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Relationship between Socioeconomic status and Type2 Diabetes: Results from Korea National Health and Nutrition Examination Survey (KNHANES) 2010-2012

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ABSTRACT

Objectives: The aim of this study was to examine the relationship between socioeconomic status and type 2 diabetes using a nationally representative data, Korea National Health and Nutrition Examination Survey (KHANES) 2010-2012.

Design: A pooled sampled cross-sectional study

Setting: A nationally representative population survey data

Participants: A total of 17,139 individuals who participated in the Korea National Health and Nutrition Examination Survey (KNHAHNES) 2010-2012 were included in our analysis.

Primary outcome: Self-reported diabetes diagnosed by a physician was our primary outcome.

Results: The relationship between income/education and type 2 diabetes was assessed using logistic after adjusting covariates including age, gender, marital status, region, BMI, physical activity, smoking and high risk drinking behaviour. After adjustment of various socio-economic factors, our results indicated that individuals with higher income were less likely to have type 2 diabetes compared to those with lowest income (OR: 0.80, 0.79, 0.73; 95%CI= 0.66-0.98, 0.63-0.99,0.57-0.94). In addition, higher educational attainment, in particular the completion of high school and post-secondary school was associated with lower risk of type 2 diabetes (OR: 0.74, 0.59; 95%CI= 0.59-0.92,0.45-0.79)

Conclusion: These findings suggest the need for developing health policy to ameliorate socioeconomic inequalities, in particular income and education-related disparities in type 2 diabetes along with risk factors at the individual level. In addition, more attention toward to social determinants of is necessary to understand various cause of illness in further investigation of type 2 diabetes among Koreans.

Strengths and limitations of this study

- This study has affirmed the association between socioeconomic status (SES) and type 2 diabetes in the Korean population, using a nationally representative survey data.
- This study provided evidence on income and education-related inequalities in prevalence of type 2 diabetes in the Korea population.
- To our knowledge, this is the first attempt to understand the relationship between SES and prevalence of type 2 diabetes using a nationally representative survey.
- These findings, which are also observed in Western populations, suggested the need for developing health policy to ameliorate socioeconomic inequalities at the population level.
- However, this study limits to conclude causal relationships between SES and type 2 diabetes because of the cross-sectional study design.

Introduction

Diabetes mellitus is a serious chronic condition that causes lower quality of life and devastates health conditions. [1 2] The estimated prevalence of diabetes in Korea is approximately 7.7%, which is higher than average prevalence of 6.9% among Organisation for Economic Co-operation and Development (OECD) countries, and it gradually becomes a life-threatening chronic disease in Korea.[3-5] Previous studies suggested that majority Korean who diagnosed with diabetes suffer from type 2 diabetes, and the incident rate of type 2 is continuously elevating with a rapid growth in aging populations and a continues change in diet and life style [6]. In addition to the change in lifestyle, it has been suggested that the increasing prevalence of diabetes is closely associated with socio-economic conditions [7-9]. With respect to type 2 diabetes, it has been suggested that greater prevalence of diabetes is commonly found among materially and socially disadvantaged individuals in developed countries.[10] In addition, higher risk of diabetes tend to be observed among people who are obese, physically inactive, and unhealthy diet habit and all these conditions are more common among people with lower socioeconomic position.[11] While most current studies have addressed clinical risk factors along with a strong emphasis on health behaviours at the individual level,[12] social determinants of diabetes have not explicitly addressed in public health literature in Korea.[13] Increasing evidence on a close relationship between socio-economic levels and health outcomes among Koreans after the rapid economic success in the past modern era suggests a deeper understanding of social determinants among those living with diabetes.[14]

This paper aims to assess the relationship between socioeconomic status (SES) and prevalence of diabetes using Korean National Health and Nutrition Examination Survey (KNHANES) that allows to represent the whole Korean population and to use abundant socio-demographic information.

Methods

Data and Study population

This study used data from Korea National Health and Nutrition Examination Survey (KNHANES) 2010-2012, a nationally representative population-based survey. The KNHANES was conducted by the Ministry of Health and Welfare (MoHW) and the Korea Centre for Disease Control and Prevention (KCDC) to examine general health and nutrition status of the Korean populations.[15] The KNHANES consists of four different components; health interview survey, health behaviour survey, health examinations and nutrition survey. The survey information was collected by fact to face interview upon individual's agreement and following-up health examination was performed. The survey 2010-2012 included a total of 24,173 individuals. For this study, individuals who self-reported having diabetes diagnosed by a physician and responded to socio-demographic questions in both the health interview and health behaviour survey were identified.

Prevalence of diabetes: the survey participants were asked whether they have diabetic condition and have ever diagnosed with diabetes by a physician. Individuals who self-reported having diabetes and diagnosed the condition by a physician in these questions were classified as patients with diabetes. Because KNAHES did not include any information on type of diabetes, this study assumed respondents were diagnosed with diabetes before 19 years old were patients with type 1 diabetes, based on epidemiological trends among the Korean population and previous suggestions on the trend of diabetes in a national survey data.[16] Individuals who self-reported diagnosed diabetes before 19 years of age, assumed as type 1 diabetes, were excluded in this study. In addition, respondents who have any missing variables were excluded for an accurate analysis. After exclusions, a total of 17,033 individuals self-reported having diabetes and were included in the analysis.

Income and education: Main interests of socioeconomic status in this study were income and education. Income were used to assess the association between income and prevalence of

type 2 diabetes. In KNAHNES household income quartiles were calculated based on self-reported household income. In relation to educational attainment, the participants were asked their completion of education level. The educational attainment was classified into 4 educational categories: completion of elementary school, middle school, high school and post-secondary school.

Covariates: Socio-demographic information such as age, marital status, region, and housing possession were included as adjustments in the analysis model. Age was reclassified into 3 categories as follows: young (19-44years), middle-aged (45-64 years), and older (65 years and over). Marital status was categorized into single and married, and single category includes divorced and widowed individuals. In the KNHANES, region was originally categorized to 16 regions, including Seoul, 6 metropolitan cities, and 9 provinces. In this study, we re-categorized 16 regions into 2 regions: Metro Seoul and non-Metro Seoul regions as the uneven distribution of population and resource between Metro Seoul and non-Metro Seoul regions has been previously discussed.[17] Metro Seoul Region includes Seoul, Incheon metropolitan city and Kyunggi province, which contain approximately half of the entire Korean population. Housing possession was categorized into owner and non-owner.

In addition, healthy risk factors for diabetes, such as Body Mass Index (BMI), physical activity, smoking and drinking were included. In the KNAHNES, respondent's height and weight were measured by trained examiners. After individual's height and weight were measured, BMI was calculated and classified into underweight, normal and obese based on the following categories: obese (BMI $\geq$ 25), normal weight (BMI 18.5-24.9), and underweight (BMI $\leq$ 18.5). Participation of physical activity was categorized into moderate and vigorous activities. The participants were also asked current smoking and hi-risk drinking behaviour. Respondents were asked about current smoking behaviour and was categorized into currently smoke or not. In the KNAHNES survey defined high risk drinking behaviours by gender. If males drink more than 7 cups of alcohol at a single event and more than 2 times a week, they were classified into

individuals with high-risk drinking behaviour. For female, individuals who drink more than 5 cups of alcohol at a single event and more than 2 times a week were classified as high-risk drinking group.

The relationship between SES and prevalence of type 2 diabetes was assessed using logistic regression after adjusting covariates including age, gender, marital status, region, BMI, physical activity, smoking, and high risk behaviour. All analyses were conducted using STATA 12- window and results are reported as odds ratio (OR) and 95% confidence intervals (95% CI). Differences were considered significant at $p<0.05$, and population weight provided by KNHANES was applied to produce estimates representative of the Korean population.[15]

Results

Basic characteristics of individuals with diabetes are described in table 1. Among estimated 35,476,956 respondents, 2,151,998 individuals self-reported that they have diagnosed with diabetes by a physician.

Higher prevalence of diabetes, approximately 18%, was observed in respondents who were 65 years or older of age. Prevalence of diabetes between male and female groups were not significantly different; 6.4% of male self-reported diabetes while 5.7% of female self-reported the condition. Type 2 diabetes was more prevalent in individuals with lower educational attainment and lower income in the Korean population. Of total respondents, 68.9% of individuals possessed their own house while 31.1% of them responded that they did not own a house. In terms of respondent's BMI and Physical activity, more than 60% of the respondents were in normal weight range, and 11,065,886 individuals answered that they participated in regular vigorous physical activity. Among individuals who self-reported type 2 diabetes,

Figure 1 shows prevalence of type 2 diabetes by household income quartiles. The highest prevalence of diabetes was observed in the lowest income quartiles and this pattern was found in both male and female groups. The higher prevalence of diabetes was observed in the highest

income quartile among males compared to the second and third income quartiles while the negative income gradient on diabetes prevalence was observed in total population and female groups.

