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Different socioeconomic inequalities exist in terms of the prevention, diagnosis and control of diabetes

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Objective: To evaluate socioeconomic disadvantage in prevalence, awareness and control of diabetes in universal coverage healthcare system. **Methods:** Data from the fifth KNHNES (2010–12) were analyzed. The sample included 10 208 individuals with diabetes aged ≥30 years. Diabetes was defined by (i) a self-reported previous diagnosis of diabetes made by a physician, (ii) the current use of oral hypoglycaemic agents and/or insulin or (iii) fasting plasma glucose ≥126 mg/dl. Subjects who were first diagnosed by the survey were classified as 'undiagnosed'. Inadequate control was defined as HbA1c ≥6.5%. **Results:** It was estimated that 26.4% of subjects with diabetes were not aware of their condition and 73.1% of cases of diabetes were not adequately controlled. Inequalities in socioeconomic status were related to the diabetes prevalence in both men and women. Educational level was not predictive of diagnosis or control in men or women, whereas lower household income level was associated with diagnosis in men only. **Conclusions:** This widespread lack of awareness and inadequate control underscore the need for intensive efforts in these domains. Monitoring is expected to highlight the gaps in the preventive and care services offered to the most vulnerable individuals and it may induce governments and practitioners to address these issues.

Introduction

Non-communicable diseases have become the leading contributors to mortality and disease burden worldwide.[1] The worldwide prevalence of diabetes was estimated at 8.3% in 2012, representing a total of 371 million people living with diabetes. The prevalence of diabetes in Asian populations has increased rapidly in recent decades, with a disproportionate burden in young and middle-aged individuals.[2]

The occurrence of diabetes is not evenly distributed across society.[3] The main factors that link socioeconomic position to health and diabetes are community factors (e.g. availabilities of healthy food and places to exercise), health behaviours (e.g. diet, obesity and physical activity) and access to healthcare and diabetes care (e.g. measurement of HbA1c, smoking cessation and diabetes education).[4–11] The risk of diabetes is associated with a disadvantaged socioeconomic status in developed and developing countries. This association has been shown in both diabetes morbidity studies and diabetes mortality studies, although there is variation in the magnitude of these inequalities among different countries.[12,13]

Although much effort has been devoted to promoting awareness of diabetes, rates of detection, treatment and control remain low. Diabetes is a chronic insidious disease that develops gradually, and many individuals remain undiagnosed.[10,11,14] Those with uncontrolled diabetes are often susceptible to premature myocardial infarction and haemorrhagic stroke. Successful control depends primarily on adequate patient awareness, which is also a prerequisite for optimal treatment compliance.[15]

Diabetes is important not only because of its high frequency but also because it is the major modifiable risk factor for cardiovascular and kidney diseases. Therefore, effective control of diabetes has become a priority for global health policies. In the context of the growing interest in prevention and control of non-communicable diseases, it is vital that healthcare systems deliver appropriate interventions for diabetes.

Lower use of preventive interventions in populations of low socioeconomic status has been described in countries with universal-coverage healthcare systems.[6] However, little is known about the possible socioeconomic inequalities among secondary prevention measures in universal health insurance systems. In the context of the universal health insurance system in Korea, the Korean government provides universal medical checkups every 2 years for all individuals older than 40 years. The development of effective policies to decrease the burden of disease should be based on current data regarding risk factors related to prevalence, awareness and control at the population level.

The aim of this study was to evaluate diabetes risk factors according to the prevalence, awareness and control of diabetes. We specifically aimed to investigate socioeconomic disadvantages and weaknesses in the healthcare system.

Methods

Data sources and participants

This study was based on data obtained from the 2010–12 Korea National Health and Nutrition Examination Survey, a nationwide survey examining the general health and nutrition status of the Korean population, which included four distinct measures: the health interview survey, health behaviour survey, health examination and health nutrition survey. A stratified, multistage probability sampling design was used, and 31 641 individuals from 11 400 households (3800 households per year) and 573 districts (192 districts per year) were chosen based on location and residence type to represent the entire nation.

