

Secondhand Smoking Is Associated with Poor Mental Health in Korean Adolescents

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In Korea, the prevalence of depression is increasing in adolescents and the most common cause of death of adolescents has been reported as suicide. At a time of increasing predicament of mental health of adolescents, there are few studies on whether secondhand smoking is associated with mental health in adolescents. The objective of this study was to determine whether exposure to secondhand smoke is associated with mental health-related variables, such as depression, stress, and suicide, in Korean adolescents. Data from the eleventh Korea youth risk behavior web-based survey, a nationally representative survey of 62,708 participants (30,964 males and 31,744 females), were analyzed. For students of aged 12 to 18 years, extensive data including secondhand smoking, mental health, sociodemographic variables, and physical health were collected. Chi-square analysis, multiple logistic regression analysis and ordered logistic regression analysis were performed to estimate the association and dose-response relation between secondhand smoking and mental health. Compared with the non-exposed group, the odds ratios (OR) of depression, stress, suicidal ideation, suicidal planning and suicidal attempt in the secondhand smoking exposed group were 1.339, 1.192, 1.303, 1.437 and 1.505, respectively (all $P < 0.001$). When subjects were classified into two secondhand smoke exposure groups, with increasing secondhand smoking experience, higher was the OR for each mental health related variable, in a dose-response relation. Our findings suggest that secondhand smoking is associated with poor mental health such as depression, stress, and suicide, showing a dose-response relation in Korean adolescents.

Keywords: depression; mental health; secondhand smoking; stress; suicide

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Introduction

Secondhand smoking generally indicates inhalation of unwanted smoke by non-smokers from a smoker's tobacco smoke. It is also called passive smoking, involuntary smoking, or environmental smoking (Seo 2007). Harmful effects of smoking such as respiratory problems, cardiovascular disease, and reproductive diseases have been confirmed (Office of the Surgeon General and Office on Smoking and Health 2004). Secondhand smoking affects fetal development, infant death syndrome, and childhood asthma. It also induces various cancers and cerebrovascular diseases (Office on Smoking and Health 2006).

Recent reports have shown that secondhand smoking negatively affects mental health as well as physical health for adults. According to U.S. studies conducted in 2009, people with exposure to secondhand smoking are twice likely to develop depression compared with those who do not have such exposure (Bandiera et al. 2010). A Korean

study conducted in 2016 has suggested that exposure to secondhand smoking is associated with increased depressive symptoms and suicidal ideation in adult women (Gim et al. 2016). In addition, another study has reported that exposure to secondhand smoking in the workplace or at home is considered a risk factor for high stress in both smokers and never-smokers (Kim et al. 2015).

The number of patients suffering from depression is increasing every year, with mental health problems among adolescents being cited as important issues (Health Insurance Review and Assessment Service 2012). The rate of depressive symptoms experienced by Korean adolescents has increased from 8.5% in 2009 to 11.2% in 2013 (Korea Centers for Disease Control and Prevention 2013). According to data compiled in 2010 by Statistics Korea, stress perception by Korean adolescents was 60% in 2008 and 70% in 2010, which was above the average for all ages (Statistics Korea 2010). The Annual Report on the Cause of Death Statistics in 2011 reported that the most common

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cause of death of adolescents in Korea was suicide (Statistics Korea 2011).

At a time of increasing predicament of mental health of Korean adolescents, there are few studies on whether secondhand smoking is associated with mental health in adolescents. Previous studies have focused on the association between secondhand smoking and only depression in some groups in Korean adolescents (Lee 2014; Kim et al. 2016). The objective of this study was to determine whether exposure to secondhand smoke is associated with mental health related variables, such as depression, stress, and suicide, in Korean adolescents using national data.

Materials and Methods

Study subjects

This study used data from the eleventh Korea youth risk behavior web-based survey which was conducted in 2015 (Korea Centers for Disease Control and Prevention 2015a). The annual Korea youth risk behavior web-based survey is conducted by the Ministry of Education, the Ministry of Health and Welfare, and the Korea Centers for Disease Control and Prevention. It is an anonymous and self-administered web-based survey conducted by middle school and high school students using a standardized questionnaire for 14 areas related to health behaviors, including smoking and mental health. A stratified multistage cluster-sampling design was used to obtain nationally representative samples of middle and high school students for the survey. A total of 70,362 students from 400 middle schools and 400 high schools were engaged in the survey. After excluding long term absentee, exceptional children, and children with disability of literacy, 68,043 students from 797 schools finally participated in the survey. This study defined non-smokers as those who had never smoked and

those who had smoked before but had not smoked in the last 30 days. After excluding 5,123 smokers and 212 cases with missing data for age, a total of 62,708 non-smokers (30,964 males, 31,744 females) were included in the final analysis (Fig. 1). The study was approved by the institutional review board of the Veterans Health Service Medical Center (IRB file no. 2016-05-015).

Definition of variables

Secondhand smoking related variables: Secondhand smoke exposure was assessed with the following question: "During the past 7 days, how many days did you stay either with your families or visitors when they smoked in your home?". The exposed group comprised of participants who answered that they had exposure to secondhand smoke for more than one day per week. Based on the degree of exposure to secondhand smoke, the exposed group was further classified into subjects with secondhand smoke exposure for 1-4 days per week and those with exposure for 5 or more days per week. For 1,058 students, pre- and re- test were performed to assess the validity for the smoking related questionnaire. Urine cotinine concentration was measured to the same students in the second survey 2 weeks later. A urine cotinine concentration of 50 ng/ml or more was used as the gold standard for smokers and the validity for the smoking questionnaire was calculated as follows: sensitivity, 62.5%; specificity, 99.0%; kappa, 0.70 (Korea Centers for Disease Control and Prevention 2015b).

