ORIGINAL ARTICLE

Comparing medical expenditures of smokers and nonsmokers in studies using direct methodology in Japan

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Abstract. Numerous epidemiologic studies have revealed that smoking is a significant risk factor of many diseases. Some studies reported increase in medical expenditure by smoking using odds or hazard ratios between smoking and diseases in epidemiologic studies. The purpose of the present study is to investigate the ratios of mean medical expenditures between smokers and nonsmokers from studies conducted observing medical expenditure directly in Japan. We collected 11 published articles of studies conducted observing medical expenditures of smokers and nonsmokers directly in Japan. The weighted geometric mean of ratios between age-adjusted mean medical expenditures for smokers and nonsmokers of National Health Insurance and Government-Managed Health Insurance beneficiaries which included many elderly individuals was somewhat greater than 1.0, while the value of Society-Managed Health Insurance that included a small number of elderly people was less than 1.0. Smoking and smokers' indifference to health increase the medical expenditure of the smokers, especially elderly smokers. It was not determined, however, whether the mean medical expenditure of smokers is actually greater than that of nonsmokers. (Keio J Med 56 (2) : 53 – 60, June 2007)

Key words: medical expenditure, smoker, nonsmoker, directly observed studies, Japan

Nonstandard abbreviations used in this paper:
NHI: National Health Insurance
GMHI: Government-Managed Health Insurance
SMHI: Society-Managed Health Insurance

Introduction

Numerous epidemiologic studies have reported that smoking causes many diseases, such as cancer, cardiovascular diseases, respiratory diseases, and others. Increases in incidence and mortality rates of these diseases by smoking have been detected in the studies and described in many textbooks.

There are many studies[1–15] indicating marginal increases in medical expenditures for smokers calculated indirectly from odds or hazard ratios between smoking and the incidence and/or mortality rates cited from epidemiologic studies. The odds or hazard ratios are much greater than 1.0. Let those studies using odds or hazard ratios be indicated as "studies using indirect method." In other studies,[16–29] the medical expenditures of smokers and nonsmokers were directly observed and the marginal increases in medical expenditures by smoking were cal-

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culated. Let those studies conducted by direct observation be indicated as "studies using direct method." Some studies using the direct method reported that medical expenditures of smokers were less than those of nonsmokers while others reported that they were greater.

Mortality, incidence, and prevalence rates of lifestyle-related diseases and population medical expenditures are increasing rapidly[30,31] due to the rapid aging of society in Japan.[32] Smoking-related diseases are typical among lifestyle-related diseases. The national and local governments in Japan are in financial difficulties. Therefore, studies in which the influence of smoking on medical expenditures is investigated are necessary and very important given the recent socioeconomic condition in Japan from the viewpoint of public health.

The purpose of the present study is to compare medical expenditures of smokers and nonsmokers from studies using the direct method conducted in Japan.

Materials and Methods

Articles and information collected

We collected 12 published articles of studies conducted observing medical expenditures directly in Japan using "PubMed" and "Japana Centra Reuo Medicina WEB" regarding medical expenditure, medical cost, smoking, and/or smoker, and using requotations from articles on studies by direct and indirect methods found previously. If two or more articles were published on the same study, the most recent article was selected and the earlier article(s) not used. Eleven articles[19–29] were selected for calculating the ratio of mean medical expenditure between smokers and nonsmokers. We did not find many articles in which medical expenditures of female smokers were described. Thus, in principle, the medical expenditure ratio investigated in the present study was between male smokers and nonsmokers.

The following information was needed for the present study: (1) age-adjusted mean medical expenditures of smokers and nonsmokers, (2) numbers of subjects of smokers and nonsmokers by age category, (3) ages of smokers and nonsmokers, (4) the type of medical care insurance, and (5) the year of submission of health insurance claims. When the age-adjusted mean medical expenditures by smoking status were described in articles,[20,26,27] they were employed in the present study. When (i) the age-adjusted medical expenditures by smoking status were not given and (ii) the mean medical expenditures and numbers of subjects according to age category and smoking status were given,[19,21–25] the age-adjusted mean medical expenditures were calculated by a direct method using (ii), *i.e.*, the mean medical expenditures and numbers of subjects by smoking status and age category and numbers of total subjects for all smoking status groups by age category. When (i) and (ii) were not described in articles,[28,29] we asked the authors of the articles to provide information on (ii), and the age-adjusted mean medical expenditures were calculated by a direct method using the information provided by the authors. The age-adjusted medical expenditure ratio between smokers and nonsmokers was obtained from the age-adjusted mean medical expenditures of smokers and nonsmokers. When the numbers of smokers and nonsmokers were not indicated in an article,[21] the numbers were calculated from the number of male subjects and male smoking rate. When the mean age of subjects was not given in an article,[19–21,23,24,27,28] the mean ages were obtained from the numbers of subjects and the center ages according to age category. The mean year of submission of health insurance claims was calculated from the year of submission and the number of subjects in the 11 studies as a weighted mean.

