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ORIGINAL RESEARCH

Estimating the public economic consequences of introducing varenicline smoking cessation therapy in South Korea using a fiscal analytic framework

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ABSTRACT

Background and aims: Smoking gives rise to many cross-sectorial public costs and benefits for government. Costs arise from increased healthcare spending and work-related social benefits, while smoking itself provides significant revenue for government from tobacco taxes. To better understand the public economic impact of smoking and smoking cessation therapies, this study developed a government perspective framework for assessing smoking-attributable morbidity and mortality and associated public costs. This framework includes changes in lifetime tax revenue and health costs, as well as changes in tobacco tax revenue, from fewer smokers.

Methods: A modified generational accounting framework was developed to assess relationships between smoking-attributable morbidity and mortality and public economic consequences of smoking, including lifetime tax revenue gains/losses, government social transfers, and health spending. Based on the current prevalence of smoking in South Korean males, a cohort model was developed for smokers, former-smokers, and never-smokers. The model simulated the lifetime discounted fiscal transfers for different age cohorts in 5 year age bands, and the return on investment (ROI) from smoking cessation therapy.

Results: Former smokers are estimated to generate higher lifetime earnings and direct tax revenues and lower lifetime healthcare costs due to the reduction of smoking-attributable mortality and morbidity compared to smokers, even after accounting for reduced tobacco taxes paid. Based on the costs of public investments in varenicline, this study estimated a ROI from 1.4–1.7, depending on treatment age, with higher ROI in younger cohorts, with an average ROI of 1.6 for those aged less than 65.

Conclusions: This analysis suggests that reductions in smoking can generate positive public economic benefits for government, even after accounting for lost tobacco tax revenues. The results described here are likely applicable to countries having similar underlying smoking prevalence, comparable taxation rates, and social benefit protection provided to individuals with smoking-related conditions.

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Public economics; smoking cessation; tax; smoking policy; smoking-attributable mortality

Background

Smoking tobacco is a pervasive public health issue, accounting for 11.5% of global deaths, estimated at 7 million deaths annually^{1,2}. Moreover, smoking ranked amongst the five leading risk factors by disability adjusted life years (DALYs)^{1,2}. Smoking-attributable illnesses pose a significant burden on public health systems. A recent review identified studies reporting that ~15% of the aggregate healthcare expenditure, in high-income countries, can be attributed to smoking³. In the US, the proportion of healthcare expenditure attributable to smoking ranged between 6–18% across different states³. In the UK, the National Health Service (NHS) costs attributable to smoking were found to be between £2.7–£5.2 billion, which is equivalent to ~5% of the total annual NHS budget³. In 2013, the total economic burden of smoking-attributable cancers in South Korea was found to be USD (\$)

2,234 million in males and \$870 million in females⁴. A previous South Korean study reported that the estimated costs attributable to smoking in 1998 ranged from 0.59% of gross domestic product (GDP) to 0.78% of GDP⁵.

The cost burden of smoking is not isolated to health costs, and can be shown to influence many economic parameters. The societal burden attributable to smoking is often expressed in terms of productivity loss from premature mortality, absenteeism, presenteeism, including lost productivity from smoking breaks, and increased pension costs⁶. In the US, the total productivity losses attributed to smoking are estimated at \$151 billion annually³. Moreover, smoking-related premature mortality was found to cost \$97 billion in annual productivity losses². Furthermore, in Denmark, the negative impact on productivity attributed to smoking has been estimated to be Danish Kroner (DKK) 14 billion (\$42 billion)⁷. Many of these costs are absorbed by businesses,

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Supplemental data for this article can be accessed [here](#).

as reported in a UK study in which smoking-related absenteeism was estimated to be £4.1 billion (\$3 billion) annually⁸. Smoking has also been shown to impact an individual's wages and lifetime earnings, even after controlling for genetic and educational factors⁹. Consequently, reversing smoking trends could also offer benefits for business and individuals, as surveys have shown former smokers are more productive and have fewer sick days than current smokers^{10–12}. Taking into consideration the relationship between productivity and wages, this would suggest that quitting smoking will positively influence lifetime earnings^{10–12}.