Mental health related variables: Depression was assessed with the following question: "Have you ever had feeling of depression or desperation to make your daily life stop for two consecutive weeks in a year?". A "yes" denoted the incidence of depression. Stress was measured with the following question: "How much do you feel stress in your usual life activities?". Those who had answers of "very

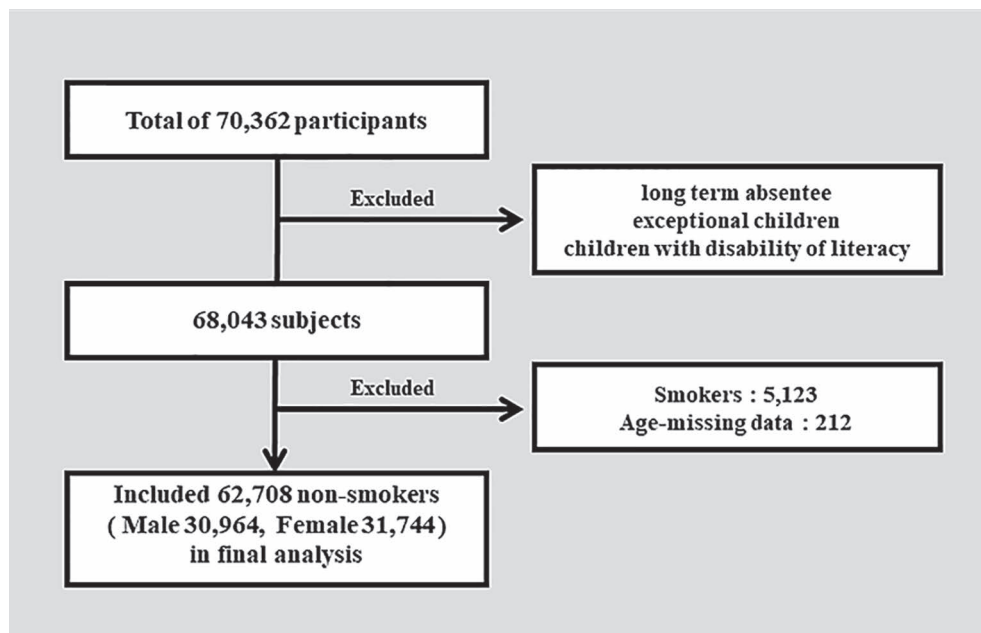


Fig. 1. Flow diagram of the study participants.

A total of 70,362 students from 400 middle schools and 400 high schools were engaged in the survey. After excluding long term absentee, exceptional children, and children with disability of literacy, 68,043 students from 797 schools finally participated in the survey. This study defined non-smokers as those who had never smoked and those who had smoked before but had not smoked in the last 30 days. After excluding 5,123 smokers and 212 cases with missing data for age, a total of 62,708 non-smokers (30,964 males, 31,744 females) were included in the final analysis.

much” or “much” were assigned into high stress group. Suicidal ideation, suicidal planning, and suicidal attempt were assessed with the following questions respectively: “Have you thought seriously about suicide in the last 12 months?”, “Have you ever had a specific plan to commit suicide in the last 12 months?”, and “Have you tried suicide in the last 12 months?”. Respondents who answered “yes” to any question were assigned into their respective groups. For 2,298 students, the reliability for mental health related questionnaires was assessed by comparing the first and second surveys to the same students every 2 weeks. As a result, the kappa value of the suicidal attempt was the highest at 0.70. The kappa values of the other mental health related variables were between 0.50 and 0.58 (Korea Centers for Disease Control and Prevention 2009).

Sociodemographic variables: Sociodemographic variables comprised of sex, age, household income, academic performance, type of parents, and type of residence. Type of parents was categorized as both parents, single parent, and orphan. Type of residence was classified into families living together, relatives living group, dormitory living group, and orphanage living group.

Physical health related variables: Participants who experienced drinking were assigned into risky drinking group if they had more than two of the following: 1) to relieve stress or for social purposes, 2) drinking alone, 3) received advice to reduce drinking from family or friends, 4) riding a motorcycle or bicycle after drinking, 5) blacked out after drinking, and 6) got into trouble with others after drinking alcohol. Regular exercise group was defined as those who had more than 5 days of physical activity that increased heart rate or made breathing more than usual for more than 60 minutes a day during the past 7 days regardless of the type of exercise. Subjective health perception was assessed by the following question: “How do you feel about your health condition at all time?”. Subjects who answered “unhealthy” or “very unhealthy” were assigned into the unhealthy group. Otherwise, they were assigned into the healthy group. Subjective body perception was assessed by the following question: “How do you feel about your body shape?”. Subjects were categorized into very fat or very thin group if they answered “very fat” or “very thin”. The rest of them were assigned into normal group. Regarding subjective sleep satisfaction, people who answered that that their sleeping time during the last 7 days was “more than enough” or “enough” to recover from fatigue were assigned into the enough sleeping group. Presence of counselor was assessed using the following question: “Whom do you usually talk to when you have difficulties or problems?”.

