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A Longitudinal Study on the Causal Association Between Smoking and Depression

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Objectives: The objective of this study was to analyze the causal relationship between smoking and depression using longitudinal data.
Methods: Two waves of the Korea Welfare Panel collected in 2006 and 2007 were used. The sample consisted of 14 426 in 2006 and 13 052 in 2007 who were aged 20 and older. Smoking was measured by smoking amount (none/<half pack a day / < one pack a day / < two packs a day / ≥ two packs). Depression was defined when the summated CESD (center for epidemiological studies depression)-11 score was greater than or equal to 16. The causal relationship between smoking and depression was tested using logistic regression. In order to test the causal effect of smoking on depression, depression at year 2 was regressed on smoking status at year 1 only using the sample without depression at year 1. Likewise, smoking status at year 2 was regressed on depression at year 1 only using those who were not smoking at year 1 in order to test the causal effect of depression on smoking. The statistical package used was Stata 10.0. Sampling weights were applied to obtain the population estimation.
Results: The logistic regression testing for the causal relationship between smoking and depression showed that smoking at year 1 was significantly related to depression at year 2. Smoking amounts associated with depression were different among age groups. On the other hand, the results from the logistic regression testing for the opposite direction of the relationship between smoking and depression found no significant association regardless of age group.
Conclusions: The study results showed some evidence that smoking caused depression but not the other way around.

Key words: Causal relationship, Depression, Longitudinal analysis, Smoking
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INTRODUCTION

According to the results of the Epidemiologic Survey on Mental Illnesses in 2006 in Korea, the country's lifetime depression (major depressive disorder and dysthimic disorder) prevalence rate is 6.1% (females: 8.4%; males: 3.8%), a sharp increase from 5.2% (females: 7.1%; males: 2.2%) in 2001 [1,2]. In particular, the lifetime depression prevalence rate among men increased about 1.73 times within five years, from 2.2% in 2001 to 3.8% in 2006. As the number of persons with depression in the country has rapidly increased, the medical expenses in health insurance also increased 44.2%, from 131.4 billion won in 2004 to 189.5 billion won in 2007, and the medical treatment expenses for depression have also sharply increased [3]. The results of the research conducted by Lee et al. [2] show that only 26.8% of the patients suffering from depressive disorder are utilizing the medical services provided by doctors or health care specialists and other mental-health specialists, and that the cost related to depressive illnesses, such as the mental distress and lowered productivity, other than the expenses related to the medical treatment of depressive illnesses, has also greatly increased.

Meanwhile, depression is closely related to smoking. The correlation between depression and smoking was found to be high in all age groups, as shown by the results of the studies that have been conducted not only on adults [4-6] but also on teenagers [7,8]. Accordingly, for the efficient and effective treatment of depressive disorder, smoking must concurrently be treated.

The smoking rate of males 20 years old and above was 79.3% in 1980, but the rate decreased to 40.9% in 2008 [9]. The comparison of the rates of male smokers 15 years old and above in OECD countries in 2005 revealed that South Korea's smoking rate was 17.8% higher than the OECD average [10]. Thus, continuous policy intervention for non-smoking inducement is needed in the country. Indeed, in South Korea's health promotion policy, the effective management of the smoking problem is still a very important policy objective, and to

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more effectively manage smoking and depressive disorder, the two must be managed together.

As the importance of the relationship between various mental illnesses including depression and smoking is increasing, research on the correlation between mental illness and smoking has been actively conducted. Through such research, it was found that the smoking rate is higher among people with schizophrenia, mania, depression, bipolar disorder, anxiety disorder, and personality disorder than among those without such afflictions, showing that mental illness and smoking are related to each other [11]. The correlation between mental illness and smoking is shown in the fact that in the United States, those who suffer from mental illness account for 7.1% of the total population, and their smoking consumption accounts for 34.2% of the total smoking consumption in the country [12]. As previously discussed, many studies on the correlation between depression and smoking in various mental illnesses have been conducted, and it can be said that the correlation between the two is relatively certain. Many studies report that the rate of dependence on nicotine of those who suffer from depression is higher than that of those who do not, and that the prevalence rate of depression is also higher in smokers than in non-smokers.

Despite the fact that many studies show a correlation between depression and smoking, such research results have not arrived at consistent conclusions with regard to concrete mechanisms, particularly the causality between depression and smoking [13]. The results of some studies support the hypothesis that smoking causes depression while the results of other studies support the hypothesis that depression causes smoking. As such, the past studies do not consistently support one-way causality.

First, the assertion that smoking causes depression is related to the hypothesis that nicotine affects the neurotransmitter related to depression directly or indirectly [14,15]. The assertion that the causality between smoking and depression is applicable only to nicotine addicts [5] is also based on such hypothesis. The research results that a correlation between smoking and depression symptoms was shown in those who smoked more than ten cigarettes a day and was not shown in those who smoked less than ten cigarettes a day or who smoked irregularly also support such hypothesis [16]. Meanwhile, the hypothesis that the social stigma related to smoking causes depression [17] is a variation of the assertion that smoking is the cause of depression.

