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Effect of Socio-Economic Status on the Prevalence of Diabetes

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Purpose: As Korean society has become industrialized and westernized, the prevalence of diabetes has increased rapidly. Environmental factors, especially socioeconomic status (SES), may account for the increased prevalence of diabetes. We evaluated the associations between the prevalence of diabetes and SES as reflected by household income and education level. **Materials and Methods:** This study was based on data obtained from the fifth Korea National Health and Nutrition Examination Survey, conducted in 2010–2012. Diabetes referred to a fasting plasma glucose ≥126 mg/dL in the absence of known diabetes, previous diagnosis of diabetes made by a physician, and/or current use of oral hypoglycemic agents or insulin. **Results:** Household income and education level were inversely associated with the prevalence of diabetes among individuals aged 30 years or older. These associations were more prominent in females aged 30–64 years. According to household income, the odds ratio (OR) [95% confidence interval (CI)] for the lowest quartile group versus the highest quartile group was 4.96 (2.87–8.58). According to education level, the OR (95% CI) for the lowest quartile group versus the highest quartile group was 8.02 (4.47–14.4). **Conclusion:** Public policies for the prevention and management of diabetes should be targeted toward people of lower SES, especially middle-aged females.

Key Words: Prevalence, diabetes mellitus, social class, nutritional surveys, Republic of Korea, epidemiology

INTRODUCTION

Diabetes mellitus is a metabolic disorder characterized by chronic hyperglycemia, resulting from defects in insulin secretion, insulin action, or both.[1] Diabetes causes secondary pathophysiological changes, damage, and failure in multiple organ systems, for example retinopathy with potential blindness, nephropathy with potential end-stage renal disease, neuropathy, cardiovascular diseases, and/or peripheral vascular disease.[2,3] According to Statistics Korea, diabetes is the fifth leading cause of death in South Korea.[3,4] As Korean society has become more industrialized and westernized, the prevalence of diabetes has increased rapidly.[5] Diabetes not only burdens the individual with diabetes but also economic and social aspects of society:[6] diabetes is a chronic disease that necessitates continuous self-management and medical care.

Environmental factors, as well as genetic factors, are known to influence the development of diabetes. Specific factors linked to the development of diabetes include a family history of diabetes, race, age, obesity, physical activities, and diet. Meanwhile, socio-economic status (SES) has also been shown to account for increases in the prevalence of diabetes.[1,6] A study conducted in the USA followed 23992 individuals from February 1993 to March 2007 and revealed that both a higher education level and income are associated with a lower incidence of diabetes.[7] Data from the Canadian Community Health Survey cycle 3.1 also suggested that higher income is associated with a decreased prevalence of type 2 diabetes.[8]

Herein, we evaluated the associations between prevalence of diabetes and SES, as reflected by household income and education level, among Korean adults using data from the fifth Korea National Health and Nutrition Examination Survey (KNHANES V), conducted in 2010–2012.

MATERIALS AND METHODS

Data sources and sample

To examine the general health and nutrition status of Koreans, the Ministry of Health and Welfare of Korea has conducted the KNHANES since 1998. KNHANES V was conducted in 2010–2012 as a nationwide representative health and nutrition evaluation consisting of several surveys: a health interview survey, a health examination survey, and a nutrition survey. In KNHANES V, the sample was recruited from 2009 resident registration population and from 2008 apartment complex price data using rolling survey sampling with stratified multistage cluster probability sampling.[9-11]

This study was based on data obtained from KNHANES V. In 2010, the sample consisted of 3840 households and 10938 individuals over 1 year of age; the participant sample consisted of 8958 individuals (response rate 81.9%). In 2011, the sample consisted of 3840 households and 10589 individuals over 1 year of age; the participant sample consisted of 8518 individuals (response rate 80.4%). In 2012, the sample consisted of 3840 households and 10069 individuals over 1 year of age; the participant sample consisted of 8057 individuals (response rate 81.0%).[9-11]

In this study, after we excluded individuals younger than 30 years of age and those with missing data, the analytic sample according to household income consisted of 14004 individuals representing 30,071,559 individuals, while the analytic sample according to education level consisted of 14123 individuals representing 30,361,360 individuals.

