Article

Association of Education and Smoking Status on Risk of Diabetes Mellitus: A Population-Based Nationwide Cross-Sectional Study

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Abstract: *Background:* Smoking, including environmental tobacco smoke (ETS) exposure is a well-known risk factor for diabetes. Low socioeconomic status, especially lack of education, also is a risk factor for diabetes. Therefore, we assessed the association of education and smoking status, including ETS exposure, with the prevalence of diabetes. *Methods:* Data were from the 2007–2013 Korea National Health and Nutritional Evaluation Survey (KNHANES). Multivariable logistic regression examined associations between various lifestyle and health factors and prevalence of diabetes while controlling for potential confounding variables. Subgroup analysis was performed according to smoking status to determine factors associated with diabetes. *Results:* Of 19,303 individuals analyzed, 1,325 (11.4%) had diabetes. Greater average age, male sex, lower educational level, unemployment, and coexisting health problems were significantly associated with diabetes. Individuals with only elementary, middle, or high school level education had significantly greater odds ratios (p<0.05) compared to college graduates; smokers and nonsmokers exposed to ETS had significantly greater OR (p<0.05) than nonsmokers unexposed to ETS. Subgroup analysis of diabetics according to smoking status revealed significant associations (p<0.05) for diabetic nonsmokers exposed to ETS with female sex, single status, elementary level education, urban residence, National Health Insurance (NHI), hypertension, no alcohol intake, and no moderate physical activity. For diabetic smokers, there were significant associations (p<0.05) with elementary education, urban residence, lack of moderate physical activity, no alcohol intake, and NHI. *Conclusions:* The results suggested that smoking status, including ETS exposure, was associated with a higher prevalence of diabetes especially in populations with less education. Thus, we should direct efforts for controlling diabetes toward individuals with lower levels of education, and those who are smokers and nonsmokers exposed to ETS.

Keywords: diabetes; education; environmental tobacco smoke; smoker

1. Introduction

Smoking is the most commonly known risk factor for diabetes [1]. In 2010, the world prevalence of diabetes among adults (age 20–79 years) was 6.4%, affecting 285 million adults; it is predicted to increase to 7.7%, and 439 million adults by 2030. Between 2010 and 2030, there will be a 69% increase in the number of adults with diabetes in developing countries and a 20% increase in developed countries [2].

Evidence has shown that there is no safe level of exposure to environmental tobacco smoke (ETS) and that exposure leads to serious and often fatal diseases, including cardiovascular and respiratory diseases as well as lung and other cancers. Children and newborns may also suffer

severe harm as a result of ETS exposure [3]. The World Health Organization has estimated that tobacco kills nearly 6 million people each year with 10% of deaths due to ETS exposure [4,5].

There has been interest in the health effects of ETS, which contains >4,000 chemical compounds that partly overlap with compounds inhaled in active smoke [6]. A recent study reported that 40% of children, 33% of male nonsmokers, and 35% of female nonsmokers globally have been exposed to ETS [7]. The association between ETS exposure and a significantly increased risk for diabetes was shown in a recent meta-analysis [8].

While there have been some studies that showed an association between smoking (including ETS) and diabetes, only a few studies have also considered socioeconomic status. Variables related to socioeconomic status have been associated with mortality in diabetic populations and are useful for identifying risk factors for diabetes [9]. In particular, education level should be considered when managing diabetic patients [10] because education level appears to be an important determinant for diabetes.

The identification of risk factors and prevention strategies for diabetes are critical concerns for public health. In addition to smoking, it is important to analyze the relationship between diabetes and ETS exposure. Therefore, we conducted a nationwide cross-sectional study to assess the association between the prevalence of diabetes, educational level, and smoking status including ETS exposure.

2. Materials and Methods

2.1. Data Source and Study Population

For this study we used data from the 2007–2013 Korea National Health and Nutritional Evaluation Survey (KNHANES). KNHANES are cross-sectional surveys that have been conducted annually since 1998 by the Korea Centers for Disease Control and Prevention (KCDC) to assess the health and nutritional status of the Korean population. A stratified multistage cluster-sampling design was used to obtain a nationally representative sample. This survey was composed of three parts: Health Interview Survey, Health Examination, and Nutrition Survey. The overall response rates were 78.4% in 2007–2009, 80.8% in 2010–2012, and 79.3% in 2013. A total of 58,422 individuals (24,781 in 2007–2009; 25,533 in 2010–2012; 8,018 in 2013) completed the survey. Individuals who were under 20 years of age were excluded from our analysis. We finally included 19,303 eligible participants in this study. This study was approved by the Institutional Review Board (IRB) from the KCDC and all participants provided written informed consent (2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C, 2013-07CON-03-4C).

