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Association between environmental tobacco smoke and depression among Korean women

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ABSTRACT

Objective: To evaluate the association between environmental tobacco smoke (ETS) exposure and depression among Korean women.

Methods: Between 2008 and 2011, we examined 731 men and 1249 women (aged 39–85 years) for the Korean Genome and Epidemiology Study (KoGES)-Kangwha. Among 1208 never-smoking women, we excluded two women taking antidepressants and five women who did not complete the Beck Depression Inventory (BDI). Therefore, we performed a cross-sectional analysis on 1201 women. ETS exposure was assessed using a self-reported questionnaire, and was classified into three groups: no exposure, occasional exposure and regular exposure. Depression was assessed using the BDI score, which ranged from 0 to 63, and the presence of depression was defined as a BDI score ≥10.

Results: Women exposed to ETS were more likely to have depression than those without ETS exposure (p=0.019). When BDI was analysed as a continuous variable, women exposed to ETS had significantly higher BDI scores after full adjustment (overall exposure: β=1.36, p=0.013; occasional exposure: β=1.15, p=0.063; regular exposure: β=1.90, p=0.039). ETS exposure was significantly associated with depression in a dose–response manner even after adjusting for age, body mass index, menopause, socioeconomic status, lifestyle and prevalent chronic diseases. The adjusted OR for depression (95% CI) was 1.72 (1.25 to 2.37) for overall ETS exposure, 1.56 (1.09 to 2.24) for occasional exposure and 2.19 (1.30 to 3.69) for regular exposure, when compared to no exposure.

Conclusions: Exposure to ETS was associated with depression among middle aged and elderly Korean women.

Strengths and limitations of this study

- This study is the first report on the association between ETS and depression in the Korean population.
- This study is an analysis of a group of community-dwelling Korean women, which includes a wide range of ages, and employed as well as unemployed women, unlike previous Asian studies.
- The main limitations are a cross-sectional study design and its use of self-reports.

INTRODUCTION

It has been estimated that there have been more than 20 million premature deaths attributable to direct and indirect tobacco smoke.[1] In the USA, the current annual burden of smoking-attributable mortality is estimated to be about 480 000, with millions more living with smoking-related diseases.[1]

Secondhand smoke, or environmental tobacco smoke (ETS), is a mixture of two forms of smoke: the sidestream smoke that comes from the lighted end of a cigarette and the mainstream smoke that is exhaled by the smoker.[2] It is known that exposure to ETS can increase the risk of cardiovascular disease, respiratory illness and cancer in adults.[1 3 4] In addition, recent studies have reported that ETS can lead to mental health problems, including depression.[5–10] Depression is the most common mental illness, with an estimated 350 million people affected. Symptoms of depression are usual mood fluctuations and short-lived emotional responses to challenges. Especially when long-lasting and with moderate or severe intensity, depression may cause an affected person to suffer greatly and function poorly in daily life. At its worst, it can lead to suicide, which results in an estimated 1 million deaths every year.[11] Many studies have found that active tobacco smoking can increase the risk of depression.[12–15] Recently, exposure to ETS has been associated with depression or depressive symptoms in some studies,[5–10] though not in others.[16 17]

The purpose of the present study was to explore the possible association between ETS and depression in never-smoking Korean women. Increasing evidence supports the hypothesis that exposure to ETS can cause various chronic disorders.[1 3 4] As these

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chronic conditions are closely related to depression,[18–21] ETS exposure can be associated with depression as well. Additionally, in animal studies, nicotine exposure has been reported to induce a negative mood, lower mobility and dopamine imbalance, all of which are known to increase the risk of depression.[22–24] Although a positive association between ETS and depression has been reported among Korean adolescents,[25] such association has not been observed in an adult Korean population. Thus, we hypothesised that ETS exposure would be associated with depression in Korean adults. We limited our analysis to never-smoking women, as the effects of former or current active smoking cannot be properly controlled with statistical adjustment.