Table 2 reveals the unadjusted and adjusted odds ratio of diabetes prevalence in Korean population as the results of univariate and multivariate logistic regressions. This study found that household income was associated with prevalence of diabetes across all different four models.

The unadjusted odd ratio for higher income indicates that risk for diabetes was less than 70% as compared to those with lower income (OR: 0.30, 95% CI=0.25-0.36). Although the association between income and type 2 diabetes was reduced with sequential adjustments, income remained a significant determinant with a clear gradient from the lowest to the highest income levels. In the fully adjusted model (Model 4), individuals in the highest income quartile were approximately 30% less likely to have diabetes compared to the counterpart of those in the lowest income quartile. All levels of educational attainment were significantly associated with type 2 diabetes, suggesting that lower education was an indicator for high-risk of type 2 diabetes in Model 2. In the full adjusted model, the effect of middle school completion vanished while the completion of high school and post-secondary school still remained (OR: 0.74, 0.59; 95% CI=0.59-0.92, 0.45-0.79). In addition to income and education, sex, age, obese condition and participation of vigorous physical activity were associated with higher prevalence of type 2 diabetes in the Korean populations.

Discussion

Using a nationally representative data, we assessed socio-economic determinants of type 2 diabetes in Korean population. While numerous studies have analyzed the risk factors of type 2 diabetes, our study is an original contribution to the literature because we tackled the importance of socio-economic determinants in relation to prevalence of type 2 diabetes among the Korean population.

Our findings suggested that household income is a major determinant of type 2 diabetes among Korean adults. Income showed an adverse association with type 2 diabetes, suggesting that individuals of lower household income were more likely to have type 2 diabetes. The pattern of lower prevalence toward the higher household income was consistently found after adjustment of various socio-demographic factors, such as age, gender, region, BMI, physical activity, smoking and high risk drinking behaviour across Model 1 to Model 4. In previous studies, income level, major reflection of the economic status, was associated with adverse health outcomes including prevalence of diabetes across studies and cross culture.[8 18-20] For instance, individuals of lower income at both individual neighbourhood levels were at higher risk of type 2 diabetes.[9 12] Higher income level can be interpreted as an indicator of having better access to goods and services of greater monetary value that leads to be affordable for healthier lifestyle, which are closely associated with chronic disease.[21]

In addition to income, the completion of high school and post-secondary school were significantly related to lower prevalence of diabetes. The effect of middle school level vanished once adjusting measured BMI, physical activity, smoking and high-risk drinking behaviour. Educational attainment considers as one of predictors affecting worse health outcomes and management of chronic disease.[22 23] A recent study on SES and incident of diabetes suggested that higher educational attainment was associated with lower risk of diabetes incidence. It is a plausible pathway that education supports the improvement of health by increasing health knowledge and motivating healthy behaviours.[24 25] Also, lower educational attainment is in part associated with lower levels of social support and more adverse physical and environmental exposures.[26] Education can be considered as a marker of the ability to turn information into practical measures and behaviours, which ultimately avoid or manage chronic disease.[27] For instance, higher education is closely linked to a better understanding of chronic condition, translating into a better control over of one's life. Also, better education usually implies more opportunities in the labour force market and raises more incomes, which ultimately prevent and

well manage chronic conditions.[28] This interrelated pathway between education and health help explain our finding that type 2 diabetes is more prevalent among individuals with lower educational attainment because those with lower educational attainment may have limited diabetes-related information affecting healthy behaviours.[29]

It is well-known that type 2 diabetes is a chronic disease influenced by multiple factors.[9] Although physiological and genetic factors, which are well addressed as major factors in the existing literature, play important roles in the prevalence of type 2 diabetes, the role of social and economic conditions need to be understood.[12] After adjusting BMI, physical activity, and healthy behaviours (smoking and high-risk drinking), which mostly captured attention as major modifiable lifestyle factors,[30] our results highlight that the effect of income and educational attainment remained quite stable. This finding may imply that type 2 diabetes could be driven by income and education level rather than individual risk behaviours. In a similar study using Canadian national survey, the effect of income also persisted after adjustment of various individual risk factors, suggesting that risk behaviours limit to address an extensive part of the association between income/education and health.[12] The consistent finding may help draw a conclusion that the increasing awareness of social determinants is useful to understand the potential contributions for the incidence and management of type 2 diabetes.[9]

Due to the nature of the complexity of socioeconomic status,[25] it is not clear what dimension of socioeconomic status mainly shape type2 diabetes.[12] The existing literature showed mixed findings on the role of income and education on prevalence of type2 diabetes. One study examining the association between diabetes and SES- with a combination of household income and educational attainment- indicated that individuals of completion of college and higher income were approximately 30% less likely to have diabetes compared to their counterpart of lower SES.[7] Other studies suggest that education plays a stronger predictor of type 2 diabetes while another study suggest that the gross effect of education disappeared after socio-demographic factor and income were adjusted in the analytic model.[31 32] To understand the structural link

between income/education and type2 diabetes, further study should be considered in order to provide more evidence on effective management of type2 diabetes among the Korean population.

The higher prevalence of tyep2 diabetes among lower income and education groups is a particular problem because it can aggravate the cycle of inequality.[33] First, increasing financial burden of health care cost further deteriorate personal economic condition.[34] Even though the Korea National Health Insurance provides universal health care coverage for health care services, individuals still share high levels of out-of-pocket payment for physician services and prescription.[35] It could be likely to happen for disadvantaged individuals with diabetes to encounter excessive burden of health care cost as they already suffer financial difficulties. Also, it is possible that disadvantaged individuals have limited access to the necessary resource for management of diabetes.[34] This includes adequate housing, healthier food, and necessary health care services.[9] Thus, diabetic condition decreases an individual's productivity at work or limits to participate in the labour force and educational opportunity.[36] These limited opportunities more affect to individual's with lower income and education, which can ultimately lead to further material and social deprived conditions.[34 36] In order to prevent exacerbation of the causes of the causes, improving prevention and management of diabetic condition with the lens of social determinants of health requires a population-based and multilevel approach.[34 37]

To our knowledge, there is not much Korean literature on the relationship between SES and prevalence of type 2 diabetes at the population level. Our study contributes to the literature, highlighting the role of income and education in the prevalence of type 2 diabetes. Despite several meaningful findings of our study, there are limitations we have identified. First, the cross-sectional design of our study limit assumptions causality, at least with respect to the association of social determinants, mainly income, and type 2 diabetes. In addition, we were unable to distinguish type 1 from type 2 diabetes. However, our exclusion of adults aged less than 20 years old likely minimized new onset type 1 diabetes[16] and therefore our findings are most likely applicable to patients with type 2 diabetes. Finally, the KNHANES is a self-reported survey and

therefore prone to measurement error and recall as well as to reporting heterogeneity in self-reported health. For example, individuals with less educational attainment are less likely to recall their socio-demographic and health information.[20 38] Also, patients with non-severe symptom of diabetes were not able to identify their diabetic condition. For accurate analysis to overcome these recognized limitations, we used the variable of diabetic condition diagnosed by a physician.[5]

Conclusion

Findings from our results reveals that socioeconomic status, in particular income and educational attainment are important factors in determining the risk of type2 diabetes, regardless of various socio-demographic factors that may confound or mediate these associations. The growing prevalence of type 2 diabetes and widening the gap between better off and worst off become substantial issues in Korea. Therefore, strategies for diabetes prevention and management should focus on social determinants in addition to risk factor at the individual level. Our findings suggest that attention should be paid to considering the social determinants such as income and education in further investigations of the cause of type 2 diabetes among Koreans.

Contributorship Statement: JH and CS contributed to the study concept, design, interpretation of the data, and preparing the manuscript. JH conducted the statistical analysis.

Competing Interests: None

Data Sharing Statement: Data were generated from the Korea National Health and Nutrition Examination Survey, a publicly available database. There are no additional data available.

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Table 1. General characteristics of individuals with and without type 2 diabetes.