The health insurance system in Japan is composed of two systems. The first is for employees and their dependents, the second is a community-based health insurance system mainly used by farmers, the self-employed, pensioners, and their dependents. The second system is called the National Health Insurance (NHI). The first contains Government-Managed Health Insurance (GMHI), Society-Managed Health Insurance (SMHI), and Seamen's Insurance, which is very small.[33] SMHI beneficiaries are employees of large corporations and the national and local governments and teachers of private schools before retirement and their dependents. GMHI beneficiaries are employees of small and medium size enterprises and their dependents. NHI and GMHI beneficiaries include many elderly individuals while SMHI beneficiaries do not.

When the age-adjusted mean medical expenditures of smokers were not described in articles,[19,22–25,28,29] the values were calculated from the age-adjusted mean medical expenditures of current and former smokers using the numbers of total subjects for all age groups of current and former smokers in the articles as the weighted means, *i.e.*, direct adjustment.

Medical expenditure in the present study is calculated from the amounts of health insurance claims. Therefore, medical expenditure in the present study does not contain indirect costs.

Geometric mean of ratios

Weighted geometric mean of ratios between age-adjusted mean medical expenditures of smokers and nonsmokers was calculated. The weight of the *i-th study is*

$$w_i = \sqrt{1 / (1/n_{Si} + 1/n_{Ni})},$$

where n_S and n_N are numbers of subjects of smokers and nonsmokers. Variance of natural logarithm of ratio is

Table 1 Year of Publication, Type of Health Insurance, Age of Subjects, Calendar Year of Submission of Health Insurance Claims, Duration of Submission of the Claims, Numbers of Smokers and Nonsmokers, the Age-adjusted Ratio of Mean Medical Expenditure between Smokers and Nonsmokers, and Annual per Capita Medical Expenditure of Nonsmokers for each Article

Reference	Published	Health	Age (years)		Submission		Number of subjects		Medical expenditure ratio	Annual per capita medical
number	year	insurance	Range	Mean	Year	Duration	Smokers	Nonsmokers		expenditure for nonsmoker (¥)
19	1987	NHI	30-70+	54.4 t	1983	12months	1,343	211	1.118	105,351
20 e	1989	SMHI	20-60+	44.2 t	1985-86	12months	484	468	0.909	77,200
21	1992	NHI	30-69	60.6 t	1990-91	12months	1,601 p	400 p	0.735	452,759
22	1993	SMHI	18-79	37.9	1986-90	48months	8,825	3,489	0.888	155,100
23 i	1994	NHI	30-80+	57.6 t	1989-90	12months	770	141	1.017	268,510
24	1996	SMHI	40-73	51.5 t	1989	12months	4,093	702	0.741	191,123
25	1996	SMHI	30-75	41.5	1990	12months	1,022	359	0.728	47,413
26 e x, f	2000	NHI	60-84	60+	1998	1month	1,585	528	1.088	———
27	2001	NHI	40-79	60.0 t	1995-97	30months	18,825	4,256	1.111	330,480
28 i	2003	GMHI	26-86	50.7 t	1998-99	12months	2,621	659	1.219	2,987
29 d	2003	SMHI	18-76	39.5	1996-98	36months	66,641	29,658	0.951	66,663

Abbreviations: d: dental expenditure excluded, e: former smokers included among nonsmokers,
ex: former smokers excluded, f: females included and sex-adjusted,
GMHI: Government-Managed Health Insurance, i: inpatients excluded,
NHI: National Health Insurance, p: proportional distribution by smoking rate,
SMHI: Society-Managed Health Insurance, t: calculation from tables
$1 = ¥80 − 105 (in 1995)

obtained as sum of reciprocal numbers of samples in groups. Confidence interval of the weighted geometric mean of the ratios is not calculated in the present study, because the information on scale parameter of the medical expenditures is not obtained.