Study population

This study is a cross-sectional analysis of baseline data from a community-based prospective cohort known as the Korean Genome and Epidemiology Study (KoGES)-Kangwha, which started in 2006 on Kanghwa Island, South Korea. This analysis enrolled participants who attended baseline health examinations between 2008 and 2011, as the BDI questionnaire has only been available since 2008. Among the initial total of 1980 participants, 1208 women were never-smokers. We excluded two women with depression medication and five women who did not complete the Beck Depression Inventory (BDI). A final total of 1201 women were enrolled in this study. All participants signed written informed consent forms.

Measurements

All participants were individually interviewed using a standardised questionnaire to obtain information about sociodemographic characteristics, health behaviours, chronic diseases and psychosocial stress. Trained interviewers conducted dialogues according to a predefined protocol and double-checked whether responses were appropriate. The income category was divided into two groups: <1 500 000 won or ≥1 500 000 won, based on the median of data. Occupations were initially classified into 13 categories based on the Korea Standard Classification of Occupations, although they were later re-categorised into two groups, employed and unemployed, which included housewives. Exposure to ETS was measured with two questions: "How many days per week are you exposed to tobacco smoke at home and/or your workplace?" and "How many minutes per day are you exposed to tobacco smoke at home and/or your workplace?". Based on the answers to these questions, ETS exposure status was categorised into three groups: no exposure, occasional exposure (≤4 days/week and/or <30 min/day) and regular exposure (>4 days/week and ≥30 min/day), according to a previous study.[26] Alcohol consumption was categorised into two groups, current alcohol drinkers and current non-drinkers. Physical exercise was categorised into two groups based on the frequency of leisure time physical activity. Psychosocial stress was divided into two groups: those who had been feeling stress for the last month and those who had not.

Participants' standing height was measured to the nearest 0.1 cm with an extensometer (DS-102, JENIX, Korea) and body weight was measured to the nearest 0.1 kg with a digital scale (DB-150, CAS, Korea). Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres. Resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured at least twice using an automatic oscilloscopic sphygmomanometer (Carescape Dinamap V100, GE Healthcare). If the first and second measurements differed by ≥10 mm Hg for SBP or DBP, then additional measurements were performed, and the average of the last two measurements was used for the current analysis. Blood samples were collected from the antecubital vein of participants, after at least 8 h of fasting. Collected blood samples were analysed at the central research laboratory for measurements of complete blood count, fasting glucose and insulin, as well as for lipid profiles. Hypertension was defined as elevated blood pressure (SBP ≥140 mm Hg or DBP ≥90 mm Hg) or use of antihypertensive medication. Diabetes mellitus was defined as elevated fasting blood glucose (≥126 mg/dL), elevated glycated haemoglobin (≥6.5%) or treatment for diabetes. Hypercholesterolaemia was defined as elevated total cholesterol (>200 mg/dL) or use of lipid-lowering medication.

Depressive symptoms were assessed using the BDI questionnaire. The BDI consists of 21 questions for emotional, cognitive, motivational, physiological and other symptoms. Each item contains four statements describing the intensities of symptoms of depression. Each item is rated on a scale from 0 to 3, reflecting how participants have felt over the past week.[27–29] Thus, the total BDI scores range from 0 to 63, with higher scores representing greater disability. This index has demonstrated acceptable sensitivity and specificity in distinguishing between participants with and without depression, and is considered a valid and reliable measure of depression.[27 28 30] The presence of depression was defined as a BDI score ≥10, and participants were further classified into three groups according to severity: mild (10–15), moderate (16–23) and severe (24–63).[27 28 30]

Statistical analysis

General and clinical characteristics were described for a total of 1201 women. Exposure to ETS and other variables were compared between women with depression (BDI score ≥10) and those without depression, and then compared again across the four groups of BDI scores: none, mild, moderate and severe depression. Independent associations between ETS and depression were assessed using serial linear and logistic regression models: (1) adjusted for age, BMI, menopause, household income and employment; (2) adjusted for age, BMI, menopause, household income, employment, alcohol intake, regular exercise, hypertension, diabetes

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and hypercholesterolaemia and (3) adjusted for age, BMI, menopause, household income, employment, alcohol intake, regular exercise, hypertension, diabetes, hypercholesterolaemia and psychosocial stress. All statistical analyses were performed using SAS V.9.2 (SAS Inc, Cary, North Carolina, USA). All analyses were two-sided and p values less than 0.05 were regarded as statistically significant.