The response rates were 81.9% in 2010, 80.4% in 2011 and 80.0% in 2012. A total of 17 292 subjects older than 30 years were included. Subjects who fasted for less than 8 h were excluded from the analysis of glucose levels; after excluding subjects with missing data, 10 208 participants met criteria for diabetes. All subjects participated voluntarily and provided informed consent. The study protocol was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention (nos. 2010-02CON-21-C, 2011-02CON-06-C and 2012-01EXP-01-2C).

Measurements and variables

Blood samples were taken by skilled nurses and transported to a central laboratory on the same day. Fasting glucose serums levels were measured enzymatically in the central laboratory using an automatic analyser 7600 (Hitachi/Japan). HbA1c values were measured using high-performance liquid chromatography-723G7 (Tosoh/Japan).

Diabetes was defined by (i) a self-reported previous diagnosis of diabetes made by a physician, (ii) the current use of oral hypoglycaemic agents and/or insulin or (iii) fasting plasma glucose $\geq$126 mg/dl. Subjects who were first diagnosed with diabetes by the survey were classified as having undiagnosed diabetes. The rate of undiagnosed diabetes was the proportion of participants with diabetes who were first diagnosed with this condition by the survey. The rate of inadequately controlled diabetes was the proportion of participants with diabetes whose control of the condition was inadequate at the time of the survey. Inadequate control of diabetes was defined as HbA1c $\geq$6.5%.

Current smoking was defined as having smoked 100 cigarettes in one's lifetime and currently smoking cigarettes. Current drinking was defined as alcohol intake more than once per month during the past 12 months. Central obesity was defined as a waist circumference of at least 90 cm in men and at least 80 cm in women. Overweight was defined as a body mass index (BMI) of 25.0–29.9, and obesity was defined as a BMI of 30.0 or higher. A family history of diabetes was coded when first-degree relatives, such as parents, brothers and sisters, were reported to have suffered from the condition.

We used education and household income level as indicators of socioeconomic status. Educational attainment was categorized into elementary school graduate or below, junior high school, high school graduate and college graduate or above. Household income included wages, pensions, unemployment benefits, social security benefits and bank interest. Household income was defined as the average monthly gross income divided by an equivalence factor (number of household members $\times$ 0.5) to adjust for differences in household size and composition. Income was categorized into quartiles.

Statistical analysis

We determined the prevalence and rates at which individuals were unaware of or had inadequate control over their condition by diabetes status. We compared these data between diabetes groups using chi-square tests. We used survey sample weights to produce non-biased estimates for descriptive or analytical data analyses.[16]

Poisson regression models with robust variance were fitted to explore factors associated with prevalence, unawareness and inappropriate control.[13,17–19] The associations with socioeconomic status are presented as prevalence ratios (PRs) and 95% confidence intervals (CIs). The analysis was performed separately for men and women. Analyses were performed using SAS ver. 9.2 (SAS Institute, Cary, NC).

Results

The prevalence of diabetes was estimated at 14.1% (95% CI, 13.0–15.1%) in all adults older than 30 years (i.e. 2 787 493 individuals), 15.9% (95% CI, 14.4–17.4%) in men and 12.2% (95% CI, 11.0–13.4%) in women (table 1). It was estimated that 26.4% (95% CI, 23.6–29.2%) of those with diabetes had been unaware that they suffered from the condition ('undiagnosed rate'). The prevalence of inadequately controlled diabetes ('uncontrolled rate'), defined by an HbA1c concentration of 6.5% or more, was 73.1% (95% CI, 69.9–76.2%) of those with diabetes. Both undiagnosed and uncontrolled rates were higher in men.

The prevalence of diabetes increased with age and with decreasing socioeconomic status. Diabetes was more prevalent in those with a family history of diabetes and in overweight and obese individuals. The unawareness rate for diabetes was highest in those 30–40 years of age, and unawareness was more prevalent in subjects with higher education levels and incomes. The undiagnosed rate for diabetes was higher in subjects without a family history and in current smokers and current drinkers. The undiagnosed and uncontrolled rates were significantly higher in those with central obesity and diabetes.