Previous policy assessments designed to evaluate the economics of smoking cessation have focused on healthcare cost arguments to indicate long-term healthcare savings or resource use efficiency (i.e. cost-utility ratios) attributed to reduced smoking-related conditions¹³. These approaches are likely utilized because most smoking-related health conditions occur later in life. There are limited health arguments based on short-term health outcomes, and the benefits that can be gained by avoiding future smoking attributed illnesses and remaining productive over the life cycle. The relationship between smoking and productivity is fundamental and, hence, societal burden of disease studies may encompass a wider spectrum of smoking-attributable costs and benefits. Notwithstanding its clinical and socioeconomic burden, smoking produces high fiscal revenues for the governments. Specifically, tobacco consumption is responsible for significant tax revenues for most governments, especially in high-income countries³.

Smoking and smoking policy create conflicting public economic consequences that conventional health economic perspectives fail to capture. Decreased prevalence of smoking can generate both gains and losses for the economics of the government, i.e. the public economy, which is a core consideration that this research seeks to understand. The aim of this study is to understand how investments in pharmacological smoking cessation interventions, specifically varenicline, may influence future public economic budgets for the South Korean government, based on changes in healthcare costs, increased productivity-linked wage increases for those that quit smoking, and subsequent increased tax revenues, while accounting for the tax losses associated with reducing the consumption of tobacco use. To inform ongoing policy discussion and treatment access in South Korea, we apply a public economic perspective for assessing the introduction of varenicline in South Korea, by quantifying the long-term fiscal transfers between the government and male citizens that stop smoking compared to the current status quo and smoking prevalence and tobacco tax revenues. The focus of this analysis is on South Korean males, as the epidemiology suggests few females smoke in South Korea^{14,15}.

Methods

Analytic framework

The analytic framework applied in this study combines concepts from human capital economics, public economics with generational accounting used to assess the intergenerational

relationship between lifetime tax burden, and social transfers¹⁶. The present analytic framework considers that several smoking-related fiscal and productivity components have either direct or indirect public economic effects. The following three productivity components are considered in the public economic framework:

- i. smokers die prematurely due to smoking-related illnesses, resulting in fewer working years and reduced lifetime direct and indirect taxes paid;
- ii. smokers have increased morbidity and absenteeism attributable to smoking-related diseases, which influences wages; and
- iii. smokers are less productive at work, which is often reflected by lower wages¹⁰.

From the perspective of public economics, reduced productivity results in lower earnings and, hence, reduced tax revenues collected by government from smokers. Moreover, three additional smoking-related fiscal effects are considered, namely:

- a. smoking-attributable morbidity is associated with increased healthcare costs;
- b. reductions in the consumption of tobacco products, resulting from smoking cessation, have negative fiscal effects in the form of reduced tobacco tax revenue for government; and
- c. Policies aimed at reducing smoking prevalence, including smoking cessation therapy, often require public investment costs to implement smoking cessation interventions.

Economic model and data

To project the fiscal impact for government attributed to varenicline, we assessed the human capital impact of smoking to estimate the indirect costs (i.e. societal perspective). In public economics, the source of revenue for government is derived from productive labor of members of society that transfer a proportion of their earnings to government through direct and indirect taxes. By recognizing this relationship, we reflect how policies that change population health, represented as morbidity and mortality, will ultimately have consequences for government, based on the wealth that citizens are able to transfer to government from their earnings. We refer to this as the fiscal impact of health, based on how a health condition or risk factor, i.e. smoking, deviates from the statistical population norms for tax transfers and public costs.

Data from the literature on age-specific earnings, unemployment, smoking prevalence by age, smoking-attributable mortality, and South Korean lifetables were used to estimate the age-specific probability of death for smokers and former-smokers (Table 1)^{14,15,17,18}. The resulting relative risk of death for smokers compared to never smokers and of former smokers to smokers, used in the model, were 1.9 and 0.6, respectively (Figure 1). We applied the average age-specific earning for numbers of people alive each year, adjusted

Table 1. Age-specific demographic and labor market inputs, males.