RESULTS

The characteristics of the study participants are summarised in table 1. The mean age was 58.7 years for all participants, 59.9 years for the group with no ETS exposure and 54.4 years for the group exposed to ETS. Overall, 21.5% (n=258) of non-smoking women were exposed to ETS; within them, 15.8% (n=190) were exposed occasionally and 5.7% (n=68) were exposed regularly. The mean BDI score was 7.9 in total participants, 8.6 in ETS exposure group and 7.7 in no exposure group. However, the difference between the no exposure and exposure groups was not statistically significant (p=0.090). The prevalence of depression was higher in the ETS exposure group (38.4%) than in the no ETS exposure group (30.4%), and this difference was statistically significant (p=0.019).

Table 2 presents the characteristics of the study population according to the presence and severity of depression. Women with depression were more likely to have lower household income (p=0.044), be unemployed or be housewives (p=0.018), report psychosocial stress (p<0.001) and be exposed to ETS (p=0.019) than

Table 1 Characteristics of participants by exposure to ETS

Variables	No ETS (n=943)	ETS (n=258)	p Value
Age, year	59.9±10.1	54.4±8.6	<0.0001
Systolic blood pressure, mm Hg	119.4±18.3	116.5±16.1	0.016
Diastolic blood pressure, mm Hg	69.9±10.0	70.3±10.2	0.647
Fasting glucose, mg/dL (n=1198)	96.5±19.0	94.4±14.0	0.048
HbA1c, % (n=1196)	5.8±0.8	5.7±0.8	0.103
Total cholesterol, mg/dL (n=1198)	199.9±34.7	196.9±31.9	0.204
Body mass index, kg/m^2	24.8±3.3	24.8±3.1	0.813
BDI score	7.7±7.2	8.6±6.8	0.090
Menopausal status			
Premenopause	172 (18.3)	82 (31.8)	<0.0001
Postmenopause	769 (81.7)	176 (68.2)	
Income			
<1 500 000 won	522 (60.5)	109 (45.8)	<0.0001
≥1 500 000 won	341 (39.5)	129 (54.2)	
Employment			
No	373 (39.6)	72 (27.9)	0.001
Yes	570 (60.5)	186 (72.1)	
Alcohol intake			
Former/non-drinkers	767 (81.3)	163 (63.4)	<0.0001
Current drinkers	176 (18.7)	94 (36.6)	
Regular exercise			
No	622 (66.0)	158 (61.2)	0.182
Yes	321 (34.0)	100 (38.8)	
Hypertension			
No	579 (61.4)	186 (72.1)	0.002
Yes	364 (38.6)	72 (27.9)	
Diabetes			
No	797 (84.6)	226 (87.9)	0.216
Yes	145 (15.4)	31 (12.1)	
Hypercholesterolaemia			
No	583 (62.0)	172 (66.9)	0.165
Yes	358 (38.0)	85 (33.1)	
Psychosocial stress			
No	394 (41.8)	97 (37.6)	0.254
Yes	549 (58.2)	161 (62.4)	
Depression			
No	656 (69.6)	159 (61.6)	0.019
Yes	287 (30.4)	99 (38.4)	

Data expressed as mean±SD or number (%).
BDI, Beck Depression Inventory; ETS, environmental tobacco smoke; HbA1c, glycated haemoglobin.

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Table 2 Characteristics by the presence and severity of depression

