

BMJ Open Current smoking and secondhand smoke exposure and depression among Korean adolescents: analysis of a national cross-sectional survey

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ABSTRACT

Objectives: To examine the association between cigarette smoke exposure and depression among Korean adolescents using the seventh Korea Youth Risk Behavior Web-based Survey (KYRBWS).

Design: Cross-sectional study.

Setting: A nationally representative sample of middle and high school students across South Korea.

Participants: 75 643 eligible participants across the country.

Primary outcome measures: Current smoking, secondhand smoke exposure and depression.

Methodology: Data were analysed from a nationally representative survey of 75 643 participants (37 873 men and 37 770 women). Data were gathered on extensive information including current smoking, secondhand smoke exposure and depression in adolescence. Multiple logistic regression analysis was used to estimate the association between current smoking, secondhand smoke exposure and depression in Korean adolescents.

Results: Among those who had never smoked, secondhand smoke exposure was positively associated with depression in male and female adolescents in a dose–response relation (OR 1.27, OR 1.52 in males; OR 1.25, OR 1.72 in females). Similar associations were observed among currently smoking men and women in a dose–response manner (OR 1.29, OR 1.55 in males; OR 1.22, OR 1.41 in females). These significant trends were consistently observed even after adjustments.

Conclusions: We suggested that current smoking and secondhand smoke exposure were positively associated with depression in male and female adolescents. Efforts to encourage no smoking and no secondhand smoke exposure will be established for adolescents.

BACKGROUND

Smoking continues to be the leading preventable cause of death and disease in the world; nearly six million die annually from cigarette smoking, and more than 600 000 deaths occur each year due to secondhand

Strengths and limitations of this study

- The main strength of this study is that data from a nationally representative sample in South Korea was used; response rate to this survey was high.
- The main limitations are a cross-sectional study design and its use of self-reports.
- Unmeasured confounding variables cannot be analysed in this study.

smoke exposure, according to the WHO.^{1 2} Smoking was reported to have caused more than 46 000 deaths a year in Korea, 18.7% of total deaths.³ In total, 88% of adult cigarette smokers who smoke daily reported that they started smoking by the age of 18, indicating that smoking was initiated and established primarily during adolescence.^{4–6} The Korean smoking rate remains significantly high in comparison with the average rate among the Organisation for Economic Co-operation Development countries. Korea had the second highest smoking rate among the Organisation for Economic Co-operation Development countries in 2009, recording 44.3% among adults.^{7 8}

Tobacco use has been associated with serious diseases, including cancer, cardiovascular and respiratory diseases.⁹ Epidemiological studies have reported that current smokers are at greater risk for mental health problems,^{10 11} although the exact nature of this association is still unclear. There has been some speculation since 1975 that secondhand smoke exposure may somehow be linked to mental illness, but until recently there has not been sufficient evidence.^{12–16} Secondhand smoke may be a proxy for stressful living conditions, and stress has been associated with poor mental health.¹⁷ Moreover, smoking was presented as a gateway to drug and alcohol consumption among adolescents. The principle of

antismoking in adolescents must be addressed to prevent many of the long-term diseases associated with smoking and other substance use in the future.^{4 5} Unfortunately, the risk of psychiatric illness such as depression are of great vulnerability to youth who are experiencing remarkable growth physically, mentally and socially. Depression can be significant sources of morbidity; adolescent suicide was reported to be the most common cause of death among Korean adolescents in 2009 and 2010.¹⁸ However, there has not yet been enough research in Korea examining adolescent smoking including secondhand smoke exposure and depression.

Here, the objective was to examine the possible association between smoke exposure and depression among Korean adolescents. In order to assess current smoking and secondhand smoke exposure among Korean adolescents and their relation to depression, data from the seventh Korea Youth Risk Behavior Web-Based Survey (KYRBWS) were analysed in this study.