There are also research results, however, that smoking is not a major cause of depression. Glassman et al [18]. provided non-smoking medical treatment to 100 smokers who had no depressive symptoms for two months and investigated the smoking and depressive symptoms three and six months afterwards. This conclusion was derived from the result that the depressive symptoms were found to be as much as 7.2 times higher in those who stopped smoking than in those who continued to smoke.

The assertion that depression causes smoking is based on the hypothesis that those who have depressive symptoms smoke as part of self-medication, in expectation of the euphoriant effects of nicotine [19]. Meanwhile, many other studies contend that the causality between smoking and depression results from the intervention of confounding factors. In other words, the reason that smoking and depression appear to be related to each other is the existence of risk factors, such as genetic and environmental factors, that smoking and depression have in common, and there are research reports that the correlation between smoking and depression considerably weakens when the analysis is made with such common risk factors taken into account [20].

Thus, to explain the causality between smoking and depression, not only should the diverse common factors related to the presence of both smoking and depression be controlled methodologically; the ways of defining the direction of the causality between smoking and depression should also be presented. Particularly, longitudinal data that can distinguish between the relations of the time of the presence of depression and smoking are needed, but no research that makes use of such data has yet been conducted since the appropriate data are hardly available in South Korea. As such, in this research, the causality between depression and smoking was analyzed using the first- and second- year survey data of Korea Welfare Panel, which are longitudinal data obtained from a questionnaire survey on smoking and depression. The purpose of this research was, first, to examine whether there is a correlation between depression and smoking, and second, to determine whether a causality exists between depression and smoking, and if a causality exists between the two, to determine its direction, by conducting multiple regression analysis taking into consideration diverse common factors related to the presence of both smoking and depression as independent variables.

METHODOLOGY

Ⅰ. Research Data

In this study, the survey data of the Korea Welfare Panel were used to identify the living conditions of the poor and the next-poor, and their desire for welfare. The first-year survey on the actual state of welfare in Korea was conducted by establishing a welfare panel in November 2006, and the second-year panel survey was conducted in April 2007. In this study, both the first- and second- year survey data were used. Survey sampling was conducted on 7000 households in the 446 survey districts after the household incomes of 517 nationwide survey districts were surveyed in the first stage from the data accounting for 90% of the 2005 population census. The final sample included 3500 households each from among the general households and the low- income households. The method of household sampling was double stratified sampling.

A survey on smoking and depression was included in the survey on the family members of the households as mental health items. The survey was conducted among the family members 15 years old and above, excluding middle and high school students. In this study, the data pertaining to the family members 20 years old and above were used for the analysis. The family members 20 years old and above numbered 14426 and 13052 in the first- and second- year survey, respectively, and the sample retainment rate was 90.48%.

Ⅱ. Analysis Variables

With regard to the smoking status, whether the subjects were smokers or non-smokers was determined through questions asking whether they smoked or not for the past one year from the time of the survey, and their smoking level was measured based on the daily average smoking quantities of "less than half a pack of cigarettes," "less than one pack," "less than two packs," and "more than two packs" in the case of the smokers.

The depression status was measured using the CESD (center for epidemiological studies depression)-11 scale developed by Kohout et al. [21]. The value of each question was inputted as 1, 2, 3, or 4 but was recoded as 0, 1, 2, or 3, and the two positive questions ("led a relatively good life" and "life without dissatisfaction") were reverse-coded. Afterwards, the total score was calculated by adding up the scores in the 11 questions, and when the total score times 20/11 was greater than or equal to 16, it was equated with the existence of depression [22].

The level of self-esteem was measured using the translated version of the Rosenberg self-esteem scale. The self-esteem scale was composed of ten questions and surveyed the level of the respondents' self-esteem based on the recognition of such on the day of the survey. Each question consisted of four levels: 1 (generally no), 2 (moderately), 3 (generally yes), and 4 (always yes). Reverse coding was done on the five questions that were negatively described. The level of self-esteem was measured by adding up the scores in the ten questions (ranging from 10 to 40 points).

The drinking status was measured using the questions that asked whether the drinking frequency was "once a week," "twice or thrice a week," "more than four times a week," and "never drank" for the past one year from the time of the survey.

To measure the socioeconomic and demographic characteristics of the sample, educational level (0= less than high school, 1= high school or above), religion, marital status (variables indicating divorce, separation, bereavement, and unmarried), residential region (1= urban; 0 = rural), household income (1=low-income, 0=general household), economic activities (variables indicating unemployed and non-engagement in economic activities), age, and gender were used.

Health status was measured as discrete variables- "fair," "bad," and "very bad" with reference to "good" or "very good," which represent the subjective perception of health.

Life events, which are variables representing the major life events that can bring about stress, included an early death of parents, parents' divorce, quitting school due to economic difficulties, and growing up in a relative's home.