Statistical analysis

A complex sample design was made by weighting the data to make national youth a target population in 2015 (Korea Centers for Disease Control and Prevention 2015a). Chi-square test was used to estimate the association among secondhand smoking, sociodemographic variables, physical health related variables, and mental health related variables (depression, stress, suicidal ideation, suicidal planning, and suicidal attempt). Multiple logistic regression analysis was performed to identify the association between secondhand smoking and mental health after adjusting covariables, such as sex, age, household income, academic performance, type of parents, type of residence, risky drinking, regular exercise, subjective health perception, subjective body perception, subjective sleep satisfaction, and presence of counselor. Unadjusted and adjusted odds ratio (OR) and 95% confidence intervals (CI) were calculated. Ordered logistic regression

analysis was performed and P value for trends was calculated to show a dose-response relation according to the level of secondhand smoke exposure. Statistical significance was considered when P value was less than 0.05. All analyses were conducted using PASW statistics 18.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

General characteristics

The total number of subjects analyzed in this study was 62,708, including 30,964 males (49.4%) (Table 1). There was no statistically significant difference in age, type of residence and risky drinking between males and females. There were 38,854 (59.0%) participants who aged 12 to 15 years, more than those who aged 16 to 18 years. Of 62,708 respondents, 17,897 (27.7%) reported that they experienced secondhand smoking. The rate of experiencing secondhand smoking in females (28.9%) was higher than that in males ($P < 0.001$). In addition, rates of mental health related variables such as depression, stress, suicidal ideation, suicidal planning, and suicidal attempt in females were higher than those in males ($P < 0.001$).

Univariate analysis for depression and stress

Based on univariate analysis for depression and stress, the following factors were found to be statistically significant ($P < 0.001$, Table 2): females, at age of 16-18 years old, low household income, poor academic performance, risky drinking, unhealthy subjective health perception, very thin or very fat subjective body perception, not enough subjective sleep satisfaction, absence of counselor, and secondhand smoking exposure. Depression and stress rates were the lowest in groups with both parents and those who resided with family ($P < 0.001$). There was no statistically significant difference in depression between the regular exercise group and no-exercise group. However, the degree of stress was lower in the regular exercise group ($P < 0.001$).

Univariate analysis for suicidal ideation, suicidal planning and suicidal attempt

Univariate analysis revealed that the following groups had significantly higher rates of suicidal ideation, suicidal planning, and suicidal attempt ($P < 0.001$, Table 3): females, low household income, poor academic performance, lower number of parents, risky drinking, unhealthy subjective health perception, very thin or very fat subjective body perception, not enough subjective sleep satisfaction, absence of counselor, and secondhand smoking exposure. When type of residence was analyzed, suicidal ideation was the highest in the group living in a relative’s house while suicidal planning and suicidal attempt were the highest in orphanage group ($P < 0.001$). There was no statistically significant relationship between age and suicide ideation. However, suicidal planning and suicidal attempt were significantly higher in the age group of 12 to 15 years ($P < 0.05$). Although the regular exercise group had significantly

Table 1. General characteristics of study subjects.

Characteristic		Male (n = 30,964)	Female (n = 31,744)	Total (n = 62,708)	P-value*
Age (years)	12-15	19,705 (60.5)	19,149 (57.6)	38,854 (59.0)	0.176
	16-18	11,259 (39.5)	12,595 (42.4)	23,854 (41.0)	
Household income	High	12,189 (39.6)	10,669 (34.0)	22,858 (36.8)	< 0.001
	Middle	14,009 (45.1)	15,709 (49.3)	29,718 (47.2)	
	Low	4,766 (15.3)	5,366 (16.8)	10,132 (16.0)	
Academic performance	Good	12,347 (39.9)	12,047 (37.8)	24,394 (38.8)	< 0.001
	Middle	8,466 (27.2)	9,277 (29.4)	17,743 (28.3)	
	Poor	10,151 (32.9)	10,420 (32.8)	20,571 (32.8)	
Type of parents	Both parents	29,036 (94.3)	29,781 (94.3)	58,817 (94.3)	< 0.001
	Single parent	1,581 (4.7)	1,787 (5.2)	3,368 (5.0)	
	Orphan	347 (1.0)	176 (0.4)	523 (0.7)	
Type of residence	With family	29,488 (95.7)	30,479 (96.5)	59,967 (96.1)	0.069
	In relative's house	221 (0.7)	213 (0.6)	434 (0.7)	
	In dormitory	1,117 (3.2)	971 (2.6)	2,088 (2.9)	
	In orphanage	138 (0.4)	81 (0.2)	219 (0.3)	
Risky drinking	Yes	913 (3.0)	941 (3.1)	1,854 (3.1)	0.795
	No	30,051 (97.0)	30803 (96.9)	60,854 (96.9)	
Regular exercise	Yes	6,516 (20.3)	2,389 (7.2)	8,905 (13.7)	< 0.001
	No	24,448 (79.7)	29,355 (92.8)	53,803 (86.3)	
Subjective health perception	Healthy	29,540 (95.2)	29,681 (93.5)	59,221 (94.4)	< 0.001
	Unhealthy	1,424 (4.8)	2,063 (6.5)	3,487 (5.6)	
Subjective body perception	Normal	27,403 (88.6)	28,996 (91.6)	56,399 (90.1)	< 0.001
	Very thin or very fat	3,561 (11.4)	2,748 (8.4)	6,309 (9.9)	
Subjective sleep satisfaction	Enough	11,133 (35.0)	7,338 (22.5)	18,471 (78.3)	< 0.001
	Not enough	19,831 (65.0)	24,406 (77.5)	44,237 (71.3)	
Presence of counselor	Present	21,317 (69.3)	27,528 (87.1)	48,845 (78.3)	< 0.001
	Absent	9,647 (30.7)	4,216 (12.9)	13,863 (21.7)	
Secondhand smoking	Yes	8,433 (26.5)	9,464 (28.9)	17,897 (27.7)	< 0.001
	No	22,531 (73.5)	22,280 (71.1)	44,811 (72.3)	
Depression	Yes	5,448 (17.9)	8,495 (26.8)	13,943 (22.4)	< 0.001
	No	25,516 (82.1)	23,249 (73.2)	48,765 (77.6)	
Stress	High	8,659 (28.4)	12,989 (41.0)	21,648 (34.7)	< 0.001
	Low	22,305 (71.6)	18,755 (59.0)	41,060 (65.3)	
Suicidal ideation	Yes	2,651 (8.8)	4,196 (13.2)	6,847 (11.0)	< 0.001
	No	28,313 (91.2)	27,548 (86.8)	55,861 (89.0)	
Suicidal planning	Yes	929 (3.1)	1,179 (3.7)	2,108 (3.4)	< 0.001
	No	30,035 (96.9)	30,565 (96.3)	60,600 (96.6)	
Suicidal attempt	Yes	467 (1.5)	837 (2.6)	1,304 (2.1)	< 0.001
	No	30,497 (98.5)	30,907 (97.4)	61,404 (97.9)	