2.2. Dependent Variable

The dependent variable in this study was the prevalence of diabetes as defined by US National Institutes of Health (NIH) and Korean Diabetes Association (KDA) criteria. Patients answered survey questions about taking anti-diabetic drugs, starting insulin therapy, or being diagnosed with diabetes [11]. Diabetes was verified by fasting plasma glucose (FPG) ≥ 126 mg/dL.

2.3. Independent Variable

Smoking status was categorized into nonsmoker unexposed to ETS, nonsmoker exposed to ETS, and current smoker. Respondents answered the following questions: “Were you exposed to ETS in indoor workplaces over the past 7 days?”, “Are there any current smokers other than yourself at home? If so, were you exposed to ETS in the home over the past 7 days?”, “Were you exposed to ETS in any indoor public place, except for smoking areas, over the past 7 days?” Public places included the school, library, public transit, concert hall, and hotels, etc.

Predisposing factors evaluated included age, sex, marital status (married, single, not applicable), educational level (elementary school, middle school, high school, college), job status (employed, unemployed), and residential location (urban, rural). Enabling factors evaluated included household income status (quartile range) and health insurance type (National Health

Insurance (NHI) or Medical Aid). Health factors included hypertension, dyslipidemia, monthly alcohol intake, moderate physical activity level, and smoking status. Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mmHg, diastolic blood pressure (DBP) ≥ 90 mmHg, or use of anti-hypertension drugs. Dyslipidemia was defined as fasting total cholesterol ≥ 240 mg/dL or use of cholesterol drugs. Monthly alcohol intake was classified into two categories, which were no intake/ intake on less than one occasion per month, or intake on more than one occasion per month over the past year. Moderate physical activity was defined as physical activity for 30 minutes per session more than five times per week.

2.4. Statistical Analyses

We used a multistage, stratified complex survey design. Sampling variability and selection bias were minimized by weighting; specifically, coverage error according to the number of households and individuals, non-response error, and sampling time frame were adjusted. Characteristics of the study population according to the prevalence of diabetes were compared using chi-squared tests, and $p<0.005$ was considered statistically significant. Multivariable logistic regression analysis was used to calculate the odds ratio (OR) with 95% confidence intervals (CI) to evaluate the association between the prevalence of diabetes and socioeconomic status variables. In the fully adjusted model, all variables were entered simultaneously. An additional subgroup analysis was carried out for diabetics according to smoking status (ETS-unexposed nonsmoker, ETS-exposed nonsmoker, and smoker) to evaluate predisposing, enabling, and health-related factors. All statistical analyses were performed using the survey procedure in SAS version 9.4 (SAS Institute Inc., Cary, NC).

3. Results

Data from 19,303 individuals in the KNHANES 2007–2013 were analyzed in this study, which included 17,040 (88.3%) normal individuals and 2,263 (11.7%) individuals with diabetes. Table 1 shows the characteristics of the normal and diabetic groups and their associations with other covariates. The number of diabetic males (1,291/9,664, 11.6%) was greater than females (972/9,639, 9.1%). There were statistically significant correlations between individuals with diabetes and lower educational levels ($p<0.0001$): elementary school 19.1% (795/4,179), middle school 15.2% (434/2,702), high school 9.5% (547/5,138), and college 6.2% (487/7,284). Regarding smoking status, diabetes patients were as follows: nonsmoker ETS-unexposed 9.5% (644/5,991), nonsmoker ETS-exposed 8.7% (294/3,228), smoker 11.4% (1,325/10,084). The results of associations between diabetes and covariates showed that most covariates had statistically significant correlations with variables of interest, except for moderate physical activity.

Table 2 shows the results of multivariate logistic regression on the prevalence of diabetes. Among predisposing factors, greater age, male sex, lower educational status, and unemployment were significantly associated with diabetes; marital status and residential location showed no significant association. Educational status showed a significant association with diabetes; furthermore, the OR increased with less education. The ORs were 1.41 (95% CI: 1.13–1.77, $p<0.0029$) for elementary school or less, 1.33 (95% CI: 1.08–1.65, $p<0.0086$) for middle school, and 1.30 (95% CI: 1.09–1.54, $p<0.0035$) for high school. The household income status and health insurance type were not significantly associated with diabetes in this study. Among health factors, individuals with hypertension and dyslipidemia had a higher prevalence of diabetes than individuals without those comorbidities (OR: 2.00, 95% CI: 1.77–2.27, $p<0.0001$; OR: 2.29, 95% CI: 2.03–2.58, $p<0.0001$). According to smoking status, compared to nonsmokers unexposed to ETS, the OR was 1.29 (95% CI: 1.07–1.56, $p<0.0073$) for nonsmokers exposed to ETS and 1.22 (95% CI: 1.02–1.46, $p<0.0333$) for smokers.