Ⅲ. Data Analysis

The effects of smoking on depression and vice versa were analyzed using logistic regression. First, the analysis of the effects of smoking on depression was conducted in three stages, as follows, using only the samples that did not suffer from depression in the first year. Model 1 included smoking or non-smoking together with the socioeconomic variables in the first year. In Model 2, CESD scores was added to the variable of Model 1. This is to control the possibility that although it is not defined as depression, the first year's low-level depressive symptoms can influence the depression in the second year. Finally, in Model 3, confounding variables such as health condition, level of self-esteem, and major life

events were added to Model 2.

The analysis of the effects of depression on smoking was conducted in two stages using only using non-smokers in the first year. In Model 4, the independent variables included the socioeconomic and depression variables of the first year. In Model 5, confounding variables were added to the independent variable of Model 4.

The statistics package that was used in the analysis was Stata 10.0 (StataCorp LP, College Station, Texas, US) The weighted value was given to estimate the population parameter by reflecting the sampling design.

RESULTS

Ⅰ. Characteristics of the Non-Depression Sample and Non-Smoking Sample in the First Year

Table 1 shows the characteristics of the subjects who were analyzed, namely non-depressed sample and non-smoking sample at the first year. The non-depressed sample in the first year numbered 10 125, 51.8% of whom were females. Those aged 20-44 comprised most (48.2%), followed by those aged 45-64 (31.5%) and those aged 65 and older (20.2%). As for the educational level, the number of those with a high school diploma and above (59.7%) was higher than the number of those with no high school diploma.

Those who had depression in the second year accounted for 17.5% among the non-depressed samples in the first year. Seventy-five percent of samples in the non-depressed samples were non-smokers, and most of the smokers smoked half a pack to one pack of cigarets a day. Most of the non-depressed samples did not drink at all (47.6%) and 29.9% drank once a week.

Non-smokers in the first year numbered 10624, 70.1% of whom were females. Those aged 20-44 comprised 40.5% of the non-smokers, those aged 45-64 accounted for 31.4%, and those aged 65 years or older accounted for 28.1%. Those with a high school diploma and those without one numbered almost the same, accounting for 50.3 and 49.7%, respectively. The samples with depression in the first- and second-year surveys accounted for 26.5 and 27.2% among the non-smokers, respectively, and 60.8% of the non-smokers did not drink at all while 26.8% had a drink less than once a week.

Table 1. Characteristics of the respondents at year 1

Variables	Respondents without depression at year 1 % (n=10 125)	Nonsmoking respondents at year 1 % (n=10 624)
Depression status		
Depression at year 1	-	26.5
Depression at year 2	17.5	27.2
Smoking status		
Nonsmoking	75.0	-
< half pack a day	9.8	-
< one pack a day	13.1	-
< two packs a day	1.9	-
≥ two packs a day	0.2	-
Socioeconomic status		
Female	51.8	70.1
Age (y)		
20 - 44	48.2	40.5
45 - 64	31.5	31.4
65 +	20.2	28.1
Education		
< Less than high school	40.3	50.3
≥ High school and more	59.7	49.7
Low income household	31.7	40.6
Urban	78.7	76.9
Having religion	52.1	56.0
Marital status		
Married	72.3	67.2
Single	16.4	13.9
Divorced	2.4	3.2
Bereaved	8.2	14.7
Separated	0.7	1.0
Economic activity status		
Employed(including self-employed)	61.5	50.8
Unemployed	4.5	4.6
Economically inactive	34.0	44.6
Rosenberg self-esteem scores(mean)	30.9	29.8
Confounding factors		
Drinking status (/wk)		
None	47.6	60.8
≤ once	29.9	26.8
≤ 3 times	14.9	8.3
≥ 4 times	7.6	4.1
Subjective health status		
Good or very good	66.5	55.0
Fair	13.3	13.5
Poor or very poor	20.0	31.5
Life events		
Lost parents early in life	16.7	18.5
Parents' divorce	1.3	1.3
Quit school due to a financial reason	12.4	16.1
Raised in a relative's home due to a financial reason	2.4	3.2

Ⅱ. Bivariate Analysis

A) Changes in smoking and depression status over the first and the second years

Table 2 shows the changes in smoking and depression in the first- and second-year surveys. The totals are

Table 2. Classification of the respondents by smoking and depression status at year 1 and year 2

Unit : n (%)

	Variables		Year 1*					
			Smoking			Depression		
			No	Yes	Total	No	Yes	Total
Year 2†	Smoking	No	9182 (95.8)	322 (10.2)	9504 (74.7)	6830 (74.8)	2478 (75.1)	9308 (74.9)
		Yes	399 (4.2)	2818 (89.8)	3217 (25.3)	2304 (25.2)	822 (24.9)	3126 (25.1)
		Total	9581 (100.0)	3140 (100.0)	12721 (100.0)	9134 (100.0)	3300 (100.0)	12434 (100.0)
				p<0.001			ns†	
	Depression	No	6677 (72.8)	2199 (74.9)	8876 (73.3)	7249 (82.5)	1474 (47.2)	8723 (73.3)
		Yes	2491 (27.2)	739 (25.2)	3230 (26.7)	1535 (17.5)	1647 (52.8)	3182 (26.7)
		Total	9168 (100.0)	2938 (100.0)	12106 (100.0)	8784 (100.0)	3121 (100.0)	11905 (100.0)
				p=0.031			p<0.001	

* Includes only the respondents observed in both year 1 and year 2, †not significant.

different because only the samples that have both the first- and second-year survey data in each cell were analyzed. For example, those who had smoking data in both the first and second years numbered the highest (12721), and those who had depression data in both the first and the second years numbered the least (11905).