METHODS

Study sample and procedures

The basis for this investigation lies with the seventh KYRBWS, which was established in 2011.¹⁹ This study is a government-approved statistical survey that has been performed annually since 2005 to monitor priority health risk behaviours among Korean adolescents by the Korea Centers for Disease Control and Prevention. A stratified multistage cluster-sampling design was used to obtain a nationally representative sample of middle and high school students for the survey. Students voluntarily completed the anonymous, self-administered web-based survey during a regular class period. This study comprised 134 questions assessing demographic characteristics and 14 areas of health-related behaviours, including cigarette smoking and mental health. Details of the study design are provided elsewhere.^{19–21}

A total of 79 202 students from 400 middle schools and 400 high schools were engaged in the survey and the response rate was 95.5%. Finally, 75 643 eligible participants (37 873 male and 37 770 female) were included in the analysis.

This study used deidentified data on the seventh KYRBWS as a government-approved statistical survey and informed consent was obtained from all persons who participated in this survey.

Assessment of exposure

The outcome variable 'depression' was assessed through responses to the question, 'During the recent 12 months, have you ever felt sad or hopeless almost every day for 2 weeks in a row that you stopped doing some usual activities?' Current smoking and drinking behaviours were determined based on the responses to the following questions: 'During the recent 30 days, how many cigarettes did you smoke per day on average?' and

'During the past 30 days, how many cups did you drink on average?' Current smoking was measured using a graded categorical variable coded from 0 to 3: 0 (never smoked), 1 (smoked 1 cigarette or less), 2 (smoked 2–9 cigarettes) and 3 (smoked 10 or more cigarettes). Current drinking behaviour was classified using a dichotomous categorical variable coded as 0 (no) or 1 (yes). Secondhand smoke exposure was assessed through the question, 'During the past 7 days, how many days did you stay either with your families or visitors when they smoked within your home?' Secondhand smoke exposure was measured using a graded categorical variable coded from 0 to 2: 0 (no exposure), 1 (exposed 1–4 days) and 2 (exposed 5 or more days). Sociodemographic variables included age, sex, height, weight, region of residence, school type and grade, socioeconomic status, perceived stress and whether the family lives together. A measure of socioeconomic status was obtained through a five-point scale measuring family economic level ranging from 1 (high) to 5 (low).

Statistical analysis

Descriptive statistics were used to examine the distribution of demographic and social characteristics. A χ^2 test was used to estimate the difference in the existence of depression by current smoke and secondhand smoke exposure. Multiple logistic regression analysis was performed to identify the association between smoke exposure and depression. Age, sex, sociodemographic and depression variables that showed a significant difference in a χ^2 test and t test were adjusted for the analysis. The adjusted OR and corresponding 95% CIs were calculated. All p values were considered to be statistically significant at less than 0.05. All estimates were calculated based on sample weights, which were evaluated by taking into consideration the sampling rate, response rate, sex, school type and grade proportions of the reference population. Of whom 4.5% were missing, and hence missing data were already reflected to response rate when calculating weight. The analysis was adjusted for the complex sample design of the survey.^{20 21} All analyses were conducted using SPSS V.14.0.

RESULTS

Characteristics of the eligible subjects

A total of 75 643 participants were analysed in this study, of whom 32.8% were classified as feeling depressed. A significantly higher prevalence of depression was observed in female patients compared with male adolescents ($p<0.001$). The social and demographic characteristics of the study participants are provided in [table 1](#). No significant differences were seen in city size, school type or grade proportions between men and women, while there was significant difference in socioeconomic status ($p<0.001$). The proportion of those who perceived stress was higher in men than in women ($p<0.001$). A