Variables		Estimated population	Percentage (%)	Type 2 Diabetes - Yes	Percentage (%)	Type 2 Diabetes - No	Percentage (%)	P-value
		35,476,956	100	2,151,998	6.1	33,324,958	93.9	
Age	Young	17,808,174	50.2	160,386	0.9	17,647,788	99.1	0.00*
	Middle-aged	12,650,847	35.7	1,097,072	8.7	11,553,775	91.3	
	Older	5,017,935	14.1	894,540	17.8	4,123,395	82.2	
Sex	Male	17,538,680	49.4	1,127,248	6.4	16,411,432	93.6	0.10
	Female	17,938,276	50.6	1,024,750	5.7	16,913,526	94.3	
Marital Status	Married/Partnered	28,020,912	79.0	2,074,706	7.4	25,946,206	92.6	0.00*
	Single	7,456,044	21.0	77,292	1.0	7,378,752	99.0	
Education	Elementary	6,788,164	19.1	990,363	14.6	5,797,800	85.4	0.00*
	Middle	3,628,441	10.2	354,719	9.8	3,273,722	90.2	
	High	13,471,097	38.0	534,904	4.0	12,936,193	96.0	
	Post-graduate	11,589,254	32.7	272,011	2.3	11,317,242	97.7	
Household income	Q1	5,671,837	16.0	723,850	12.8	4,947,987	87.2	0.00*
	Q2	9,681,609	27.3	559,280	5.8	9,122,329	94.2	
	Q3	10,291,211	29.0	458,728	4.5	9,832,483	95.5	
	Q4	9,832,299	27.7	410,140	4.2	9,422,159	95.8	
Geography	Non-Metro	17,980,785	50.7	1,169,416	6.5	16,811,369	93.5	0.03*
	Metro Seoul	17,496,171	49.3	982,582	5.6	16,513,589	94.4	
House ownership	Yes	24,434,626	68.9	1,586,081	6.5	22,848,545	93.5	0.00*
	No	11,042,330	31.1	565,917	5.1	10,476,413	94.9	
BMI	Underweight	1,681,347	4.7	40,512	2.4	1,640,835	97.6	0.00*
	Normal	22,271,198	62.8	1,167,886	5.2	21,103,312	94.8	
	Obese	11,524,411	32.5	943,600	8.2	10,580,811	91.8	
Physical activity	Moderate - Yes	3,108,638	8.8	178,633	5.7	2,930,005	94.3	0.68
	Moderate - No	32,368,318	91.2	1,973,365	6.1	30,394,953	93.9	
	Vigorous - Yes	11,065,886	31.2	427,035	3.9	10,638,851	96.1	0.00*
	Vigorous - No	24,411,070	68.8	1,724,963	7.1	22,686,107	92.9	
Smoking	Yes	9,449,901	26.6	530,178	5.6	8,919,722	94.4	0.20
	No	26,027,055	73.4	1,621,820	6.2	24,405,236	93.8	
High risk drinking	Yes	4,808,724	13.6	240,046	5.0	4,568,678	95.0	0.08
	No	30,668,232	86.4	1,911,952	6.2	28,756,280	93.8	

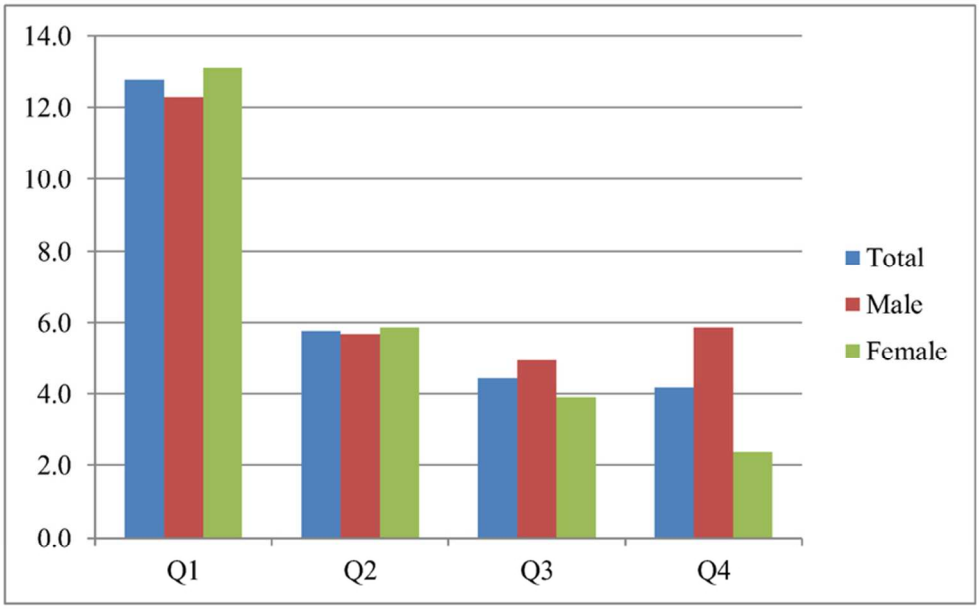
*P-value < 0.05

Table 2. Results of univariate and multivariate logistic regression analysis for socioeconomic status and type 2 diabetes in Korea

Variables	Model 1			Model2			Model3			Model4		
	OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Household income												
Q2	0.42	0.35-0.50	0.00*	0.65	0.54-0.78	0.00*	0.82	0.67-0.99	0.04*	0.80	0.66-0.98	0.03*
Q3	0.32	0.26-0.39	0.00*	0.62	0.50-0.76	0.00*	0.80	0.63-1.00	0.05*	0.79	0.63-0.99	0.04*
Q4	0.30	0.25-0.36	0.00*	0.65	0.52-0.80	0.00*	0.72	0.56-0.92	0.01*	0.73	0.57-0.94	0.02*
Educational												
Middle school				0.73	0.57-0.89	0.00*	0.86	0.69-1.08	0.20	0.88	0.70-1.10	0.18
High school				0.29	0.23-0.35	0.00*	0.71	0.57-0.88	0.00*	0.74	0.59-0.92	0.00*
Post-secondary				0.18	0.13-0.22	0.00*	0.55	0.42-0.73	0.00*	0.59	0.45-0.79	0.00*
Sex- Female							0.67	0.58-0.78	0.00*	0.68	0.57-0.82	0.00*
Age												
Middle-aged (45-64)							7.93	5.35-11.75	0.00*	8.00	5.43-11.79	0.00*
Older (65 and over)							14.30	9.42-21.72	0.00*	14.60	9.65-22.09	0.00*
Marital status-Single							0.76	0.44-1.31	0.33	0.80	0.47-1.37	0.41
Region- Metro-Seoul							1.09	0.94-1.26	0.27	1.07	0.92-1.25	0.35
House ownership -No							0.99	0.83-1.17	0.87	0.97	0.82-1.15	0.73
Measured BMI												
Normal										1.64	0.95-2.82	0.07
Obese										2.57	1.48-4.46	0.00*
Physical activity												
Moderate- Yes										0.99	0.72-1.36	0.96
Vigorous- Yes										0.72	0.59-0.88	0.00*
Smoking -Yes										1.20	0.98-1.48	0.08
High risk Drinking- Yes										1.02	0.76-1.36	0.91

*P-value < 0.05

Figure 1. Prevalence of type2 diabetes by income quartiles



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Relationship between Socioeconomic Status and Type 2 Diabetes: Results from Korea National Health and Nutrition Examination Survey (KNHANES) 2010-2012

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ABSTRACT

Objectives: The aim of this study was to examine the relationship between socioeconomic status (SES) and type 2 diabetes using the Korea National Health and Nutrition Examination Survey (KHANES) 2010-2012.

Design: A pooled sample cross-sectional study

Setting: A nationally representative population survey data

Participants: A total of 14,330 individuals who participated in the Korea National Health and Nutrition Examination Survey (KNHAHNES) 2010-2012 were included in our analysis.

Primary outcome: Prevalence of type 2 was our primary outcome.

Results: The relationship between SES and type 2 diabetes was assessed using logistic regression after adjusting for covariates including age, gender, marital status, region, BMI, physical activity, smoking and high-risk drinking behaviour. After adjustment for covariates, our results indicated that individuals with lowest income were more likely to have type 2 diabetes compared to those with highest income (OR: 1.35; 95%CI= 1.08-1.72). In addition, having lower educational attainment was an independent factor for higher prevalence of type 2 diabetes in Korea.

Conclusion: These findings suggest the need for developing health policy to ameliorate socioeconomic inequalities, in particular income and education-related disparities in type 2 diabetes along with risk factors at the individual level. In addition, more attention toward social determinants of diabetes is necessary to understand various causes of illness in further investigation of type 2 diabetes among Koreans.

Strengths and limitations of this study

- This study has affirmed the association between socioeconomic status (SES) and type 2 diabetes in the Korean population
- Our results show that the lowest income and lower educational attainment are associated with higher prevalence of type 2 diabetes in Korean adults, consistent with findings in Western populations.
- These findings suggest the need for more attention on social determinants for effective management of type 2 diabetes.
- However, causal inferences cannot be made between SES and type 2 diabetes due to the cross-sectional study design of the study.

Introduction

Diabetes mellitus is a serious chronic condition that causes lower quality of life and devastates health conditions.[1 2] The estimated prevalence of diabetes in Korea is approximately 7.7% and it gradually becomes a life-threatening chronic disease. In comparison with other Organisation for Economic Co-operation and Development (OECD) countries, Korea's recent estimated prevalence of diabetes is higher than the average prevalence of type 2 diabetes among OECD countries which stands at 6.9%.[3-5] The increasing prevalence of diabetic condition in Korea is a substantial public health issue because it continuously increases economic and social burden along with a rapid growth of mortality and morbidity.[6 7] Previous studies suggest that a majority of Koreans diagnosed with diabetes suffer from type 2 diabetes,[8] and the elevating incident rate of type 2 is closely associated with a rapid growth in aging populations and a continues change in westernized diet and life style.[9] In addition to diet and lifestyle factors, increasing evidence suggest the link between socioeconomic status (SES) and prevalence of type 2 diabetes.[10-12] For instance, greater prevalence of diabetes is commonly found among materially and socially deprived individuals in developed countries.[13] It has been also suggested that higher risk of diabetes is more likely to be observed in individuals who are obese, physically inactive, and have unhealthy diet habits because these conditions are more common among people with lower socioeconomic position.[14] While there is an increasing need for a deeper understanding of the relationship between socioeconomic levels and health outcomes, most existing Korean studies on type 2 diabetes focus on clinical risk factors along with a strong emphasis on health behaviours at the individual level.[15-17]

This paper aims to assess the relationship between socioeconomic status (SES) and prevalence of diabetes using Korean National Health and Nutrition Examination Survey (KNHANES) that allows to represent the whole Korean population and to use abundant socio-demographic information.