Among the non-smokers in the first year, those who continued to be non-smokers in the second year numbered 9182 (95.8%), and those who became smokers numbered 399 (4.2%). Those who were smokers in the first year and who became non-smokers in the second year numbered 322 (10.2%), and those who continued to be smokers numbered 2818 (89.9%). The smoking status in the first year was significantly correlated with the smoking status in the second year ($p<0.001$).

Those who did not have depression in the first year and who were smokers in the second year numbered 2304 (25.2%), and those who had depression in the first year and who were smokers in the second year numbered 822 (24.9%). The chi-square test results showed, however, that this difference was not significant.

Next, smoking status in the first year and depression status in the second year were correlated as follows. Among the non-smokers in the first year, 2491 (27.2%) of them had depression in the second year, whereas among the smokers in the first year, 739 (25.2%) were found to have depression in the second year. This difference was statistically significant ($p=0.031$) with a 95% confidence.

Finally, with regard to the relation between depression in the first and second years, the rate of depression in the second year (52.8%) among those who had depression in the first year was higher than the one (17.5%) among those who did not have depression in the first year. This correlation was statistically significant ($p<0.001$).

B) Factors related to the presence of depression in the second year among those who did not have depression in the first year

To determine the factors related to the presence of depression in the second year among those who did not have depression in the first year, chi-square test and t-test analyses were conducted (Table 3). First, the level of smoking in the first year was correlated with the presence of depression in the second year. Depression occurred in the second year among 31.3% of those who smoked more than two packs of cigarettes a day, and among 18.7% of those who smoked less than half a pack a day. The rate of depression among the non-smokers was 17.8%, which was lower than the one for those who smoked less than half a pack or more than two packs a day, but higher than the one for those who smoked half a pack to one pack a day or one pack to two packs a day.

Gender, age, educational level, household income, urban residence, marital status, economic activities, level of self-esteem, drinking condition, subjective health, and life events in childhood were also found to be correlated with the presence of depression. The presence of depression in those who did not engage in economic activities. had low self-esteem, had no spouse, had a worse subjective health, had quitted school due to economic difficulties, and who were living in a relative's home was found to be higher than that in the control group.

Meanwhile, the rate of presence of depression was highest among those who never drank, but this can be attributed to the fact that the proportion of females in this group was high.

C) Factors related to the presence of smoking in the second year among the non-smokers in the first year

Table 3 shows the characteristics of those who did not smoke in the first year but who smoked in the second-year survey. First, depression in the first year was found

Table 3. Associations between the characteristics at year 1 and depression and smoking at year 2

Characteristics at year 1	Depression at year 2*		Smoking at year 2†	
	%	p-value	%	p-value
Depression status				
Depression	-		4.4 (4.0)	ns
Smoking status				
Non-smoking	17.8	0.033	-	
< half pack of cigarettes per day	18.7		-	
< one pack of cigarettes per day	15.6		-	
< two packs of cigarettes per day	11.3		-	
≥ two packs of cigarettes per day	31.3		-	
Socioeconomic status				
Sex				
Male	14.3	<0.001	7.1	<0.001
Female	20.4		2.9	
Age (y)				
20 - 44	13.9	<0.001	5.0	0.002
45 - 64	17.0		3.4	
65 +	26.1		3.8	
Education				
< Less than high school	23.4	<0.001	3.9	ns
≥ High school and more	13.5		4.4	
Low income household	25.6 (13.5)	<0.001	4.5 (3.9)	ns
Urban	16.8 (19.7)	0.003	4.1 (4.3)	ns
Religion	17.7 (17.3)	ns	3.8 (4.7)	0.017
Marital status				
Married	15.8	<0.001	3.7	<0.001
Single	16.1		7.0	
Divorced	31.8		5.1	
Bereaved	24.9		3.9	
Separated	25.9		1.2	
Economic activity status				
Employed (including self-employed)	16.2	0.005	4.3	0.016
Unemployed	20.6		6.4	
Economically inactive	18.6		3.6	
Rosenberg self-esteem scores (mean)	29.7 (31.2)	<0.001	29.1 (29.8)	0.001
Confounding factors				
Drinking status (/wk)				
None	20.2	<0.001	3.4	<0.001
≤ once	14.7		4.7	
≤ 3 times	14.6		7.6	
> 4 times	16.6		5.7	
Subjective health status				
Excellent or good	13.1	<0.001	4.3	ns
Fair	17.2		3.4	
Poor or very poor	31.4		4.3	
Life events				
Lost parents early in life	20.3 (16.9)	0.002	3.1 (4.4)	0.010
Parents' divorce	21.9 (17.4)	ns	4.8 (4.1)	ns
Quit school due to financial reasons	27.2 (16.0)	<0.001	3.8 (4.2)	ns
Raised by a relative due to financial reasons	24.8 (17.3)	0.004	3.9 (4.2)	ns

