Costs of environmental tobacco smoke in Korea

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Abstract

Objectives: To estimate the number of cases of lung cancer, cervical cancer, coronary heart disease/acute myocardial infarction, chronic obstructive pulmonary disease and asthma from self-reported exposure to environment tobacco smoke (ETS) and the cost of treating these estimated cases, given responses about exposure to ETS at home and at work in the Korea National Health and Nutrition Examination Survey.

Methods: We related responses from the Korea National Health and Nutrition Examination Survey about active smoking and exposure to environmental tobacco smoke (ETS), known as second hand smoke, to the risks of contracting 5 diseases associated with tobacco smoke. We estimated the number of the cases attributable to active smoking and ETS and the costs of treating them. We estimated the risks for active smokers, non-smokers currently exposed to ETS and non-smokers not currently exposed to ETS.

Results: The risks facing non-smokers not currently exposed to ETS were similar between sexes, even though smoking behavior between the sexes in Korea was very different. The most expensive disease for both male and female smokers and those exposed to ETS was chronic obstructive pulmonary disease (COPD) because of the large number of cases, especially among males. The estimated total cost of treatment was about 30 billion won (about US$30 million) per year for male smokers, about 9 billion won per year for males exposed to ETS, about 5 billion won per year for females exposed to ETS and about 3 billion won per year for the relatively small number of female smokers. Coronary heart disease and asthma were the next most costly diseases in this study, for male and female smokers and for those exposed to ETS. These diseases were also widespread, although the risks of contracting them are not as high as the risk of contracting COPD for smokers and those exposed to ETS.

Conclusions: Korean men have higher self-reported exposure to ETS at work and have higher estimated treatment costs for COPD and coronary heart disease than women. In general, among the 5 diseases studied, estimated treatment costs are highest for COPD and coronary heart disease because of the large number of estimated cases among those exposed to ETS. For comparison, active smokers are also estimated to have a large number of cases of these diseases and large treatment costs.

keywords: *environmental tobacco smoke, second hand smoke, medical costs, insurance costs, chronic obstructive pulmonary disease, coronary heart disease, acute myocardial infarction, asthma, lung cancer, cervical cancer*

Introduction

Environmental tobacco smoke (ETS) is popularly called ‘second-hand smoke’, ‘involuntary smoking’ or ‘passive smoking’. ETS can come from the exhaled smoke from an active smoker, a burning cigarette or another tobacco product or from any other residue from a smoked tobacco product.

The Korea National Health and Nutrition Examination Survey is a cross-sectional survey that was first conducted in 1998. Originally, it was designed to be a three-year survey, so it was then conducted in 2001 and 2005. In 2007, the surveyors started to conduct the survey every year. At the time of writing, the latest data available are from 2013. Four thousand households were randomly selected for the Health Behavior Survey, the section of the overall survey which asks about active smoking and

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ETS exposure. Questions about ETS exposure were first asked in 2005, which had an overall response rate of 92.8%.

The participants are supposed to be a representative sample of the Korean non-institutionalized civilian population. However, non-responses or missing data may cause the data to become unrepresentative and estimates to be biased. Of course, the survey data are self-reported and therefore have all of the accompanying biases of self-reported data.

The survey calculates the standard errors of the observations in the survey, which account for the probable range of values that are supposed to include the true value in the population. We use the standard errors to adjust the survey observations when the unadjusted values result in implausible results.

Given survey responses, we estimate the number of cases of lung cancer, cervical cancer, coronary heart disease/acute myocardial infarction, chronic obstructive pulmonary disease and asthma attributable to environmental tobacco and smoke active smoking. We estimate these cases by the relative risk of contracting each disease and the number cases of each disease.

We then estimate the costs of treating them with the average costs of treatment and the estimated number of cases. While the costs of treating active smokers with a particular disease could also be determined from hospital surveys that ask their patients about their smoking status and treatment costs, we know of no hospital survey that considers the exposure to ETS and its costs. Therefore, we must rely on the average cost of treatments and the estimated number of cases.

The cost estimates in this paper are likely most applicable to asthma, which can have a quick onset, but can also be applied to diseases with a slow onset, like lung cancer, as long as trends in smoking and ETS exposure are stable over time. The cost estimates can be used by policy makers and insurance companies to determine the costs of exposure to ETS and active smoking in Korea.

Because of the costs of active smoking and ETS, the Korean government has increasingly restricted the use of tobacco in public places, has imposed higher taxes, and has restricted labeling and advertising of tobacco. This paper aims to show how much these restrictions are necessary or relevant by measuring the extent and cost of active smoking and ETS exposure.

Methods

The methods that we use are summarized in Figure 1.

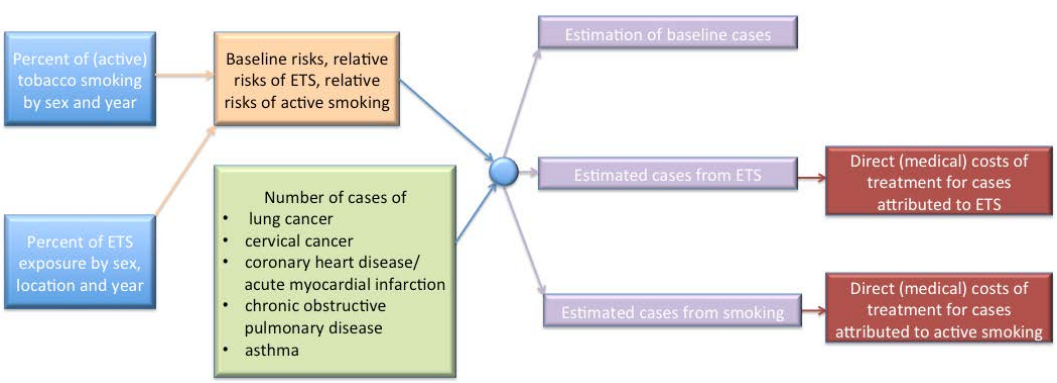

Figure 1. Summary of methods

We first analyze trends in active smoking by sex and by year and analyze trends in ETS exposure by sex, by location and by year. We then calculate the baseline risk, relative risk for ETS exposure and relative risk for active smoking of contracting five tobacco-related diseases. We examine the total number of cases of these five diseases by year and then use the baseline risk and the percentage of the population without any exposure to tobacco smoke to estimate the number of cases of the five diseases

that would occur without any exposure to tobacco smoke. We use relative risks and percentages of the population exposed to ETS and active smoking to estimate the number of cases attributable to ETS and active smoking. Finally, we use the average cost of treatment for each disease and the number of cases for each disease attributable to either ETS or active smoking to estimate the direct medical costs of treatment for each disease when exposure to ETS or active smoke occurs.

Trends in tobacco smoking

The survey asks about current smoking status and the age at which respondents first started smoking, but not whether respondents are ex-smokers. It also asks how many cigarettes current smokers smoke in a day, which averages about 12-19 cigarettes per day depending on age and sex, but we use only the yes-no response for current smoking status to analyze the risk of using tobacco and effectively assume that the risk of using tobacco corresponds to smoking an average amount of cigarettes.

Active smokers were defined as people who had smoked at least 100 cigarettes previously in their lifetimes and continue to smoke on a daily basis at the time of the survey. People other than active smokers were defined as non-smokers, which included occasional or part-time smokers, ex-smokers and never smokers. Because active smokers are defined as daily smokers, the numbers of active smokers under-estimates the number of people who have smoked tobacco and can be expected to have health effects from occasional or past smoking.

According to the survey, tobacco smoking rates on average and for men have declined somewhat since 2005, although they remain significantly higher than women's smoking rates. Figure 1 and Table 1 show that tobacco smoking rates on average declined from 28.8% in 2005 to 23.2% in 2013, although the decline was not monotonic. Smoking rates for men declined from 52.3% in 2005 to 41.4% in 2013, although the decline was not monotonic.

Women's tobacco smoking rates have risen at times since 2005, although they remain significantly lower than men's tobacco smoking rates. Figure 1 and Table 1 show that tobacco smoking rates for women were 5.7% in 2005 and in 2013, and in the intervening years the rates fell and rose slightly.

