to Korean population due to possible difference of smoking habit.

To focus on the measuring the economic and health burden, disease definitions such as cancer incidence and cancer patients were based on the records of claims made by health service providers to the NHIC to measure the economic and health burden. While this method has been validated and used in previous studies to estimate the burden of disease (Ha et al., 2003; Lee et al., 2006; Yoon et al., 2007; Kim et al., 2010), the original purpose of these records were to claim costs incurred by the health service providers to NHIC, and therefore inaccuracies may exist. The accuracy of death records from the NSO could be another limitation. While the NSO death record is nationally representative, death certificates are only issued by physicians for 50-60% of all death cases. Therefore, cause-of-death figures used in this study have some limitation in terms of exactness (Jo et al., 2004).

Also, the cost of complementary and alternative medicine (CAM) was not considered. Although some CAM services including Chinese medicine are partially covered by the NHIC, the Chinese medicine claims are not based on the ICD code, thus those costs were excluded from this study. In addition, some possible costs such as over-the-counter drug costs and intangible costs connected with patients and caregivers were excluded in this study due to limitations of data and objectivity related to costs as well. Finally, although we assume that costs due to premature death and productivity loss were not incurred by individuals in those 65 years and older, the results relating to costs may have changed under a different assumption.

Despite these limitations, this study determined the health burden and economic cost of smoking in 2008 using nationally representative data such as NHIC claims records, cause-of-death records from the NSO, and Korea Health Panel Survey data, and the findings were

compared with previous studies conducted in Korea.

In conclusion, the results of this study show that the health and economic burden of cancer due to smoking are substantial, despite the fact that the prevalence of smoking has decreased sharply over the past 15 years. Although Korean government's tobacco control policy has been found to have been successful in decreasing the smoking rate (Park et al., 2009; Levy et al., 2010), the effect of the policy appears to have lessened recently (KCDC and MOHW, 2011). Considering the substantial health and economic burden of cancers due to smoking in Korea, adequate policy and investments are still needed to decrease the prevalence of smoking, and should specifically target the increasing prevalence of smoking in women.

Acknowledgements

This study was supported by a grant from the National R&D Program for Cancer Control, Ministry of Health & Welfare, Republic of Korea (Grant Number: 1020310). The authors have no conflict of interest.

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