Methods

Data and Study population

This study used data from Korea National Health and Nutrition Examination Survey (KNHANES) 2010-2012, a nationally representative population-based survey. The KNHANES was conducted by the Ministry of Health and Welfare (MoHW) and the Korea Centre for Disease Control and Prevention (KCDC) to examine general health and nutrition status of the Korean populations.[18] The KNHANES consists of four different components; health interview survey, health behaviour survey, health examinations and nutrition survey. The survey information was collected by face to face interview upon individual's agreement and follow-up health examination was performed. The 2010-2012 survey included a total of 25,534 individuals. For this study, 14,330 individuals who responded to socio-demographic questions in both the health interview and health behaviour survey and participated in health examinations were identified.

Prevalence of diabetes: The survey classified individual's diabetic conditions with three different measures. First, participants were asked whether they have diabetic condition and have ever diagnosed with diabetes by a physician. Individuals who self-reported having diabetes diagnosed by a physician were classified as patients with diabetes. Second, individuals were classified into diabetes, pre-diabetes, and normal based on fasting glucose level over 126mg/dl in health examination. Lastly, individuals who self-reported were under diabetic treatment were classified into diabetic condition. Based on three indicators for diabetes, we re-categorized all individuals into diabetic condition and non-diabetic condition. Despite the richness of information from the KNAHES, it did not have any information on type of diabetes. We therefore assumed respondents were diagnosed with diabetes before 29 years old were patients with type 1 diabetes,

based on epidemiological trends among the Korean population and previous suggestions on the trend of diabetes in a national survey data.[8] Individuals who self-reported diagnosed diabetes before 29 years of age, assumed as type 1 diabetes, were excluded in this study. In addition, respondents who have any missing or no response values (n = 488) were excluded for an accurate analysis.

House hold income and education: Main indicators of socioeconomic status in this study were household income and education. In KNAHNES, household income quartiles were calculated based on equivalised income (total household income divided by the square root of the numbers of household members). In relation to educational attainment, the participants were asked their completion of education level. The educational attainment was classified into 4 educational categories: completion of elementary school, middle school, high school and post-secondary school.

Covariates: Socio-demographic information such as age, marital status, region, and house ownership were included as covariates in the analysis model. Age was reclassified into 3 categories as follows: young (30-44years), middle-aged (45-64 years), and older (65 years and over). Marital status was categorized into single and married and single category includes divorced and widowed individuals. In the KNHANES, region was originally categorized to 16 regions, including Seoul, 6 metropolitan cities, and 9 provinces. In this study, we re-categorized 16 regions into 2 regions: Metro Seoul and non-Metro Seoul regions as the uneven distribution of population and resource between Metro Seoul and non-Metro Seoul regions has been previously discussed.[19] Metro Seoul Region includes Seoul, Incheon metropolitan city and Gyeonggi province, which contain approximately half of the entire Korean population. Housing possession was categorized into owner and non-owner.

In addition, risk factors for diabetes, such as increased Body Mass Index (BMI), physical inactivity, smoking and alcohol intake were included. In the KNAHNES, respondent's height and weight were measured by trained examiners. After individual's height and weight were measured,

BMI was calculated and classified into normal/underweight and obese based on the following categories: obese (BMI ≥ 25), and normal (BMI 18.5-24.9) and underweight (BMI ≤ 18.5). Participation of physical activity was categorized into moderate and vigorous activities. The participants were also asked about their current smoking and high-risk drinking behaviour. Current smoking behaviour was categorized into currently smoke or not. In the KNAHNES survey, high-risk drinking behaviours were defined by gender. If males drink more than 7 cups of alcohol at a single event and more than 2 times a week, they were classified into individuals with high-risk drinking behaviour.[20] For females, individuals who drink more than 5 cups of alcohol at a single event and more than 2 times a week were classified as high-risk drinking group.[20]

Statistical analysis

The relationship between SES and prevalence of type 2 diabetes was assessed using logistic regression after sequential adjustment of covariates including age, gender, marital status, region, BMI, physical activity, smoking, and high-risk drinking behaviour. Model 1 adjusted age and income while Model 2 adjusted age and educational attainment. Model 3 examined the relation with both income and education while adjusting for demographic characteristics. Model 4 adjusted for health behaviours. Because existing literatures suggest there might be a gender-related difference in the relationship between SES and health outcomes,[21 22] we also performed gender-stratified analysis. All analyses were conducted using STATA version 12- window and results are reported as odds ratio (OR) and 95% confidence intervals (95% CI). Differences were considered significant at $p<0.05$, and population weight provided by KNHANES was applied to produce estimates representative of the Korean population.[18]

Results

Basic characteristics of individuals with diabetes are described in table 1. Among estimated 27,378,600 respondents over 30 years old, 2,765,586 individuals (10.1%) were identified to have type 2 diabetes. Higher prevalence of diabetes, approximately 53.3%, was

observed in respondents who were middle-aged (between 45-64 years old). Prevalence of diabetes between male and female groups was slightly different; 55.5% of male had type 2 diabetes while 45.5% of female had diabetic condition. Type 2 diabetes was more prevalent in individuals with lower educational attainment and lower income in the Korean population. Of total patients with diabetes, 72.7% of individuals self-reported possessing their own house while 27.3% of them responded that they did not own a house. In terms of respondent's BMI and physical activity, more than 52% of the respondents were in normal range, and 632,725 individuals with type 2 diabetes participated in regular vigorous physical activity. In relation to smoking and high-risk drinking behaviours, approximately 26% of individuals with diabetes were currently smoking, and more than 9% of individuals had high-risk drinking behaviours.

Table 2 shows the unadjusted and adjusted odds ratios of diabetes prevalence in Korean population as the results of univariate and multivariate logistic regressions. The lowest household income was associated with the higher risk of diabetes across all different models. In the age-adjusted prevalence of diabetes with income, individuals of the lowest income were more likely to have type 2 diabetes compared to those with the highest income (OR: 1.56, 95% CI=1.25-1.94). Although the association between income and type 2 diabetes was reduced with sequential adjustments, the lowest income remained a significant determinant. In the fully adjusted model (Model 4), individuals in the lowest income quartile were a 35% greater likelihood of having diabetes compared to the counterpart of those in the highest income quartile. All levels of educational attainment were significantly associated with type 2 diabetes, showing a clear gradient from the lowest to the highest education levels. In addition to income and education, sex, age, BMI and participation of vigorous physical activity were associated with lower prevalence of type 2 diabetes in the Korean populations.

In the gender-stratified model (Table 3), lower income was associated with higher prevalence of type 2 diabetes in female group while there was no significant relationship between income and type 2 diabetes in male group.

Discussion

Using a nationally representative data, we assessed socio-economic determinants of type 2 diabetes in Korean population. Our results show a pattern of higher prevalence toward the lowest household income after adjustment of various socio-demographic factors, suggesting that the income is a major determinant of type 2 diabetes among Korean adults. In previous studies, income level, major reflection of the economic status, was closely associated with adverse health outcomes including prevalence of diabetes across studies and across cultures.[11 23-25] For instance, individuals of lower income at both individual neighbourhood levels were at higher risk of type 2 diabetes.[12 15] In line with previous studies, our findings also support the link between income and prevalence of type 2 diabetes, implying that higher income is an indicator of having better access to goods and services of greater monetary value that leads to affordable and healthier lifestyle.[26]

It is worth noting that income was not a significant factor associated with type 2 diabetes among Korean males whereas inverse relationship between income and prevalence of type 2 diabetes was observed among Korean females. Current literature also have found the inverse relationship between chronic condition such as obesity and diabetes and SES among Korean women, but the reason for different relationship between income and type 2 diabetes by gender is unclear. A possible explanation is traditional perception on gender that women's social class is lower than men. This different perception on gender might lead women to be more influenced by income in relation to health, health behaviours and lifestyle.[26] To provide a deeper understanding on gender-related difference in the relationship between income and type 2 diabetes, further studies are needed.