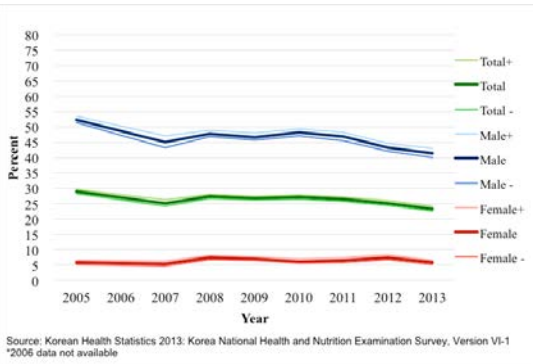

Figure 2. Percent of smokers for men and women and on average in Korea, 2005-2013

	2005	2007	2008	2009	2010	2011	2012	2013
Average	28.8 (0.7)	25.0 (1.1)	27.3 (0.7)	26.6 (0.6)	26.9 (0.7)	26.3 (0.8)	25.0 (0.8)	23.2 (0.8)
Male	52.3 (1.0)	45.1 (1.9)	47.7 (1.0)	46.7 (1.1)	48.1 (1.2)	46.8 (1.3)	43.3 (1.2)	41.4 (1.4)
Female	5.7 (0.5)	5.3 (0.8)	7.3 (0.6)	6.9 (0.5)	6.1 (0.6)	6.5 (0.6)	7.4 (0.7)	5.7 (0.5)

Note: 2006 data are not available. Standard errors are shown in parentheses.
Source: Korean Health Statistics 2013: Korea National Health and Nutrition Examination Survey, Version VI-1

Table 1. Percent of smokers for men and women and on average in Korea, 2005-2013

Table 1 shows standard errors below the responses in parentheses. Figure 1 represents the standard errors by creating band in lighter colors around the value of the (estimated) response, equal to equal to 2 times the magnitude of the standard deviation, labeled with a "+" and a "–".

Trends in environmental tobacco smoke exposure

According to the survey, those exposed to ETS are not active smokers—that is, they are classified as non-smokers—even though active smokers can also be exposed to ETS in addition to their own smoke. Active smoking is assumed to be a more important causative factor for disease than passive or environmental tobacco smoke.

The questions about ETS exposure were self-assessed, as were the questions about active smoking. Participants were asked about ETS exposure at home and at work separately. If participants said that any household member smoked at home (in the house),

they were reported as being exposed to ETS at home. If participants said that they could smell tobacco smoke at work, they were reported as being exposed to ETS at work. The survey does not have a single question about exposure both at home and at work together, but we later try to analyze the effect of combined exposed at home and at work.

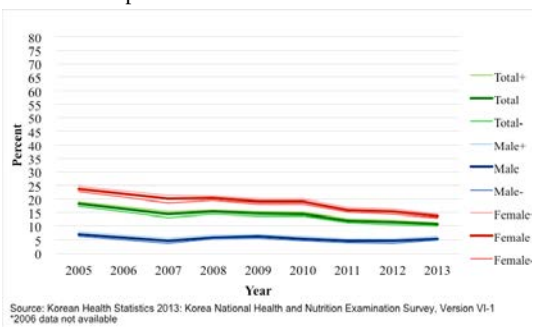

Figure 3. ETS exposure at home men and women and on average in Korea, 2005-2013

Except for the fact that there are separate questions about ETS exposure at work or at home, there is also no question about the degree or the frequency, duration or severity of exposure. The survey does not ask about exposure to ETS outside of the home or workplace, such as at restaurants and bars, nor does the survey ask about past exposure to ETS. But because the survey is an annual survey, we assume that exposure to ETS means generally or occasionally during the last year, according to the assessment of the participants.

Figure 2 and Table 2 show exposure to environmental tobacco smoke (ETS) at home. Females have more ETS exposure than males because men—husbands, fathers, uncles, brothers, grandfathers, et cetera—typically smoke more frequently at home, thereby exposing female family members. In a household with multiple adult members, men with higher smoking rates would tend to expose non-smoking women more frequently to ETS. Women have such low smoking rates that they should only infrequently expose non-smoking males to ETS within a household. A male smoker could expose other males in the household who are non-smokers to ETS, but apparently this is not common.

Like tobacco smoking rates for men, rates of exposure to ETS at home have fallen since 2005—for men, for women and on average. The ETS exposure rate at home for women was 23.9% in 2005, but only 13.7% in 2013. The ETS exposure rate at home for men was 7.1% in 2005 and 5.4% in 2013. On average, the ETS exposure at home has fallen from 18.3% in 2005 to 10.6% in 2013.

As for ETS exposure at work, we see different levels and trends. Table 2 and Figure 3 show that ETS exposure for men at work is higher than it is for women at work. This would occur when more men work than women (and therefore men have a larger potential for exposure at a workplace with tobacco smoke) and more non-smoking men associate or work with male colleagues who smoke at the workplace relative to non-smoking women.

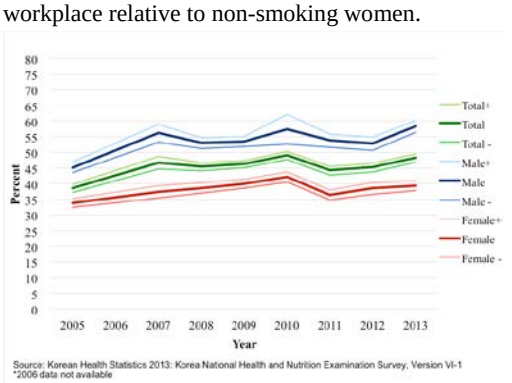

Figure 4. ETS exposure at work for men and women and on average in Korea, 2005-2013

Table 2. Percent of non-smokers exposed to ETS at work or at home in Korea, 2005-2013

		2005	2007	2008	2009	2010	2011	2012	2013
Work	Average	38.6 (1.2)	46.8 (2.0)	45.5 (1.3)	46.3 (1.1)	49.1 (1.3)	44.3 (1.4)	45.3 (1.4)	48.3 (1.3)
	Male	45.3 (1.7)	56.3 (2.9)	53.1 (1.7)	53.6 (1.6)	57.6 (4.7)	53.9 (2.1)	52.9 (2.0)	58.5 (1.9)
	Female	34.0 (1.4)	37.5 (2.0)	38.8 (1.7)	40.1 (1.4)	42.3 (1.6)	36.6 (1.6)	38.7 (1.9)	39.6 (1.6)
Home	Average	18.3 (0.8)	14.4 (1.0)	15.3 (0.7)	14.5 (0.8)	14.4 (0.7)	12.0 (0.7)	11.3 (0.8)	10.6 (0.6)
	Male	7.1 (0.9)	4.5 (1.1)	5.9 (0.8)	6.3 (0.8)	5.4 (0.9)	4.5 (0.8)	4.5 (0.9)	5.4 (0.8)
	Female	23.9 (1.0)	20.1 (1.3)	20.4 (0.8)	19.1 (1.0)	19.2 (1.0)	16.1 (0.9)	15.4 (1.0)	13.7 (0.8)

Note: 2006 data are not available. Standard errors are shown in parentheses.
Source: Korean Health Statistics 2013: Korea National Health and Nutrition Examination Survey, Version VI-1

In addition, we do not see a downward trend in ETS exposure at work like we saw for ETS exposure at home. For men in the workplace, ETS exposure has risen from 45.3% in 2005 to 58.5% in 2013, although the rise has not been monotonic. For women in the workplace, ETS exposure has risen from 34.0% in 2005 to 39.6% in 2013, although the rise has not been monotonic. On average, ETS exposure in the workplace has risen from 38.6% in 2005 to 48.3% in 2013.

We can not explain these upward trends given the restrictions on workplace and public smoking that have been put in place since 2005 and given the decreasing number of men who smoke since 2005. Perhaps due to the restrictions on workplace and public smoking, survey respondents have become more aware of ETS and therefore have become more likely to report it.

The percent of non-smokers who are not exposed to ETS at home has increased for both men and women, as shown in Figure 4 and Table 3. We calculate this percent as a residual, equal to 100% minus the percent of smokers (by sex) minus the percent of those exposed to ETS at home (by sex). This residual has increased for men from 40.6% in 2005 to 53.2% in 2013 because both the percent of male smokers and the percent of male household members exposed to ETS have decreased. This residual has also increased for women from 70.4% in 2005 to 80.6% in 2013 because the percent of female household members exposed to ETS has decreased, while the percent of female smokers has been roughly stable. On average, this residual has also increased from 52.9% in 2005 to 66.2% in 2013, although the trend has not been monotonic.