Table 1 Background characteristics of the study participants

Characteristics	Total	Male	Female	p Value†
Age (years)	15.15±0.019	15.18±0.039	15.12±0.040	0.443
Height (cm)	165.42±0.140	170.23±0.113	160.08±0.045	<0.001***
Weight (kg)	56.51±0.137	60.77±0.136	51.79±0.071	<0.001***
City size				
Large	39 177 (53.5)	19 830 (53.6)	19 347 (53.4)	
Medium	29 365 (42.5)	14 488 (42.4)	14 877 (42.6)	
Small	7101 (4.0)	3555 (4.0)	3546 (4.0)	0.469
Grade in school				
Middle first	12 728 (16.0)	6548 (15.8)	6180 (16.1)	
Middle second	12 903 (16.7)	6413 (16.4)	6490 (17.0)	
Middle third	12 843 (16.9)	6589 (16.9)	6254 (16.9)	
High first	12 569 (17.2)	6386 (17.3)	6183 (17.1)	
High second	12 508 (16.7)	5954 (16.8)	6554 (16.5)	
High third	12 092 (16.6)	5983 (16.7)	6109 (16.4)	0.941
School type				
Middle school	38 474 (49.5)	19 550 (49.1)	18 924 (50.0)	
General high school	27 303 (38.8)	13 971 (38.8)	13 332 (38.7)	
Vocational high school	9866 (11.7)	4352 (12.1)	5514 (11.3)	0.853
Family economic level				
High	4777 (6.7)	3165 (8.6)	1612 (4.5)	
Middle high	17 654 (24.1)	9401 (25.1)	8253 (22.9)	
Average	35 762 (46.8)	16 929 (44.4)	18 833 (49.6)	
Middle low	13 549 (17.5)	6336 (16.6)	7213 (18.4)	
Low	3901 (5.0)	2042 (5.3)	1859 (4.6)	<0.001***
Stress				
No	32 117 (42.0)	13 547 (35.8)	18 570 (49.0)	
Yes	43 526 (58.0)	24 326 (64.2)	19 200 (51.0)	<0.001***
Family live together				
Yes	71 859 (95.7)	35 886 (95.3)	35 973 (96.1)	
No	3784 (4.3)	1987 (4.7)	1797 (3.9)	0.008**
Depression (recent 12 month)				
No	50 482 (67.2)	27 266 (72.0)	23 216 (61.8)	
Yes	25 161 (32.8)	10 607 (28.0)	14 554 (38.2)	<0.001***
Total	75 643 (100.0)	37 873 (50.1)	37 770 (49.9)	

p<0.01, *p<0.001.

†By unpaired t test and χ^2 test.

significantly higher proportion of men did not live with their families compared with women ($p=0.008$).

Table 2 shows the proportions of current smoking and secondhand smoke exposure by depression. The proportion of those who had never smoked was lower than that of current smokers in adolescents who felt depressed ($p<0.001$). Among adolescents who felt depressed, the percentages of no exposure were lower than that of secondhand smoke exposure ($p<0.001$). Similar significant trends were observed in male and female adolescents ($p<0.001$).

Associations between firsthand and secondhand smoke exposure and depression

To examine the association between current smoking and depression, a multiple logistic regression analysis was performed (table 3). Currently smoking adolescents were more prone to feeling depressed compared with those who had never smoked. A twofold increase in depression was observed in those smoking 10 or more

cigarettes per day versus those who have never smoked (OR 2.27, 95% CI 2.07 to 2.49). The effect was slightly smaller, although still significant association after adjustments (OR 1.69, 95% CI 1.51 to 1.88). Secondhand smoke exposure was positively associated with depression compared with no exposure (those exposed 1–4 days, OR 1.27; those exposed 5 or more days, OR 1.68). After adjustment for significant control variables, significant associations remained (those exposed 1–4 days, OR 1.22; those exposed 5 or more days, OR 1.36). In the sex-stratified analyses, these trends were observed consistently in male and female adolescents.

We performed an additional analysis of the relationship between secondhand smoke exposure and depression with data stratified by current smoking status (table 4). Among those who had never smoked, secondhand smoke exposure was positively related to depression in a dose-response relation with an increasing risk for an increasing frequency (those exposed 1–4 days, OR 1.26; those exposed 5 or more days, OR 1.71). Significant