Age-specific variables	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65
Total population	3,269,169	3,722,920	3,859,858	4,212,223	4,211,450	4,117,453	3,753,069	2,722,767
Prevalence of smoking	52.90%	52.90%	54.06%	54.06%	54.06%	54.06%	54.06%	54.06%
Average number of daily cigarettes	15.50	15.50	15.50	15.70	15.70	14.78	14.78	13.79
Average annual age-specific wage smokers (KRW)	33,513,480	33,513,480	38,623,830	38,623,830	39,717,510	39,717,510	39,717,510	19,744,830
Average annual wage former smokers (KRW)	36,036,000	36,036,000	41,531,000	41,531,000	42,707,000	42,707,000	42,707,000	21,231,000
Unemployment rate	10.3%	3.2%	3.2%	2.1%	2.1%	2.3%	2.3%	2.2%

Figure 1. Age-specific annual probabilities of death for the general population, smokers, former smokers, and never smokers.

for unemployment. Consistent with the generational accounting approach, earnings were inflated annually. For the estimation of income tax revenue (direct tax), an average tax burden of 29.1% was applied to estimated age-specific earnings^{19–21}. A proxy of consumption tax (indirect tax) was estimated based on the current value added tax (VAT) rate of 10%, and the average annual disposable income for South Korea, estimated at 82% of earnings¹⁷.

In South Korea, tobacco tax corresponds to 76% of the price per pack of cigarettes²¹. An average price of South Korean Won (KRW) 4,500 (\$3.96) per 20-cigarette pack was assumed in the analysis. Tax per pack of cigarettes was combined with age-specific data for the prevalence of smoking, the daily number of cigarettes consumed, and smokers' average life expectancy (Table 1 and Figure 1) to estimate expected tobacco tax revenue for the South Korean government¹⁵. Finally, a 5% discount rate was used for all costs and benefits in this analysis. The smoking-attributable fractions (SAF), and the corresponding costs of chronic obstructive pulmonary disease (COPD), cardiovascular disease, and smoking-related cancers reported by Bae *et al.*²² were used to estimate the expected lifetime healthcare costs of smokers and former smokers. Healthcare costs were inflated at the average annual inflation rate of 2.2% to reflect 2016 prices²³. The estimated lifetime smoking-attributable health costs for smokers and former smokers were estimated to be KRW5,043,144 and KRW1,702,478, respectively (Table 1, Supplementary material).

Study assessments

The public economic framework considers the number of smokers and former smokers between the ages of 26–65. For

each year of the model, a detailed description of metrics and the discounted incremental analysis conducted for evaluating public economic impact are described in the [Supplementary materials](#). The short- and long-term consequences of smoking and smoking cessation on the public budget were discounted to reflect present values. The time horizon of this analysis was based on the productive working life, with an average age of retirement at 65 years of age. The present value of expected earnings, tax revenue, healthcare costs, and tobacco tax revenue were estimated for smokers and former smokers. Subsequently, the difference in the aforementioned metrics between smokers and never smokers was calculated to reflect the costs and benefits of smoking cessation. The analysis considered the likely fiscal consequences of introducing smoking cessation within different 5-year age groups: 26–30, 31–35, 36–40, 41–45, 46–50, 51–55, 56–60, and 61–65. The calculations for estimating discount lifetime earnings, tax revenues, tobacco taxes, and public costs are described in [Supplementary Table S2](#). Finally, one-way ($\pm 20\%$) sensitivity analysis for key parameters was conducted.

Results

The duality of assessing the incremental public economic effects of smoking cessation therapies across different age groups are described in Table 2. The modeled assessment indicates that former smokers are estimated to result in higher lifetime earnings and direct tax revenues for the government and lower lifetime healthcare costs, due to the reduction of smoking-attributable mortality and morbidity compared to smokers. Whilst smoking cessation results in higher direct and indirect tax revenues from increased productivity, the opposite occurs to tobacco tax revenues due to

Table 2. Incremental public economic effects of smoking cessation per individual (25–65 years of age) for South Korean males.