Diabetes and socioeconomic status

Diabetes was defined as a fasting plasma glucose (FPG) level ≥126 mg/dL in the absence of known diabetes, previous diagnosis of diabetes made by a physician, and/or current use of oral hypoglycemic agents or insulin.

In the health interview survey, equalized average monthly household income was defined as the average monthly household income divided by the square root of the number of household members, and was quadrisected according to age and sex. SES was classified by household income and education level. SES was quadrisected according to household income: Q1 (lowest quartile), Q2 (second lowest quartile), Q3 (second highest quartile), and Q4 (highest quartile). SES was quadrisected according to education level: E1 (less than 7 years of education), E2 (7–9 years of education), E3 (10–12 years of education), and E4 (more than 12 years of education).

Covariates

Body mass index (BMI) was calculated as the ratio of weight (kg) to height squared (m^2). FPG, total cholesterol, triglycerides, low-density lipoprotein cholesterol, and high-density lipoprotein cholesterol levels were measured using a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan).

In the health interview survey, participants recalled what they had eaten the day before, and daily energy and carbohydrate intakes were calculated based on this information. Current smokers were defined as individuals who smoke currently; frequent drinkers were defined as individuals who drink more than twice per week. Physical activity referred to individuals who work out moderately or strenuously more than twice per week. Residence was divided into urban (individuals who live in a Dong) and rural (individuals who live in an Eup/Myeon). Depression referred to individuals who have depression; stressed referred to individuals with high or very high levels of stress.

Statistical analysis

The data were analyzed using a complex-samples procedure. The stratification variables and sampling weights designated by KNHANES were used. A general linear model was used for continuous variables. Continuous variables are presented as means±standard error, nominal variables as percentages, and categorical variables as frequencies (%). Odds ratios (ORs) for the prevalence of diabetes were calculated using multivariate logistic regression analysis across household income and education level quartiles. Covariates known to influence diabetes risk, including age, sex, family history of diabetes, BMI, smoking status, alcohol intake, physical activity, residence, daily energy intake, daily carbohydrate intake, stress and depression, were adjusted to assess the independent associations between SES and diabetes.[12-15] The results are presented as ORs with 95% confidence intervals (95% CIs). All data were analyzed using SPSS statistical software (version 19.0, SPSS Inc., Chicago, IL, USA). A p-value of <0.05 represented statistical significance.

RESULTS

Table 1 lists the characteristics of the 14004 individuals according to household income: for the lowest quartile thereof (Q1), the mean age was 62.2 years, 41.2% were male, and the prevalence of diabetes was 14.7%. Table 2 shows the characteristics of 14123 individuals according to education level: for the lowest quartile thereof (E1), the mean age was 65.3 years, 31.7% were male, and the prevalence of diabetes was 15.4%. The number of participants with a family history of diabetes, daily energy intake, daily carbohydrate intake, physical activity, and residence in an urban area were higher in the high SES group, whereas mean age, systolic blood pressure, waist circumference, and depression rate were higher in the low SES group.

Table 3 shows the association between the prevalence of diabetes and household income. Without adjustment, the OR (95% CI) for Q1 vs. Q4 was 2.87 (2.35–3.50). There was an inverse association between the two factors (Model 1). However, after adjustment for age, sex, and other covariates, the inverse association was attenuated (Models 2 and 3). The results were similar after further adjustment for education level (data not shown). Table 4 reveals results from the analysis of the prevalence of diabetes according to household income, age, and sex. Among individuals aged 65 years or older, there was no significant association be-