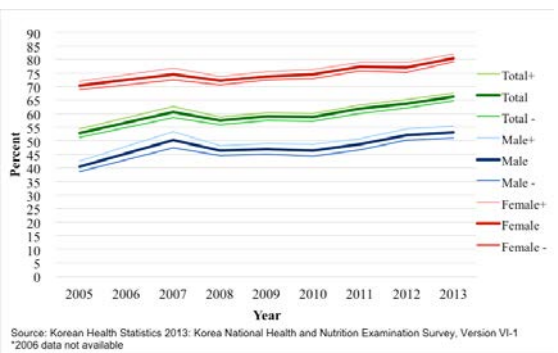

Figure 5. Percent of non-smokers who are not exposed to ETS at home, 2005-2013

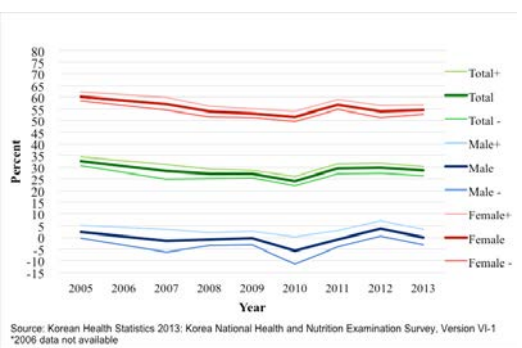

Figure 6. Percent of non-smokers who are not exposed to ETS at work, 2005-2013

In general, Figure 4 and Table 3 show that the percent of male non-smokers not exposed to ETS at home is higher than it is for females, apparently because male non-smokers more frequently have female spouses at home who are also non-smokers. On the other hand, female non-smokers should more frequently have male spouses at home who are smokers because men smoke at much higher rates.

Figure 5 and Table 3 show the percent of male and female non-smokers not exposed to ETS at work. In contrast to the results that we see for ETS exposure at home, the percent of male non-smokers not exposed to ETS at work is lower than it is for females, because males are less frequently non-smokers and likely because non-smoking men more frequently have (male) colleagues at work who create ETS.

Table 3. Percent of non-smokers who are not exposed to ETS, 2005-2013

		2005	2007	2008	2009	2010	2011	2012	2013
Work	Average	32.6 (1.9)	28.2 (3.1)	27.2 (2.0)	27.1 (1.7)	24.0 (2.0)	29.4 (2.2)	29.7 (2.2)	28.5 (2.1)
	Male	2.4 (2.7)	-1.4 (4.8)	-0.8 (2.7)	-0.3 (2.7)	-5.7 (5.9)	-0.7 (3.4)	3.8 (3.2)	0.1 (3.3)
	Female	60.3 (1.9)	57.2 (2.8)	53.9 (2.3)	53.0 (1.9)	51.6 (2.2)	56.9 (2.2)	53.9 (2.6)	54.7 (2.1)
Home	Average	52.9 (1.5)	60.6 (2.1)	57.4 (1.4)	58.9 (1.4)	58.7 (1.4)	61.7 (1.5)	63.7 (1.6)	66.2 (1.4)
	Male	40.6 (1.9)	50.4 (3.0)	46.4 (1.8)	47.0 (1.9)	46.5 (2.1)	48.7 (2.1)	52.2 (2.1)	53.2 (2.2)
	Female	70.4 (1.5)	74.6 (2.1)	72.3 (1.4)	74.0 (1.5)	74.7 (1.6)	77.4 (1.5)	77.2 (1.7)	80.6 (1.3)

Note: 2006 data are not available. Standard errors are shown in parentheses.
Source: Korean Health Statistics 2013: Korea National Health and Nutrition Examination Survey, Version VI-1

For females, this residual is large but has decreased from 60.3% in 2005 to 54.7% in 2013, because the percent of female workers exposed to ETS has reportedly increased. Recall that less than 10% of women report themselves as active smokers.

For males, the percent of non-smokers not exposed to ETS at work is close to zero and sometimes *negative*, especially in 2010 when the standard error for men exposed to ETS in the workplace was particularly high. Essentially, all males report themselves as either smokers or exposed to ETS at work, and some years the residual value of non-smoking males not exposed to ETS even becomes negative because of the (standard) errors involved in surveys.

To avoid the impossibility of having a negative percent of non-smoking males not exposed to ETS in the workplace, we subtract the value of the standard error from the reported percent of ETS exposure and the value of the standard error from the reported percent of smoking. This reduces the reported values and therefore increases the residual values in all cases to at least 0%. We use the residual values to calculate the risks of contracting 5 diseases from smoking and ETS exposure, as well as the background or baseline risk that exists without smoking and ETS exposure.

Relative risks from ETS and smoking tobacco

Behan, Eriksen and Lin (2005) calculated the risks of contracting five diseases from ETS exposure by summarizing the results of hundreds of published studies involving tens of thousands of cases for men, women or both sexes. These diseases are lung cancer, cervical cancer, coronary heart disease, COPD and asthma. Except for cervical cancer, the authors found no significant difference between cases involving men and women, across the studies. Table 4 shows average risk of contracting each disease from ETS that the authors found relative to the background or baseline risk (which is normalized to 1.00). For example, the relative risk for lung cancer is 1.22, indicating that the risk of contracting lung cancer is 22% higher when non-smokers are exposed to ETS than when they are not exposed to ETS.

Disease	Smokers	ETS[5]	Baseline risk
Lung cancer	4.2[1]	1.22	1.00
Cervical cancer	1.7[2]	1.41	1.00
Coronary heart disease	2.0[1]	1.10	1.00
Chronic obstructive pulmonary disease	7.2[3]	1.83	1.00
Asthma	3.9[4]	1.44	1.00

Sources:
[1]H.Y. Kang, H.J. Kim, T.K. Park, S.H. Jee, C.M. Nam, H.W. Park, (2003), Economic burden of smoking in Korea, Tobacco Control.
[2]Carol J. Jones, Louise A. Brinimi, Richard F. Hamman, Paul D. Stolley, Herman F. Lehman, Robert S. Levine, Katherine Mailin, (1990), Risk Factors for in Situ Cervical Cancer: Results from a Case-Control Study, Cancer Research 50, 3657-3662.
[3]Frank A. Lederle, David B. Nelson, Anne M. Joseph. D, (2003), Smokers' relative risk for aortic aneurysm compared with other smoking-related diseases: A systematic review, Journal of Vascular Surgery.
[4]Gilliland FD, Islam T, Berhane K, Gauderman W J, McConnell R, Avol E and Peters JM, (2006), Regular Smoking and Asthma Incidence in Adolescents. American Journal of Respiratory and Critical Care Medicine, Vol 174, pp. 1094–1100.
[5]Donald F. Behan, Michael P. Eriksen and Yijia Lin, (2005), Economic Effects of Environmental Tobacco Smoke, Society of Actuaries.

Table 4. Risks from smoking tobacco and from ETS exposure for various diseases, relative to the baseline risk

The table also shows the risk of contracting each disease from smoking tobacco relative to the baseline risk as estimated by Kang, et alia, (2003); Jones, et alia, (1990); Lederle, et alia, (2003); and Barclay (2008). These numbers range from 7.2 for chronic obstructive pulmonary disease (COPD) to 1.7 for cervical cancer, indicating that smokers are 620% more likely to contract COPD and 70% more likely to contract cervical cancer compared to non-smokers not exposed to ETS, who face a background or baseline risk nonetheless.

Number of cases of five tobacco-related diseases

Table 5 shows the number of cases of the five diseases for the most recent year for which we have data, as well as the cases per 100,000 people in the targeted population. Chronic obstructive pulmonary disease (COPD) was the most common disease in Korea, with about 2.4 million cases in 2012, with men being afflicted more than three times as much as women. There were also about 53,100 total cases of lung cancer in 2012, with about 2/3 of these cases afflicting men. There were about 959,000 cases of heart disease in 2005, the most recent year for which we have data. From 2007-2012, we have data for acute myocardial infarction, a kind of coronary heart disease in which the heart tissue dies due to a lack of blood supply. (Other kinds of coronary heart disease include ventricular fibrillation and congestive heart failure.) In 2012, there were about 236,000 cases of acute myocardial infarction. Coronary heart disease in general afflicts males and females about equally, while acute myocardial infarction in particular afflicts males almost twice as much as females. There were about 914,000 cases of asthma in 2012, which afflicted men and women about equally. In 2012, there were more than 43,000 cases of cervical cancer.