In addition to income, a higher prevalence of type 2 diabetes among individuals with lower educational attainment was also observed in our results. Lower educational attainment has been considered as a predictor affecting poor health outcomes and management of chronic disease.[27 28] For instance, a recent study on SES and incidence of diabetes suggested that higher

educational attainment was associated with lower risk of diabetes incidence. Our finding is in line with previous findings that might support an interrelated pathway between education and health. Education level is a marker of the ability to turn information into practical behaviours, with the ultimate goal to prevent or manage chronic diseases.[29] In this sense, it is plausible that higher education level supports the improvement of health by increasing health knowledge and motivating healthy behaviours.[30 31] In addition, higher educational attainment is closely linked to better physical and social environment. For example, lower educational attainment is in part associated with lower levels of social support and more adverse physical and environmental exposures.[32] Furthermore, a better education usually implies more opportunities in the labour force market and raises more incomes, which closely influence on healthy behaviours for chronic disease management.[33] Overall, our finding that type 2 diabetes is more prevalent among individuals with lower educational attainment could be due to the fact that lower educational attainment possibly limits information and resource linking to healthy behaviours and environment exposures.[34]

It is well-known that type 2 diabetes is a chronic disease influenced by multiple factors.[12] Although physiological and genetic factors, which are well addressed as major risk factors in the existing literature, play important roles in the prevalence of type 2 diabetes, the role of social and economic conditions need to be understood.[15] After adjusting for BMI, physical activity, and unhealthy behaviours (smoking and high-risk drinking), which mostly captured attention as major modifiable lifestyle factors,[35] our results indicate that the effect of income and educational attainment remained quite stable. This finding may imply that type 2 diabetes could be driven by income and education level rather than individual risk behaviours. In a similar study using Canadian national survey, the effect of income also persisted after adjustment of various individual risk factors, suggesting that risk behaviours limit to address an extensive part of the association between income/education and health.[15] The consistent finding may help draw a

conclusion that the increasing awareness of social determinants is useful to understand the potential contributions for the incidence and management of type 2 diabetes.[12]

Due to the nature of the complexity of socioeconomic status,[31] it is not clear what dimension of socioeconomic status mainly shapes type2 diabetes.[15] The existing literature shows mixed findings on the role of income and education on prevalence of type2 diabetes. One study examining the association between diabetes and SES- with a combination of household income and educational attainment- indicated that individuals of completion of college and higher income were approximately 30% less likely to have diabetes compared to their counterpart of lower SES.[10] Other studies suggest that education plays a stronger role in type 2 diabetes while another study suggest that the gross effect of education disappeared after socio-demographic factors and income were adjusted in the analytic model.[36 37] To understand the structural link between income/education and type2 diabetes, further study should be considered in order to provide more evidence on effective management of type2 diabetes among the Korean population.

The higher prevalence of tyep2 diabetes among lower income and education groups is a particular problem because it can aggravate the cycle of inequality.[38] First, increasing financial burden of health care cost further deteriorates personal economic condition.[39] Even though the Korean National Health Insurance provides universal health care coverage for health care services, individuals still share high levels of out-of-pocket payment for physician services and prescription.[40] It could be likely to happen for disadvantaged individuals with diabetes to encounter excessive burden of health care cost as they already suffer financial difficulties. Also, it is possible that disadvantaged individuals have limited access to necessary resource for management of diabetes.[39] This includes adequate housing, healthier food, and necessary health care services.[12] Thus, diabetic condition decreases an individual's productivity at work or limits to participate in the labour force and educational opportunity.[41] These limited opportunities more affect to individual's with lower income and education, which can ultimately lead to further material and social deprived conditions.[39 41] In order to prevent exacerbation of the causes of the

causes, improving prevention and management of diabetic condition with the lens of social determinants of health requires a population-based and multi-level approach.[39 42]

To our knowledge, there is not much Korean literature on the relationship between SES and prevalence of type 2 diabetes at the population level. Our study contributes to the literature, highlighting the role of income and education on the prevalence of type 2 diabetes. While numerous studies have analyzed the risk factors of type 2 diabetes, our study is an original contribution to the literature because we tackled the importance of socio-economic determinants in relation to prevalence of type 2 diabetes among the Korean population.

Despite several meaningful findings of our study, there are limitations we have identified. First, the cross-sectional design of our study limit assumptions of causality, at least with respect to the association of social determinants, mainly income, and type 2 diabetes. Also, we cannot exclude reverse causality in the observed findings. That is, pre-existing diagnosed diabetes may cause reduced income due to, for instance, loss of job hence causing reduced income. In addition, we were unable to distinguish type 1 from type 2 diabetes. However, our exclusion of adults aged less than 20 years old likely minimized new onset type 1 diabetes[8] and therefore our findings are most likely applicable to patients with type 2 diabetes. Finally, the KNHANES is a self-reported survey and therefore prone to measurement error and recall bias as well as to reporting heterogeneity in self-reported health. For example, individuals with less educational attainment are less likely to recall their socio-demographic and health information.[25 43] Also, patients with non-severe symptom of diabetes were not able to identify their diabetic condition. For accurate analysis to overcome these recognized limitations, we used the variable of diabetic condition diagnosed by a physician.[5] Further studies should consider the use of administrative or registry-based data.

Conclusion

Findings from our results reveal that socioeconomic status, in particular income and educational attainment, are important factors in higher prevalence of type2 diabetes, regardless of various socio-demographic factors that may confound or mediate these associations. The growing prevalence of type 2 diabetes and widening the gap between better off and worst off become substantial issues in Korea. Therefore, strategies for diabetes prevention and management should focus on social determinants in addition to risk factor at the individual level. Our findings suggest that attention should be paid to the social determinants of health such as income and education in further investigations of the cause of type 2 diabetes among Koreans.

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Contributorship Statement: JH and CS contributed to the study concept, design, interpretation of the data, and preparing the manuscript. JH conducted the statistical analysis.

Competing Interests: None

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Table 1. General characteristics of individuals with type 2 diabetes.

Variables		Type 2 Diabetes - Yes	Percentage (%)	Estimated population	Percentage (%)	p-value
		2,765,586	10.1	27,378,600	100	
Age	Young	345,158	12.5	10,892,589	39.8	**<0.001**
	Middle-aged	1,474,576	53.3	12,122,164	44.3	
	Older	945,851	34.2	4,363,847	15.9	
Sex	Male	1,536,256	55.5	13,477,425	49.2	**<0.001**
	Female	1,229,330	44.5	13,901,175	50.8	
Marital Status	Married/Partnered	2,145,967	77.6	22,242,029	81.2	**0.001**
	Single	619,618	22.4	5,136,571	18.8	
Education	Elementary	1,080,057	39.1	6,060,731	22.1	**<0.001**
	Middle	444,298	16.1	3,280,320	12.0	
	High	820,982	29.7	9,505,375	34.7	
	Post-graduate	420,248	15.2	8,532,173	31.2	
Income	Q1	807,879	29.2	4,494,685	16.4	**<0.001**
	Q2	733,076	26.5	7,554,779	27.6	
	Q3	646,824	23.4	7,783,332	28.4	
	Q4	577,807	20.9	7,545,804	27.6	
Region	Non-Metro	1,491,763	53.9	14,127,908	51.6	0.148
	Metro Seoul	1,273,822	46.1	13,250,692	48.4	
House ownership	Yes	2,009,688	72.7	19,428,320	71.0	0.242
	No	755,897	27.3	7,950,280	29.0	
BMI	Normal/Underweight	1,438,949	52.0	17,878,573	65.3	**<0.001**
	Obese	1,326,636	48.0	9,500,026	34.7	
Physical activity	Moderate - Yes	233,861	8.5	2,410,729	8.8	0.688
	Moderate - No	2,531,725	91.5	24,967,871	91.2	
	Vigorous - Yes	632,725	22.9	8,414,982	30.7	**<0.001**
	Vigorous - No	2,132,860	77.1	18,963,618	69.3	
Smoking	Yes	726,243	26.3	7,069,758	25.8	0.745
	No	2,039,343	73.7	20,308,841	74.2	
High-risk drinking	Yes	269,421	9.7	3,053,311	11.2	0.199
	No	2,496,164	90.3	24,325,289	88.8	

Table 2. Results of univariate and multivariate logistic regression analysis for socioeconomic status and type 2 diabetes in Korea