Values are presented as number (% weighted percentage).

*P-value was estimated by Chi-square test.

lower suicidal ideation compared with the no-exercise group, suicidal attempt in the regular exercise group was relatively higher ($P < 0.05$). However, there was no significant difference in suicidal planning between the regular exercise group and the no-exercise group.

Logistic regression analysis for secondhand smoking and mental health related variables

The odds ratios are calculated to assess the association between covariables (sex, age, household income, academic performance, type of parents, type of residence, risky drinking, regular exercise, subjective health perception, subjective body perception, subjective sleep satisfaction, and presence of counselor) and mental health related variables

Table 2. Factors related to depression and stress in study subjects (n = 62,708).

		Depression			Stress		
		Yes	No	P-value*	High	Low	P-value*
Sex							
	Male	5,448 (17.9)	25,516 (82.1)	< 0.001	8,659 (28.4)	22,305 (71.6)	< 0.001
	Female	8,495 (26.8)	23,249 (73.2)		12,989 (41.0)	18,755 (59.0)	
Age (years)							
	12-15	8,027 (20.9)	30,827 (79.1)	< 0.001	12,326 (31.9)	26,528 (68.1)	< 0.001
	16-18	5,916 (24.6)	17,938 (75.4)		9,322 (38.8)	14,532 (61.2)	
Household income							
	High	4,690 (20.8)	18,168 (79.2)	< 0.001	6,968 (30.9)	15,890 (69.1)	< 0.001
	Middle	6,219 (21.2)	23,499 (78.8)		9,954 (33.7)	19,764 (66.3)	
	Low	3,034 (29.6)	7,098 (70.4)		4,726 (46.4)	5,406 (53.6)	
Academic performance							
	Good	4,723 (19.4)	19,671 (80.6)	< 0.001	7,754 (32.1)	16,640 (67.9)	< 0.001
	Middle	3,744 (21.3)	13,999 (78.7)		5,733 (32.5)	12,010 (67.5)	
	Poor	5,476 (26.8)	15,095 (73.2)		8,161 (39.8)	12,410 (60.2)	
Type of parents							
	Both parents	12,946 (22.2)	45,871 (77.8)	< 0.001	20,138 (34.5)	38,679 (65.5)	< 0.001
	Single parent	834 (25.3)	2,534 (74.7)		1,309 (38.6)	2,059 (61.4)	
	Orphan	163 (31.4)	360 (68.6)		201 (38.1)	322 (61.9)	
Type of residence							
	With family	13,247 (22.2)	46,720 (77.8)	< 0.001	20,568 (34.5)	39,399 (65.5)	< 0.001
	In relative's house	151 (37.8)	283 (62.2)		198 (46.7)	236 (53.3)	
	In dormitory	485 (23.8)	1,603 (76.2)		805 (38.6)	1,283 (61.4)	
	In orphanage	60 (28.5)	159 (71.5)		77 (36.0)	142 (64.0)	
Risky drinking							
	Yes	790 (43.0)	1,064 (57.0)	< 0.001	926 (50.3)	928 (49.7)	< 0.001
	No	13,153 (21.7)	47,701 (78.3)		20,722 (34.2)	40,132 (65.8)	
Regular exercise							
	Yes	1,947 (22.0)	6,958 (78.0)	0.280	2,671 (29.7)	6,234 (70.3)	< 0.001
	No	11,996 (22.5)	41,807 (77.5)		18,977 (35.5)	34,826 (64.5)	
Subjective health perception							
	Healthy	12,478 (21.2)	46,743 (78.8)	< 0.001	19,243 (32.7)	39,978 (67.3)	< 0.001
	Unhealthy	1,465 (41.9)	2,022 (58.1)		2,405 (69.0)	1,082 (31.0)	
Subjective body perception							
	Normal	12,282 (21.9)	44,117 (78.1)	< 0.001	18,893 (33.7)	37,506 (66.3)	< 0.001
	Very thin or very fat	1,661 (26.9)	4,648 (73.1)		2,755 (43.6)	3,554 (56.4)	
Subjective sleep satisfaction							
	Enough	2531 (14.1)	15,940 (85.9)	< 0.001	3,673 (20.0)	14,798 (80.0)	< 0.001
	Not enough	11412 (25.8)	32,825 (74.2)		17,975 (40.6)	26,262 (59.4)	
Presence of counselor							
	Present	10,746 (22.0)	38,099 (78.0)	< 0.001	16,102 (33.1)	32,743 (66.9)	< 0.001
	Absent	3,197 (23.7)	10,666 (76.3)		5,546 (40.5)	8,317 (59.5)	
Secondhand smoking							
	Yes	4,832 (27.3)	13,065 (72.7)	< 0.001	6,940 (39.0)	10,957 (61.0)	< 0.001
	No	9,111 (20.5)	35,700 (79.5)		14,708 (33.1)	30,103 (66.9)	

Values are presented as number (% weighted percentage).