Table 6, Figure 6 and Figure 7 show the trends in the rates of these diseases during the past several years. Lung cancer and cervical cancer exhibited a large increase a few years ago, although changes in reporting and diagnosis could be the reason for these changes. Figure 6 shows that the risks for lung cancer and cervical cancer have risen during 2007-2012, and that men's rates of lung cancer are about 2 times as high as women's rates for lung cancer.

Cases of COPD and asthma have not significantly increased in the past few years, and have sometimes decreased. Figure 7 shows that the rates of COPD remain significantly higher than for men than for women, but the rates of asthma for both sexes are roughly comparable. Acute myocardial infarction has increased during the past several years for both males and females, although the magnitude of the increase is small relative to the magnitude of cases of COPD and asthma.

Disease	Number of cases			Estimated cases per 100,000 people[5]		
	Total	Male	Female	Average	Male	Female
Lung cancer[1]	53,100	34,514	19,237	225	309	155
Cervical cancer[1]	43,221	0	43,221	--	0	156
Coronary heart disease[2]	959,037	462,231	496,806	4,926	5,007	4,880
Acute myocardial infarction[3]	236,339	149,648	86,691	1,003	1,339	700
COPD[4]	2,398,449	1,823,866	569,807	10,719	16,322	4,847
Asthma[4]	914,286	417,703	481,039	2,487	2,324	2,560

Sources:
[1]Cancer Facts and Figures 2014, National Cancer Center, Ministry for Health and Welfare, Statistics Korea, http://kosis.kr/. Cases represent those diagnosed in 2012 for 5-year prevalence.
[2]Hoo-Sun Chang, Han-Joong Kim, Chung-Mo Nam, Seung-Ji Lim, Young-Hwa Jang, Sera Kim, Hye-Young Kang, (2012), The Socioeconomic Burden of Coronary Heart Disease in Korea, Journal of Preventive Medicine and Public Health. Cases represent those diagnosed in 2005 for patients 20 years or older.
[3]Seo H, Yoon S-J, Yoon J, Kim D, Gong Y, Kim AR, et al. (2015) Recent Trends in Economic Burden of Acute Myocardial Infarction in South Korea. PLoS ONE 10(2): e0117446. doi:10.1371/ journal.pone.0117446
[4]Korean Health Statistics, (2012), 5th Korea National Health and Nutrition Examination Survey. Cases of asthma represent those diagnosed in 2012 for patients 19 years or older. Cases of COPD represent those diagnosed in 2012 for patients 40 years or older.
[5]100,000 people from the national population in 2012 who are 40 years or older in the cases of lung cancer and COPD, who are 35 years or older in the case of cervical cancer, and who are 20 years or older in the cases of coronary heart disease and asthma.

Table 5. Number of cases and estimated risk for 5 diseases affected by smoking and ETS

		2005	2007	2008	2009	2010	2011	2012
Lung cancer	Total		25,381	27,906	30,533	43,229	48,279	53,100
	male		17,474	18,734	20,435	32,577	31,948	34,514
	female		8,126	9,085	10,201	14,736	16,961	19,237
Cervical cancer	Total		16,920	16,744	16,397	38,426	40,598	43,221
	male							
	female		16,920	16,744	16,397	38,426	40,598	43,221
CHD/acute myocardial infarction	Total	959,037	188,493	191,424	201,296	222,662	227,316	236,339
	male	462,231	111,899	115,416	122,594	136,625	141,764	149,648
	female	496,806	76,594	76,008	78,702	86,037	85,552	86,691
COPD	Total		3,028,232	2,601,174	2,135,292	2,152,033	2,168,461	2,398,449
	male		1,984,796	1,790,932	1,532,447	1,527,682	1,574,448	1,823,866
	female		1,038,374	732,970	590,448	604,341	587,074	569,807
Asthma	Total		803,960	978,734	978,734	1,012,246	1,012,246	914,286
	male		308,366	376,891	428,286	498,031	417,703	417,703
	female		499,054	623,818	570,347	530,802	613,740	481,039

Sources:
Cancer Facts and Figures 2014, National Cancer Center, Ministry for Health and Welfare, Statistics Korea, http://kosis.kr/.
Hoo-Sun Chang, Han-Joong Kim, Chung-Mo Nam, Seung-Ji Lim, Young-Hwa Jang, Sera Kim, Hye-Young Kang, (2012), The Socioeconomic Burden of Coronary Heart Disease in Korea, Journal of Preventive Medicine and Public Health.
Seo H, Yoon S-J, Yoon J, Kim D, Gong Y, Kim AR, et al. (2015) Recent Trends in Economic Burden of Acute Myocardial Infarction in South Korea. PLoS ONE 10(2): e0117446. doi:10.1371/ journal.pone.0117446
Korean Health Statistics 2013: Korea National Health and Nutrition Examination Survey, Version VI-1

Table 6. Number of cases for 5 diseases affected by smoking and ETS, 2005, 2007-2012

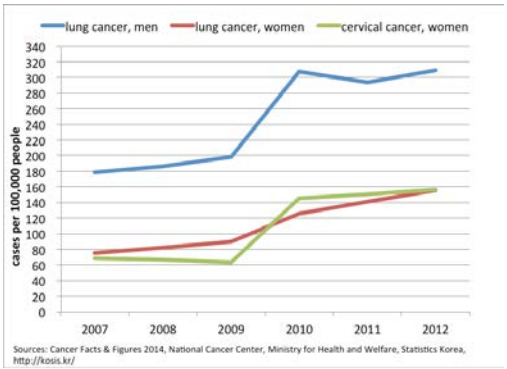

Figure 7. Average risk (rates) of lung and cervical cancer in Korea, 2007-2012

The onset of asthma can happen quickly, whereas the onset of COPD and cancer takes years or even decades. So if smoking rates and ETS exposure have fallen, reported asthma cases can quickly fall too, but the trends for COPD and cancer depend on smoking behavior and ETS exposure years prior.

Notice also that risk of COPD and asthma are about 10-100 times larger than the risk of cancer. The risk of coronary heart disease is comparable to the risk of asthma for both sexes, at about 4880-5007 cases per 100,000 people, but we have data only for 2005. The risk of acute myocardial infarction is somewhat smaller than the risk of asthma for both sexes.

Given the total number of cases and the risks of contracting the diseases in a given year, we next estimate the number of cases suffered by smokers, non-smokers who are exposed to ETS and non-smokers who are not exposed to ETS.

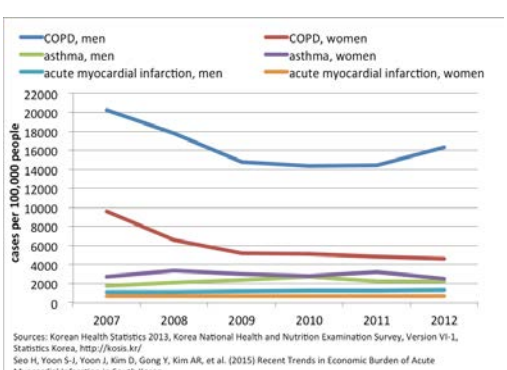

Figure 8. Average risk (rates) of COPD, asthma and acute myocardial infarction in Korea, 2007-2012

Estimation of baseline cases

We start first with estimating the number of cases suffered by non-smokers who are not exposed to ETS. These cases are called baseline cases, and they are supposed to come from a baseline or background risk absent of smoking tobacco and ETS exposure.