Each number in the parentheses indicates that of its corresponding referents, na = not significant.
* Among the respondents who did not have depression at year 1.
† Among the respondents who were not smoking at year 1.

not to be correlated with smoking in the second year. The factors that were correlated with smoking were gender, age, religion, marital status, economic activities, level of self-esteem, drinking condition, and loss of parents. The number of non-smokers in the first year who became smokers in the second year was high among males, those aged 20-44 years, who had no religion, who were unmarried or divorced, who were unemployed, who had low self-esteem, or who drank more than once a week.

Table 4. Odds ratios and 95% confidence intervals of the smoking effect on depression

	< half pack a day	< one pack a day	< two packs a day	≥ two packs a day
All (20 and older)				
Unadjusted	1.08 (0.87 - 1.33)	0.86 (0.71 - 1.05)	0.63 (0.37 - 1.08)	3.22 (1.00 - 10.33)
Model 1	1.58 (1.23 - 2.01)	1.38 (1.08 - 1.76)	1.02 (0.58 - 1.80)	5.85 (1.66 - 20.65)
Model 2	1.50 (1.17 - 1.91)	1.30 (1.02 - 1.65)	0.91 (0.51 - 1.61)	5.38 (1.58 - 18.32)
Model 3	1.50 (1.17 - 1.92)	1.26 (0.99 - 1.61)	0.89 (0.50 - 1.59)	5.83 (1.68 - 20.28)
20-44				
Unadjusted	0.84 (0.61 - 1.16)	0.82 (0.62 - 1.09)	0.64 (0.28 - 1.48)	5.09 (1.06 - 24.58)
Model 1	1.14 (0.78 - 1.68)	1.16 (0.80 - 1.69)	0.91 (0.36 - 2.29)	8.28 (1.45 - 47.12)
Model 2	1.11 (0.75 - 1.64)	1.10 (0.76 - 1.60)	0.84 (0.33 - 2.10)	7.06 (1.29 - 38.53)
Model 3	1.09 (0.73 - 1.63)	1.06 (0.73 - 1.55)	0.82 (0.32 - 2.08)	7.30 (1.22 - 43.64)
45-64				
Unadjusted	1.81 (1.23 - 2.67)	1.30 (0.94 - 1.80)	0.88 (0.39 - 1.95)	1.70 (0.20 - 14.67)
Model 1	2.46 (1.60 - 3.80)	1.64 (1.10 - 2.46)	1.28 (0.56 - 2.90)	2.63 (0.28 - 24.72)
Model 2	2.32 (1.53 - 3.59)	1.56 (1.04 - 2.33)	1.13 (0.49 - 2.59)	2.86 (0.28 - 28.91)
Model 3	2.46 (1.60 - 3.79)	1.59 (1.06 - 2.40)	1.07 (0.45 - 2.55)	3.14 (0.39 - 25.62)
65 and older				
Unadjusted	0.84 (0.61 - 1.16)	0.82 (0.62 - 1.09)	0.64 (0.28 - 1.48)	5.09 (1.06 - 24.58)
Model 1	1.75 (1.10 - 2.78)	1.23 (0.70 - 2.16)	0.55 (0.12 - 2.56)	-
Model 2	1.60 (0.99 - 2.57)	1.17 (0.66 - 2.07)	0.49 (0.11 - 2.17)	-
Model 3	1.63 (1.02 - 2.61)	1.08 (0.61 - 1.90)	0.57 (0.14 - 2.39)	-

The sample consisted of the respondents who were not depressed at baseline.
Unadjusted model included smoking status as an independent variable.
Model 1 added socioeconomic variables to the unadjusted model, Model 2 added the CESD score at baseline to Model 1, Model 3 added confounding variables to Model 2.

Ⅲ. Logistic Regression Analysis

A) The effect of smoking on depression

To determine the effect of smoking on depression, logistic regression analysis was conducted only on the samples who did not have depression in the first year. The dependent variable was the depression status in the second year. Table 4 shows the odds ratios and their 95% confidence intervals of the smoking variables in the first year which were estimated in the basic model that contains only the smoking variable and the three models containing other independent variables. The smoking variables in the first year consisted of four variables reflecting the level of smoking, to confirm the dose-response relationship between smoking and depression. As the correlation between smoking and depression may differ depending on the age, analysis by age group was also conducted.

The results of the analysis using the entire sample showed that only smoking more than two packs a day was found to be correlated with the presence of depression (OR=3.22) in the basic model that contained only the smoking variables. In Models 1, 2, and 3, the depression rate was found to be significantly high in those who smoked least (less than half a pack a day) and in those who smoked most (more than two packs a day). In Models 1 and 2, the depression rate was found to be higher in those who smoked half a pack to one pack a day than in the non-smokers. In sum, it was not the case that the more one smokes the higher the depression rate. Therefore, the dose-response relationship between smoking and depression was unclear.