Age group	Societal perspective		Government fiscal perspective			
	Present value of lifetime earnings (KRW)	Present value of lifetime tax revenue for the government (KRW)	Present value of lifetime tobacco tax (KRW)	Present value of healthcare system savings (KRW)	Total public economic of effects of smoking cessation (KRW)	ROI from smoking cessation therapy
26–30	15,169,828	4,558,685	–4,453,616	3,340,666	3,445,736	1.67
31–35	14,288,789	4,293,924	–4,102,527	3,340,666	3,532,063	1.71
36–40	13,100,500	3,936,831	–4,145,924	3,340,666	3,131,573	1.51
41–45	11,351,216	3,411,154	–3,247,237	3,340,666	3,504,583	1.69
46–50	9,286,069	2,790,557	–2,720,370	3,340,666	3,410,852	1.65
51–55	6,869,737	2,064,425	–2,121,304	3,340,666	3,283,786	1.59
56–60	4,173,189	1,254,085	–1,500,077	3,340,666	3,094,674	1.5
61–65	1,378,135	414,143	–780,585	3,340,666	2,974,225	1.44

Abbreviations. ROI, return on investment; KRW, South Korean Won.

Figure 2. Tornado diagram: $\pm 20\%$ one-way sensitivity analysis of the ROI to key parameters.

reduced demand for tobacco products. In aggregate, the cross-sectorial public economic effects are the sum of the present value of the additional tax revenue resulting from smoking cessation, and the healthcare cost-savings deducted by the tobacco tax revenue loss. The cost of a smoking cessation program with varenicline, in South Korea, is KRW475,658 per individual. Using a 1-year cessation rate for varenicline of 23%^{22,24} suggests the cost per responder or per long-term quitter is KRW 2,068,079.

The ROI, reflecting the return on public capital, expressed as the benefit:cost ratio, ranges from 1.4–1.7 (Table 2) depending on the age group in which varenicline is introduced. Due to the productivity effect, earlier smoking cessation yields higher fiscal benefits, as expected. By taking into consideration the prevalence of smokers in each age group, the weighted average of ROI across different groups is 1.6, which represents a KRW 1.60 return for every KRW 1.00 invested in smoking cessation with varenicline.

Figure 2 shows the results of the one-way ($\pm 20\%$) sensitivity analysis. The modeled ROI is consistently higher than 1, suggesting that benefits exceed the costs. ROI is mostly sensitive to the lifetime healthcare cost difference between smokers and non-smokers. Reduction of greater than 25% in incremental lifetime healthcare costs between smokers and former smokers would be needed in order for ROI to be below 1. Influential parameters also include the cost-per responder of smoking cessation, as defined by both the cost and the long-term efficacy of varenicline. The ROI is also sensitive to the level of tobacco tax and parameters relating to the lifetime earnings and, thus, to the expected tax revenues,

i.e. the effect of smoking on productivity and average earnings per annum in South Korea.

Discussion

This government perspective analysis considered the fiscal relationship and transference of wealth between citizens, aged 26–65, and the South Korean government. The age-specific smoking prevalence, per capita earnings, tax revenues, and healthcare costs were considered in the model for smokers and those that quit smoking due to a public investment in a pharmacological cessation intervention with varenicline. This study showed that the South Korean government may anticipate in the long-run that the investment in varenicline will have positive returns and, thus, positive net fiscal effects.

Healthcare in South Korea is eligible to all citizens and is financed through national insurance contributions from employees and employers. Although payments to the National Insurance are premiums, they meet the definition of a tax, as they are linked to earnings and are not avoidable. Additional contributions are provided to the National Health Insurance by the National Government, as well as a surcharge on tobacco^{25,26}. Delivery of services is through the private sector; however, all payments for services are made by the nationally administered health insurance scheme. In the context of our analysis, varenicline would be reimbursed through the national insurance system, representing an additional cost to the national health insurance. The benefits are observed in the public sector through changes in income tax

payments and tobacco taxes, both of which are linked to changes in smoking prevalence.

The ROI analysis demonstrates the added public economic benefits of early intervention in younger aged cohorts. The age-specific public consequences transition over the lifetime, depending on when the intervention is successfully introduced. In earlier cohorts, benefits are mostly attributed to productivity gains and increased tax revenues. This finding is consistent with a previous study reporting the indirect cost benefits in younger cohorts aged 35–50 compared with those over the age of 55⁷. In contrast, implementing smoking cessation in cohorts over the age of 55 offers economic benefits mostly attributed to reduced healthcare cost savings that are captured in traditional health technology assessments used to evaluate medical technologies. Although the results described here are based on public economic costs and taxes in South Korea with diminished fiscal returns in older age cohorts, we would expect similar trends in other countries as workers reach older ages.