Table 1. General Characteristics According to Household Income

	Total	Q1	Q2	Q3	Q4	p value*
N	14004	3067	3622	3673	3642	-
Age (yrs)	51.4±0.2	62.2±0.5	49.5±0.3	46.7±0.3	47.3±0.3	<0.001
Male (%)	48.8	41.2	48.1	51.2	51.7	<0.001
BMI (kg/m^2)	23.9±0.04	23.8±0.10	24.0±0.08	23.9±0.08	23.9±0.09	0.472
WC (cm)	82.2±0.1	83.0±0.3	82.3±0.2	81.8±0.2	81.6±0.2	<0.001
SBP (mm Hg)	121±0.2	127±0.5	120±0.4	118±0.4	118±0.4	<0.001
DBP (mm Hg)	77.2±0.1	76.2±0.3	77.1±0.3	77.6±0.3	78.0±0.2	<0.001
FPG (mg/dL)	99±0.3	103±0.7	98±0.5	98±0.5	97±0.4	<0.001
Total cholesterol (mg/dL)	192±0.4	192±0.9	191±0.8	191±0.8	193±0.8	0.431
TG (mg/dL)	141±1.3	145±2.7	142±2.8	139±2.4	139±2.9	0.228
LDL (mg/dL)	117±0.8	117±2.1	116±1.3	117±1.4	119±1.2	0.458
HDL (mg/dL)	49±0.1	48±0.3	48±0.3	49±0.2	49±0.3	<0.001
Daily energy intake (kcal)	2015±11	1754±22	2007±20	2130±20	2172±20	<0.001
Daily carbohydrate intake (g)	325±2	304±3	324±3	335±3	339±3	<0.001
Family history of DM	20.7	13.8	19.5	22.5	24.1	<0.001
Current smokers (%)	24.7	21	27.1	25.9	23.4	<0.001
Frequent drinkers (%)	24.8	20.3	24.4	25.9	26.7	<0.001
Physical activity (%)	48.1	35.8	45.5	48.9	57.7	<0.001
Residence in urban area (%)	78.1	64.4	77.3	82.8	82.8	<0.01
Stressed (%)	26	29	25	24	26	0.001
Depression (%)	14	21	16	12	11	<0.01
DM (%)	7.8±0.3	14.7±0.7	7.6±0.5	5.7±0.5	5.7±0.5	<0.001

N, unweighted number of individuals; BMI, body mass index; WC, waist circumstance; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose; TG, triglycerides; LDL, low-density lipoprotein cholesterol; HDL, high-density lipoprotein cholesterol; DM, diabetes mellitus.
Q1 (lowest quartile), Q2 (medium-lowest quartile), Q3 (medium-highest quartile), and Q4 (highest quartile). Values are presented as mean±standard error or percentage.
*p-value by general linear model for continuous variables and multivariate logistic regression for categorical variables.

Table 2. General Characteristics According to Education Level

	Total	E1	E2	E3	E4	p value*
N	14123	4269	1727	4247	3880	-
Age (yrs)	52.1±0.1	65.3±0.2	55.4±0.3	46.4±0.2	41.6±0.2	<0.001
Male (%)	48.8	31.7	50	51	59	<0.001
BMI (kg/m^2)	24.0±0.04	24.1±0.08	24.2±0.10	23.9±0.07	23.6±0.07	<0.001
WC (cm)	82.4±0.1	83.6±0.2	83.5±0.3	81.5±0.2	81.1±0.2	<0.001
SBP (mm Hg)	121±0.2	129±0.4	123±0.5	118±0.3	115±0.3	<0.001
DBP (mm Hg)	77.5±0.1	76.4±0.2	78.4±0.3	77.9±0.2	77.0±0.2	0.001
FPG (mg/dL)	100±0.3	103±0.5	103±0.8	98±0.4	94±0.4	<0.001
Total cholesterol (mg/dL)	193±0.5	195±0.8	194±1.2	192±0.8	190±0.7	<0.001
TG (mg/dL)	142±1.3	148±2.3	147±3.4	140±2.5	134±2.3	<0.001
LDL (mg/dL)	118±0.8	118±1.7	118±2.0	117±1.3	117±1.2	0.794
HDL (mg/dL)	49±0.1	47±0.2	49±0.4	49±0.2	49±0.2	<0.001
Daily energy intake (kcal)	2014±12	1690±20	2025±30	2106±19	2237±20	<0.001
Daily carbohydrate intake (g)	327±2	307±4	332±4	330±3	339±3	<0.001
Family history of DM	20.8	12.8	19.0	21.6	25.9	<0.001
Current smokers (%)	24.7	15.1	24.1	28.4	28.1	<0.001
Frequent drinkers (%)	24.6	18.3	28.4	28	24.1	<0.001
Physical activity (%)	48	32.8	46.8	50.5	56.9	<0.001
Residence in urban area (%)	78.2	62.1	73.7	80.8	89	<0.001
Stressed (%)	26	26	21	25	29	0.001
Depression (%)	14	21	16	13	10	<0.01
DM (%)	7.7±0.3	15.4±0.7	11.4±0.9	5.5±0.4	3.1±0.3	<0.001