Variables	Without depression (n=815)	With depression			p Value*	p Trend†
		Overall (n=386)	Mild (n=228)	Moderate to severe (n=158)		
Age, year	58.4±9.9	59.5±10.2	59.4±10.2	59.5±10.3	0.079	0.213
Systolic BP, mm Hg	119.2±18.1	117.9±17.2	120.0±17.5	114.8±16.4	0.248	0.010
Diastolic BP, mm Hg	70.0±10.2	70.1±9.6	71.2±9.7	68.6±9.3	0.800	0.046
Fasting glucose, mg/dL	95.8±18.0	96.5±18.3	96.5±17.6	96.4±19.4	0.561	0.842
HbA1c, %	5.8±0.8	5.8±0.8	5.9±0.9	5.7±0.7	0.657	0.146
Total cholesterol, mg/dL	199.2±34.2	199.4±34.1	198.3±34.5	201.1±33.5	0.909	0.734
Body mass index, kg/m^2	24.9±3.3	24.7±3.1	24.7±3.0	24.6±3.2	0.392	0.649
Menopause						
Premenopause	178 (21.9)	76 (19.7)	45 (19.7)	31 (19.8)	0.444	0.439
Postmenopause	636 (78.1)	309 (80.3)	183 (80.3)	126 (80.3)		
Income						
<1 500 000 won	411 (55.2)	220 (61.8)	126 (60.0)	94 (64.4)	0.044	0.025
≥1 500 000 won	334 (44.8)	136 (38.2)	84 (40.0)	52 (35.6)		
Employment						
No	283 (34.7)	162 (42.0)	95 (41.7)	67 (42.4)	0.018	0.022
Yes	532 (65.3)	224 (58.0)	133 (58.3)	91 (57.6)		
Alcohol intake						
Former/non-drinkers	633 (77.8)	297 (76.9)	174 (76.3)	123 (77.9)	0.807	0.877
Current drinkers	181 (22.2)	89 (23.1)	54 (23.7)	35 (22.2)		
Regular exercise						
No	532 (65.3)	248 (64.3)	143 (62.7)	105 (66.5)	0.777	0.979
Yes	283 (34.7)	138 (35.8)	85 (37.3)	53 (33.5)		
Hypertension						
No	527 (64.7)	238 (61.7)	134 (58.8)	104 (65.8)	0.344	0.705
Yes	288 (35.3)	148 (38.3)	94 (41.2)	54 (34.2)		
Diabetes						
No	695 (85.5)	328 (85.0)	189 (82.9)	139 (88.0)	0.883	0.745
Yes	118 (14.5)	58 (15.0)	39 (17.1)	19 (12.0)		
Hypercholesterolaemia						
No	508 (62.6)	247 (64.0)	145 (63.6)	102 (64.6)	0.679	0.606
Yes	304 (37.4)	139 (36.0)	83 (36.4)	56 (35.4)		
Psychosocial stress						
No	389 (47.7)	102 (26.4)	69 (30.3)	33 (20.9)	<0.001	<0.001
Yes	426 (52.3)	284 (73.6)	159 (69.7)	125 (79.1)		
ETS						
No exposure	656 (80.5)	287 (74.4)	163 (71.5)	124 (78.5)	0.019	0.113
Exposure	159 (19.5)	99 (26.7)	65 (28.5)	34 (21.5)		

Data are expressed as mean±SD or number (%).
*p Value for difference between no depression and overall depression.
†p Trend for linear trend across no, mild and moderate-to-severe depression.
BP, blood pressure; ETS, environmental tobacco smoke; HbA1c, glycated haemoglobin.

those without depression. When depression was further classified according to severity, a higher severity of depression was associated with lower blood pressure, lower income, unemployment, psychosocial stress and ETS exposure.

Table 3 describes the association between ETS and BDI scores as continuous variables in serial regression models. Compared to those without ETS exposure, women exposed to ETS had significantly higher BDI scores when adjusted for age, BMI, menopause, income and employment (β=1.38, p=0.010). This association did not change with further adjustment for alcohol intake, regular exercise, hypertension, diabetes and hypercholesterolaemia (β=1.36, p=0.013). The association was weakened by additional adjustment for psychosocial stress, yet still remained significant (β=1.21, p=0.022). When ETS was divided by the degree of exposure, regular ETS exposure was significantly associated with higher BDI scores (β=1.78, p=0.046), although occasional exposure was not significant (β=0.98, p=0.100). Figure 1 displays the distribution of BDI scores separately for women with no exposure, occasional exposure and regular exposure. Women with regular ETS exposure had higher BDI scores than those with no exposure or occasional exposure.