We estimate the baseline risk with a function of the average risk of contracting the disease, as well as functions of the percentages of and risks for smokers and of non-smokers exposed to ETS. For example, suppose that the actual number of cases of chronic obstructive pulmonary disease (COPD) is 2,398,449. These people would be active smokers, ex-smokers, non-smokers currently exposed to ETS, non-smokers currently not exposed to ETS and non-smokers never exposed to ETS. For a population of 23,562,416 for both sexes in 2012 who were 40 years or older, 11,174,562 for males in 2012 who are 40 years or older and 12,387,853 for females in 2012 who are 40 years or older; the cases per 100,000 people in the relevant population would be 10179 (or about 10.2%) on average, 16322 (or about 16.3%) for males and 4600 (or about 4.6%) for females.

But these calculations represent the average risk to smokers, non-smokers exposed to ETS and non-smokers not exposed to ETS who are exposed to the baseline risk. The relative risk of COPD for active smokers is estimated to be 7.2 times the baseline risk for non-smokers not currently exposed to ETS; the relative risk of COPD for those currently exposed to ETS is estimated to be 1.83 times the baseline risk, as shown in Table 4. So the baseline risk should be smaller than the average risk, while the risk to smokers should be larger than the average risk.

We estimate baseline risk from the average risk in the following way. Let the proportion of smokers be p_s, the proportion of non-smokers currently exposed to ETS be pets and the proportion of non-smokers currently not exposed to ETS be p_{ns_nets}. And let the risk for smokers be r_s, for those currently exposed to ETS be rets, and for non-smokers currently not exposed to ETS be r_{ns_nets}. r_{ns_nets} is also called the baseline risk. If we assume that these 3 groups are mutually exclusive and collectively exhaustive (ignoring ex-smokers and non-smokers previously exposed to ETS), then the (weighted) average risk that is observed by looking at the number of cases and people's tobacco smoke exposure equals

$$(p_{ns\_nets} \times r_{ns\_nets}) + (p_{ets} \times r_{ets}) + (p_s \times r_s) = \text{average risk}$$

We next use risks *relative* to the baseline risk:

$$(p_{ns\_nets} \times 1.00) + (p_{ets} \times rr_{ets}) + (p_s \times rr_s) = \frac{\text{average risk}}{r_{ns\_nets}}$$

where rr_s is the risk of contracting a disease for smokers relative to the baseline risk, rr_{ets} is the risk of contracting a disease for non-smokers currently exposed to ETS relative to the baseline risk and 1.00 represents relative risk for non-smokers not currently exposed to ETS.

Therefore, the baseline risk, r_{ns_nets}, equals

$$r_{ns\_nets} = \frac{\text{average risk}}{(p_{ns_{nets}} \times 1.00) + (p_{ets} \times rr_{ets}) + (p_s \times rr_s)}$$

For example, when the average risk equals 0.16322 or 16322 cases per 100,000; the relative risk for smokers equals 7.2, the relative risk for non-smokers exposed to ETS equals 1.83, the proportion of male smokers equals 43.3%, the proportion of male non-smokers currently exposed to ETS equals 52.9% and the proportion of male non-smokers not currently exposed to ETS equals 7.0%; then the baseline risk for male non-smokers not currently exposed to ETS equals

$$r_{ns\_nets} = \frac{0.16322}{0.07 \times 1.0 + 0.509 \times 1.83 + 0.421 \times 7.2} = 0.04047$$

or 4.047%. Estimated cases of COPD not linked to active smoking or ETS ("baseline cases") equal this baseline risk times the percent of the male population who neither currently smokes (nor previously smoked) nor are (nor have been) exposed to ETS = 4.047% × 7.0% = 0.002833 = 283.3 cases per 100,000. 283.3 cases per 100,000 represents 1.7% of the total 16322 observed cases for men.

The estimated risk of COPD from ETS equals 1.83 times the baseline risk or 7.41%. Estimated cases from ETS equals this risk times the percent of the male population who is currently exposed to ETS, or 7.41% × 50.9% = 0.03770 = 3770 cases per 100,000. 3770 cases per 100,000 represent about 23.1% of the total 16322 observed cases for men.

The estimated risk of COPD from smoking equals 7.2 times the baseline risk or 29.14%. Estimated cases from smoking equals this risk times the percent of the male population who smoke tobacco, or 29.14% × 42.1% = 0.12382 = 12382 cases per 100,000. 12382 cases represents about 75.9% of the total 16322 observed cases for men.

For females, we estimate baseline cases as

$$r_{ns\_nets} = \frac{0.04600}{0.565 \times 1.0 + 0.067 \times 7.2 + 0.368 \times 1.83} = 0.02673$$

or 2.673%. Estimated baseline cases of COPD equal this baseline risk times the percent of the female population who neither currently smokes (nor previously smoked) nor are (nor have been) exposed to ETS = 2.723% × 56.5% at most = 0.01510 at most = 1510 cases per 100,000 at most. 1510 cases per 100,000 represents 32.8% of the total 4600 observed cases. I write "at most" because the calculation does not consider women exposed to ETS at home, so it neglects some of the cases that were caused by ETS exposure, thereby inflating the number of cases attributable to baseline risk. But in a later calculation we consider ETS exposure at home in addition ETS exposure at work.

Table 7 shows that for both sexes and for all diseases the estimated baseline risk (per year) ranges from about 4.0% (for COPD) to about 0.1% (for cancers). This risk is similar between sexes for lung cancer, coronary heart disease and acute myocardial infarction, but about 2 times higher for women for asthma, and about 1.5 times lower for women for COPD. Differences between sexes can arise due to reporting errors or due to the fact that the calculation does not account for ex-smokers, who should have a higher risk for diseases than the baseline risk. The population of ex-smokers is likely to be different across sexes, since it is likely that men and women to not quit tobacco at the same rate. The calculation also does not account for the intensity or duration of smoking or exposure to ETS, which is also likely to differ across sexes.

Table 7 also shows the estimated cases per 100,000 people (in the age-appropriate population) who are predicted to contract a disease from baseline risk and the percent of total cases that are contracted from baseline risk. Even though the baseline risks are roughly similar between sexes, because so few men are non-smokers who are not exposed to ETS, only about 2%-5% of the total number of cases for each disease for men are predicted to be caused by baseline or background risk. Baseline or background risk is predicted to cause a larger percent of cases for

women, on the order of about 28%-57%, because a larger fraction of women are non-smokers who are not exposed to ETS. For example, about half of the cases of coronary heart disease and acute myocardial infarction for women are predicted to be caused by baseline risk, whereas only about 5% of cases for men are predicted to be caused by baseline risk. Note that women have only about 60% as many cases of acute myocardial infarction as men, probably because women smoke less, as shown in Table 5 and Table 6. However, women have about the same number of cases of coronary heart disease in general as men, which has many causal or contributing factors such as diet and a sedentary lifestyle.

Disease	Sex	Possible ETS exposure *of others*	Baseline risk	Estimated cases per 100,000 people from baseline risk in 2012	Percent of total cases from baseline risk
Lung cancer	M	work	0.126%	8.8	2.8%
	F	work	0.120%	67.7	43.6%
	F	work + home	0.118%	58.4	37.6%
Cervical cancer	M	work	-	-	-
	F	work	0.130%	73.7	47.2%
	F	work + home	0.127%	62.8	40.2%
Coronary heart disease	M	work	3.217%	164.0	3.3%
	F	work	4.499%	2,798.7	57.3%
	F	work + home	4.452%	2,259.6	46.3%
Acute myocardial infarction	M	work	0.910%	63.7	4.8%
	F	work	0.634%	358.2	51.2%
	F	work + home	0.630%	310.5	44.4%
Chronic obstructive pulmonary disease	M	work	4.047%	283.3	1.7%
	F	work	2.673%	1,510.2	32.8%
	F	work + home	2.583%	1,273.5	27.7%
Asthma	M	work	0.933%	65.3	2.9%
	F	work	1.849%	1,044.9	41.7%
	F	work + home	1.807%	891.0	35.5%

Table 7. Baseline risk and estimated cases from baseline risk per 100,000 people, 2012

Estimated cases from ETS

Using the formula above, we estimate the number of cases from ETS exposure at work for males and females for the 5 diseases. In addition, we consider ETS exposure at home, at least for females.