Results

Table 1 shows the reference number, year of publication, type of health insurance, age of subjects (range and mean), calendar year of submission of health insurance claim, duration of the submission of the claims, numbers of subjects of smokers and nonsmokers, the age-adjusted mean medical expenditure ratio between smokers and nonsmokers, and annual per capita medical expenditure of nonsmokers in each of the 11 articles. The articles are arranged in the order of year of publication in Table 1.

The weighted geometric mean of ratios between age-adjusted mean medical expenditures of smokers and nonsmokers for all articles was 0.95. Removing an article in which nonsmokers included former smokers[20] and one in which smokers did not include former smokers,[26] as well as an article including females,[26] those excluding medical expenditures of inpatients,[23,28] and one excluding dental expenditures[29] showed no notable effects.

Table 2 indicates weighted geometric mean of ratios between age-adjusted mean medical expenditures of smokers and nonsmokers according to insurance group. When medical insurance beneficiaries as study subjects were divided by type of insurance (a) National Health Insurance (NHI) and Government-Managed Health Insurance (GMHI) and (b) Society-Managed Health Insurance (SMHI), the geometric mean ratio of group (a) was somewhat greater than 1.0 (Table 2-A) and that of group (b) was considerably less than 1.0 with statistical significance (Table 2-B). A similar division into (c) NHI and (d) GMHI and SMHI gave similar results (Table 2-CD).

Pearson's chi-square tests for 2x2 contingency tables of (i) study subjects {group (a) or (b)} and mean age (-49 or 50+ years old) and (ii) study subjects {group (a) or (b)} and the medical expenditure ratio (<1.0 or 1.0≦) were statistically significant (both $p<0.01$, Yates' correction: $p<0.05$). This means that (a) NHI and GMHI beneficiaries are older than (b) SMHI beneficiaries and that the ratio of group (a) is greater than that of group (b). The two 2x2 contingency tables with statistical tests are shown in Table 3.

In the above, the standard population for age-adjustment was the total population of smokers and nonsmokers by age group in each article. The calculation was also conducted using the male census population in Japan in 1995 as the standard population for age-adjustment, and the results were nearly equal to those using the population by age group in the articles cited in the present study. The mean calendar year of submission of health insurance claims in the 11 studies selected in the present study was 1995.

The results of analysis including duration of submission of health insurance claims were almost same as those not including the duration.

In the above, current and former smokers were treated as smokers. Ratios of values between current smokers

Table 2 Geometric Mean of Ratios of Mean Medical Expenditures between Smokers and Nonsmokers

Articles for meta-analysis	Reference number	Geometric mean Ratio
A) NHI and GMHI	19, 21, 23, 26-28	1.06
B) SMHI	20, 22, 24-25, 29	0.90
C) NHI	19, 21, 23, 26-27	1.03
D) GMHI and SMHI	20, 22, 24-25, 28-29	0.92

Abbreviations: GMHI: Government-Managed Health Insurance,
NHI: National Health Insurance,
SMHI: Society-Managed Health Insurance

and nonsmokers were also calculated. The difference in the geometric mean ratios between (i) current smokers versus nonsmokers and (ii) current and former smokers versus nonsmokers of NHI and GMHI group was not notable.

Discussion

Increases in the incidence and mortality rates of many diseases due to smoking have been reported in numerous epidemiologic studies and described in many textbooks. There are many studies using the indirect method[1−15] indicating marginal increases in medical expenditures of smokers calculated indirectly from odds or hazard ratios between smoking and incidence and/or mortality rates cited from these epidemiologic studies. The odds or hazard ratios are much greater than 1.0. On the other hand, medical expenditures of smokers and nonsmokers were directly observed and the excessive medical costs by smoking were calculated in a number of studies using the direct method.[16−29] Some studies using the direct method reported that medical expenditures of smokers were less than those of nonsmokers while other studies using the direct method reported greater expenditures.