Table 4 shows the association between ETS and depression using serial logistic models. Compared to

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Table 3 Association between environmental tobacco smoke and BDI score

Variables	N	Model 1 β	Model 1 p Value	Model 2 β	Model 2 p Value	Model 3 β	Model 3 p Value
ETS							
No exposure	943	Ref		Ref		Ref	
Exposure (overall)	258	1.379	0.010	1.361	0.013	1.207	0.022
Occasional exposure	190	1.179	0.053	1.149	0.063	0.983	0.100
Regular exposure	68	1.890	0.038	1.903	0.039	1.779	0.046
Age							
Per 10 years	1201	0.014	0.656	0.017	0.607	0.010	0.749
Body mass index							
Per 1 kg/m^2	1201	−0.002	0.977	0.001	0.983	0.025	0.714
Menopause							
Premenopause	254	Ref		Ref		Ref	
Postmenopause	945	0.325	0.622	0.389	0.560	0.456	0.480
Income							
<1 500 000 won	631	Ref		Ref		Ref	
≥1 500 000 won	470	−0.720	0.176	−0.763	0.157	−0.952	0.068
Employment							
No	445	Ref		Ref		Ref	
Yes	756	−1.105	0.014	−1.023	0.024	−1.216	0.006
Alcohol intake							
No	930			Ref		Ref	
Yes	270			0.151	0.774	0.202	0.692
Regular exercise							
No	780			Ref		Ref	
Yes	421			0.429	0.350	0.299	0.501
Hypertension							
No	765			Ref		Ref	
Yes	436			0.022	0.965	−0.176	0.712
Diabetes							
No	1023			Ref		Ref	
Yes	176			0.151	0.814	0.228	0.711
Hypercholesterolaemia							
No	755			Ref		Ref	
Yes	443			−0.285	0.539	−0.378	0.398
Psychosocial stress							
No	491					Ref	
Yes	710					3.695	<0.001

BDI, Beck Depression Inventory; ETS, environmental tobacco smoke.

those with no exposure, people with ETS exposure had significantly higher odds for depression, with an OR of 1.70 (95% CI 1.25 to 2.33) after adjusting for age, BMI, menopausal status, income and employment. This association did not change when further adjusting for lifestyle factors, comorbidity and psychosocial stress. There was also a dose–response relationship between ETS exposure and depression. In contrast to the no exposure group, occasional and regular exposure groups showed gradually increased ORs for depression after adjusting for age, BMI, menopausal status, income and employment (occasional: 1.55 (95% CI 1.08 to 2.21); regular: 2.16 (95% CI 1.29 to 3.61)). This dose–response association was robust to further adjustment for lifestyle factors, comorbidity and psychosocial stress. We performed further analysis to assess whether psychosocial stress could modify the association between ETS and depression. Although the association was slightly weaker among women who reported psychosocial stress than among those who did not, dose–response association was observed in both groups (data presented in online supplementary table S1).

DISCUSSION

We observed a significant association between ETS exposure and depression among never-smoking Korean women. We also observed that regular ETS exposure might have a higher risk for depression than occasional exposure to ETS. To the best of our knowledge, this is the first report on the association between ETS and depression in a community-dwelling Korean adult population.

A previous study analysing the US National Health and Nutrition Examination Survey found that ETS was positively associated with depressive symptoms after adjusting for age, ethnicity, gender, education, cardiovascular

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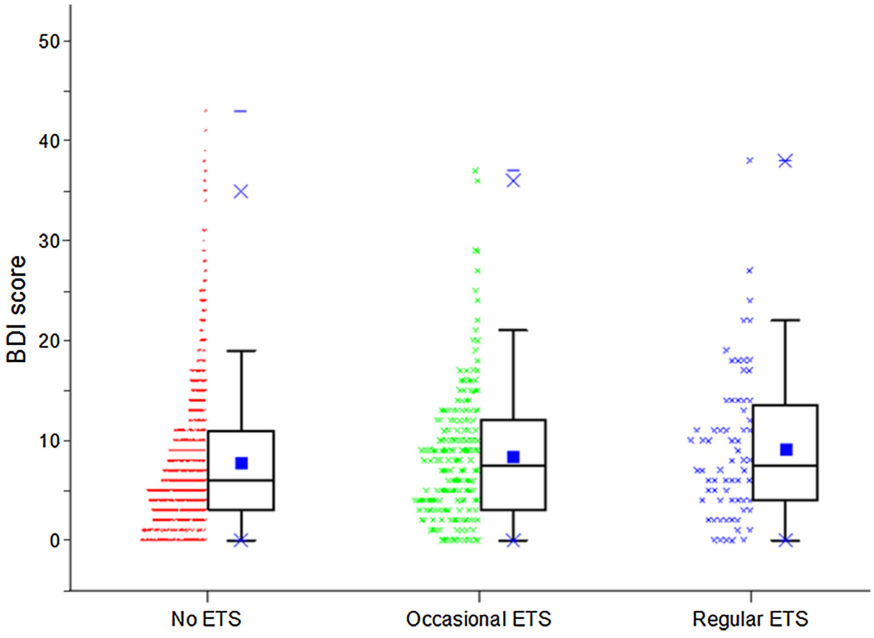