The survey does not ask about the frequency, duration or severity of ETS exposure. It does not distinguish among people exposed to ETS at home only, people exposed to ETS at work only and people exposed to ETS both at home and at work. In general, ETS exposure at work and/or at home would likely cause more cases of disease than ETS exposure only at work or only at home, because the frequency, duration or severity of exposure would be greater. Depending on the year, the survey results tell us that approximately 34%-42% of women are exposed to ETS at work and approximately 15%-24%

of women are exposed to ETS at home according to the response to a separate question. We first consider ETS exposure at work according to a single survey response, and then estimate ETS exposure at work and ETS exposure at home together in the following way.

Because about 50% of adult women are in the labor force, we estimate that the number of women exposed to ETS at work or at home during the same period as 34%-42% + 0.5×(14%-24%). This calculation assumes that 50% of women who answer the survey do not participate in the labor force and face the same ETS exposure rates at home as women in general. But in reality, those who do not participate in the labor force might face ETS exposure rates lower or higher than the reported 14%-24%. Also, some women might be exposed to ETS at work and at home, increasing the frequency, duration and severity of exposure relative to being exposed to ETS at work or at home.

But because nearly all men are either exposed to ETS at work or are smokers themselves and because so few men are exposed to ETS at home, we do not estimate this case for men. Given the already high percent of male smokers and males exposed to ETS at work, adding to the percent of men exposed to ETS at home would often make the estimation of baseline cases untenable because the percent of non-smoking men not exposed to ETS would be estimated at less than 0%.

Disease	Sex	Possible ETS exposure	2005	2007	2008	2009	2010	2011	2012
Lung cancer	M	work		46.5	44.8	48.7	75.6	72.1	78.0
	F	work		26.6	28.5	32.6	49.2	47.4	53.8
	F	work + home		33.1	35.5	39.7	59.2	56.9	63.6
Cervical cancer	M	work							
	F	work		29.1	28.9	28.7	69.1	62.5	67.7
	F	work + home		35.7	35.3	34.4	82.0	74.1	79.0
CHD/acute myocardial infarction	M	work	1,543	452	427	450	492	492	509
	F	work	1,614	256	253	266	299	249	257
	F	work + home	2,157	321	316	325	363	301	305
Chronic obstructive pulmonary disease	M	work		4,808	3,873	3,311	3,204	3,222	3,770
	F	work		3,965	2,595	2,127	2,280	1,881	1,800
	F	work + home		4,778	3,133	2,515	2,670	2,205	2,080
Asthma	M	work		546	613	706	814	674	684
	F	work		1,089	1,334	1,260	1,237	1,230	980
	F	work + home		1,334	1,634	1,511	1,469	1,460	1,145
Note: 2006 data are not available.									

Table 8. Estimated cases per 100,000 people from ETS exposure, 2005-2012

Table 8 shows that the estimated number of cases from ETS exposure at work for men and women and at work or at home for women. Recall that men generally have higher ETS exposure at work, but women generally have higher ETS exposure at home. Notice also that the estimated number of cases for ETS exposure at work or at home together for women are higher than the number of estimated cases for ETS exposure at work only.

The estimated number of cases from ETS exposure

is higher for women than for men for coronary heart disease (CHD) in 2005 because men are more frequently smokers than women so more of the causation of CHD for men is attributed to active smoking. (See Table 9.) When we consider ETS exposure at work or at home for women, the estimated number of cases from ETS exposure is even higher. There were 1543 estimated cases of CHD per 100,000 men in 2005 due to ETS exposure and 1614-2157 estimated cases of CHD per 100,000 women in 2005 due to ETS exposure.

However, for acute myocardial infarction (2007-2012) specifically, the estimated number of cases from ETS exposure is higher for men than for women, although the estimated number of cases of acute myocardial infarction for women rises by about 20%-25% when we consider ETS exposure at work or at home, similar to the 33% increase in the estimated number of cases for CHD. There were 427-509 estimated cases of acute myocardial infarction per 100,000 men and 249-363 estimated cases of acute myocardial infarction per 100,000 women from 2007-2012 due to ETS exposure.

For asthma, the estimated number of cases is higher for women than for men. Again, because men are more commonly smoke than women, more of the causation of asthma is attributed to active smoking for men than to ETS. There were 546-814 estimated cases of asthma per 100,000 men and 980-1634 estimated cases of asthma per 100,000 women from 2007-2012 due to ETS exposure. The estimated number of cases first rose and then fell for both men and women, as the total number of cases rose and fell, as smoking rates for men and ETS exposure at home for women fell and as ETS exposure at work for both sexes generally rose.

For COPD, the estimated number of cases from ETS exposure at work is higher for men, at 3204-4808 cases per 100,000 men, than for women, at 1800-4778 cases per 100,000 women from 2007-2012. For men, the estimated number of COPD cases from ETS exposure has fallen then risen, while the estimated number of cases for women has fallen, even though ETS exposure rates at work for both sexes have generally risen. However, because COPD can take years for onset, we should focus on average levels over the entire survey instead of annual changes.

For lung cancer, the estimated number of cases from ETS exposure at work is also higher for men, at 44.8-78.0 cases per 100,000 men, than for women, at 26.6-63.6 cases per 100,000 women.

For cervical cancer, the estimated number of cases has risen during 2007-2012, from 29.1 cases per 100,000 women to 67.7 cases per 100,000 women for those exposed to ETS at work. For women exposed to ETS at work or at home, the estimated number of cases has risen from 35.7 cases per 100,000 women to 79.0 cases per 100,000 women. The estimated number of cases for ETS exposure at work or at home are about 20% higher than the estimated number of cases for ETS exposure at work only. There was a sharp increase in the estimated number of cases in 2010 for those exposed to ETS as the number of reported cases increased significantly.

Estimated cases from smoking

Table 9 shows that the estimated number of cases from smoking is much greater for men than for women, with the exception of cervical cancer. Recall that men generally have higher smoking rates that are almost 10 times as high as those for women.

COPD is the most common disease for male and female smokers, and active smoking is predicted to cause about 75% of the 14,000-20,000 cases per 100,000 men from 2007-2012. The estimated number of cases of COPD from smoking was 11175-15305 per 100,000 men and 1160-1978 per 100,000 women. Because women smoke much less, the estimated number of cases of COPD for female smokers is much smaller than for male smokers, although these cases are still large compared to cases of other diseases for women. For men and women, the estimated number of COPD cases has fallen then risen from 2007-2012, following the trend in the total reported cases per 100,000 people shown in Figure 7.

Disease	Sex	Possible ETS exposure *of others*	2005	2007	2008	2009	2010	2011	2012
Lung cancer	M	work		129.6	140.0	147.0	230.9	218.0	222.1
	F	work		11.6	17.7	18.6	22.9	27.5	33.7
	F	work + home		11.4	17.4	18.3	22.5	27.1	33.3
Cervical cancer	M	work							
	F	work		4.5	6.3	5.7	11.3	12.7	14.9
	F	work + home		4.3	6.1	5.6	10.9	12.4	14.5
CHD/acute myocardial infarction	M	work	3,300	665	705	717	793	786	766
	F	work	468	59	83	80	73	76	85
	F	work + home	463	59	82	79	73	76	84
Chronic obstructive pulmonary disease	M	work		15,305	13,844	11,423	11,175	11,135	12,268
	F	work		1,978	1,844	1,384	1,212	1,247	1,289
	F	work + home		1,884	1,761	1,326	1,160	1,201	1,246
Asthma	M	work		1,195	1,508	1,677	1,955	1,604	1,532
	F	work		374	652	565	453	561	483
	F	work + home		362	632	548	440	548	472
Note: 2006 data are not available.									

Table 9. Estimated cases from smoking per 100,000 people, 2005-2012

There were 3300 estimated cases of coronary heart disease per 100,000 men in 2005 due to smoking and 463-468 estimated cases of coronary heart disease per 100,000 women in 2005 due to smoking. For acute myocardial infarction, male smokers were predicted to suffer from 665-793 cases from 2007-2012, and female smokers were predicted to suffer from 59-85 cases from 2007-2012.

For asthma, there were 1195-1955 estimated cases of asthma per 100,000 men due to smoking and 362-652 estimated cases of asthma per 100,000 women due to smoking from 2007-2012. The estimated number of cases first rose and then fell for men, and for women there was no discernible trend.

For lung cancer, the estimated number of cases from smoking is higher for men, at 129.6-230.9 cases per 100,000 men, than for women, at 11.4-33.7 cases per 100,000 women. For women, the estimated number of lung cancer cases has steadily risen from 2007-2012, and for men there was a significant increase in 2010, following the trend in the total number of cases.