	Model 1			Model 2			Model 3			Model 4		
	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
Age- Young (30-44)	0.14	0.11-0.18	**<0.001**	0.15	0.12-0.19	**<0.001**	0.17	0.13-0.22	**<0.001**	0.16	0.12-0.21	**<0.001**
Middle-aged (45-64)	0.58	0.49-0.68	**<0.001**	0.55	0.47-0.63	**<0.001**	0.61	0.52-0.72	**<0.001**	0.60	0.51-0.72	**<0.001**
Income Q1	1.56	1.25-1.94	**<0.001**				1.37	1.09-1.73	**0.008**	1.35	1.08-1.72	**0.012**
Q2	1.23	1.01-1.50	**0.040**				1.11	0.91-1.36	0.304	1.09	0.89-1.34	0.408
Q3	1.18	0.95-1.45	0.129				1.11	0.89-1.37	0.346	1.09	0.88-1.35	0.456
Education- Elementary				1.59	1.25-2.03	**<0.001**	1.74	1.33-2.26	**<0.001**	1.64	1.26-2.15	**<0.001**
Middle school				1.53	1.18-1.99	**0.002**	1.59	1.22-2.09	**<0.001**	1.51	1.15-1.98	**0.003**
High school				1.42	1.14-1.77	**0.002**	1.46	1.17-1.83	**<0.001**	1.44	1.15-1.82	**0.002**
Sex- Female							0.61	0.53-0.70	**<0.001**	0.61	0.52-0.72	**<0.001**
Marital status- Single							0.85	0.73-1.00	**0.045**	0.86	0.73-1.01	0.070
Region- Metro-Seoul							1.05	0.91-1.22	0.480	1.04	0.90-1.21	0.585
House ownership -Yes							0.97	0.82-1.15	0.753	0.99	0.83-1.17	0.876
BMI- obese										1.93	1.69-2.21	**<0.001**
Physical activity- Moderate										0.96	0.74-1.24	0.753
Vigorous										0.75	0.64-0.90	**<0.001**
Smoking -Yes										1.14	0.95-1.36	0.154
High-risk Drinking- Yes										0.97	0.74-1.28	0.854

Table 3. Gender stratified multivariate logistic regression analysis for socioeconomic status and type 2 diabetes

	Male (Estimated N= 13,477,425)			**Female** (Estimated N= 13,901,175)		
	OR	95% CI	p-value	OR	95% CI	p-value
Age- Young (30-44)	0.17	0.11-0.24	**<0.001**	0.23	0.15-0.36	**<0.001**
Middle aged(45-64)	0.70	0.55-0.88	**0.002**	0.59	0.46-0.74	**<0.001**
Income Q1	1.22	0.87-1.72	0.244	1.68	1.18-2.38	**0.006**
Q2	0.88	0.66-1.16	0.351	1.55	1.13-2.12	**0.004**
Q3	0.97	0.75-1.27	0.850	1.31	0.92-1.88	0.133
Education- Elementary	1.27	0.92-1.77	0.152	2.41	1.48-3.92	**<0.001**
Middle school	1.52	1.11-2.10	**0.010**	1.84	1.10-3.07	**0.020**
High school	1.43	1.10-1.85	**0.008**	1.68	1.06-2.66	**0.028**
Marital status- Single	1.18	0.84-1.65	0.334	0.76	0.61-0.93	**0.009**
Region- Metro-Seoul	1.04	0.85-1.29	0.686	1.08	0.88-1.32	0.468
House ownership -Yes	1.03	0.80-1.31	0.846	0.96	0.76-1.21	0.724
BMI- obese	1.45	1.19-1.78	**<0.001**	2.58	2.16-3.09	**<0.001**
Physical activity- Moderate	1.10	0.80-1.52	0.556	0.76	0.54-1.07	0.128
Vigorous	0.73	0.59-0.90	**0.004**	0.80	0.60-1.07	0.118
Smoking -Yes	1.16	0.95-1.41	0.151	0.96	0.62-1.47	0.655
High-risk Drinking- Yes	1.00	0.74-1.33	0.979	0.83	0.37-1.87	0.836

Relationship between Socioeconomic Status and Type 2 Diabetes: Results from Korea National Health and Nutrition Examination Survey (KNHANES) 2010-2012

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ABSTRACT

Objectives: The aim of this study was to examine the relationship between socioeconomic status (SES) and type 2 diabetes using the Korea National Health and Nutrition Examination Survey (KHANES) 2010-2012.

Design: A pooled sample cross-sectional study

Setting: A nationally representative population survey data

Participants: A total of 14,330 individuals who participated in the Korea National Health and Nutrition Examination Survey (KNHAHNES) 2010-2012 were included in our analysis.

Primary outcome: Prevalence of type 2 was our primary outcome.

Results: The relationship between SES and type 2 diabetes was assessed using logistic regression after adjusting for covariates including age, gender, marital status, region, BMI, physical activity, smoking and high-risk drinking behaviour. After adjustment for covariates, our results indicated that individuals with lowest income were more likely to have type 2 diabetes compared to those with highest income (OR: 1.35; 95%CI= 1.08-1.72). In addition, having lower educational attainment was an independent factor for higher prevalence of type 2 diabetes in Korea.

Conclusion: These findings suggest the need for developing health policy to ameliorate socioeconomic inequalities, in particular income and education-related disparities in type 2 diabetes along with risk factors at the individual level. In addition, more attention toward social determinants of diabetes is necessary to understand various causes of illness in further investigation of type 2 diabetes among Koreans.

Strengths and limitations of this study

- This study has affirmed the association between socioeconomic status (SES) and type 2 diabetes in the Korean population

- Our results show that the lowest income and lower educational attainment are associated with higher prevalence of type 2 diabetes in Korean adults, consistent with findings in Western populations.
- These findings suggest the need for more attention on social determinants for effective management of type 2 diabetes.
- However, causal inferences cannot be made between SES and type 2 diabetes due to the cross-sectional study design of the study.

Introduction

Diabetes mellitus is a serious chronic condition that causes lower quality of life and devastates health conditions.[1 2] The estimated prevalence of diabetes in Korea is approximately 7.7% and it gradually becomes a life-threatening chronic disease. In comparison with other Organisation for Economic Co-operation and Development (OECD) countries, Korea's recent estimated prevalence of diabetes is higher than the average prevalence of type 2 diabetes among OECD countries which stands at 6.9%.[3-5] The increasing prevalence of diabetic condition in Korea is a substantial public health issue because it continuously increases economic and social burden along with a rapid growth of mortality and morbidity.[6 7] Previous studies suggest that a majority of Koreans diagnosed with diabetes suffer from type 2 diabetes,[8] and the elevating incident rate of type 2 is closely associated with a rapid growth in aging populations and a continues change in westernized diet and life style.[9] In addition to diet and lifestyle factors, increasing evidence suggest the link between socioeconomic status (SES) and prevalence of type 2 diabetes.[10-12] For instance, greater prevalence of diabetes is commonly found among materially and socially deprived individuals in developed countries.[13] It has been also suggested that higher risk of diabetes is more likely to be observed in individuals who are obese, physically inactive, and have unhealthy diet habits because these conditions are more common among people with lower socioeconomic position.[14] While there is an increasing need for a deeper understanding of the relationship between socioeconomic levels and health outcomes, most existing Korean studies on type 2 diabetes focus on clinical risk factors along with a strong emphasis on health behaviours at the individual level.[15-17]

This paper aims to assess the relationship between socioeconomic status (SES) and prevalence of diabetes using Korean National Health and Nutrition Examination Survey (KNHANES) that allows to represent the whole Korean population and to use abundant socio-demographic information.

Methods

Data and Study population

This study used data from Korea National Health and Nutrition Examination Survey (KNHANES) 2010-2012, a nationally representative population-based survey. The KNHANES was conducted by the Ministry of Health and Welfare (MoHW) and the Korea Centre for Disease Control and Prevention (KCDC) to examine general health and nutrition status of the Korean populations.[18] The KNHANES consists of four different components; health interview survey, health behaviour survey, health examinations and nutrition survey. The survey information was collected by face to face interview upon individual's agreement and follow-up health examination was performed. The 2010-2012 survey included a total of 25,534 individuals. For this study, 14,330 individuals who responded to socio-demographic questions in both the health interview and health behaviour survey and participated in health examinations were identified.

Prevalence of diabetes: The survey classified individual's diabetic conditions with three different measures. First, participants were asked whether they have diabetic condition and have ever diagnosed with diabetes by a physician. Individuals who self-reported having diabetes diagnosed by a physician were classified as patients with diabetes. Second, individuals were classified into diabetes, pre-diabetes, and normal based on fasting glucose level over 126mg/dl in health examination. Lastly, individuals who self-reported were under diabetic treatment were classified into diabetic condition. Based on three indicators for diabetes, we re-categorized all individuals into diabetic condition and non-diabetic condition. Despite the richness of information from the KNAHES, it did not have any information on type of diabetes. We therefore assumed respondents were diagnosed with diabetes before 29 years old were patients with type 1 diabetes, based on epidemiological trends among the Korean population and previous suggestions on the trend of diabetes in a national survey data.[8] Individuals who self-reported diagnosed diabetes before 29 years of age, assumed as type 1 diabetes, were excluded in this study. In addition,

respondents who have any missing or no response values (n = 488) were excluded for an accurate analysis.

House hold income and education: Main indicators of socioeconomic status in this study were household income and education. In KNAHNES, household income quartiles were calculated based on equivalised income (total household income divided by the square root of the numbers of household members). In relation to educational attainment, the participants were asked their completion of education level. The educational attainment was classified into 4 educational categories: completion of elementary school, middle school, high school and post-secondary school.