N, unweighted number of individuals; BMI, body mass index; WC, waist circumstance; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose; TG, triglycerides; LDL, low-density lipoprotein cholesterol; HDL, high-density lipoprotein cholesterol; DM, diabetes mellitus.
E1 (less than 7 years of education), E2 (7–9 years of education), E3 (10–12 years of education), and E4 (more than 12 years of education). Values are presented as mean±standard error or percentage.
**p*-value by general linear model for continuous variables and multivariate logistic regression for categorical variables.

Table 3. Multivariate-Adjusted ORs for the Presence of Diabetes According to Household Income

	Total	Q1	Q2	Q3	Q4	p value*	r	p value†
DM (%)	7.8±0.3	14.7±0.7	7.6±0.5	5.7±0.5	5.7±0.5	<0.001		
ORs (95% CI)								
Model 1		2.87 (2.35–3.50)	1.37 (1.10–1.69)	1.01 (0.79–1.28)	1.00	<0.001	1.44 (1.35–1.55)	<0.001
Model 2		1.13 (0.89–1.44)	1.11 (0.89–1.38)	1.02 (0.80–1.30)	1.00	0.661	1.05 (0.97–1.13)	0.235
Model 3		1.04 (0.80–1.35)	1.01 (0.79–1.29)	0.96 (0.74–1.26)	1.00	0.960	1.04 (0.96–1.12)	0.346

ORs, odds ratios; CI, confidence interval; DM, diabetes mellitus; BMI, body mass index.
Q1 (lowest quartile), Q2 (medium-lowest quartile), Q3 (medium-highest quartile), and Q4 (highest quartile). Model 1: unadjusted; Model 2: adjusted for age and sex; Model 3: adjusted for age, sex, family history of diabetes, BMI, smoking status, alcohol intake, physical activity, residence and education level.
**p* value by likelihood ratio test.
†*p* value by test for linear trend.

tween the prevalence of diabetes and household income, regardless of sex. However, among males aged 30–64 years, the prevalence of diabetes was higher in Q1 than in Q4. Moreover, among females aged 30–64 years, there was an inverse association between the prevalence of diabetes and household income.

Table 5 shows the association between the prevalence of diabetes and education level. Without adjustment, the OR (95% CI) was 5.61 (4.41–7.12) for E1 vs. E4. There was also a significant inverse association between the prevalence of diabetes and education level (Model 1). The inverse association did not change after adjustment for age and sex, even though the ORs were largely reduced (Model 2). Moreover, the inverse association did not change after adjustment for household income, age, sex, family history of diabetes, BMI, smoking status, alcohol intake, physical activity, and residence (Model 3). It also did not change after additional adjustment for daily energy intake, daily carbohydrate intake, stress, and depression (data not shown). The results were also similar after further adjustment for

Table 4. Multivariate-Adjusted ORs for the Presence of Diabetes According to Household Income, Sex, and Age Groups