In the group aged 20-44, the depression rate was found to be significantly high in those who smoked more than two packs a day, but in the groups aged 45-64 and 65 or older, respectively, the depression rate was found to be high in those who smoked less than half a pack a day or half a pack to one pack a day. This indicates that when interpreting the results of the analysis using the entire sample, the effects of age should be taken into account.

Table 5 shows the results of the final model (Model 3) which analyzed the effect of smoking on depression. In the entire sample, smoking less than half a pack a day, smoking more than two packs a day, gender (female), coming from a low-income household, not engaging in economic activities, being unmarried, loss of parents, experience of parents' divorce, having low self-esteem, and having a poor health condition were found to have effects on depression. The results of the analysis by age group showed that in all age groups, high CESD scores, low self-esteem, and poor health condition were found to have effects on depression. Besides, among the young people aged 20-44 years, smoking more than two packs a day, gender (female), coming from a low-income household, being unmarried, and experience of parents' divorce had effects on depression. In the middle-aged (45-64), smoking less than half a pack a day, smoking

Table 5. Characteristics at year 1 predicting depression at year 2: multiple logistic regression results (Model 3)

Characteristics at year 1	OR	p-value	95% CI
All (20 and older)			
Smoking (ref. non-smoking)			
< half pack a day	1.50	0.001	1.17 - 1.92
Smoking (ref. non-smoking)			
≥ two packs a day	5.83	0.006	1.68 - 20.28
Male	0.60	0.000	0.49 - 0.72
Low income household	1.56	0.000	1.33 - 1.81
Economically inactive (ref. employed)	0.82	0.017	0.70 - 0.96
Single (ref. married)	1.41	0.003	1.12 - 1.76
Bereaved (ref. married)	1.31	0.033	1.02 - 1.67
Parent's divorce	1.89	0.013	1.15 - 3.12
Rosenberg self-esteem scores	0.95	0.000	0.93 - 0.97
Poor or very poor health	1.79	0.000	1.48 - 2.16
20-44			
Smoking (ref. non-smoking)			
≥ two packs a day	7.30	0.029	1.22 - 43.64
CESD scores	1.06	0.000	1.04 - 1.08
Male	0.59	0.001	0.44 - 0.80
Low income household	1.65	0.000	1.30 - 2.11
Single (ref. married)	1.43	0.019	1.06 - 1.92
Parent's divorce	1.99	0.012	1.17 - 3.39
Rosenberg self-esteem scores	0.95	0.001	0.92 - 0.98
Poor or very poor health	1.92	0.001	1.29 - 2.87
45-64			
Smoking (ref. non-smoking)			
< half pack a day	2.46	0.000	1.60 - 3.79
< one pack a day	1.59	0.027	1.06 - 2.40
CESD scores	1.07	0.000	1.04 - 1.10
Low income household	1.51	0.003	1.15 - 1.99
Single (ref. married)	2.29	0.022	1.12 - 4.65
Rosenberg self-esteem scores	0.95	0.006	0.91 - 0.98
Poor or very poor health	1.75	0.000	1.29 - 2.38
65 and older			
Smoking (ref. non-smoking)			
< half pack a day	1.63	0.42	1.02 - 2.61
CESD scores	1.07	0.000	1.04 - 1.10
Male	0.57	0.003	0.40 - 0.82
Rosenberg self-esteem scores	0.95	0.021	0.92 - 1.97
Poor or very poor health	1.77	0.001	1.25 - 2.51

OR: odds ratio, CI: confidence interval,
CESD: center for epidemiological studies depression.

less than one pack a day, coming from a low-income household, and being unmarried presupposed depression, while in the age group of 65 years or older, smoking less than half a pack a day and gender (female) were found to have effects on depression.

B) Factors related to smoking in the second year among the non-smokers in the first year

Table 6 shows the results of the analysis using the two models (Models 4,5) in which the effect of depression in the first year on smoking in the second year was tested using only the non-smokers in the first year. To determine the dose-response relationship between depression and smoking, the original CESD scores rather than the discrete variable were used for the presence of depression in the first year. There were few results showing that depression had an effect on smoking.

Table 6. Odds ratios and 95% confidence intervals of depression effect on smoking

	OR	95% CI
All (20 and older)		
Unadjusted	1.01	1.00 - 1.02
Model 4	1.01	1.00 - 1.02
Model 5	1.00	0.99 - 1.02
20-44		
Unadjusted	0.99	0.97 - 1.01
Model 4	0.99	0.97 - 1.01
Model 5	0.98	0.96 - 1.01
45-64		
Unadjusted	1.03	1.01 - 1.05
Model 4	1.03	1.00 - 1.05
Model 5	1.02	1.00 - 1.04
65 and older		
Unadjusted	1.01	0.99 - 1.03
Model 4	1.02	1.00 - 1.03
Model 5	1.00	0.98 - 1.03

The sample consisted of the respondents who were non-smokers at baseline.
Unadjusted model included CESD score at baseline as an independent variable.
Model 4 added socioeconomic variables to the Unadjusted model.
Model 5 added confounding variables to Model 4.