Covariates: Socio-demographic information such as age, marital status, region, and house ownership were included as covariates in the analysis model. Age was reclassified into 3 categories as follows: young (30-44years), middle-aged (45-64 years), and older (65 years and over). Marital status was categorized into single and married and single category includes divorced and widowed individuals. In the KNHANES, region was originally categorized to 16 regions, including Seoul, 6 metropolitan cities, and 9 provinces. In this study, we re-categorized 16 regions into 2 regions: Metro Seoul and non-Metro Seoul regions as the uneven distribution of population and resource between Metro Seoul and non-Metro Seoul regions has been previously discussed.[19] Metro Seoul Region includes Seoul, Incheon metropolitan city and Gyeonggi province, which contain approximately half of the entire Korean population. Housing possession was categorized into owner and non-owner.

In addition, risk factors for diabetes, such as increased Body Mass Index (BMI), physical inactivity, smoking and alcohol intake were included. In the KNAHNES, respondent's height and weight were measured by trained examiners. After individual's height and weight were measured, BMI was calculated and classified into normal/underweight and obese based on the following categories: obese (BMI $\geq$ 25), and normal (BMI 18.5-24.9) and underweight (BMI $\leq$ 18.5). Participation of physical activity was categorized into moderate and vigorous activities. The

participants were also asked about their current smoking and high-risk drinking behaviour. Current smoking behaviour was categorized into currently smoke or not. In the KNAHNES survey, high-risk drinking behaviours were defined by gender. If males drink more than 7 cups of alcohol at a single event and more than 2 times a week, they were classified into individuals with high-risk drinking behaviour.[20] For females, individuals who drink more than 5 cups of alcohol at a single event and more than 2 times a week were classified as high-risk drinking group.[20]

Statistical analysis

The relationship between SES and prevalence of type 2 diabetes was assessed using logistic regression after sequential adjustment of covariates including age, gender, marital status, region, BMI, physical activity, smoking, and high-risk drinking behaviour. Model 1 adjusted age and income while Model 2 adjusted age and educational attainment. Model 3 examined the relation with both income and education while adjusting for demographic characteristics. Model 4 adjusted for health behaviours. Because existing literatures suggest there might be a gender-related difference in the relationship between SES and health outcomes,[21 22] we also performed gender-stratified analysis. All analyses were conducted using STATA version 12- window and results are reported as odds ratio (OR) and 95% confidence intervals (95% CI). Differences were considered significant at $p<0.05$, and population weight provided by KNHANES was applied to produce estimates representative of the Korean population.[18]

Results

Basic characteristics of individuals with diabetes are described in table 1. Among estimated 27,378,600 respondents over 30 years old, 2,765,586 individuals (10.1%) were identified to have type 2 diabetes. Higher prevalence of diabetes, approximately 53.3%, was observed in respondents who were middle-aged (between 45-64 years old). Prevalence of diabetes between male and female groups was slightly different; 55.5% of male had type 2 diabetes while 45.5% of female had diabetic condition. Type 2 diabetes was more prevalent in

individuals with lower educational attainment and lower income in the Korean population. Of total patients with diabetes, 72.7% of individuals self-reported possessing their own house while 27.3% of them responded that they did not own a house. In terms of respondent's BMI and physical activity, more than 52% of the respondents were in normal range, and 632,725 individuals with type 2 diabetes participated in regular vigorous physical activity. In relation to smoking and high-risk drinking behaviours, approximately 26% of individuals with diabetes were currently smoking, and more than 9% of individuals had high-risk drinking behaviours.

Table 2 shows the unadjusted and adjusted odds ratios of diabetes prevalence in Korean population as the results of univariate and multivariate logistic regressions. The lowest household income was associated with the higher risk of diabetes across all different models. In the age-adjusted prevalence of diabetes with income, individuals of the lowest income were more likely to have type 2 diabetes compared to those with the highest income (OR: 1.56, 95% CI=1.25-1.94). Although the association between income and type 2 diabetes was reduced with sequential adjustments, the lowest income remained a significant determinant. In the fully adjusted model (Model 4), individuals in the lowest income quartile were a 35% greater likelihood of having diabetes compared to the counterpart of those in the highest income quartile. All levels of educational attainment were significantly associated with type 2 diabetes, showing a clear gradient from the lowest to the highest education levels. In addition to income and education, sex, age, BMI and participation of vigorous physical activity were associated with lower prevalence of type 2 diabetes in the Korean populations.

In the gender-stratified model (Table 3), lower income was associated with higher prevalence of type 2 diabetes in female group while there was no significant relationship between income and type 2 diabetes in male group.

Discussion

Using a nationally representative data, we assessed socio-economic determinants of type 2 diabetes in Korean population. Our results show a pattern of higher prevalence toward the lowest household income after adjustment of various socio-demographic factors, suggesting that the income is a major determinant of type 2 diabetes among Korean adults. In previous studies, income level, major reflection of the economic status, was closely associated with adverse health outcomes including prevalence of diabetes across studies and across cultures.[11 23-25] For instance, individuals of lower income at both individual neighbourhood levels were at higher risk of type 2 diabetes.[12 15] In line with previous studies, our findings also support the link between income and prevalence of type 2 diabetes, implying that higher income is an indicator of having better access to goods and services of greater monetary value that leads to affordable and healthier lifestyle.[26]

It is worth noting that income was not a significant factor associated with type 2 diabetes among Korean males whereas inverse relationship between income and prevalence of type 2 diabetes was observed among Korean females. Current literature also have found the inverse relationship between chronic condition such as obesity and diabetes and SES among Korean women, but the reason for different relationship between income and type 2 diabetes by gender is unclear. A possible explanation is traditional perception on gender that women's social class is lower than men. This different perception on gender might lead women to be more influenced by income in relation to health, health behaviours and lifestyle.[26] To provide a deeper understanding on gender-related difference in the relationship between income and type 2 diabetes, further studies are needed.

In addition to income, a higher prevalence of type 2 diabetes among individuals with lower educational attainment was also observed in our results. Lower educational attainment has been considered as a predictor affecting poor health outcomes and management of chronic disease.[27 28] For instance, a recent study on SES and incidence of diabetes suggested that higher educational attainment was associated with lower risk of diabetes incidence. Our finding is in line with previous findings that might support an interrelated pathway between education and

health. Education level is a marker of the ability to turn information into practical behaviours, with the ultimate goal to prevent or manage chronic diseases.[29] In this sense, it is plausible that higher education level supports the improvement of health by increasing health knowledge and motivating healthy behaviours.[30 31] In addition, higher educational attainment is closely linked to better physical and social environment. For example, lower educational attainment is in part associated with lower levels of social support and more adverse physical and environmental exposures.[32] Furthermore, a better education usually implies more opportunities in the labour force market and raises more incomes, which closely influence on healthy behaviours for chronic disease management.[33] Overall, our finding that type 2 diabetes is more prevalent among individuals with lower educational attainment could be due to the fact that lower educational attainment possibly limits information and resource linking to healthy behaviours and environment exposures.[34]

It is well-known that type 2 diabetes is a chronic disease influenced by multiple factors.[12] Although physiological and genetic factors, which are well addressed as major risk factors in the existing literature, play important roles in the prevalence of type 2 diabetes, the role of social and economic conditions need to be understood.[15] After adjusting for BMI, physical activity, and unhealthy behaviours (smoking and high-risk drinking), which mostly captured attention as major modifiable lifestyle factors,[35] our results indicate that the effect of income and educational attainment remained quite stable. This finding may imply that type 2 diabetes could be driven by income and education level rather than individual risk behaviours. In a similar study using Canadian national survey, the effect of income also persisted after adjustment of various individual risk factors, suggesting that risk behaviours limit to address an extensive part of the association between income/education and health.[15] The consistent finding may help draw a conclusion that the increasing awareness of social determinants is useful to understand the potential contributions for the incidence and management of type 2 diabetes.[12]

Due to the nature of the complexity of socioeconomic status,[31] it is not clear what dimension of socioeconomic status mainly shapes type2 diabetes.[15] The existing literature shows mixed findings on the role of income and education on prevalence of type2 diabetes. One study examining the association between diabetes and SES- with a combination of household income and educational attainment- indicated that individuals of completion of college and higher income were approximately 30% less likely to have diabetes compared to their counterpart of lower SES.[10] Other studies suggest that education plays a stronger role in type 2 diabetes while another study suggest that the gross effect of education disappeared after socio-demographic factors and income were adjusted in the analytic model.[36 37] To understand the structural link between income/education and type2 diabetes, further study should be considered in order to provide more evidence on effective management of type2 diabetes among the Korean population.