*P-value was estimated by Chi-square test.

(Table 4). And multiple logistic regression analysis was performed after adjusting for covariables to estimate the association between secondhand smoking and mental health (Table 5). Compared with non-exposed group, OR for depression in the secondhand smoking group was 1.339 (95% CI: 1.285-1.396). OR for stress, suicidal ideation, suicidal planning, and suicidal attempt were 1.192 (95% CI: 1.146-1.241), 1.303 (95% CI: 1.232-1.377), 1.437 (95% CI: 1.308-1.579), and 1.505 (95% CI: 1.342-1.688), respectively. When secondhand smoke exposed group was further classified into subjects with secondhand smoke exposure for 1-4 days per week and those with exposure for 5 or more days per week, compared with non-exposed group, their ORs for depression were 1.274 (95% CI: 1.218-1.332) and 1.528 (95% CI: 1.422-1.642), respectively; ORs for

stress were 1.113 (95% CI: 1.064-1.165) and 1.437 (95% CI: 1.343-1.538), respectively; ORs for suicidal ideation were 1.199 (95% CI: 1.124-1.278) and 1.588 (95% CI: 1.458-1.729), respectively; ORs for suicidal planning were 1.360 (95% CI: 1.224-1.511) and 1.641 (95% CI: 1.424-1.892), respectively; and ORs for suicidal attempt were 1.363 (95% CI: 1.193-1.557) and 1.866 (95% CI: 1.592-2.186), respectively. The more the secondhand smoking exposure, the higher the OR for each mental health related variable with a dose-response relation (P-value for trend < 0.001).

Discussion

Various hypotheses have been proposed to explain the association between secondhand smoking and poor mental

Table 3. Factors related to suicidal ideation, suicidal planning, suicidal attempt in study subjects (n = 62,708).

		Suicidal ideation			Suicidal planning			Suicidal attempt		
		Yes	No	P-value*	Yes	No	P-value*	Yes	No	P-value*
Sex	Male	2,651 (8.8)	28,313 (91.2)	< 0.001	929 (3.1)	30,035 (96.9)	< 0.001	467 (1.5)	30,497 (98.5)	< 0.001
	Female	4,196 (13.2)	27,548 (86.8)		1,179 (3.7)	30,565 (96.3)		837 (2.6)	30,907 (97.4)	
Age (years)	12-15	4,254 (11.1)	34,600 (88.9)	0.407	1,378 (3.6)	37,476 (96.4)	0.002	925 (2.4)	37,929 (97.6)	< 0.001
	16-18	2,593 (10.9)	21,261 (89.1)		730 (3.1)	23,124 (96.9)		379 (1.6)	23,475 (98.4)	
Household income	High	2,204 (9.9)	20,654 (90.1)	< 0.001	735 (3.2)	22,123 (96.8)	< 0.001	453 (2.0)	22,405 (98.0)	< 0.001
	Middle	2,891 (9.8)	26,827 (90.2)		794 (2.7)	28,924 (97.3)		486 (1.6)	29,232 (98.4)	
	Low	1,752 (17.3)	8,380 (82.7)		579 (5.6)	9,553 (94.4)		365 (3.5)	9,767 (96.5)	
Academic performance	Good	2,362 (9.9)	22,032 (90.1)	< 0.001	697 (2.9)	23,697 (97.1)	< 0.001	409 (1.7)	23,985 (98.3)	< 0.001
	Middle	1,748 (9.7)	15,995 (90.3)		540 (3.0)	17,203 (97.0)		315 (1.7)	17,428 (98.3)	
	Poor	2,737 (13.5)	17,834 (86.5)		871 (4.2)	19,700 (95.8)		580 (2.8)	19,991 (97.2)	
Type of parents	Both parents	6298 (10.8)	52,519 (89.2)	< 0.001	1,891 (3.2)	56,926 (96.8)	< 0.001	1,163 (1.9)	57,654 (98.1)	< 0.001
	Single parent	454 (13.6)	2,914 (86.4)		163 (4.9)	3,205 (95.1)		104 (3.3)	3,264 (96.7)	
	Orphan	95 (18.2)	428 (81.8)		54 (11.8)	469 (88.2)		37 (7.6)	486 (92.4)	
Type of residence	With family	6,533 (11.0)	53,434 (89.0)	< 0.001	1,990 (3.3)	57,977 (96.7)	< 0.001	1,234 (2.0)	58,733 (98.0)	< 0.001
	In relative's house	77 (19.8)	357 (80.2)		38 (10.5)	396 (89.5)		23 (5.7)	411 (94.3)	
	In dormitory	199 (10.4)	1,889 (89.6)		54 (3.1)	2,034 (96.9)		32 (1.7)	2,056 (98.3)	
	In orphanage	38 (17.7)	181 (82.3)		26 (13.5)	193 (86.5)		15 (7.9)	204 (92.1)	
Risky drinking	Yes	395 (22.3)	1,459 (77.7)	< 0.001	132 (7.5)	1,722 (92.5)	< 0.001	78 (3.9)	1,776 (96.1)	< 0.001
	No	6,452 (10.7)	54,402 (89.3)		1,976 (3.2)	58,878 (96.8)		1,226 (2.0)	59,628 (98.0)	
Regular exercise	Yes	930 (10.4)	7,975 (89.6)	0.044	325 (3.7)	8,580 (96.3)	0.062	219 (2.6)	8,686 (97.4)	0.001
	No	5,917 (11.1)	47,886 (88.9)		1,783 (3.3)	52,020 (96.7)		1,085 (2.0)	52,718 (98.0)	
Subjective health perception	Healthy	5,893 (10.0)	53,328 (90.0)	< 0.001	1,781 (3.0)	57,440 (97.0)	< 0.001	1,108 (1.8)	58,113 (98.2)	< 0.001
	Unhealthy	954 (27.5)	2,533 (72.5)		327 (9.4)	3,160 (90.6)		196 (5.7)	3,291 (94.3)	
Subjective body perception	Normal	5,879 (10.5)	50,520 (89.5)	< 0.001	1,786 (3.2)	54,613 (96.8)	< 0.001	1,088 (1.9)	55,311 (98.1)	< 0.001
	Very thin or very fat	968 (15.5)	5,341 (84.5)		322 (5.1)	5,987 (94.9)		216 (3.4)	6,093 (96.6)	
Subjective sleep satisfaction	Enough	1,161 (6.4)	17,310 (93.6)	< 0.001	443 (2.4)	18,028 (97.6)	< 0.001	248 (1.3)	18,223 (98.7)	< 0.001
	Not enough	5,686 (12.9)	38,551 (87.1)		1,665 (3.7)	42,572 (96.3)		1,056 (2.4)	43,181 (97.6)	
Presence of counselor	Present	4,833 (9.9)	44,012 (90.1)	< 0.001	1,449 (3.0)	47,396 (97.0)	< 0.001	901 (1.8)	47,944 (98.2)	< 0.001
	Absent	2,014 (15.0)	11,849 (85.0)		659 (4.8)	13,204 (95.2)		403 (2.9)	13,460 (97.1)	
Secondhand smoking	Yes	2,437 (13.8)	15,460 (86.2)	< 0.001	812 (4.6)	17,085 (95.4)	< 0.001	528 (2.9)	17,369 (97.1)	< 0.001
	No	4,410 (10.0)	40,401 (90.0)		1,296 (2.9)	43,515 (97.1)		776 (1.7)	44,035 (98.3)	