In the present study, we compared age-adjusted medical expenditures between smokers and nonsmokers in studies using the direct method conducted in Japan. The age-adjusted geometric mean ratio of Society-Managed Health Insurance (SMHI) with small numbers of elderly persons was less than 1.0 (Table 2-B) and the value of National Health Insurance (NHI) and Government-Managed Health Insurance (GMHI) with many elderly persons was greater than 1.0 (Table 2-A). Table 3 shows that most ratios of medical expenditures between smokers and nonsmokers for insurance groups with many elderly individuals were greater than 1.0, while all ratios for insurance groups with small numbers of elderly individuals were less than 1.0. This does not indicate that the mean medical expenditure of smokers is actually greater than that of nonsmokers.

The ratio of mean medical expenditures between smokers and nonsmokers is divided into elements due to smoking and elements other than smoking. Poor health due to smoking is apt to appear many years after the start of habitual smoking, *i.e.*, the influence of smoking on the ratio of younger persons is very small and aging increases the ratio. Many younger smokers are not yet in bad health, while many elderly smokers are in worse health than elderly nonsmokers. The elements due to factors other than smoking coincide with selection bias from the viewpoint of investigating the influence of smoking on the ratio. These elements can be divided into two parts, one which increases by age and the other which remains constant. The latter corresponds to an intercept of regression and the former corresponds to a slope of regression. The slope means that the ratio of younger persons is less than 1.0 and the ratio of elder persons is greater than 1.0. Generally the ratios of medical expenditure between smokers and nonsmokers for

Table 3 Two 2x2 Contingency Tables for (i) Insurance Group and Mean Age and (ii) Insurance Group and the Mean Medical Expenditure Ratio between Smokers and Nonsmokers

Table for the Insurance Group and Mean Age (i)

	Mean age (years)	
Insurance group	−49	50+
NHI and GMHI	0	6
SMHI	4	1

Pearson: $p<0.01$, Yates: $p<0.05$
Abbreviations: GMHI: Government-Managed Health Insurance,
NHI: National Health Insurance,
SMHI: Society-Managed Health Insurance

Table for the Insurance Group and the Ratio (ii)

	Medical expenditure ratio	
Insurance group	<1.0	1.0≦
NHI and GMHI	1	5
SMHI	5	0

Pearson: $p<0.01$, Yates: $p<0.05$

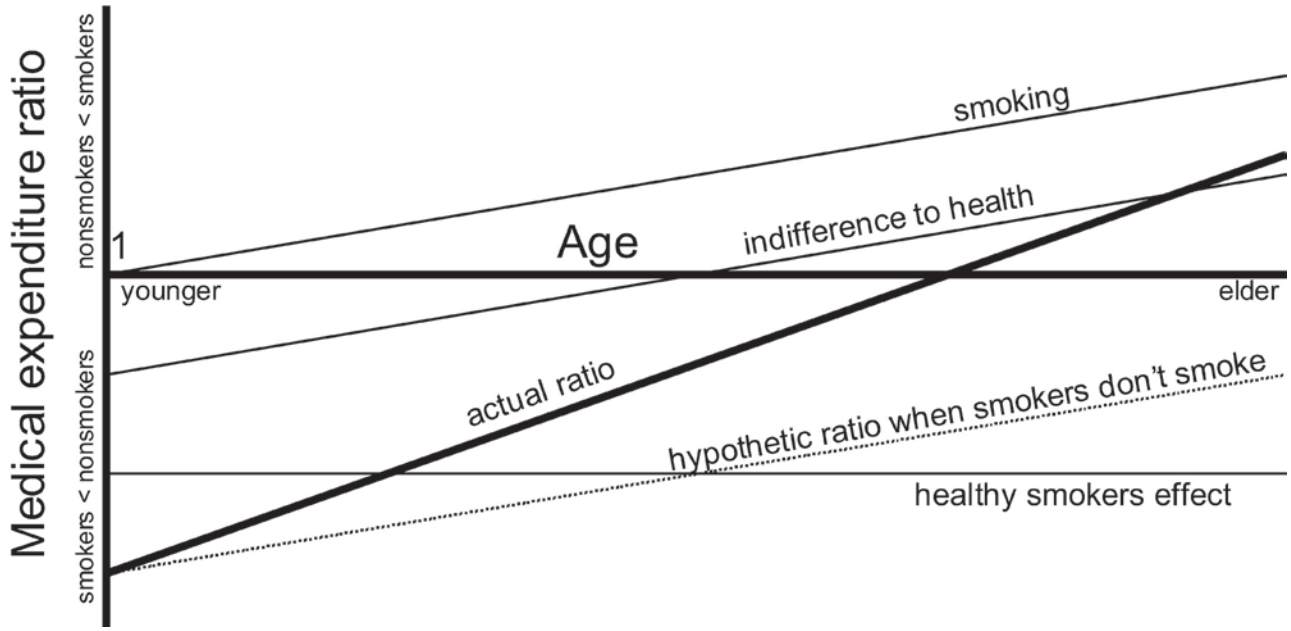

Fig. 1 Scheme of the ratio of mean medical expenditure between smokers and nonsmokers by age with factors which influence the ratio.