Finally, Table 7 shows the results of the analysis using the final model (Model 5) to determine the effect of depression on smoking. In the analysis of the entire sample, the variables of the first year that were related to smoking in the second year included the male gender, a young age, drinking two to three times a week, separation from one's spouse by death, and low self-esteem. The factors that had effects on smoking varied depending on the age group. First, in the young people aged 20-44 years, being male, being unemployed, and drinking two to three times a week were found to make people start smoking; in the middle-aged people (45-64), only a decrease in the number of people who started smoking appeared; and in the old people aged 65 years or older, being male and having low self-esteem were found to be related to starting smoking.

DISCUSSION

The main purpose of this study was, first, to determine if depression and smoking were correlated with each other; second, to determine whether causality existed between depression and smoking, and if it existed, what

Table 7. Characteristics at year 1 predicting smoking at year 2: multiple logistic regression results (Model 5)

Variables	OR	p-value	95% CI
All (20 and older)			
Male	2.76	0.000	2.06 - 3.69
Age	0.98	0.001	0.96 - 0.99
Drinking > once and ≤ 3 times/wk	1.83	0.002	1.26 - 2.67
Bereaved (ref. married)	1.87	0.007	1.18 - 2.95
Rosenberg self-esteem scores	0.96	0.010	0.92 - 0.99
20-44			
Male	3.46	0.000	2.36 - 5.07
Unemployed (ref. employed)	2.60	0.005	1.33 - 5.08
Drinking > once and ≤ 3 times/wk	2.71	0.000	1.64 - 4.49
45-64			
Age	0.95	0.002	0.91 - 0.98
65 and older			
Male	2.31	0.017	1.17 - 4.61
Rosenberg self-esteem scores	0.93	0.038	0.87 - 1.00

OR: odds ratio, CI: confidence interval.

its direction was; and third, what other variables had significant effects on the presence of depression and of smoking. In analyzing the correlation between smoking and depression, studies utilizing cross-sectional data have limitations in examining the effects of smoking on the presence of depression or vice versa. As such, this study is significant in that it uses longitudinal data to verify the causality between smoking and depression, particularly the panel data obtained from the Korea Welfare Status Survey, which was conducted from November 2006 to April 2007. In Korea, there have been a few longitudinal studies on the initiation of smoking among high school students [23], on the resumption of smoking of adults who have quit smoking [24,25], and on teenagers' depression and anxiety [26]. However, longitudinal studies that aim to analyze the causality between smoking and depression can hardly be found.

The cross-tabulation analysis for testing the simple correlation between depression and smoking in this study showed a significant correlation between smoking in the first year and depression in the second year, but no significant correlation between depression in the first year and smoking in the second year. Moreover, in the multiple logistic regression in which various socioeconomic and confounding variables were controlled, partial evidence that smoking was the cause of depression was found, but no evidence that depression was the cause of smoking was obtained. The research result that smoking was the cause of depression has been found in teenagers [27,28], the aged [29], the population group [15,30], and the workers [31].

The effect of smoking on depression can be explained by the presence of nicotine or other ingredients in cigarettes, which affect the central non-adrenalin receptor system [13,32]. There is also an assertion that depression occurs only in nicotine-addicted smokers due to the nicotine ingredient of cigarettes, which causes depression as it influences the neuro-transmitter directly or indirectly [5]. This hypothesis seemed to be supported by this study results in that depression occurred among heavy smokers who smoked more than two packs of cigarettes a day. In conclusion, it can be said that smoking, particularly nicotine addiction, can have an effect on a person's mental health such as depression.

In this study, however, depression also occurred to light smokers who smoked less than half a pack of cigarettes a day, indicating that depression can also occur to people who are not nicotine addicts. This was the phenomenon that occurred to those who were 45 years or older. If a person smokes small amount of cigarettes a day can be regarded as a beginner, it is likely that smoking initiated at middle age or old age is due to the stress caused by their various socioeconomic problems.

Meanwhile, no evidence supporting that depression was the cause of smoking was found in this study. The study results conflict with those of other studies [4] which have found that depression was one of the major causes of smoking. In the studies of Anda et al. [4] and Patton et al. [6], it was asserted that depression was a cause of smoking based on the fact that the smokers with depressive symptoms stopped smoking less than the smokers without depressive symptoms did. These studies, however, are different from this study in that we used only the samples that were not smoking at the baseline. In the study conducted by Patton et al. [8], which was conducted on middle-school teenagers, depression was not found to directly influence smoking. Instead, depression affected smoking only when the peer group smoked. Along with the findings from our study, it seems that previous studies do not provide sufficient evidence that depression is the direct cause of smoking.

