

Relative and combined effects of socioeconomic status and diabetes on mortality

A nationwide cohort study

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Abstract

Both low socioeconomic status (SES) and diabetes mellitus (DM) are important risk factors for mortality. However, little is known about their combined effects and relative contribution to the mortality risk.

From a nationwide cohort provided by the National Health Insurance Service in Korea, 153,075 subjects who were over 30 years of age from 2003 to 2004 were followed-up until 2010. The SESs of the subjects in the DM and non-DM (NDM) groups were categorized into 3 groups (highest 30% as S1, middle 40% as S2, and lowest 30% as S3) based on the subjects' income levels.

During the 7.9-year follow-up, 3933 deaths occurred. When the subjects were stratified into 6 groups by their socioeconomic and diabetes status, a linearly increasing pattern of the hazard ratio (HR) of mortality from the higher SES without diabetes group (NDM-S1, as a reference) to the lower SES with diabetes group (DM-S3; HR, 2.04, 95% confidence interval (CI), 1.80–2.36) was observed (P for trend < 0.001). Notably, subjects with DM in the highest SES group (DM-S1) had a significantly higher mortality risk than did non-DM subjects in the lowest SES group (NDM-S3). This pattern was maintained in cause-specific mortality but was more prominent in cardiovascular disease (CVD) and less prominent in cancer mortality. The association was not affected by gender; however, in individuals <60 years of age, the combined effects of SES and DM on mortality were more prominent (DM-S3; HR, 3.68, 95% CI, 2.95–4.60) than in those ≥60 years of age.

Low SES and DM were major determinants of mortality and synergistically increased the risks of all-cause, CVD, and cancer mortality.

Abbreviations: BMI = body mass index, CVD = cardiovascular disease, HR = hazard ratio, NHIS = National Health Insurance System, SES = socioeconomic status.

Keywords: cardiovascular mortality, diabetes mellitus, health disparity, mortality, socioeconomic status

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1. Introduction

Diabetes mellitus (DM), with its increasing prevalence and economic burden, is a major health problems worldwide.^[1,2] Recently, the increasing epidemic of diabetes has become prominent, particularly in Asian countries.^[3] In Korea, the prevalence of diabetes has increased continuously over last few decades and is currently approximately 11.0%.^[4] It is also a well-known risk factor for cardiovascular diseases (CVDs) and mortality.^[5]

Socioeconomic status (SES) is the economic and sociological position of an individual in a society, which is commonly measured by education level, income, residential area, and occupation.^[6] Epidemiologic studies already have shown that there is health inequality in the general population with differing SES; a low educational level or low income gives rise to higher incidence rates of various diseases and a higher risk of mortality.^[7,8] Poor nutritional status, a lack of access to medical care, a lack of time for physical activity, and psychological distress contribute to adverse health outcomes in people with a low SES.^[6,9,10]

SES also contributes to the morbidity and mortality of subjects with diabetes. Previous cohort studies have indicated that the incidence of type 2 diabetes, diabetes-related morbidity, and all-cause and cardiovascular mortality were higher in diabetic subjects with a low SES than in those with a high SES.^[11–15] However, few studies have evaluated the combined effects of SES and DM on mortality. In other words, we questioned whether

DM and low SES synergistically increased the mortality risk and how diabetic subjects with a high SES had different mortality risks compared to nondiabetic subjects with a low SES. In addition, we wondered whether cause-specific mortality, including cardiovascular and cancer mortality, would be differently affected by DM for different SES groups.

To answer these questions, we analyzed the National Health Insurance Service (NHIS) cohort (2002–2010), which is a nationwide longitudinal cohort in Korea. We examined and compared the all-cause, CVD, and cancer mortality risks in subjects with and without DM stratified by different SES levels based on income.

2. Methods

2.1. Study population

South Korea has a National Health Insurance System (NHIS) that encompasses all citizens living in South Korea. The NHIS also manages all individual health-related information and health service utilization. The recently released NHIS Cohort (2002–2010) database consists of 1,025,340 Koreans, which is a representative sample of 2.2% from the all-population data. It is longitudinally structured from 2002 to 2010. It contains demographic information regarding health insurance and medical information, including medical histories, treatments, and prescriptions. Importantly, this cohort contains the general health examination data of subjects who participated in biannual examinations and is merged with death records. The proportion of subjects participating in the health examinations was about 10% to 15% annually. Detailed information about the NHIS cohort was included in our previously published article.^[16]

From this cohort, we selected subjects over 30 years of age who had undergone at least 1 health examination between 2003 and 2004. We then excluded subjects who had preexisting CVD or cancer to minimize reverse causal relationship. Therefore, 153,075 subjects were included at baseline. The mean duration of follow-up was 7.9 years.