We also performed subgroup analysis to determine variables affecting the relationship between smoking (including ETS exposure) and diabetes (Table 3). Each covariate was evaluated as a subgroup. Subgroup analysis was adjusted to age and other covariates using multivariate logistic regression. Table 3 shows the results of subgroup analysis of predisposing factors in diabetic individuals according to smoking status. Among educational levels, the proportion of individuals

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with no more than an elementary school education was statistically significant in nonsmokers exposed to ETS and smokers (OR: 1.40, 95% CI: 1.07–1.84, p<0.0148; OR: 1.45, 95% CI: 1.09–1.93, p<0.0099, respectively). College graduates had a significantly higher OR 1.72 (95% CI: 0.97–3.04, p=0.0620) than ETS non-exposed nonsmokers OR 1.76 (95% CI: 1.07–2.90, p=0.0264). Our study reported significant associations between diabetes and urban residence, health insurance type, alcohol intake, or lack of moderate physical activity, but we could not find any trend.

Table 1. Characteristics of the study population with diabetes in the development dataset; comparison of factors between diabetics and normal individuals.

Classification	Normal		Diabetes		Total		*p*
Predisposing factors							
Age (n, mean age±SE)	17,040	49.1±0.2	2,263	59.4±0.3	19,303	50.2±0.2	<.0001
Sex							<.0001
Women	8,667	90.9	972	9.1	9,639	49.9	
Men	8,373	88.4	1,291	11.6	9,664	50.1	
Marital status							<.0001
Married	14,127	90.1	1,741	9.9	15,868	82.2	
Single	2,092	82.7	482	17.3	2,574	13.3	
not applicable	821	95.4	40	4.6	861	4.5	
Educational level							<.0001
Elementary school	3,384	80.9	795	19.1	4,179	21.7	
Middle school	2,268	84.8	434	15.2	2,702	14.0	
High school	4,591	90.5	547	9.5	5,138	26.6	
College	6,797	93.8	487	6.2	7,284	37.7	
Job status							<.0001
Employed	10,462	91.5	1,048	8.5	11,510	59.6	
Unemployed	6,578	85.8	1,215	14.2	7,793	40.4	
Residential location							0.0039
Urban	13,116	90.0	1,680	10.0	14,796	76.7	
Rural	3,924	88.0	583	12.0	4,507	23.4	
Enabling factors							
Household income status							<.0001
1 (Lowest)	3,294	81.6	786	18.4	4,080	21.1	
2	4,380	89.5	591	10.5	4,971	25.8	
3	4,656	91.7	464	8.3	5,120	26.5	
4 (Highest)	4,710	92.3	422	7.7	5,132	26.6	
Health insurance type							<.0001
NHI	16,577	89.8	2,124	10.2	18,701	96.9	
Medical Aid	463	80.4	139	19.6	602	3.1	
Health factors							
Hypertension							<.0001
No	11,937	93.5	899	6.5	12,836	66.5	
Yes	5,103	80.1	1,364	19.9	6,467	33.5	
Dyslipidemia							<.0001
No	9,554	94.2	702	5.8	10,256	53.1	
Yes	7,483	84.1	1,561	15.9	9,047	46.9	
Monthly alcohol intake							<.0001
No	7,692	87.8	1,218	12.2	8,910	46.2	
Yes	9,348	90.8	1,045	9.2	10,393	53.8	
Moderate Physical Activity							0.3847
No	15,494	89.6	2,045	10.4	17,539	90.9	

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Yes	1,546	89.3	218	10.7	1,764	9.1	
Smoking status							<.0001
ETS-unexposed nonsmoker	5,347	90.5	644	9.5	5,991	31.0	
ETS-exposed nonsmoker	2,934	91.3	294	8.7	3,228	16.7	
Current smoker	8,759	88.6	1,325	11.4	10,084	52.2	

All variables were adjusted by weighting; ETS, environmental tobacco smoke; NHI, National Health Insurance; SE, standard error

Table 2. Multivariate logistic regression analysis of the association of diabetes with predisposing, enabling, and health-related factors.