groups including many elderly individuals are greater than 1.0, while the ratios for groups with small numbers of elderly individuals are less than 1.0 (Tables 2-3). This shows the presence of "smokers' indifference to health," meaning that smokers seldom receive medical care even if they recognize morbidness and reluctantly receive care after they recognize severe symptoms and/or signs. Smoking was detected as a risk factor in diabetes mellitus in some epidemiologic studies.[34,35] It is noted that the personality of diabetes patients is often carefree.[36,37] Smokers' indifference to health must decrease medical expenditure of younger smokers and increase that of elder smokers. The intercept means that the ratio is not greater than 1.0 in the present study, having no relation to age. It is not determined that mean medical expenditure of smokers is greater than that of nonsmokers, in spite of poor health due to smoking. This shows a "healthy smoker effect," meaning that healthy persons who are not in poor health due to smoking can start and continue to smoke habitually, analogous to the "healthy worker effect" in the occupational health field. Factors which influence the medical expenditure ratio are (i) smoking, (ii) smokers' indifference to health, and (iii) healthy smoker effect.

A scheme in which these findings are expressed is shown in Fig. 1. In Fig. 1, the transverse which intersects at 1.0 of the ordinate is the level of nonsmokers. The figure shows the actual medical expenditure ratio by age with three factors which influence the ratio. The three factors are (i) smoking, (ii) smokers' indifference to health, and (iii) healthy smoker effect. The sum of the three factors is equal to the actual ratio. The dotted line in Fig. 1 shows a hypothetic ratio if smokers did not smoke. The scaling of the ordinate is not known, so the linearity or curvature of the lines or curves is not known. In the present study, the three factors have not been verified. Therefore, the presence of the three factors should be strictly verified and their magnitude estimated in the future. Excessive medical expenditures of smokers in the studies using the indirect method must be derived from smoking and smokers' indifference to health.

The difference in the age-adjusted geometric mean ratios between (a) the NHI and GMHI group (Table 2-A) and (b) the SMHI group (Table 2-B) was notable because of age difference. In the present study, the main effect is smoking status, *i.e.*, smokers or nonsmokers, and age is a significant interaction. It should be noted that when interaction is significant the main effect is often meaningless.

In the present study, the age-adjusted medical expenditure ratios between smokers and nonsmokers were investigated from studies using the direct method conducted in Japan. Studies using direct estimation[16–18] conducted in countries other than Japan were not used. The definitions of medical expenditures, medical service systems including medical security systems, socioeconomic status, and cultural background in the articles were notably different from those of the present study. Differences among medical expenditures under different conditions are not meaningful. Therefore, comparing medical ex-

penditure ratios between smokers and nonsmokers of many countries is not appropriate.

The proportions of medical expenditures for inpatients per total medical expenditure in 1985 and 1995 were 44.2% and 36.8%, respectively.[38] These values are great, while the number of inpatients is somewhat less than that of outpatients. The medical expenditures for inpatients were not included in two studies[23,28] in which the subjects were NHI and GMHI beneficiaries. In particular, the annual per capita medical expenditure of Nakagaki's article[28] excluding inpatients was very low (Table 1). The variations of the ratios must be enlarged when the medical expenditures for inpatients are included.

In the present study, we treated current smokers and former smokers as smokers in principle. The reasons are as follows. Current smoking affects lifestyle-related diseases after many years. It cannot be denied that one of the causes of diseases for former smokers is their past smoking when they are taken ill. Therefore, we investigated differences in medical expenditures of persons with and without smoking experience in the present study. Many studies using this comparison have been published.

A lot of studies reported that the medical expenditures of former smokers were larger than those of current smokers. In Kondou's study,[20] nonsmokers included former smokers. This shows that the ratio of the article[20] may be somewhat less than that of current and former smokers versus nonsmokers. In Fujimoto's study,[26] however, the medical expenditure of former smokers was less than that of current smokers. Therefore, the medical expenditure ratio including current and former smokers is less than the value in the article[26] excluding former smokers.