This study was based on data from the NHIS; therefore, informed consent was not specifically obtained from each individual. This study was approved by the institutional review board of Korea University Anam Hospital (IRB number: ED14188).

2.2. Determinants of DM, SES, and mortality

DM was identified by 3 measures: clinic and pharmacy codes of the diseases from the Korean version of the International Classification of Disease, 10th revision (ICD-10); a self-reported medical history of DM; and laboratory data (fasting serum glucose ≥ 126 mg/dL).

The individual SES of the subjects was identified by their medical insurance premium. Because the medical insurance premium is directly proportional to income, and this cohort was systemically sampled by age, gender, and income level from the total population, we could objectively and precisely identify the subjects' SES based on their income level. The income level was originally classified into 20 strata; therefore, we categorized the subjects' SES into 3 groups (lowest 30%, middle 40%, and highest 30%).

Health examination data included basic anthropometric measurements, and the subjects' weight, height, and systolic and diastolic blood pressure were recorded. Serum hemoglobin,

total cholesterol, and serum glucose levels were measured after an overnight fast. Details on the frequency and amount of smoking, alcohol consumption, and physical activity were also obtained.

Death records from the National Statistical Office data were included in this cohort. Causes of death were classified by the Korean version of ICD-10 codes, including CVD death (I00–I99) and cancer death (C00–D48).

2.3. Statistical analyses

The mortality risk based on the SES classification and DM status was analyzed by the Cox proportional hazards regression model. We stratified all subjects into 2 groups based on the presence or absence of DM (DM and NDM) and 3 classes of SES (S1, S2, and S3 as the highest 30%, middle 40%, and lowest 30%, respectively). For most analyses, the reference group was NDM-S1. The hazard ratio (HR) and 95% confidence interval (CI) for each group relative to the reference group were estimated for all-cause, CVD, and cancer mortality after adjusting for confounding variables, including age, gender, body mass index (BMI), alcohol, smoking, and physical activity. We used simplified status classifications for smoking (current, former, or never); alcohol (drinker or nondrinker); and physical activity (no activity, ≤ 2 times/week, or ≥ 3 times/week).

We also conducted subgroups analyses stratified by gender (male and female) and age (< 60 years old and ≥ 60 years old). The interaction between subgroups (*P*-interaction) was tested to examine the differences in the HRs across strata. All statistical analyses were performed by using SAS version 9.4 (SAS Institute, Inc., Cary, NC). All *P* values were 2-tailed, and values less than 0.05 were considered statistically significant.

3. Results

Table 1 shows the baseline characteristics of the 6 groups according to DM status (2 groups) and SES (3 classes) of the subjects. Subjects with DM were older and had a higher BMI than did those without DM. The proportion of physically active individuals (≥ 3 times/week) was highest in the S1 group and lowest in the S3 group of both the DM and NDM groups. Among the subjects with DM, the metabolic parameters differed depending on the SES; individuals in the S1 group had significantly lower fasting glucose levels and systolic blood pressure than did those in the S2 and S3 groups (Supplementary Table 1, <http://links.lww.com/MD/B153>).

The adjusted HRs of mortality were analyzed by the Cox proportional hazards regression model using the NDM-S1 group as a reference (Table 2). Generally increasing trends of the risks of all-cause, CVD, and cancer mortality were observed from the NDM-S1 to DM-S3 groups, and the increasing pattern was more prominent for CVD mortality than for cancer mortality. In a fully adjusted model, after adjusting for age, gender, BMI, smoking, alcohol, and physical activity, the DM-S2 and DM-S3 subjects had more than twice the risk of all-cause mortality (HR, 2.14 and 2.04, respectively) than did the NDM-S1 subjects, and the corresponding HR values for CVD mortality were 2.06 and 2.29, respectively. The DM-S1 group, as well as the DM-S2 and DM-S3 groups, had a significantly higher risk of all-cause mortality than did all three NDM groups (Fig. 1).