For cervical cancer, the estimated number of cases for female smokers has risen during 2007-2012, from 4.5 cases per 100,000 women to 14.5-14.9 cases per 100,000 women, depending on whether we consider ETS exposure for others at work or at home, or at work only. When we consider women exposed to ETS at work or at home, the estimated number of cases is not much different. Notice that the estimated number of cases of cervical cancer attributable to smoking are about 5-8 times smaller than the estimated number of cases of cervical cancer attributable to ETS exposure, even those the risk of contracting the disease is higher for smokers. Because the number of female smokers is reported to be so small, the number of cases attributable to smoking is likewise small.

Results

Direct medical costs from ETS

Given the estimated number of "excess" cases from ETS and active smoking relative to the baseline number of cases, we next estimate the cost of treating them, given the average cost of medical treatment. We conjecture that because ETS exposure and smoking cause more cases of disease than would occur otherwise, the cost of treating these diseases increases for each additional case at the average rate, although in reality the cost of treatment may increase at an increasing rate as resources become more scarce or may increase at a decreasing rate as economies of scale take effect.

We find that even though cancer is a relatively rare disease, the cost of treatment is relatively expensive. Lung cancer costs about 14 million won to treat for an average case, approximately equal to US$14,000. Because the number of cancer cases has risen in the past 5 years, the total cost of treating cancer has risen. The total cost of treating men has risen from 652 million won in 2007 to 1093 million won in 2012. For women, the cost has risen from 464 million won in 2007 to 891 million won in 2012 when we estimate the number of cases from ETS exposure at work or at home.

Cervical cancer costs about 4 million won to treat an average case. The estimated cost of treating women exposed to ETS at work or at home has risen from 147 million won to 325 million won. Because the estimated number of cases from ETS exposure only at work and ETS exposure at work or at home were nearly the same in each year, the estimated total cost of treating cervical cancer was nearly the same whether we considered ETS exposure at home or not.

However, because the onset of lung cancer and cervical cancer can take decades, the estimated total medical costs presented in Table 10 (and Table 11) might be better interpreted as the estimated future total medical costs for those currently exposed to ETS (and those currently smoking) if current trends continue indefinitely.

The costs of treating coronary heart disease, acute myocardial infarction, COPD and asthma are inexpensive relative to the costs of treating cancers, at about 1.3 million-3.3 million won for an average case. But because there are large amounts of cases, the estimated total costs of treating these diseases are larger than for treating cancers.

However, because the number of reported cases of COPD for women and men has generally fallen or remained stable, the cost of treating cases attributable to ETS exposure has fallen or remained stable as well, even though the percent of the population exposed to ETS at work has risen slightly. For men exposed to ETS at work, the estimated total cost of treating COPD has fallen from about 11.9 billion won to about 9.3 billion won during 2007-2012. For women exposed to ETS at work or at home, the estimated total cost of treating COPD has fallen from about 10.8 billion won to about 4.7 billion won.

As for asthma, costs have risen or fallen as the number of estimated cases from ETS exposure have risen or fallen. For men exposed to ETS at work, the estimated total cost of treating asthma rose from 1.4 billion won in 2007 to 2.1 billion won in 2010, and then fell to 1.7 billion won in 2012. For women who were exposed to ETS at work or at home, the estimated total cost of treating asthma rose from 3.0 billion won in 2007 to 3.6 billion won in 2008, and then fell to 2.5 billion won in 2012.

For coronary heart disease, the estimated total cost of treatment was 2.8 billion won in 2005 for men exposed to ETS at work and 2.1 billion-2.8 billion won in 2005 for women exposed to ETS at work or at home. For acute myocardial infarction, the estimated total cost of treatment was about 1.5 billion-1.7 billion won for men exposed to ETS at work and about 0.7 billion-1.1 billion won for women exposed to ETS at work or at home from 2007-2012.

In addition to direct medical costs of treatment, we could consider indirect costs of contracting diseases like lost days of work, costs of physical disability and the remedies for it, costs of home care and other costs. But because we have data only for the direct cost of medical treatment, we estimate only that cost.

Disease	Average cost of treatment	Sex	Possible ETS exposure	2005	2007	2008	2009	2010	2011	2012
Lung cancer	14.018	M	work		652	628	683	1,060	1,011	1,093
	14.018	F	work		373	400	457	689	664	754
	14.018	F	work + home		464	497	556	830	798	891
Cervical cancer		M	work							
	4.110	F	work		120	119	118	284	257	278
	4.110	F	work + home		147	145	141	337	305	325
CHD/acute myocardial infarction	1.826/ 3.236	M	work	2,817	1,500	1,416	1,491	1,632	1,632	1,690
	1.271/ 3.317	F	work	2,051	793	782	822	926	772	794
	1.271/ 3.096	F	work + home	2,743	994	979	1006	1123	933	944
Chronic obstructive pulmonary disease	2.477	M	work		11,910	9,593	8,201	7,936	7,981	9,338
	2.260	F	work		8,961	5,865	4,808	5,154	4,250	4,068
	2.260	F	work + home		10,799	7,081	5,683	6,035	4,983	4,701
Asthma	2.554	M	work		1,394	1,565	1,803	2,079	1,722	1,747
	2.222	F	work		2,419	2,964	2,801	2,748	2,732	2,178
	2.222	F	work + home		2,965	3,632	3,357	3,265	3,244	2,544
Notes: Units are in 1 million won. 2006 data are not available										

Table 10. Total direct cost due to cases attributable to ETS, 2005-2012

Direct medical costs from smoking

The average cost of treating smokers is assumed to be the same as the average cost of treating those exposed to ETS, although this might not be true if smokers have more acute or more chronic conditions due to their more intense exposure to tobacco smoke. Nonetheless, we assume that any case of a disease is treated in the same way and has the same average cost of treatment regardless of its cause.

Table 11 and Table 10 show that the estimated total cost of treating lung cancer for male smokers is higher than for males exposed to ETS. And from 2007-2012 the estimated total medical cost for treating lung cancer for male smokers rose from 652 million won to 1093 million won. But because there are few female smokers in Korea, the estimated total cost of treating female lung cancer patients who are (or were) active smokers is lower than it is for males and for non-smoking females exposed to ETS. For female smokers with lung cancer the estimated total cost rose from about 160 million won in 2007 to 467 million won in 2012.

Notice that when we consider ETS exposure at work or at home for women in Table 11, lung cancer cases attributable to ETS exposure for women increase but lung cancer cases attributable to smoking for women decrease. Essentially, the calculations show that when ETS exposure becomes more common (at work or at home), it becomes a more significant cause of disease for a given number of cases, so that smoking becomes a less significant cause for the same number of cases.

The estimated total cost of treating female smokers for cervical cancer has risen from 18 million won to 60 million won, when we consider ETS exposure at work or at home. The results are barely different when we consider only ETS exposure at work.

Disease	Average cost of treatment	Sex	Possible ETS exposure *of others*	2005	2007	2008	2009	2010	2011	2012
Lung cancer	14.018	M	work		1,816	1,963	2,061	3,236	3,056	3,113
	14.018	F	work		163	248	260	321	385	473
	14.018	F	work + home		160	244	256	316	380	467
Cervical cancer		M	work							
	4.110	F	work		18	26	23	46	52	61
	4.110	F	work + home		18	25	23	45	51	60
CHD/acute myocardial infarction	1.826/ 3.236	M	work	6,027	2,206	2,340	2,378	2,630	2,606	2,541
	1.271/ 3.317	F	work	595	183	257	247	227	237	263
	1.271/ 3.096	F	work + home	589	181	254	245	226	235	261
Chronic obstructive pulmonary disease	2.477	M	work		37,910	34,291	28,296	27,681	27,581	30,388
	2.260	F	work		4,469	4,167	3,128	2,740	2,819	2,914
	2.260	F	work + home		4,258	3,980	2,997	2,622	2,715	2,816
Asthma	2.554	M	work		3,053	3,852	4,282	4,992	4,096	3,912
	2.222	F	work		830	1,450	1,254	1,006	1,247	1,074
	2.222	F	work + home		805	1,405	1,219	976	1,217	1,049
Notes: Units are in 1 million won. 2006 data are not available										

Table 11. Total direct cost due to cases attributable to smoking, 2005-2012

The estimated total cost of treating COPD for male smokers has fallen from about 37.9 billion won to about 30.4 billion won during 2007-2012. For female smokers, the estimated total cost of treating COPD has fallen from about 4.3 billion won to about 2.8 billion won when we estimate the number of cases from ETS exposure at work or at home. Because there are so few reported female smokers relative to male smokers and relative to females exposed to ETS, the estimated total cost of treating female smokers is smaller than both of these alternative cases.