Sex	Age	OR	Q1	Q2	Q3	Q4	*p* value*
M	30–64	crude	1.89 (1.26–2.84)	0.80 (0.54–1.19)	0.71 (0.50–1.02)	1.00	<0.001
		adjusted	1.88 (1.18–3.00)	0.79 (0.52–1.21)	0.68 (0.46–1.02)	1.00	0.001
M	≥65	crude	0.74 (0.46–1.20)	0.83 (0.49–1.39)	0.67 (0.36–1.14)	1.00	0.397
		adjusted	0.90 (0.53–1.55)	0.89 (0.50–1.58)	0.67 (0.35–1.28)	1.00	0.615
F	30–64	crude	4.74 (2.88–7.79)	2.50 (1.59–3.93)	1.89 (1.14–3.12)	1.00	<0.001
		adjusted	4.96 (2.87–8.58)	2.68 (1.63–4.40)	2.02 (1.20–3.41)	1.00	<0.001
F	≥65	crude	1.05 (0.68–1.62)	1.03 (0.63–1.68)	1.31 (0.74–2.30)	1.00	0.716
		adjusted	0.81 (0.51–1.30)	0.77 (0.44–1.35)	1.10 (0.60–2.03)	1.00	0.459

ORs, odds ratios; CI, confidence interval; BMI, body mass index.
Q1 (lowest quartile), Q2 (medium-lowest quartile), Q3 (medium-highest quartile), and Q4 (highest quartile). Values are presented as ORs (95% CI). Adjusted for family history of diabetes, BMI, smoking status, alcohol intake, physical activity and residence.
**p* value by multivariate logistic regression.

Table 5. Multivariate-Adjusted ORs for the Presence of Diabetes According to Education Level

	Total	E1	E2	E3	E4	*p* value*	*r*	*p* value†
DM (%)	7.7	15.4	11.4	5.5	3.1	<0.001		
ORs (95% CI)								
Model 1		5.61 (4.41–7.12)	3.98 (3.00–5.28)	1.78 (1.37–2.31)	1.00	<0.001	1.78 (1.67–1.90)	<0.001
Model 2		1.70 (1.25–2.30)	1.97 (1.45–2.68)	1.39 (1.06–1.81)	1.00	<0.001	1.18 (1.08–1.29)	<0.001
Model 3		1.86 (1.33–2.62)	2.12 (1.52–2.97)	1.47 (1.10–1.97)	1.00	<0.001	1.21 (1.10–1.34)	<0.001

ORs, odds ratios; CI, confidence interval; BMI, body mass index; DM, diabetes mellitus.
E1 (less than 7 years of education), E2 (7–9 years of education), E3 (10–12 years of education), and E4 (more than 12 years of education). Model 1: unadjusted; Model 2: adjusted for age and sex; Model 3: adjusted for age, sex, family history of diabetes, BMI, smoking status, alcohol intake, physical activity, residence and household income.
**p* value by likelihood ratio test.
†*p* value by test for linear trend.

Table 6. Multivariate-Adjusted ORs for the Presence of Diabetes According to Education Level, Sex, and Age Groups

Sex	Age	OR	E1	E2	E3	E4	*p* value*
M	30–64	crude	5.36 (3.54–8.11)	3.80 (2.49–5.80)	1.84 (1.27–2.67)	1.00	<0.001
		adjusted	5.79 (3.40–9.86)	4.23 (2.60–6.89)	1.95 (1.28–2.96)	1.00	<0.001
M	≥65	crude	0.72 (0.46–1.11)	1.36 (0.85–2.18)	1.27 (0.80–2.00)	1.00	0.001
		adjusted	0.90 (0.55–1.46)	1.50 (0.90–2.48)	1.15 (0.69–1.92)	1.00	0.095
F	30–64	crude	8.49 (4.90–14.71)	4.88 (2.52–9.47)	2.01 (1.12–3.59)	1.00	<0.001
		adjusted	8.02 (4.47–14.4)	5.06 (2.54–10.10)	2.06 (1.15–3.71)	1.00	<0.001
F	≥65	crude	0.94 (0.34–2.62)	1.00 (0.33–3.07)	0.63 (0.20–1.95)	1.00	0.542
		adjusted	1.84 (0.66–5.15)	1.58 (0.51–4.87)	1.10 (0.36–3.38)	1.00	0.292