Table 2 Current smoking and secondhand smoke exposure according to depression

Variables	Depression		χ^2	p Value†
	No N (%)	Yes N (%)		
<i>Male and female</i>				
Current smoking				
Never smoked	45 771 (69.1)	20 884 (30.9)		
1 cigarette or less per day	1266 (57.6)	984 (42.4)		
2–9 cigarettes per day	2543 (54.2)	2233 (45.8)		
10 or more cigarettes per day	902 (46.8)	1060 (53.2)	973.499	<0.001***
Secondhand smoke exposure				
No exposure	31 491 (70.6)	13 425 (29.4)		
1–4 days per week	13 147 (64.9)	7188 (35.1)		
5 or more days per week	5844 (56.7)	4548 (43.3)	791.501	<0.001***
<i>Male</i>				
Current smoking				
Never smoked	23 500 (74.7)	8022 (25.3)		
1 cigarette or less per day	969 (66.4)	512 (33.6)		
2–9 cigarettes per day	2043 (59.8)	1371 (40.2)		
10 or more cigarettes per day	754 (51.8)	702 (48.2)	703.657	<0.001***
Secondhand smoke exposure				
No exposure	17 233 (74.9)	5826 (25.1)		
1–4 days per week	7123 (69.5)	3098 (30.5)		
5 or more days per week	2910 (63.2)	1683 (36.8)	302.983	<0.001***
<i>Female</i>				
Current smoking				
Never smoked	22 271 (63.7)	12 862 (36.3)		
1 cigarette or less per day	297 (38.0)	472 (62.0)		
2–9 cigarettes per day	500 (36.9)	862 (63.1)		
10 or more cigarettes per day	148 (28.8)	358 (71.2)	780.817	<0.001***
Secondhand smoke exposure				
No exposure	14 258 (65.6)	7599 (34.4)		
1–4 days per week	6024 (59.6)	4090 (40.4)		
5 or more days per week	2934 (51.0)	2865 (49.0)	438.810	<0.001***

***p<0.001.

†By χ^2 test.

associations were observed between secondhand smoke exposure and depression among current smokers. Compared with no exposure, those exposed to secondhand smoke between 1 and 4 days/week showed a 33% increased risk of depression (95% CI 1.19 to 1.48) while those exposed to secondhand smoke 5 or more days per week exhibited a 62% increased risk (95% CI 1.44 to 1.82). The difference between ORs was smaller when adjusted.

The sex-specific associations between secondhand smoke exposure and depression in never smokers and current smokers are given in table 5. When exposed between 1 and 4 days/week, a 27% increased risk of feeling depressed was observed compared with no exposure among male adolescents who had never smoked (95% CI 1.20 to 1.35). When exposed 5 or more days per week, the extent of the increase in feeling depressed was greater than when exposed between 1 and 4 days/week (OR 1.52; 95% CI 1.39 to 1.65). Among currently smoking male adolescents, a significant association between secondhand smoke exposure and depression was consistently observed in dose-response relations

(OR 1.29 in those exposed 1 to 4 days; OR 1.55 in those exposed 5 or more days). There was a slightly smaller, although still significant association after adjustments. Female adolescents had a significant relationship between secondhand smoke exposure and depression. Among those who had never smoked, secondhand smoke exposure was positively associated with depression in a dose-response relation after adjustments (OR 1.17 in those exposed 1–4 days; OR 1.41 in those exposed 5 or more days). Similar associations were observed among current smokers (OR 1.25 in those exposed 1–4 days; OR 1.30 in those exposed 5 or more days). When exposed to secondhand smoke 5 or more days per week, the extent of increased risk in feeling depressed was more profound in females who had never smoked than in males (OR_{females} 1.41; OR_{males} 1.32).

DISCUSSION

The present results suggested a strong association between depression and cigarette smoke exposure including firsthand and secondhand smoke exposure in