If we want to establish an exact causality between smoking and depression, various conditions, such as time sequence, theoretical mechanisms, dose-response relationship, and exclusion of alternatives should be satisfied [30]. The causality mechanism of smoking and depression can be explained theoretically in both directions, as discussed in the introduction. Accordingly, which theoretical mechanisms are realistic can be determined based on the results of an empirical analysis like this study.

To examine the second condition, the dose-response relationship, smoking amount and the CESD scores were used as independent variables. The results showed

that a dose-response relationship was partly found in the effect of smoking on depression but was not found in the effect of depression on smoking. Such inconsistent relations between smoking and depression prevent the establishment of the conclusion that smoking is the cause of depression.

The final condition of causality, the exclusion of alternatives, depends on how well the confounding variables are controlled. In this study, an attempt was made to exclude the effects of all conditions other than smoking or depression, by controlling various socioeconomic variables and the variables of past personal experiences that could be related with smoking and depression. As the initiation or presence of smoking and depression is a dependent variable, only non-smokers in the first year were used when analyzing the smoking initiation, while only non-depressed samples were used when analyzing the presence of depression.

Although the main purpose of this study was to determine the causality between smoking and depression, other variables that had effects on the initiation of smoking and depression were also identified. In the analysis of the entire sample, gender (female), coming from a low-income household, non-engagement in economic activities, being unmarried, separation from one's spouse by death, experience of parents' divorce, low self-esteem, and poor health condition were found to have effects on depression. High CESD scores, low self-esteem, and poor health condition were found to have effects on depression in all age groups of interest. In the young people aged 20-44 years, gender (female), coming from a low-income household, being unmarried, and experience of parents' divorce were found to have effects on depression; in the middle-aged people aged 45-64 years, coming from a low-income household and being unmarried predicted depression; and in the senior people aged 65 years or older, only gender (female) was found to predict depression.

The results of the analysis of the entire sample showed that being a male, being young, drinking two to three times a week, being bereaved, and low self-esteem could raise the probability of starting smoking. Such results suggest that efforts to prevent smoking should be focused on young people, males, and those who drink two to three times a week. The results also suggest that contents enhancing self-esteem should be included in the education for young people to prevent them from smoking or to help those trying to quit smoking succeed in their efforts, since high self-esteem was found to keep one from starting to smoke or from smoking. Factors influencing smoking differed by age group. And it is noteworthy that in the young people aged 20-44 years, unemployment was the strongest predictor of smoking. This suggests that economic issues like unemployment can also be a health issue.

This study has several limitations. First, those who had smoked but quit smoking at the time of survey were included in the non-smokers. A smoking beginner, in the strict sense of the term, should be clearly defined as those who have had no prior experience of smoking as there can be a difference in the correlation with the presence of depression between the case of a beginning smoker as defined above and the case of a past smoker who quit smoking and then resumed it. For this reason, related studies in foreign countries have often been made only on teenagers to examine the correlation between beginning smoking and the presence of depression [7,8,27,28]. In this study, however, adults aged 20 years or older were included but their smoking history (i.e., whether they were smokers or non-smokers in the past, how much they smoke, and their smoking period) was not surveyed. As such, the smoking beginners, in the strict sense of the term, could not be distinguished from them.

Second, the reliability of measurement of smoking variables may be low since the Korea Welfare Panel collected data through an interview survey. For example, smoking is still considered taboo among women in Korea, which may have lead many female smokers to report themselves as non-smokers. Whether one is a smoker or not can be accurately determined by using biochemical indicators such as the numerical value of nicotine in the blood.

Third, the CESD-11 scale that was used to measure depression was developed for application to a big population group to screen their depression, and the scores that are beyond the cut-off point do not always coincide with the clinical diagnosis of depression. As the validity and reliability of the cut-off point that was used in this study (i.e., 16 points) have not been proven, further research on this matter should be undertaken.

Fourth, as the observation period was only about one year, the long-term influence of smoking and depression on each other was not observed. studies on the long-term correlation between smoking and depression should thus be conducted by using the Korea Welfare Panel.

Fifth, this study focused on the initiation of smoking and depression, and it used only the non-smokers and non-depressed persons in the first year for the analysis. In the future, longitudinal studies that include those who experience both smoking and depression and that

analyze the causality between the two variables with more diverse aspects of correlation between them being taken into account must be conducted.

Finally, in this study, differences among diverse population groups (except age) in the correlation between smoking and depression were not taken into account. Particularly, as it is known [33] that there are differences between males and females in terms of coping with depression, this must thus be taken into account. In this study, however, the number of samples consisting of females who were non-smokers in the first year and who became smokers in the second year was so small that it was difficult to analyze by distinguishing between the males and the females.

This study analyzed the existence and direction of the causality between smoking and depression using the first two waves of the Korea Welfare Panel. The results showed partial evidence that smoking can be a cause of depression was found, but little evidence that depression can be a cause of smoking was found. This shows that smoking can cause not only diseases like lung cancer but also mental health problems such as depression. The results of this study must be verified, however, through studies that address its limitations.

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