Classification	OR	95% CI	*p*
Predisposing factors			
Age (n, mean age±SE)	1.03	1.03–1.04	<.0001
Sex			
Women	1.00		
Men	1.53	1.27–1.84	<.0001
Marital status			
Married	1.00		
Single	1.08	0.92–1.26	0.3725
not applicable	0.83	0.56–1.21	0.3273
Educational level			
Elementary school	1.41	1.13–1.77	0.0029
Middle school	1.33	1.08–1.65	0.0086
High school	1.30	1.09–1.54	0.0035
College	1.00		
Job status			
Employed	1.00		
Unemployed	1.25	1.09–1.43	0.0016
Residential location			
Urban	1.00		
Rural	1.07	0.92–1.25	0.3581
Enabling factors			
Household income status			
1 (Lowest)	1.15	0.96–1.38	0.1426
2	1.09	0.92–1.29	0.3061
3	1.05	0.88–1.25	0.6220
4 (Highest)	1.00		
Health insurance type			
NHI	1.00		
Medical Aid	1.29	0.97–1.72	0.0776
Health factors			
Hypertension			
No	1.00		
Yes	2.00	1.77–2.27	<.0001
Dyslipidemia			
No	1.00		
Yes	2.29	2.03–2.58	<.0001
Monthly alcohol intake			
No	1.00		
Yes	0.90	0.80–1.01	0.0776
Moderate Physical Activity			
No	1.00		

Yes	1.12	0.92–1.36	0.2727
Smoking status			
ETS-unexposed nonsmoker	1.00		
ETS-exposed nonsmoker	1.29	1.07–1.56	0.0073
Current smoker	1.22	1.02–1.46	0.0333

All variables were adjusted by weighting; NHI, National Health Insurance.

Table 3. Multivariable logistic regression subgroup analysis of predisposing factors in diabetic individuals according to smoking status

Classification	ETS-unexposed nonsmoker	ETS-exposed nonsmoker			Current smoker		
	OR	OR	95% CI	*P*	OR	95% CI	*p*
Predisposing factors							
Sex							
Women	1.00	1.37	1.10–1.70	0.0046	1.18	0.92, 1.50	0.1924
Men	1.00	1.21	0.75, 1.97	0.4350	1.26	0.89, 1.80	0.1988
Marital status							
Married	1.00	1.23	0.99, 1.54	0.0628	1.27	1.02, 1.57	0.0342
Single	1.00	1.64	1.13, 2.38	0.0090	1.24	0.88, 1.74	0.2162
not applicable	1.00	0.41	0.07, 2.46	0.3287	0.35	0.10, 1.30	0.1185
Educational level							
Elementary school	1.00	1.40	1.07, 1.84	0.0148	1.45	1.09, 1.93	0.0099
Middle school	1.00	0.83	0.53, 1.29	0.4001	0.72	0.45, 1.14	0.1600
High school	1.00	1.24	0.82, 1.90	0.3124	1.23	0.84, 1.80	0.2963
College	1.00	1.72	0.97, 3.04	0.0620	1.76	1.07, 2.90	0.0264
Job status							
Employed	1.00	1.04	0.77, 1.41	0.7946	1.27	0.93, 1.72	0.1282
Unemployed	1.00	1.73	1.33, 2.24	<.0001	1.10	0.86, 1.41	0.4607
Residential location							
Urban	1.00	1.39	1.12, 1.71	0.0025	1.28	1.04, 1.57	0.0186
Rural	1.00	0.99	0.65, 1.49	0.9428	1.05	0.73, 1.50	0.7958
Enabling factors							
Household income status							
1 (Lowest)	1.00	1.12	0.78, 1.61	0.5469	1.24	0.91, 1.70	0.1788
2	1.00	1.23	0.85, 1.78	0.2769	1.19	0.84, 1.68	0.3227
3	1.00	1.46	0.95, 2.24	0.0837	1.48	1.01, 2.19	0.0465
4 (Highest)	1.00	1.28	0.81, 2.01	0.2869	1.28	0.81, 2.01	0.9448
Health insurance type							
NHI	1.00	1.29	1.06, 1.57	0.0106	1.26	1.04, 1.52	0.0177
Medical Aid	1.00	1.26	0.53, 2.96	0.5999	0.86	0.45, 1.68	0.6671
Health factors							
Hypertension							
No	1.00	1.31	0.97, 1.77	0.0840	1.46	1.12, 1.90	0.0050
Yes	1.00	1.30	1.01, 1.67	0.0417	1.06	0.82, 1.36	0.6656
Dyslipidemia							
No	1.00	1.44	1.04, 2.00	0.0274	1.33	0.96, 1.83	0.0874
Yes	1.00	1.22	0.97, 1.55	0.0967	1.18	0.95, 1.47	0.1421
Monthly alcohol intake							
No	1.00	1.38	1.10, 1.73	0.0052	1.52	1.20, 1.93	0.0006
Yes	1.00	1.14	0.80, 1.62	0.4766	0.94	0.69, 1.28	0.7076
Moderate Physical Activity							