Table 3 ORs for depression by current smoking and secondhand smoke exposure

Variables	OR	(95% CI)	OR*	(95% CI)	OR†	(95% CI)
<i>Male and female</i>						
Current smoking						
(1 cigarette or less per day/no)	1.57	(1.44 to 1.72)	1.54	(1.41 to 1.69)‡	1.44	(1.31 to 1.59)§
(2–9 cigarettes per day/no)	1.77	(1.65 to 1.90)	1.58	(1.47 to 1.70)‡	1.50	(1.40 to 1.62)§
(10 or more cigarettes per day/no)	2.27	(2.07 to 2.49)	1.89	(1.71 to 2.10)‡	1.69	(1.51 to 1.88)§
Secondhand smoke exposure						
(1–4 days per week/no)	1.27	(1.22 to 1.32)	1.25	(1.20 to 1.30)‡	1.22	(1.17 to 1.27)§
(5 or more days per week/no)	1.68	(1.60 to 1.76)	1.54	(1.47 to 1.61)‡	1.36	(1.29 to 1.43)§
<i>Male</i>						
Current smoking						
(1 cigarette or less per day/no)	1.44	(1.29 to 1.62)	1.30	(1.16 to 1.47)	1.27	(1.12 to 1.43)
(2–9 cigarettes per day/no)	1.87	(1.73 to 2.03)	1.49	(1.37 to 1.62)	1.43	(1.31 to 1.57)
(10 or more cigarettes per day/no)	2.51	(2.25 to 2.80)	1.82	(1.61 to 2.05)	1.61	(1.42 to 1.82)
Secondhand smoke exposure						
(1–4 days per week/no)	1.28	(1.21 to 1.34)	1.26	(1.20 to 1.33)	1.24	(1.18 to 1.32)
(5 or more days per week/no)	1.49	(1.38 to 1.61)	1.44	(1.34 to 1.56)	1.31	(1.21 to 1.42)
<i>Female</i>						
Current smoking						
(1 cigarette or less per day/no)	2.65	(2.29 to 3.08)	2.16	(1.85 to 2.52)	1.88	(1.61 to 2.19)
(2–9 cigarettes per day/no)	2.78	(2.48 to 3.12)	1.97	(1.74 to 2.23)	1.76	(1.55 to 1.99)
(10 or more cigarettes per day/no)	3.80	(3.11 to 4.65)	2.50	(2.01 to 3.11)	2.17	(1.73 to 2.74)
Secondhand smoke exposure						
(1–4 days per week/no)	1.25	(1.18 to 1.32)	1.23	(1.16 to 1.29)	1.18	(1.12 to 1.25)
(5 or more days per week/no)	1.68	(1.57 to 1.79)	1.61	(1.51 to 1.72)	1.39	(1.30 to 1.50)

*Adjusted for age and alcohol consumption.

†Additionally adjusted for age, alcohol consumption, socioeconomic status, stress and family live together.

‡Adjusted for age, sex and alcohol consumption.

§Additionally adjusted for age, sex, alcohol consumption, socioeconomic status, stress and family live together.

Korean adolescents with a dose–response relation. To our knowledge, this is the first study to assess the association between secondhand smoke exposure and depression in a nationally representative sample of Korean adolescents. Secondhand smoke exposure was positively associated with depression among the total sample of non-smokers even after adjustments. Furthermore, we found a dose–response relation so that likelihood of depression increased with an increasing number of cigarettes smoked per day for current smokers. Similarly,

the increasing frequency of secondhand smoke exposure was associated with increasing risk of depression. The observed association between smoking and depression might reflect a causal influence of smoking on depression. In previous studies with adolescents, changes in early emergence of depression and smoking behaviours are described, although model variation and inconsistent findings make the evidence unclear.^{22–24} However, we must address the fact that early use of tobacco has substantial health consequences that begin almost

Table 4 Association between secondhand smoke exposure and depression in those who have never smoked and current smokers

Variables	N	OR	(95% CI)	OR*	(95% CI)	OR†	(95% CI)
<i>Never smoked (n=66 655)</i>							
Secondhand smoke exposure							
No exposure	40 815	1	(reference)	1	(reference)	1	(reference)
1–4 days per week	17 778	1.26	(1.21 to 1.31)	1.23	(1.18 to 1.29)	1.20	(1.15 to 1.25)
5 or more days per week	8062	1.71	(1.63 to 1.81)	1.57	(1.49 to 1.66)	1.38	(1.30 to 1.46)
<i>Current smoker (n=8988)</i>							
Secondhand smoke exposure							
No exposure	4101	1	(reference)	1	(reference)	1	(reference)
1–4 days/week	2557	1.33	(1.19 to 1.48)	1.26	(1.13 to 1.41)	1.26	(1.12 to 1.42)
5 or more days per week	2330	1.62	(1.44 to 1.82)	1.44	(1.28 to 1.62)	1.33	(1.17 to 1.50)

*Adjusted for age, sex and alcohol consumption.

†Additionally adjusted for age, sex and alcohol consumption, socioeconomic status, stress and family live together.