According to our robust Poisson model, older age, family history, abdominal obesity and obesity were associated significantly with a higher risk of diabetes (tables 2 and 3). Family history was protective with respect to unawareness for both men and women. Obesity and current drinking were risk factors for undiagnosed diabetes in men.

Inequalities in socioeconomic status were related to the diabetes prevalence in both men and women. The PR for men with a junior high school education level was 1.33. The corresponding value for women was 2.51. The PR was 2.88 for women with education levels of elementary school or less, compared with those with a college or higher education level. The PR for men with a household income in the lowest quartile was 1.27 and that for women was 1.29. Socioeconomic differences in diabetes are larger among women in terms of prevalence. Educational level was not predictive of diagnosis or control in men or women, whereas lower household income level was associated with diagnosis in men.

Discussion

The prevalence of diabetes in participants older than 30 years was 14.1%. Projections based on sample weighting suggest that this may represent up to 2 787 493 individuals nationwide. This proportion is higher than the 9.1% rate reported in Korea in a 2005 survey[20] and the 11.6% rate in China.[1]

Diabetes is important not only because of its high frequency but also because it is related to modifiable risk factors and therefore provides a powerful means of predicting risk and preventing disease and death. Public health systems should offer expanded access to primary prevention services that rest on a comprehensive approach focusing on several interrelated risks to health, including alcohol, tobacco, central obesity, high BMI, physical inactivity and consumption of fruits and vegetables. The epidemic of diabetes requires that all governments and policymakers address the need for both population-based approaches and large-scale intervention programs directed at the large high-risk population.[21]

It was estimated that 26.4% of individuals with diabetes were unaware of their condition. Fortunately, the unawareness rate of diabetes has decreased in Korea.[20,22] However, more than two-thirds of patients (73.1%) had inadequate glycaemic control. Numerous studies have revealed that people in many countries have poor awareness and unsatisfactory control over diabetes.[15,22–24] Indeed, a substantial proportion of individuals with diabetes in both developed and developing countries remain undiagnosed, and

Table 1 Prevalence and undiagnosed and inadequate control rates of diabetes in Korea: 2010–12