No	1.00	1.29	1.06, 1.58	0.0114	1.27	1.05, 1.53	0.0147
Yes	1.00	1.25	0.62, 2.51	0.5322	0.75	0.40, 1.41	0.3781

All variables were adjusted by weighting. All subgroup analyses were adjusted according to age and other subgroup variables; NHI, National Health Insurance

4. Discussion

The proportion of individuals with diabetes continues to grow in South Korea as well as other countries. Smoking is a well-known to risk factor for diabetes. While smoking is known to be harmful to our health, ETS also has harmful effects and leads to chronic diseases including diabetes, cardiovascular, respiratory disease, and cancer. Thus, it is necessary to identify the effect of risk factors for diabetes according to smoking status, including ETS. Our results suggested a positive relationship between smoking including ETS and diabetes according to educational level. Nonsmokers exposed ETS can be at increased risk for diabetes.

Factors that were significantly associated with the prevalence of diabetes were those associated with health vulnerabilities, including greater age, female sex, lower educational level, unemployment, and hypertension or dyslipidemia. With ETS-unexposed nonsmokers as the reference group, nonsmokers exposed to ETS were significantly associated with diabetes. As expected, current smokers were significantly associated with diabetes.

There are reports of a strong association in active smokers and nonsmokers with ETS exposure and subsequent development of impaired fasting glucose or diabetes. Both smokers and nonsmokers exposed to ETS were associated with an increased risk of diabetes [12,13]. Exposure to ETS and active smoking were positively and independently associated with the risk of diabetes [14]. In another cohort study, exposure to ETS was associated with an increased risk for diabetes after adjusting for confounders [15]. This relationship was strengthened by older age and physical inactivity [6].

Even for nonsmokers exposed to ETS, our results showed a significant association between smoking status and diabetes. Thus, we confirmed the association between diabetes and smoking status through covariates that were used for subgroup analysis. In our results, lower educational level was related to an increased prevalence of diabetes. As a result of subgroup analysis of diabetics, there was an increasing significant association between smoking status and educational level from college to elementary school levels. This finding held for nonsmokers exposed to ETS as well.

Among nonsmoker women, ETS is prevalent and remains a public health problem [16]. We noted that women with lower levels of education had a higher probability of exposure to ETS [17].

It has been suggested that ETS poses serious health risks to diabetics and additional public health measures are required to reduce overall exposure [18]. It is more important that the government protect nonsmokers from ETS exposure [19].

This study had several strengths compared to previous research. First, we used nationally representative data, so our study results are generalizable to South Korea citizens. Such data are especially helpful in establishing evidence-based health policies. To our knowledge, this is the first attempt to study the relationship between smoking status that includes ETS and diabetes in terms of socioeconomic status. Therefore, our findings should be helpful in identifying ways to address these critical issues.

Our study also had some limitations. First, because the study focused on the cross-sectional nature of the KNHANES, there may have been weaknesses in fully explaining the causal relationship between smoking-related ETS and diabetes. However, because the study indicated a correlation between smoking including ETS and diabetes, smoking-related factors could be considered as motivations for not smoking in high-risk group of participants. Second, there was a drawback associated with using the smoking variables surveyed. Surely, we could have used urinary cotinine test results, but that test was not consistently employed in 2005, and 2007~2012 years. In addition, because we needed environmental tobacco smoking variables to separate

ETS-exposed nonsmokers from ETS-unexposed nonsmokers, we had to use the available smoking and ETS variables.

Nonetheless, our results found that both EST-exposed nonsmokers and smokers were significantly associated with the prevalence of diabetes in the low education level population. Thus, it is necessary to construct health policy and preventative efforts for managing the prevalence of diabetes in these populations.

5. Conclusions

Our analysis showed that the prevalence of diabetes was significantly higher in nonsmokers with ETS exposure and current smokers compared to nonsmokers without ETS exposure, especially in populations with the least education. Thus, we suggest a political approach toward addressing diabetes that considers educational level. Furthermore, we need to expand the scope of the study to examine the effects of ETS exposure in nonsmokers.

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Conflicts of Interest: The authors declare no conflict of interest.

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