Figure 1 Beck Depression Inventory (BDI) score by the exposure to environmental tobacco smoke (ETS).

disease, respiratory disease, diabetes mellitus, hypertension, thyroid disease and cancer.[8] Another study reported that ETS exposure is associated with psychological distress and risk of future psychiatric illness in a Scottish adult population.[5] A recent study also observed that in utero and childhood exposure to ETS was associated with an increased risk of depression in midlife, even after adjusting for direct and indirect exposure to tobacco smoke in adulthood.[9] In the Midlife Development in the US Survey (MIDUS), persistent exposure to ETS across the course of life was associated with an increased risk of depression and panic attacks.[10] Other studies demonstrated that ETS exposure was strongly associated with hyperactivity, conduct disorder and depression, in children and adolescents.[6 25] On the contrary, ETS was not associated with depression or mental health in the UK Health and Lifestyle Survey (HALS),[17] the Netherlands Study of Depression and Anxiety (NESDA), and the Netherlands Twin Register (NTR).[16]

There are several possible explanations for the association of ETS exposure with depression among non-smoking women. First, the secondhand smoke itself can be stressful for non-smokers. Regular exposure to ETS at home and the workplace is a chronic stressor for non-smoking women, and the chronic stress may lead to the development of depressive symptoms.[31] In addition, women exposed to ETS at home might also be exposed to other risk factors of depression as well. Smoking partners are likely to have other adverse health-related behaviours and poor socioeconomic characteristics. Thus, women who have a smoking partner might be more exposed to other risk factors of depression than women who have a non-smoking partner. To indirectly assess the effects of smoking partners on depression, we performed our analysis separately for ETS exposure at home and at the workplace. However, depression was associated with both ETS at home, and ETS at the workplace, and the association was stronger for ETS at the workplace (data are presented in online supplementary table S2). Thus, the partner characteristics were unlikely to be major contributors of the ETS-related depression in our study. Another possible mechanism is the dopamine system, which is known to be related to the risk of depression.[22] Several animal studies support the hypothesis that ETS has an acute and long-term effect on the dopamine system. Another study found that ETS greatly elevated dopamine D1 and D2 receptors in the brains of rats.[32] Furthermore, other studies have provided evidence indicating that exposure to ETS impacts γ-aminobutyric acid b2 receptors (GABAB2), dopamine transporter messenger RNA expression and dopamine receptors.[33] Additionally, an animal study found that nicotine and tobacco particulate matter has an influence on long-term imbalances of dopamine transports.[24] Most importantly, one animal study observed that nicotine exposure induced a negative mood and decreased mobility in rats.[23] Another biological mechanism that may link ETS exposure to depression is chronic inflammation.[4 34 35] Several studies have proposed that the activation of inflammatory cytokines plays a role in the development of depression.[36–40] Cytokines are related to microglia, which may be over-activated in major depression.[40] Additionally, cytokines induce enzyme indoleamine 2,3-dioxygenase (IDO), which limits tryptophan and serotonin transporter and can thus cause depression.[39]

The present study has several limitations. First, as a cross-sectional study in which all information was gathered at the same point in time, we cannot establish a temporal relationship between ETS exposure and depression. Second, we measured the degree of ETS and depressive symptoms using an interviewer-assisted questionnaire. The misclassification bias in measuring ETS exposure, if any, is likely to be a non-differential reduction of the association. The BDI has shown high

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Table 4 Association between environmental tobacco smoke (ETS) and depression