		Prevalence rate (estimated population = 2 787 493)					Undiagnosed rate[a] (estimated population = 734 907)				Uncontrolled rate[b] (estimated population = 1 499 942)			
		No.	%	95% CI		P	%	95% CI		P	%	95% CI		P
Overall		1672	14.1	13.0	15.1		26.4	23.6	29.2		73.1	69.9	76.2	
Sex	Men	872	15.9	14.4	17.4	<0.0001	29.3	25.1	33.4	0.025	74.9	70.7	79.0	0.208
	Women	800	12.2	11.0	13.4		22.7	18.9	26.5		71.0	66.4	75.6	
Age (years)	30–40	59	3.3	2.3	4.2	<0.0001	55.5	41.2	69.8	<0.0001	76.9	59.7	94.0	0.040
	40–50	170	8.6	6.9	10.3		48.5	40.1	57.0		78.8	69.2	88.5	
	50–60	382	18.0	15.9	20.0		28.4	22.5	34.4		75.3	68.7	81.9	
	60–70	543	25.9	23.4	28.4		14.1	10.8	17.3		75.9	70.7	81.1	
	70+	518	28.5	25.6	31.3		13.9	10.1	17.7		64.5	59.2	69.9	
Family history	No	1184	11.9	10.9	12.9	<0.0001	29.1	25.7	32.5	0.006	70.8	66.9	74.7	0.030
	Yes	488	23.1	20.4	25.7		20.5	15.8	25.2		77.4	72.7	82.2	
Waist circumference (cm)	<90 in men, <80 in women	1068	11.6	10.6	12.7	<0.0001	24.1	20.7	27.5	0.030	70.3	66.1	74.4	0.007
	≥90 in men, ≥80 in women	604	22.8	20.4	25.2		30.6	25.7	35.5		78.7	74.4	83.1	
BMI (kg/cm^2)	<25	893	11.4	10.3	12.5	<0.0001	21.2	17.6	24.8	0.000	70.3	65.9	74.8	0.076
	<30	655	17.9	16.0	19.7		30.4	25.5	35.3		75.6	70.8	80.4	
	≥30	124	25.4	20.4	30.4		39.8	28.6	50.9		81.6	72.4	90.8	
Current smoking	No	1312	13.9	12.7	15.1	0.553	24.7	21.5	27.9	0.060	72.2	68.6	75.7	0.347
	Yes	360	14.5	12.6	16.3		31.1	25.1	37.1		75.8	69.3	82.3	
Current drinking	No	925	15.5	14.1	16.9	0.001	19.6	16.3	22.9	<0.0001	73.0	68.7	77.3	0.959
	Yes	747	12.9	11.6	14.2		32.8	28.3	37.3		73.2	68.4	77.9	
Educational level	≤Elementary	745	24.3	21.8	26.7	<0.0001	17.6	14.2	21.1	<0.0001	67.5	62.8	72.2	0.022
	Junior high	276	19.2	16.5	21.8		25.2	17.6	32.9		74.8	66.7	83.0	
	High school	421	11.9	10.4	13.4		35.0	29.1	40.8		78.5	72.6	84.4	
	≥College	230	6.9	5.7	8.1		33.6	25.1	42.2		78.6	70.5	86.7	
Household income	Lower quartile	554	24.6	22.0	27.2	<0.0001	21.1	16.9	25.3	0.099	67.7	62.1	73.3	0.098
	Third quartile	431	13.5	11.8	15.1		27.3	22.0	32.6		73.4	67.3	79.4	
	Second quartile	359	11.7	10.1	13.3		30.2	23.5	37.0		77.7	71.1	84.2	
	Upper quartile	328	10.6	9.1	12.1		28.2	21.9	34.5		76.0	69.4	82.7	

a: Among subjects with diabetes.
b: Among subjects with diagnosed diabetes.

Table 2 Factors associated with prevalence and undiagnosed and inadequate control rates of diabetes in Korean men: 2010–12

		Prevalence			Undiagnosed[a]			Inadequate control[b]		
		PR	95% CI		PR	95% CI		PR	95% CI	
Age (years)	30–40	1.00			1.00			1.00		
	40–50	2.58	1.76	3.78	0.81	0.57	1.15	0.93	0.72	1.21
	50–60	5.48	3.82	7.85	0.42	0.29	0.62	0.89	0.70	1.12
	60–70	7.50	5.22	10.78	0.26	0.17	0.39	0.95	0.75	1.20
	70+	7.00	4.79	10.21	0.20	0.13	0.33	0.92	0.72	1.18
Family history	No	1.00			1.00			1.00		
	Yes	2.23	1.98	2.52	0.64	0.48	0.86	1.01	0.91	1.11
Waist circumference (cm)	<90 in men, <80 in women	1.00			1.00			1.00		
	≥90 in men, ≥80 in women	1.31	1.12	1.54	0.63	0.47	0.84	1.06	0.94	1.19
BMI (kg/cm^2)	<25	1.00			1.00			1.00		
	<30	1.08	0.93	1.26	1.47	1.11	1.94	1.00	0.89	1.12
	≥30	1.46	1.03	2.06	2.47	1.58	3.85	0.91	0.66	1.25
Current smoking	No	1.00			1.00			1.00		
	Yes	1.10	0.98	1.25	0.83	0.65	1.06	1.11	1.01	1.23
Current drinking	No	1.00			1.00			1.00		
	Yes	0.91	0.81	1.03	1.48	1.11	1.98	0.94	0.85	1.03
Educational level	≥College	1.00			1.00			1.00		
	High school	1.19	1.01	1.40	1.05	0.77	1.42	1.03	0.91	1.17
	Junior high	1.33	1.09	1.61	0.89	0.60	1.31	1.03	0.89	1.19
	≤Elementary	1.08	0.89	1.31	1.04	0.70	1.54	0.89	0.75	1.04
Household income level	Highest quartile	1.00			1.00			1.00		
	Second quartile	1.00	0.85	1.18	1.19	0.85	1.65	1.03	0.91	1.16
	Third quartile	0.95	0.80	1.13	1.48	1.06	2.06	1.00	0.88	1.14
	Lowest quartile	1.27	1.06	1.52	1.47	1.02	2.11	0.99	0.85	1.14

a: In subjects with diabetes.
b: In subjects with diagnosed diabetes.