For asthma, costs have risen or fallen as the number of estimated cases from smoking have risen or fallen. For men, the estimated total cost of treating asthma rose from 3.1 billion won in 2007 to 5.0 billion won in 2010, and then fell to 3.9 billion won in 2012. For women who were exposed to ETS at work or at home, the estimated total cost of treating asthma rose from 0.8 billion won in 2007 to 1.4 billion won in 2008, and then fell to 1.0 billion won in 2012.

For coronary heart disease, the estimated total cost of treatment was 5.0 billion won in 2005 for male smokers and about 0.5 billion won in 2005 for female smokers. For acute myocardial infarction, the estimated total cost of treatment was about 1.5 billion-1.7 billion won for male smokers and about 0.7 billion-1.1 billion won for female smokers from 2007-2012.

Discussion

Strengths, weaknesses and further research

As stated in earlier sections, survey questions about ETS exposure were self-assessed and did not ask about the frequency, duration or severity of ETS exposure, and in particular did not ask about ETS exposure both at work and at home. Self-assessed

responses can be very unreliable because they depend on the accuracy of recall, emotional responses to the questions and interpretations of the wording of the questions. Likewise, the questions about active smoking were also self-assessed, and the definition of active smoking was set at a high level of daily smoking, omitting people who smoke only occasionally.

Future surveys could ask more precise questions about ETS exposure (ex., both at work and at home? how frequent? how severe?) and active smoking (ex., once a day, a few times per week, a few times per month, a few times per year). Given more precise survey questions, we could make a more precise study of the effects of ETS exposure. Also, one could also try to assess the ill effects of past smoking. Nonetheless, the current survey is an unbiased attempt to assess the prevalence of ETS exposure and active smoking in Korea. The current survey could ask more precise questions in the future if resources are available.

The costs of treating each disease in this study must rely on the average cost, even though some cases would be less or more costly than average, depending on the severity of the disease, among other factors. Data from hospitals that sums that costs for all cases could be a more accurate assessment of the cost of treating each disease. However, we would also need to know whether or to what degree the diseases were caused by active smoking and/or ETS exposure.

Conclusion

In this paper, we relate survey responses from the Korea National Health and Nutrition Examination Survey about smoking and environmental tobacco smoke to the risks of contracting 5 diseases associated with tobacco smoke (lung cancer, cervical cancer, coronary heart disease/acute myocardial infarction, chronic obstructive pulmonary disease and asthma) to estimate the number of cases attributable to active smoking and environmental tobacco smoke and the costs of treating them.

We estimate the risks of contracting these diseases for three groups: active smokers, non-smokers currently exposed to ETS and non-smokers not currently exposed to ETS. The latter group is exposed to background or baseline risks absent of any tobacco smoke. We find that baseline risks for men and women are similar, even though smoking behavior between the sexes in Korea is very different. Baseline risks are small, less than 0.2% for cancers and less than 5% for other diseases.

During most years of the survey, slightly less than 50% of men in Korea are active smokers, while slightly more than 50% of men in Korea are exposed to ETS at work, leaving only a tiny fraction of men not exposed to tobacco smoke in some way. On the other hand, only about 5% of women in Korea are active smokers. Korean women have less reported exposure to ETS at work than Korean men, although they have more reported exposure to ETS at home than Korean men. Nonetheless, ETS exposure for women, and men, remains higher at work than at home.

Because of this difference in smoking behavior and ETS exposure, the cases and the costs associated with treating cases are different between sexes.

Cases of lung cancer caused by smoking and ETS and the costs of treatment are predicted to be higher for men than for women, since men smoke more and have more ETS exposure at work, even when we estimate the effect of ETS exposure at home for women. And even though smoking rates for men have decreased and smoking rates for women are stable, cases of lung cancer have increased, arguably because of high smoking rates in the past and a delayed onset.

As for cervical cancer, about as many cases are predicted to be caused by or associated with ETS exposure as caused by or associated with baseline risk. But because the number of females who are active smokers is reported to be so low, there are few additional cases of cervical cancer associated with active smoking, even though the risk of contracting cervical cancer for female smokers is about 70% higher than the risk of contracting it with no exposure to tobacco smoke.

More than half of coronary heart disease cases in general and acute myocardial infarction cases in particular for men are associated with smoking and about 40% of the cases are associated with ETS exposure, leaving only about 5% of cases associated with baseline risk that non-smokers who are not exposed to ETS face. On the other hand, because women smoke much less, only about 10% of

coronary heart disease cases and acute myocardial infarction cases are associated with active smoking, while about half of acute myocardial infarction cases for women are associated with baseline risk. However, women's cases of coronary heart disease and acute myocardial infarction associated with ETS exposure is similar to men's cases, at about 40% of the total.

COPD cases are also strongly associated with tobacco smoke. About 75% of the COPD cases for men are predicted to be attributable to active smoking, and about 23% of these cases are predicted to be associated with ETS exposure, leaving only a tiny remainder associated with baseline risk. Because women smoke much less than men, only about 26% of the COPD cases for women are associated with active smoking among women. Because the fraction of women exposed to ETS at work or at home is higher than the fraction of women who actively smoke, COPD cases for women associated with ETS are predicted to be higher, at about 43%. Likewise, cases of COPD for women associated with baseline risk are fairly high for women relative to men, at about 28% of the total.

Asthma cases are also strongly associated with tobacco smoke, although asthma cases are more equally divided between the sexes than are COPD cases, which predominately afflict men. About 66% of the asthma cases for men are predicted to be attributable to active smoking, and about 29% of asthma cases for men are predicted to be attributable to ETS exposure. About 18% of asthma cases for women are predicted to be attributable to active smoking, and about 45% of asthma cases from women are predicted to be attributable to ETS exposure. The fraction of cases of asthma for women associated with baseline risk is predicted to be 36%.

Because we use an average cost of treating the diseases, the direct medical costs of treatment are directly proportional to the estimated number of excess cases caused by active smoking and ETS exposure. The most expensive disease to treat for both male and female smokers and those exposed to ETS is COPD—not because the average cost of treatment is expensive but because the estimated number of cases is so high. The estimated total cost of treatment of COPD is about 30 billion won per year for male smokers and about 9 billion won per year for males exposed to ETS. The estimated total cost of treatment of COPD is about 3 billion won per year for female smokers and about 5 billion won per year for females exposed to ETS at work or at home. Even though active smoking is much more hazardous for COPD than ETS exposure, few women reportedly smoke so the estimated total cost of treatment of COPD female smokers is relatively low.

Coronary heart disease in general and asthma are the next most costly diseases to treat in this study, for male and female smokers and for those exposed to ETS. The estimated total cost of treatment of coronary heart disease was about 6 billion won in 2005 for male smokers and about 2.8 billion won in 2005 for males exposed to ETS. The estimated total cost of treatment of coronary heart disease was about 0.6 billion won in 2005 for female smokers and about 2.7 billion won in 2005 for females exposed to ETS at work or at home. The estimated total cost of treatment of asthma is about 4 billion won per year for male smokers and about 1.7 billion won per year for males exposed to ETS. The estimated total cost of treatment of asthma is about 1 billion won per year for female smokers and about 3 billion won per year for females exposed to ETS at work or at home.

Lung cancer and cervical cancer associated with active smoking and ETS exposure are relatively rare, but the average cost of treatment is about 6 times as high as the average cost of treatment for COPD (14 million won versus 2.2 million-2.4 million won). Estimated costs of treating lung cancer have risen to more than 3 billion per year for male smokers and the estimated costs of treating lung cancer have risen to more than 1 billion per year for males exposed to ETS. Estimated costs of treating females for lung cancer and cervical cancer are less than 1 billion per year.

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