Variables	N	OR (95% CI) for depression Model 1	Model 2	Model 3
ETS				
No exposure	943	1.000	1.000	1.000
Exposure (overall)	258	1.704 (1.246 to 2.331)	1.723 (1.254 to 2.366)	1.700 (1.226 to 2.356)
Occasional exposure	190	1.548 (1.083 to 2.213)	1.562 (1.088 to 2.242)	1.526 (1.052 to 2.214)
Regular exposure	68	2.158 (1.288 to 3.614)	2.191 (1.302 to 3.688)	2.212 (1.295 to 3.778)
Age				
Per 10 years	1201	1.011 (0.993 to 1.030)	1.010 (0.991 to 1.030)	1.009 (0.989 to 1.029)
Body mass index				
Per 1 kg/m^2	1201	0.988 (0.950 to 1.028)	0.984 (0.944 to 1.026)	0.991 (0.949 to 1.034)
Menopause				
Premenopause	254	1.000	1.000	1.000
Postmenopause	945	0.963 (0.644 to 1.440)	0.976 (0.650 to 1.466)	0.992 (0.654 to 1.505)
Income				
<1 500 000 won	631	1.000	1.000	1.000
≥1 500 000 won	470	0.807 (0.586 to 1.112)	0.809 (0.585 to 1.119)	0.754 (0.541 to 1.052)
Employment				
No	445	1.000	1.000	1.000
Yes	756	0.697 (0.535 to 0.909)	0.713 (0.546 to 0.932)	0.661 (0.502 to 0.872)
Alcohol intake				
No	930		1.000	1.000
Yes	270		1.024 (0.747 to 1.404)	1.039 (0.752 to 1.437)
Regular exercise				
No	780		1.000	1.000
Yes	421		1.076 (0.818 to 1.415)	1.038 (0.784 to 1.375)
Hypertension				
No	765		1.000	1.000
Yes	436		1.142 (0.852 to 1.531)	1.086 (0.803 to 1.468)
Diabetes				
No	1023		1.000	1.000
Yes	176		1.087 (0.745 to 1.585)	1.110 (0.753 to 1.635)
Hypercholesterolaemia				
No	755		1.000	1.000
Yes	443		0.924 (0.700 to 1.220)	0.895 (0.673 to 1.189)
Psychosocial stress				
No	491			1.000
Yes	710			2.797 (2.117 to 3.694)

internal consistency (α=0.88) and test–retest reliability (r=0.60, p<0.001) in previous reports.[27] Thus, our findings are unlikely to be severely distorted by measurement error. Third, objective measurement of participants' psychosocial stress was unavailable in this study. Psychosocial stress was measured only by asking the participants whether they had been stressed during the last month. Thus, we could not properly investigate whether any psychosocial stress confounded or modified the association between ETS and depression. Lastly, our study population was limited to women from a single rural area; therefore, our findings may not be generalisable to other regions or the male population.

The strength of this study was the analysis of a community-based adult population. Previous studies in the Asian population were conducted at school or occupational settings, thus the target populations were adolescents and working adults.[25 41 42] Although our study population was limited to one rural population, there was a wide range of ages, and employed and unemployed women were both included. Cigarette smoking and depression are among the most serious health problems in the Korean population. According to our calculation, 20.7% of depression cases in the current study population were attributed to ETS exposure. This finding implies that a considerable portion of depression cases can be prevented by reducing exposure to ETS, particularly in underlying populations with a high smoking rate.

CONCLUSIONS

Exposure to ETS was associated with depression in a dose–response manner among community-dwelling Korean women. Further studies are needed to confirm the causal effects of ETS on the development and aggravation of depression, and to identify the underlying biological mechanisms.

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Contributors NHK contributed to the study concept and design, performed statistical analyses, and drafted and revised the manuscript. HCK contributed to the conception and design, and analysis and interpretation of the data, and revised the article. JYL and J-ML managed KoGES data and supported analysis. IS supervised data analysis and revised the manuscript. All the authors contributed in revising the article critically for important intellectual content, and gave final approval of the version to be published. HCK is responsible for the overall content as the guarantor.

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Competing interests None declared.

Patient consent Obtained.

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