Table 3 Factors associated with prevalence and undiagnosed and inadequate control rates of diabetes in Korean women: 2010–12

		Prevalence			Undiagnosed[a]			Inadequate control[b]		
		PR	95% CI		PR	95% CI		PR	95% CI	
Age (years)	30–40	1.00			1.00			1.00		
	40–50	2.39	1.54	3.70	0.90	0.55	1.48	1.27	0.79	2.04
	50–60	3.07	1.98	4.78	0.49	0.29	0.84	1.29	0.81	2.04
	60–70	4.49	2.88	7.02	0.25	0.14	0.47	1.28	0.81	2.05
	70+	5.47	3.47	8.64	0.20	0.11	0.39	1.09	0.68	1.75
Family history	No	1.00			1.00			1.00		
	Yes	2.41	2.12	2.73	0.56	0.41	0.77	0.99	0.90	1.09
Waist circumference (cm)	<90 in men, <80 in women	1.00			1.00			1.00		
	≥ 90 in men, ≥ 80 in women	1.54	1.30	1.82	1.38	0.96	1.99	1.14	1.00	1.30
BMI (kg/cm^2)	<25	1.00			1.00			1.00		
	<30	1.39	1.19	1.63	1.28	0.88	1.86	0.95	0.84	1.07
	≥30	1.99	1.57	2.51	1.37	0.81	2.34	0.95	0.78	1.16
Current smoking	No	1.00			1.00			1.00		
	Yes	1.37	1.06	1.76	1.44	0.92	2.27	0.99	0.78	1.25
Current drinking	No	1.00			1.00			1.00		
	Yes	0.77	0.66	0.90	1.13	0.83	1.54	0.98	0.87	1.11
Educational level	≥College	1.00			1.00			1.00		
	High school	1.74	1.22	2.48	0.89	0.54	1.45	0.94	0.77	1.15
	Junior high	2.51	1.70	3.70	1.18	0.68	2.06	0.93	0.76	1.15
	≤Elementary	2.88	1.97	4.21	1.07	0.61	1.87	0.95	0.79	1.15
Household income level	Highest quartile	1.00			1.00			1.00		
	Second quartile	1.20	0.96	1.50	1.05	0.69	1.60	1.01	0.87	1.16
	Third quartile	1.31	1.07	1.62	1.02	0.69	1.51	0.98	0.85	1.12
	Lowest quartile	1.29	1.04	1.60	1.01	0.66	1.54	0.88	0.76	1.02

a: In subjects with diabetes.
b: In subjects with diagnosed diabetes.

their conditions remain uncontrolled.[25] Despite differences between this study and previous research with respect to survey methods and analytic strategies, our results suggest that diabetes is far from adequately controlled. These low rates of diagnosis and control reflect many lost opportunities for reducing the growing global burden of diabetes. This study presents a reliable and meaningful snapshot of the current situation regarding the levels of awareness and management of diabetes in Korean adults.

According to our robust Poisson model, age, obesity, family history, income and education were predictors of disease prevalence.[22,24] The prevalence of diabetes increased with age, which means that lifestyle changes must be initiated early in life.[26] Age and family history were protective factors against unawareness[15] and these findings are in agreement with the literature. The protective effect of age may be attributable to increased screening as a function of age and/or the presence of other risk factors. A family history of health problems increased the awareness of these conditions.[15]

Inequalities in socioeconomic status were related to diabetes prevalence.[4,5,8,13,24,25,27] This implies that investment in primary prevention strategies directed at socioeconomically disadvantaged groups could yield great benefits.[28] As in other previous studies, inequalities in diabetes prevalence in Korea were more marked in women than in men.[4,9,13,14] The different pattern in women can be explained by inequalities in health behaviours, because people with a disadvantaged socioeconomic status have a higher prevalence of obesity, lower physical activity and high psychosocial risks, and these inequalities are higher in women than in men.[9,14]

Lower household income level was risk factor for undiagnosed diabetes in men. This implies that household income inequalities could be actually stronger in prevalence of diabetes in men.