Values are presented as number (% weighted percentage).

*P-value was estimated by Chi-square test.

health. First, secondhand smoking has similar physiological effects as firsthand smoking, such as a decrease in hormones and neurotransmitters, thus increasing the risk of depression and suicide. Similar to direct smoking, secondhand smoking reduces the secretion of dopamine and gamma aminobutyric acid (GABA), thereby increasing the risk of depression (Bandiera 2011). Another study further suggests that secondhand smoking can reduce dopamine secretion related to suicidal attempts in non-depressed patients (Pitchot et al. 2001). Smoking is also associated with decreased serotonin and monoamine oxidase levels in the body, which might be the cause of depression (Hughes 2008). Second, persistent exposure to secondhand smoke can be a stress factor that causes unwanted smoking among adolescents. Secondhand smoking can lead to poor quality of life by giving teenagers physical discomfort such as coughing and eye irritation, thus causing anxiety about their health (Woods et al. 2005). A study has reported that children feel unhappy when parents smoke at home (Chen et al. 2015a). In addition, this stress is considered a risk factor for suicide, especially in Korea which has the highest suicide rate among Organization for Economic Cooperation

and Development (OECD) countries (Song et al. 2014). Third, secondhand smoking is associated with other mental disorders besides depression and stress. Serum cotinine levels are associated with major depressive disorder, anxiety disorder, attention deficit disorder, and behavioral disorders when non-smokers are exposed to secondhand smoking (Bandiera et al. 2011; Bot et al. 2013; Taha and Goodwin 2014). These mental disorders might be risk factors for suicides (Kessler et al. 2005; Bandiera et al. 2011).

Results of OR calculated for secondhand smoking group compared with non-exposed group suggest that secondhand smoking is associated with depression, stress, suicidal ideation, suicidal planning, and suicidal attempt. With increasing secondhand smoking exposure, higher OR was obtained for each mental health related variable with a dose-response relation. A study has investigated associations between mental health and secondhand smoking exposure, which was objectively measured using salivary cotinine level as a circulating biochemical marker (Hamer et al. 2010). In that study, the OR for psychological distress in high exposure group with high cotinine level was 1.49 (95% CI: 1.13-1.97) compared with the group with low

Table 4. Odds ratio (OR)* and 95% confidence interval* of covariables for mental health related variables.