It was revealed that the dental expenditures of smokers were larger than those of nonsmokers.[20] Dental expenditure was removed in Urano's article,[29] indicating that the medical expenditure ratio in the article[29] may be less than the value including dental expenditures. The proportion of dental expenditures per total medical expenditures was small, 8.8% in 1995.[38]

In Table 1, the ratios are distributed widely; in particular the ratio of one article[21] for NHI is less than those of the other articles for the same type of insurance. The reasons for the variation in medical expenditure ratio are as follows. (i) Many articles included medical expenditures of inpatients or dental expenditures while a few[23,29] did not. (ii) Former smokers were treated as smokers in many articles, while former smokers were treated as nonsmokers in one article[20] and excluded in another.[26] (iii) The durations of submission of health insurance claims differed notably and the range of submission year were distributed widely. (iv) When high cost medical expenditures were defrayed for a few patients, the mean medical expenditure of the group including such patients increased dramatically. The most important element of the variation in the medical expenditure ratio is the increase in medical expenditure due to a few high cost patients. The variation in medical expenditure was indicated to be very large in one figure.[19] In Table 1, the annual per capita medical expenditure of Nakagaki's article[28] excluding inpatients shows an especially low value, while very expensive values are shown in some articles including inpatients. In this study area, the medical expenditure ratio excluding high cost patients may be stable, but the significance of the ratio must be poor from the viewpoint of medical economics. In order to obtain a stable medical expenditure ratio, too many study subjects are necessary. In this study area, dramatically elevated medical expenditure due to a few high cost patients is a very troublesome problem for obtaining stable values.

A very heavy right tail was indicated as a characteristic of medical expenditure distribution.[19] The most important element of the large variation in the medical expenditure is the increase in medical expenditure due to a few high cost patients. The mean medical expenditures of nonsmokers were distributed widely in Table 1. Especially, the annual per capita medical expenditure of Nakagaki's article[28] excluding inpatients was very low (Table 1). In order to compare the mean medical expenditure of smokers with that of nonsmokers, a difference between the two values is inappropriate, but a ratio is appropriate. Therefore, in the present study, the ratios between the mean medical expenditures of smokers and nonsmokers were calculated.

Differences in the ratios and the mean ages between (a) the NHI and GMHI group and (b) the SMHI group were statistically significant (Table 3), meaning that (a) and (b) groups were different from each other qualitatively. Therefore, calculating geometric mean ratio using the ratios including all studies is not appropriate. However, the geometric mean ratio for all studies is significant only in sensitivity analysis, *e.g.* confirming slight influence of treatment of former smokers, including female subjects, and excluding inpatients and dental expenditures. This does not mean, however, that obtaining geometric mean ratio from the ratios of (a) the NHI and GMHI group or (b) the SMHI group separately is inappropriate, because each (a) or (b) group is not heterogeneous from the viewpoint of social backgrounds and ages of the insurance beneficiaries.

The purpose of the present study is to investigate the ratios between mean medical expenditures of smokers and nonsmokers from studies conducted observing medical expenditure directly in Japan as cross-sectional studies. It was reported[39,40] that innovations in medical technologies and improvement of life-style *e.g.* smoking cessation would lead to decrease the medical expendi-

tures in the short term, but to increase the cumulative medical expenditures in the long term in other developed countries than Japan. Studies on the life-time medical expenditures according to smoking experience should be conducted in Japan, making it possible to compare the medical expenditures of smokers and nonsmokers in short term and life-time.

In the present study, the influence of smoking on medical expenditures was investigated using published articles of studies conducted directly observing medical expenditures of smokers and nonsmokers in Japan. Mortality, incidence, and prevalence rates of lifestyle-related diseases and population medical expenditures are fast increasing[30,31] due to the rapid aging of society in Japan.[32] The national and local governments in Japan are in financial difficulties. Smoking-related diseases are typical among lifestyle-related diseases. Therefore, the present study is significant in light of this recent socioeconomic condition in Japan from the viewpoint of public health.

The present study does not indicate that medical expenditure of smokers is actually greater than that of nonsmokers. This does not mean that lower quality of life (QoL) and premature death of smokers can be neglected.

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