Education inequalities were not found in the diagnosis or control of diabetes in men or women.[25,29,30] Lower household income level was not associated with diagnosis in women. This is an encouraging finding, especially given the large socioeconomic inequalities characterizing many health outcomes,[25] and it may reflect an absence of differences in optimal management according to socioeconomic status. Once a relatively high standard of access to care at the level of a health system is achieved, individual socioeconomic characteristics, such as education or income, are less likely to play an important role than they do when overall access remains poor.[31] In the context of the universal health insurance system in Korea, the Korean government provides universal medical checkups every 2 years for all people older than 40 years.

This observation is inconsistent with the association between socioeconomic status and diabetes prevalence. Inequalities in diabetes mortality are higher than those in diabetes morbidity.[9] When diabetes is diagnosed, several factors related to disease progression can widen the inequalities in diabetes mortality related to socioeconomic status. These factors include less access to and use of healthcare services and poorer quality of care, as well as lower levels of diabetes education and control of variables related to diabetes in patients in disadvantaged socioeconomic groups. The fact that inequalities are not entirely consistent may be due to the inclusion of studies with different epidemiological designs and outcome measures. Furthermore, it is important to consider that the lack of consistency may also be due to differences among the healthcare systems in the different countries evaluated.[10]

Our findings contribute to a body of evidence that suggests that diabetes monitoring strategies should focus on prevalence and incidence trends as a function of social position. Chronic diseases, such as diabetes, have been proposed as good tracer conditions that can help identify weaknesses in a national healthcare system.[29,31] This study also suggests that future interventions should include primary prevention efforts targeted at those of lower socioeconomic status to reduce the aforementioned disparities. Such monitoring may highlight gaps in the preventive and care services offered to the most vulnerable individuals and may induce governments and practitioners to address these issues.[27]

Several limitations of this study should be considered. First, our data were cross-sectional, precluding any inferences regarding causation because of the possibility of reverse causality. In terms of the association of diabetes with income level, it is possible that having a disease and suffering from its complications lead to less affluence rather than *vice versa*. With respect to educational level, however, we believe it is reasonable to assume that a diagnosis of diabetes was probably made following completion of formal education in most instances; therefore, it is plausible that educational level influenced disease risk rather than *vice versa*.[27] The second limitation of this study may be related to the single fasting glucose test to diagnose diabetes is not the universal standard of care. However, this method has been endorsed as a way to establish the population-level prevalence of diabetes.[23] Despite these limitations, this study contributes to our understanding of the prevalence, diagnosis and control of these conditions, to the determination of risk groups and to the identification of potential weaknesses in the primary and secondary prevention strategies for diabetes. Another major strength of this study is its use of population-based data, which reduced the possibility of selection bias.

Rapid aging of populations and greater longevity result in increased prevalences of chronic diseases, which lead to deficiencies in the organization and quality of care. Care for chronically ill patients is characterized by under-diagnosis, under-treatment and failure to use primary and secondary preventive measures. The chronic care model aims to transform the system of chronic disease care delivery from acute and reactive to proactive, planned and population based.[29] Monitoring is expected to highlight the gaps in the preventive and care services offered to the most vulnerable individuals, and it may induce governments and practitioners to address these issues.

Conflicts of interest: None declared.

Key points

- No educational disadvantage was found in secondary prevention in the context of a universal health insurance system of Korea. Lower household income level was associated with diagnosis in men only.
- Additional interventions should include more targeted efforts to decrease a socioeconomic disparity in primary prevention.
- This widespread lack of awareness and inadequate control underscore the need for intensive efforts.

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