		Adjusted OR [†]				
		Depression	Stress	Suicidal ideation	Suicidal planning	Suicidal attempt
Sex	Male	1	1	1	1	1
	Female	1.659 (1.580-1.743)	1.749 (1.679-1.821)	1.661 (1.556-1.773)	1.288 (1.160-1.429)	1.910 (1.673-2.181)
Age (years)	12-15	1	1	1	1	1
	16-18	1.039 (0.990-1.090)	1.109 (1.064-1.155)	0.794 (0.744-0.847)	0.711 (0.638-0.793)	0.544 (0.476-0.621)
Household income	High	1	1	1	1	1
	Middle	0.868 (0.829-0.909)	0.955 (0.919-0.992)	0.868 (0.814-0.925)	0.735 (0.656-0.823)	0.680 (0.591-0.782)
	Low	1.157 (1.093-1.226)	1.395 (1.320-1.472)	1.412 (1.304-1.529)	1.285 (1.129-1.462)	1.240 (1.064-1.446)
Academic performance	Good	1	1	1	1	1
	Middle	1.100 (1.045-1.158)	0.961 (0.920-1.004)	0.958 (0.896-1.024)	1.046 (0.932-1.174)	1.070 (0.915-1.252)
	Poor	1.379 (1.313-1.448)	1.213 (1.161-1.266)	1.198 (1.123-1.278)	1.257 (1.131-1.397)	1.406 (1.229-1.607)
Type of parents	Both parents	1	1	1	1	1
	Single parent	0.966 (0.879-1.062)	0.945 (0.872-1.024)	0.999 (0.892-1.118)	1.174 (0.990-1.393)	1.292 (1.037-1.611)
	Orphan	1.520 (1.226-1.885)	1.160 (0.949-1.417)	1.608 (1.260-2.051)	2.799 (2.016-3.885)	3.258 (2.125-4.997)
Type of residence	With family	1	1	1	1	1
	In relative's house	1.760 (1.397-2.218)	1.389 (1.111-1.737)	1.549 (1.176-2.040)	2.392 (1.645-3.480)	1.906 (1.181-3.076)
	In dormitory	1.034 (0.918-1.164)	1.094 (0.975-1.228)	0.959 (0.833-1.104)	0.962 (0.727-1.273)	0.980 (0.688-1.395)
	In orphanage	1.100 (0.791-1.529)	0.900 (0.623-1.302)	1.211 (0.811-1.809)	2.284 (1.420-3.675)	1.966 (1.048-3.691)
Risky drinking	No	1	1	1	1	1
	Yes	2.267 (2.046-2.511)	1.583 (1.437-1.744)	2.189 (1.917-2.501)	2.165 (1.763-2.658)	1.854 (1.451-2.369)
Regular exercise	Yes	1	1	1	1	1
	No	0.864 (0.815-0.915)	1.052 (0.996-1.110)	0.927 (0.860-0.999)	0.846 (0.746-0.959)	0.668 (0.571-0.781)
Subjective health perception	Healthy	1	1	1	1	1
	Unhealthy	2.139 (1.984-2.306)	3.498 (3.237-3.781)	2.631 (2.425-2.855)	2.689 (2.347-3.081)	2.521 (2.137-2.975)
Subjective body perception	Normal	1	1	1	1	1
	Very thin or very fat	1.159 (1.086-1.237)	1.317 (1.240-1.398)	1.298 (1.195-1.410)	1.309 (1.143-1.499)	1.475 (1.251-1.738)
Subjective sleep satisfaction	Enough	1	1	1	1	1
	Not enough	1.849 (1.753-1.949)	2.348 (2.246-2.454)	1.906 (1.779-2.043)	1.440 (1.285-1.613)	1.673 (1.442-1.942)
Presence of counselor	Present	1	1	1	1	1
	Absent	1.194 (1.133-1.259)	1.541 (1.477-1.608)	1.696 (1.588-1.811)	1.579 (1.414-1.764)	1.611 (1.420-1.828)
Secondhand smoking	No	1	1	1	1	1
	Yes	1.339 (1.285-1.396)	1.192 (1.146-1.241)	1.303 (1.232-1.377)	1.437 (1.308-1.579)	1.505 (1.342-1.688)

*Estimated by multiple logistic regression analysis.

[†]Adjusted for sex, age, household income, academic performance, type of parents, type of residence, risky drinking, regular exercise, subjective health perception, subjective body perception, subjective sleep satisfaction, presence of counselor and secondhand smoking.

cotinine concentration. In addition, the adjusted hazard ratio for the risk of psychiatric hospital admission is found to be 2.84 (95% CI: 1.07-7.59), suggesting that secondhand smoking is related to mental health. On the other hand,

Lam et al. (2013) have reported that there is no significant association between secondhand smoking and mental health in adults. In that study, exposure to secondhand smoke was measured by exhaled carbon monoxide and salivary coti-

Table 5. Odds ratio* and 95% confidence interval* of secondhand smoking for mental health related variables.

Secondhand smoking	Depression	Stress	Suicidal ideation	Suicidal planning	Suicidal attempt
Unadjusted					
No	1 [‡]	1 [‡]	1 [‡]	1 [‡]	1 [‡]
Yes	1.457 (1.401-1.515)	1.293 (1.246-1.342)	1.449 (1.374-1.527)	1.600 (1.459-1.755)	1.731 (1.545-1.938)
No	1 [§]	1 [§]	1 [§]	1 [§]	1 [§]
1-4 days/week	1.346 (1.289-1.405)	1.171 (1.122-1.221)	1.286 (1.210-1.367)	1.464 (1.320-1.623)	1.496 (1.311-1.706)
≥ 5 days/week	1.793 (1.675-1.920)	1.690 (1.588-1.799)	1.928 (1.773-2.096)	1.984 (1.727-2.280)	2.394 (2.050-2.796)
Adjusted [†]					
No	1 [‡]	1 [‡]	1 [‡]	1 [‡]	1 [‡]
Yes	1.339 (1.285-1.396)	1.192 (1.146-1.241)	1.303 (1.232-1.377)	1.437 (1.308-1.579)	1.505 (1.342-1.688)
No	1 [§]	1 [§]	1 [§]	1 [§]	1 [§]
1-4 days/week	1.274 (1.218-1.332)	1.113 (1.064-1.165)	1.199 (1.124-1.278)	1.360 (1.224-1.511)	1.363 (1.193-1.557)
≥ 5 days/week	1.528 (1.422-1.642)	1.437 (1.343-1.538)	1.588 (1.458-1.729)	1.641 (1.424-1.892)	1.866 (1.592-2.186)

*Estimated by multiple or ordered logistic regression analysis.