The higher prevalence of tyep2 diabetes among lower income and education groups is a particular problem because it can aggravate the cycle of inequality.[38] First, increasing financial burden of health care cost further deteriorates personal economic condition.[39] Even though the Korean National Health Insurance provides universal health care coverage for health care services, individuals still share high levels of out-of-pocket payment for physician services and prescription.[40] It could be likely to happen for disadvantaged individuals with diabetes to encounter excessive burden of health care cost as they already suffer financial difficulties. Also, it is possible that disadvantaged individuals have limited access to necessary resource for management of diabetes.[39] This includes adequate housing, healthier food, and necessary health care services.[12] Thus, diabetic condition decreases an individual's productivity at work or limits to participate in the labour force and educational opportunity.[41] These limited opportunities more affect to individual's with lower income and education, which can ultimately lead to further material and social deprived conditions.[39 41] In order to prevent exacerbation of the causes of the causes, improving prevention and management of diabetic condition with the lens of social determinants of health requires a population-based and multi-level approach.[39 42]

To our knowledge, there is not much Korean literature on the relationship between SES and prevalence of type 2 diabetes at the population level. Our study contributes to the literature, highlighting the role of income and education on the prevalence of type 2 diabetes. While numerous studies have analyzed the risk factors of type 2 diabetes, our study is an original contribution to the literature because we tackled the importance of socio-economic determinants in relation to prevalence of type 2 diabetes among the Korean population.

Despite several meaningful findings of our study, there are limitations we have identified. First, the cross-sectional design of our study limit assumptions of causality, at least with respect to the association of social determinants, mainly income, and type 2 diabetes. Also, we cannot exclude reverse causality in the observed findings. That is, pre-existing diagnosed diabetes may cause reduced income due to, for instance, loss of job hence causing reduced income. In addition, we were unable to distinguish type 1 from type 2 diabetes. However, our exclusion of adults aged less than 20 years old likely minimized new onset type 1 diabetes[8] and therefore our findings are most likely applicable to patients with type 2 diabetes. Finally, the KNHANES is a self-reported survey and therefore prone to measurement error and recall bias as well as to reporting heterogeneity in self-reported health. For example, individuals with less educational attainment are less likely to recall their socio-demographic and health information.[25 43] Also, patients with non-severe symptom of diabetes were not able to identify their diabetic condition. For accurate analysis to overcome these recognized limitations, we used the variable of diabetic condition diagnosed by a physician.[5] Further studies should consider the use of administrative or registry-based data.

Conclusion

Findings from our results reveal that socioeconomic status, in particular income and educational attainment, are important factors in higher prevalence of type2 diabetes, regardless of various socio-demographic factors that may confound or mediate these associations. The

growing prevalence of type 2 diabetes and widening the gap between better off and worst off become substantial issues in Korea. Therefore, strategies for diabetes prevention and management should focus on social determinants in addition to risk factor at the individual level. Our findings suggest that attention should be paid to the social determinants of health such as income and education in further investigations of the cause of type 2 diabetes among Koreans.

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Competing Interests: None

Data Sharing Statement: Data were generated from the Korea National Health and Nutrition Examination Survey, a publicly available database. There are no additional data available.

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Table 1. General characteristics of individuals with type 2 diabetes.

Variables		Type 2 Diabetes - Yes	Percentage (%)	Estimated population	Percentage (%)	p-value
		2,765,586	10.1	27,378,600	100	
Age	Young	345,158	12.5	10,892,589	39.8	**<0.001**
	Middle-aged	1,474,576	53.3	12,122,164	44.3	
	Older	945,851	34.2	4,363,847	15.9	
Sex	Male	1,536,256	55.5	13,477,425	49.2	**<0.001**
	Female	1,229,330	44.5	13,901,175	50.8	
Marital Status	Married/Partnered	2,145,967	77.6	22,242,029	81.2	**0.001**
	Single	619,618	22.4	5,136,571	18.8	
Education	Elementary	1,080,057	39.1	6,060,731	22.1	**<0.001**
	Middle	444,298	16.1	3,280,320	12.0	
	High	820,982	29.7	9,505,375	34.7	
	Post-graduate	420,248	15.2	8,532,173	31.2	
Income	Q1	807,879	29.2	4,494,685	16.4	**<0.001**
	Q2	733,076	26.5	7,554,779	27.6	
	Q3	646,824	23.4	7,783,332	28.4	
	Q4	577,807	20.9	7,545,804	27.6	
Region	Non-Metro	1,491,763	53.9	14,127,908	51.6	0.148
	Metro Seoul	1,273,822	46.1	13,250,692	48.4	
House ownership	Yes	2,009,688	72.7	19,428,320	71.0	0.242
	No	755,897	27.3	7,950,280	29.0	
BMI	Normal/Underweight	1,438,949	52.0	17,878,573	65.3	**<0.001**
	Obese	1,326,636	48.0	9,500,026	34.7	
Physical activity	Moderate - Yes	233,861	8.5	2,410,729	8.8	0.688
	Moderate - No	2,531,725	91.5	24,967,871	91.2	
	Vigorous - Yes	632,725	22.9	8,414,982	30.7	**<0.001**
	Vigorous - No	2,132,860	77.1	18,963,618	69.3	
Smoking	Yes	726,243	26.3	7,069,758	25.8	0.745
	No	2,039,343	73.7	20,308,841	74.2	
High-risk drinking	Yes	269,421	9.7	3,053,311	11.2	0.199
	No	2,496,164	90.3	24,325,289	88.8	

Table 2. Results of univariate and multivariate logistic regression analysis for socioeconomic status and type 2 diabetes in Korea

	Model 1			Model 2			Model 3			Model 4		
	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
Age- Young (30-44)	0.14	0.11-0.18	**<0.001**	0.15	0.12-0.19	**<0.001**	0.17	0.13-0.22	**<0.001**	0.16	0.12-0.21	**<0.001**
Middle-aged (45-64)	0.58	0.49-0.68	**<0.001**	0.55	0.47-0.63	**<0.001**	0.61	0.52-0.72	**<0.001**	0.60	0.51-0.72	**<0.001**
Income Q1	1.56	1.25-1.94	**<0.001**				1.37	1.09-1.73	**0.008**	1.35	1.08-1.72	**0.012**
Q2	1.23	1.01-1.50	**0.040**				1.11	0.91-1.36	0.304	1.09	0.89-1.34	0.408
Q3	1.18	0.95-1.45	0.129				1.11	0.89-1.37	0.346	1.09	0.88-1.35	0.456
Education- Elementary				1.59	1.25-2.03	**<0.001**	1.74	1.33-2.26	**<0.001**	1.64	1.26-2.15	**<0.001**
Middle school				1.53	1.18-1.99	**0.002**	1.59	1.22-2.09	**<0.001**	1.51	1.15-1.98	**0.003**
High school				1.42	1.14-1.77	**0.002**	1.46	1.17-1.83	**<0.001**	1.44	1.15-1.82	**0.002**
Sex- Female							0.61	0.53-0.70	**<0.001**	0.61	0.52-0.72	**<0.001**
Marital status- Single							0.85	0.73-1.00	**0.045**	0.86	0.73-1.01	0.070
Region- Metro-Seoul							1.05	0.91-1.22	0.480	1.04	0.90-1.21	0.585
House ownership -Yes							0.97	0.82-1.15	0.753	0.99	0.83-1.17	0.876
BMI- obese										1.93	1.69-2.21	**<0.001**
Physical activity- Moderate										0.96	0.74-1.24	0.753
Vigorous										0.75	0.64-0.90	**<0.001**
Smoking -Yes										1.14	0.95-1.36	0.154
High-risk Drinking- Yes										0.97	0.74-1.28	0.854

Table 3. Gender stratified multivariate logistic regression analysis for socioeconomic status and type 2 diabetes

	Male (Estimated N= 13,477,425)			**Female** (Estimated N= 13,901,175)		
	OR	95% CI	p-value	OR	95% CI	p-value
Age- Young (30-44)	0.17	0.11-0.24	**<0.001**	0.23	0.15-0.36	**<0.001**
Middle aged(45-64)	0.70	0.55-0.88	**0.002**	0.59	0.46-0.74	**<0.001**
Income Q1	1.22	0.87-1.72	0.244	1.68	1.18-2.38	**0.006**
Q2	0.88	0.66-1.16	0.351	1.55	1.13-2.12	**0.004**
Q3	0.97	0.75-1.27	0.850	1.31	0.92-1.88	0.133
Education- Elementary	1.27	0.92-1.77	0.152	2.41	1.48-3.92	**<0.001**
Middle school	1.52	1.11-2.10	**0.010**	1.84	1.10-3.07	**0.020**
High school	1.43	1.10-1.85	**0.008**	1.68	1.06-2.66	**0.028**
Marital status- Single	1.18	0.84-1.65	0.334	0.76	0.61-0.93	**0.009**
Region- Metro-Seoul	1.04	0.85-1.29	0.686	1.08	0.88-1.32	0.468
House ownership -Yes	1.03	0.80-1.31	0.846	0.96	0.76-1.21	0.724
BMI- obese	1.45	1.19-1.78	**<0.001**	2.58	2.16-3.09	**<0.001**
Physical activity- Moderate	1.10	0.80-1.52	0.556	0.76	0.54-1.07	0.128
Vigorous	0.73	0.59-0.90	**0.004**	0.80	0.60-1.07	0.118
Smoking -Yes	1.16	0.95-1.41	0.151	0.96	0.62-1.47	0.655
High-risk Drinking- Yes	1.00	0.74-1.33	0.979	0.83	0.37-1.87	0.836