In the subgroup analyses, the increasing pattern across the 6 strata was comparable in men and women. However, when analyzed by age, the increase in slope was steeper in individuals under 60 years of age than in those over 60 years (Fig. 2). The

Table 1
Baseline characteristics of subjects with and without diabetes, according to socioeconomic status.

	NDM			DM			P for trend
	S1 (highest 30%)	S2 (middle 40%)	S3 (lowest 30%)	S1 (highest 30%)	S2 (middle 40%)	S3 (lowest 30%)	
No. of subjects	58,177	48,035	26,387	8302	7015	4903	
Age, y	46.1 (10.7)	44.4 (11.6)	49.2 (12.3)	53.8 (11.7)	52.7 (11.9)	56.1 (11.4)	<0.001
Male sex, %	66.5	64.8	42.9	64.2	63.1	51.2	<0.001
Body mass index (BMI), kg/m ²	23.8 (2.9)	23.6 (3.1)	23.5 (3.1)	24.6 (3.1)	24.6 (3.2)	24.4 (3.3)	<0.001
Smoking, %							<0.001
Current, or former	39.3	41.5	28.0	35.2	38.3	30.5	
Never	60.7	58.5	72.0	64.8	61.7	69.5	
Alcohol, %							<0.001
Yes	53.7	53.2	41.9	48.1	47.0	38.9	
No	46.3	46.8	58.1	51.9	53.0	61.4	
Physical activity, %							<0.001
≥3 times a week	20.8	15.5	14.5	24.4	18.4	17.4	
≤ Twice a week	30.7	26.4	21.4	26.5	23.1	19.1	
No	48.5	58.1	64.1	49.1	58.5	63.4	
Fasting glucose, mg/dL	90.4 (12.7)	90.2 (13.3)	90.7 (13.0)	125.3 (48.7)	128.9 (52.4)	129.0 (52.7)	<0.001
Total cholesterol, mg/dL	197.2 (36.4)	194.6 (37.0)	195.3 (37.6)	204.6 (41.1)	203.3 (42.7)	203.6 (42.0)	<0.001
Systolic blood pressure, mm Hg	123.3 (16.2)	124.3 (16.7)	125.7 (18.0)	129.8 (18.1)	131.1 (18.3)	132.5 (19.1)	<0.001

DM=diabetes mellitus, NDM=nondiabetes mellitus.

highest HR of all-cause mortality was 3.68 (95% CI, 2.95–4.60) in the DM-S3 group. Similar patterns were observed in the analyses of CVD and cancer mortality, although the statistical significance was attenuated because of the low number of cause-specific deaths (Supplementary Table 2, <http://links.lww.com/MD/B153>).

Because the effects of SES and DM on mortality were prominent in CVD deaths, we further analyzed the CVD incidence rates in each group (Fig. 3). Although the incidence rate of CVD was not significantly different in the DM group, the mortality risk was inversely associated with SES (a higher risk for a lower SES).

4. Discussion

In this large, prospective, cohort study, we found that low SES and DM were the major determinants of mortality, and the

mortality risk increased significantly when these 2 risk factors were combined. Individuals with DM with a mid to low SES had more than a 2 times greater risk of all-cause and CVD mortality than did those without DM with a high SES after adjusting for major confounders. Although the size of the risk increment was attenuated, there was a similar association for cancer mortality.

In addition, we proved that there were disparities in mortality based on the SES in a developing Asian country. Although many studies have already reported on the SES-related differences in mortality, most were performed in developed or Western countries. Considering that the growing burden of noncommunicable diseases is more rapid^[17] and that changes in social structure characterized by rapid and unplanned urbanization have aggravated economic and health inequalities in developing countries in recent decades,^[18] information about SES-related health differences in our population is important for global public health strategy. In addition, because the socioeconomic structure

Table 2
HRs for all-cause, CVD, and cancer mortality in subjects with and without diabetes, according to SES.