[†]Adjusted for sex, age, household income, academic performance, type of parents, type of residence, risky drinking, regular exercise, subjective health perception, subjective body perception, subjective sleep satisfaction, and presence of counselor.

[‡]P-value < 0.001.

[§]P-value for trend < 0.001.

nine level. However, these two values measured in non-smokers were not statistically related to psychological distress. It was mentioned that measurable time range of exhaled carbon monoxide might be too narrow and the accuracy of measurement time might be required. In addition, it is possible that high metabolic rate of nicotine and different instrumentation of mental health assessment might lead to different results. Kim et al. (2016) have conducted a self-report questionnaire survey of high school students about exposure to secondhand smoke and depression. They reported that the OR for having depressive symptoms among male adolescents with regular secondhand smoke exposure was 3.65 (95% CI: 1.52-8.73) compared with students who did not have experience of secondhand smoking, similar to results of this study. A cohort study that analyzed causes of death among adolescents who experienced smoking reported an adjusted hazard ratio of 2.83 (95% CI: 1.54-5.20) for adolescents who were exposed to secondhand smoke of 20 or more cigarettes per day, compared with non-exposed group (Chen et al. 2015b). These findings were similar to our results showing that secondhand smoking was associated with suicidal ideation, suicidal planning, and suicidal attempt.

Results of this study suggest that strong regulation of exposure to secondhand smoke is needed to protect the mental health of adolescents. National policies and practices are the most basic and important strategies to reduce exposure to secondhand smoke. And it is necessary to create a social atmosphere so that it is easy for non-smokers to ask smokers not to smoke by providing institutional devices (Willemsen and de Vries 1996). In order to do this, the transition of perception of secondhand smoke among smokers and non-smokers is a prerequisite. To change the perception of adolescents who can be affected by exposure to secondhand smoke, school-based secondhand smoking prevention education, a community-centered organization, is

required. It has been reported that youth smoking prevention programs are the most effective when school-based programs, parental and community involvement, and mass media use are combined (Jung et al. 2008).

On the other hand, this study analyzed variables that might affect or seemed to be related to mental health of adolescents. Variables of household income, academic performance, type of parents, type of residence, risky drinking, subjective health perception, subjective body perception, subjective sleep satisfaction, and presence of counselor were all related to mental health regardless of sex (data not shown). However, variables of age and regular exercise showed differences according to sex. We conducted multiple logistic regression analysis of the association between secondhand smoking and mental health by sex, but there was no difference between the results of the whole study.

This study has several limitations. First, this study could not clarify the causal relationship between secondhand smoking and mental health by cross-sectional study based on self-report questionnaire. Second, biochemical quantitative analysis for the degree of secondhand smoke exposure was not made. In this study, the degree of exposure of secondhand smoke was determined through a self-report questionnaire. Biochemical quantitative data such as *in vivo* cotinine level were unavailable. However, self-reported smoking has also been reported to be highly valid compared with serum cotinine levels (Vartiainen et al. 2002). The reliability and validity of the questionnaire used in this study were verified through expert consultation and preliminary investigation (Korea Centers for Disease Control and Prevention 2009, 2015b). Therefore, the lack of biochemical quantitative analysis might not have made a significant impact on the outcome of this study. Third, not all variables such as psychiatric history and personality characteristics of adolescents and parents were considered. However, attempts were made to statistically correct related

variables such as academic performance, subjective body perception, and subjective health perception, the main causes of youth suicide (Statistics Korea 2014). Fourth, this study did not use diagnostic criteria for psychiatric disorders like DSM-5 (*Diagnostic and Statistical Manual of Mental Disorders, 5th Edition*) to assess mental health problems. However, this study used the question recommended for routine screening of children and adolescents by US preventive service task force (USPSTF), and it was reported the questionnaire may be as effective as using longer screening measures (Sharp and Lipsky 2002). Fifth, this study did not reveal any differences between the source of secondhand smoking exposure such as from a mother, father, or someone else. Because the information on who smoke in the house was not investigated in the eleventh Korea youth risk behavior web-based survey that this study used as the secondary data.

This study has the following strengths. Previous studies have focused on the association between secondhand smoking and only depression in adults and adolescents. To our knowledge, this is the first study to assess the association between secondhand smoking and other mental health related variables including stress and suicide in Korean adolescents. And this study used data from a nationally representative sample in South Korea and a complex sample design was made by weighting the data to make national youth a target population in 2015, and obtained generalizability of the results. Furthermore, this study analyzed and adjusted variables that might affect or seemed to be related to mental health of adolescents to obtain reliability of the results.

In conclusion, this study demonstrated that secondhand smoking was associated with poor mental health such as depression, stress, and suicide, showing a dose-response relation according to the level of secondhand smoke exposure in Korean adolescents. Therefore, a multifaceted approach such as institutional measures for prevention of secondhand smoking and improvement of recognition conversion is needed in order to protect the mental health of adolescents.

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Author Contributions

Bang, I.H. was a major contributor in writing the manuscript, and analyzed and interpreted the data. Jeong, Y.J. and Lee, J.Y. supervised the work and made substantial contributions to the conception and design of the study. All authors were involved in critically revising the work. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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