Conventional approaches for assessing the value of smoking cessation therapies focus on healthcare costs to inform access decisions made by reimbursement agencies²⁷. Whilst such an assessment can reflect the impact of smoking on health costs, it fails to recognize the broader cross-sectorial economic consequences of smoking; especially in light of observations that the indirect economic losses from smoking are likely greater than the direct healthcare costs^{7,28}. Previous studies have estimated the likely lost revenue attributed to increasing or introducing taxes and/or levies and their impact on smoking prevalence^{3,29}. However, these studies only partially reflect fiscal consequences, as they do not account for reductions in morbidity and mortality, and how they translate into ongoing tax revenues and reduced spending on social benefit protection. This is the distinguishing feature between studies that estimate productivity losses and our study, in that our approach translates the proportion of productivity-related wages that is collected by government in the form of direct and indirect (i.e. VAT) tax.

The analysis described here applies a public economic perspective for evaluating how public programs and public policies aimed at reducing smoking cessation influence government public transfer costs and tax revenues. To understand the impact to tobacco tax revenue, the framework captures reductions in tobacco taxes collected due to smoking cessation, and also estimates how changes in morbidity and mortality translate into improved longevity and productivity, both of which generate ongoing taxes for government.

The ROI attributed to smoking cessation is influenced by several factors that transition over the lifetime. The ROI is a composite ratio in which public economic costs, including taxes and health costs, are considered in relation to smoking cessation investments. In this regard, remaining lifetime productivity is an important factor that influences public costs. Consequently, early intervention to reduce smoking in younger age-cohorts offers increased public economic benefit for governments, as indicated in Table 2. Although it is tempting to compare the ROI across countries, such a comparison is hampered by variations in tobacco taxation,

epidemiology, and social benefits available in different markets. This would suggest our results are only applicable in countries with comparable taxation rates, productivity growth, and smoking prevalence.

The public economic framework described here has several limitations that need to be considered in relation to the modeled results. First, the analytic framework has been conducted for the ages of 26–65, which represents retirement age, without assessing the long-term impact of survival. This would invariably increase costs associated with pensions and other programs. The analysis described here applies long-term projections based on current macroeconomic trends for unemployment, discounting, and taxation rates. Any change to these factors could influence the investment benefits attributed to smoking cessation. Furthermore, we have evaluated the benefits of smoking cessation based on efficacy studies of a singular intervention collected in randomized studies. However, policy-makers are often faced with different policy options to address a population effect. In this regard, we have not compared other likely policy interventions considered by governments.

Governments often rely on revenue from cigarette taxes to fund healthcare and other social services. However, this analysis showed that, in South Korea, in addition to the health benefits, there is more to be gained in tax revenue from promoting quitting smoking than there is to be gained from tobacco taxes from people who continue to smoke. The findings described here offer a unique framework for policy-makers to better understand the consequences of policies that influence smoking prevalence. Although the analysis described here is based on smoking cessation therapy, the public economic framework described here can be applied to any policy or intervention, for example counseling, that influences smoking rates. The framework described here should be applied in other markets to see whether the public economic principles are comparable to those described here. Furthermore, research on the health shocks attributed to smoking should be explored to support the labor market impact that drives public economics described in this paper.

Transparency

Declaration of funding

This study was sponsored by Pfizer, Inc., New York, NY.

Declaration of financial relationships

CLB is an employee and stockholder of Pfizer, Inc. MPC and NK are employees of Global Market Access Solutions (GMAS). GMAS received funding from Pfizer for conducting this study and for the development of this manuscript. JME peer reviewers on this manuscript have no relevant financial or other relationships to disclose.

Previous presentation

Work from a previously conducted analysis using South Korean fiscal data on smoking policy was presented at the International Society for Pharmacoeconomics and Outcomes Research meeting in Singapore

2016. The results described here are an updated analysis, and have not been previously presented.

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