Table 5 Sex-specific association between secondhand smoke exposure and depression in those who have never smoked and current smokers

Variables	N	OR	(95% CI)	OR*	(95% CI)	OR†	(95% CI)
<i>Male</i>							
Never smoked							
Secondhand smoke exposure	31 522						
No exposure	19 995	1	(reference)	1	(reference)	1	(reference)
1–4 days per week	8444	1.27	(1.20 to 1.35)	1.25	(1.18 to 1.32)	1.23	(1.16 to 1.30)
5 or more days per week	3083	1.52	(1.39 to 1.65)	1.46	(1.34 to 1.59)	1.32	(1.20 to 1.44)
Current smoker							
Secondhand smoke exposure	6351						
No exposure	3064	1	(reference)	1	(reference)	1	(reference)
1–4 days per week	1777	1.29	(1.13 to 1.47)	1.28	(1.12 to 1.47)	1.26	(1.09 to 1.46)
5 or more days per week	1510	1.55	(1.35 to 1.78)	1.46	(1.28 to 1.68)	1.34	(1.16 to 1.54)
<i>Female</i>							
Never smoked							
Secondhand smoke exposure	35 133						
No exposure	20 820	1	(reference)	1	(reference)	1	(reference)
1–4 days per week	9334	1.25	(1.18 to 1.32)	1.22	(1.16 to 1.29)	1.17	(1.11 to 1.24)
5 or more days per week	4979	1.72	(1.60 to 1.84)	1.64	(1.54 to 1.76)	1.41	(1.30 to 1.52)
Current smoker							
Secondhand smoke exposure	2637						
No exposure	1037	1	(reference)	1	(reference)	1	(reference)
1–4 days per week	780	1.22	(1.00 to 1.48)	1.21	(0.99 to 1.47)	1.25	(1.02 to 1.54)
5 or more days per week	820	1.41	(1.15 to 1.73)	1.35	(1.10 to 1.66)	1.30	(1.04 to 1.62)

*Adjusted for age and alcohol consumption.

†Additionally adjusted for age, alcohol consumption, socioeconomic status, stress and family live together.

immediately in adolescence. Furthermore, tobacco use in adolescence increases the possibility of continuing to smoke as an adult. We further speculate that very few people will begin to smoke if they remain tobacco-free in adolescence.⁴ Consistent with this study, Nakata *et al*¹⁵ found that the self-report of secondhand smoke exposure was related to depression among Japanese workers, although the study participants were adults, not adolescents. Bandiera *et al*³ found a significant association between secondhand smoke exposure and depression among 2901 children and adolescents.

Possible explanations for these results are that secondhand smoke exposure may contribute to lowering levels of dopamine and γ -aminobutyric acid, which have been related to an increased risk for depression, similar to those observed in firsthand smokers.^{25–27} Being exposed to secondhand smoke may be a proxy to stressful living, and stress has been associated with depression.²⁵ In fact, Pahl *et al*²⁸ found that homes that did not allow smoking had persons having a healthy lifestyle of diet and exercise, which in turn was associated with less risk of depression.

The main limitations of this study were a cross-sectional study design and its use of self-reports. This study design cannot prove a causal or temporal relation between smoking and depression. Similarly, when we considered depression and secondhand exposure, our analyses were based on the use of self-reports and it may result in the possibility of information bias. Finally, unmeasured confounding variables cannot be analysed

in this study. The known limitations of cross-sectional studies notwithstanding, the present study has the following strengths: it used a large nationwide representative sample of Korean middle and high school students for the survey; response rate to this survey was high; and finally, firsthand and secondhand smoke exposure were investigated as depression-related risk factors for depression in adolescents.

CONCLUSION

In conclusion, it is suggested that current smoking and secondhand smoke exposure are positively associated with depression in male and female adolescents. We suggest that secondhand smoke exposure with current smoking might be an important factor associated with depression in Korean adolescents. Therefore, effective strategies to encourage adolescents not to smoke and to reduced their exposure to secondhand smoke will need to be established. Stricter smoking bans will need to be implemented in homes and metropolitan areas, as well as in all enclosed public areas such as schools.

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Competing interests None.

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