ORs, odds ratios; CI, confidence interval; BMI, body mass index.
E1 (less than 7 years of education), E2 (7–9 years of education), E3 (10–12 years of education), and E4 (more than 12 years of education). Values are presented as ORs (95% CI). Adjusted for family history of diabetes, BMI, smoking status, alcohol intake, physical activity, residence.
**p* value by multivariate logistic regression.

household income (data not shown). Table 6 shows the results from the analysis of the prevalence of diabetes according to education level, age, and sex. Among individuals aged 65 years or older, there was no significant association between the prevalence of diabetes and education level, regardless of sex. However, among individuals aged 30–64 years, there was an inverse association between prevalence of diabetes and education level. This inverse association was more prominent in females and did not change after full adjustment for family history of diabetes, BMI, smoking status, alcohol intake, physical activity, and residence. It also did not change after additional adjustment for daily energy intake, and daily carbohydrate intake (data not shown).

DISCUSSION

In accordance with previous studies,[16-22] this study revealed that SES, according to household income and education level, is inversely associated with the prevalence of diabetes among individuals aged 30 years or older. Specifically, the prevalence of diabetes in the lowest household income group was higher than that in the highest household income group. Moreover, lower education level was associated with an increased prevalence of diabetes. Interestingly, these associations were prominent in individuals aged 30–64 years and in females. However, the inverse associations were not seen among individuals aged 65 years or older, regardless of sex.

First, the ORs for high versus low SES were dramatically reduced after adjusting for age and sex (Table 3-6). Moreover, the inverse association between the prevalence of diabetes and SES disappeared in the elderly, regardless of sex. This suggests that aging may be an important risk factor for diabetes. Therefore, in the elderly, age may attenuate the effect of SES on diabetes. This is consistent with a previous population-based study conducted in southern Germany that included 1653 subjects aged 55–74 years, used four objective SES measures (global Helmert index, income, education level, and occupational status), and investigated the association between SES and incidence of diabetes. The study revealed no significant associations in the elderly population.[19,20,23,24]

Second, in the present study, the higher SES group was physically active, had smaller waist circumferences, had lower systolic blood pressure, and lived in urban areas (Table 1 and 2). Individuals with higher SES tend to care for their health, eat healthy diets containing more fruits and vegetables, as well as less fat and sugar, work out more frequently, and utilize health care more frequently. This healthy lifestyle modifies risk factors for diabetes, including obesity, and affects the prevalence of diabetes.[16,19,20] In our data, family history of diabetes, daily energy intake, and daily carbohydrate intake were more common/higher in the high SES group. These might not be strong enough to change the inverse association between prevalence of diabetes and SES. Since hidden factors might have affected the prevalence of diabetes, we additionally adjusted for stress and depression according to household income and education. For household income, among males aged 30–64 years, the inverse association was attenuated (data not shown). This may have resulted from the effect of psycho-social stress on the prevalence of diabetes: according to previous studies, psycho-social stress, which affects the neuroendocrine system and eventually diabetes, is more intense in low SES groups.[16,19,20]

Third, the inverse association between education level and diabetes was more obvious than that between household income and diabetes. Household income is preferable indicator than education level, because people are unwilling to reveal their income. As this study was based on self-reporting, assessment of education level was more objective and thus easier to obtain. Moreover, people with a high level of education may be able to comprehend health information better and utilize health care more appropriately.[25]

This study included a nationwide representative sample and utilized the most recent KNHANES data. However, the presence of diabetes was based in part on self-reporting. Moreover, the calculated prevalence of diabetes may be lower than the actual prevalence, because although individuals over 10 years of age have since 2011 been checked for HbA1c to detect diabetes, this was excluded as a definition of diabetes in this study.

In conclusion, assessing data from the KNHANES V, which was conducted in 2010–2012, we discovered an inverse association between prevalence of diabetes and SES, as reflected by household income and education level. In light of this finding, public policies and interventions for the prevention and management of diabetes should be targeted toward people of lower SES, especially middle-aged females.

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