	NDM			DM		
	NDM-S1	NDM-S2	NDM-S3	DM-S1	DM-S2	DM-S3
All-cause mortality						
No. of deaths	933	972	821	420	418	355
Model 1	Ref.	1.42 (1.30–1.56)	1.42 (1.29–1.56)	1.60 (1.43–1.80)	2.16 (1.93–2.43)	2.09 (1.85–2.36)
Model 2	Ref.	1.31 (1.19–1.44)	1.28 (1.16–1.41)	1.67 (1.48–1.88)	2.14 (1.90–2.41)	2.04 (1.80–2.32)
CVD mortality						
No. of deaths	128	140	111	60	55	62
Model 1	Ref.	1.50 (1.18–1.91)	1.31 (1.02–1.69)	1.58 (1.16–2.15)	1.99 (1.45–2.73)	2.46 (1.82–3.34)
Model 2	Ref.	1.45 (1.13–1.85)	1.24 (0.95–1.62)	1.59 (1.15–2.20)	2.06 (1.49–2.84)	2.29 (1.66–3.16)
Cancer mortality						
No. of deaths	338	273	285	126	112	84
Model 1	Ref.	1.10 (0.94–1.29)	1.37 (1.17–1.61)	1.34 (1.09–1.64)	1.61 (1.30–1.99)	1.38 (1.09–1.76)
Model 2	Ref.	1.04 (0.88–1.22)	1.24 (1.05–1.46)	1.36 (1.10–1.69)	1.60 (1.29–1.99)	1.35 (1.06–1.73)

CVD=cardiovascular disease, DM=diabetes mellitus, HR=hazard ratio, NDM=nondiabetes mellitus, SES=socioeconomic status.

Model 1: adjusted for age, and sex.

Model 2: adjusted for age, sex, BMI, smoking, alcohol, and physical activity.

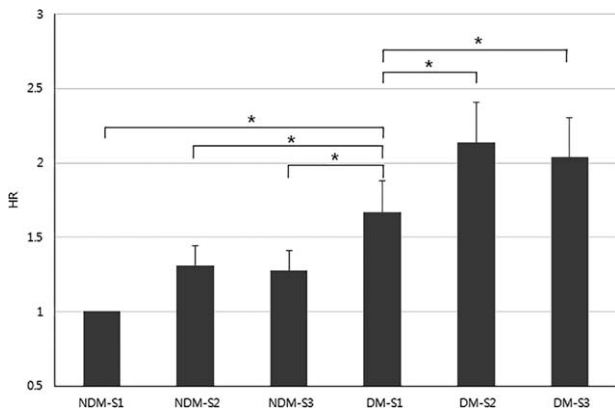


Figure 1. Differences in all-cause mortality according to SES and diabetes (adjusted for age, gender, BMI, smoking, alcohol, and physical activity) (* $P < 0.01$).

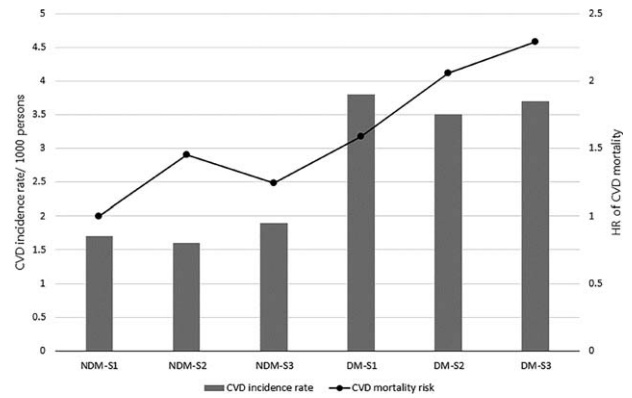


Figure 3. Differences in CVD incidence rates and CVD mortality according to SES and diabetes status.

of different countries varies according to their economic productivity, medical system, and unique social customs, our study added important evidence about health disparities in patients with DM.

We selected income as an indicator of SES rather than educational level or residential area because of the specific social structure of South Korea, which differs from that of other countries. South Korea has a high educational level, and the population is concentrated in urban areas. Currently, a majority of students (approximately 98%) go to high school, and more than 60% of high school students get a college education.^[19] In addition, one-third of the population resides in the 3 major cities.^[20] Therefore, SES measured by education level and area was not suitable to classify individuals' socioeconomic positions.

Although several previous studies have also shown that SES measured by education level, occupation, income, and area was an important contributor to mortality, particularly CVD mortality, they assessed the risk in the general population^[9,21] or only in subjects with diabetes.^[12,14,15,22,23] Only 1 study assessed the effects of educational disparities on mortality separately in adults with and without diabetes, and that study showed that the effect of SES on mortality was weaker in adults with diabetes than in those without.^[13] We had initially questioned whether there would be a difference in mortality

between diabetic subjects with a high SES and nondiabetic subjects with a low SES as well as the combined effects of low SES and DM on mortality. As a result, if an individual had diabetes but was in higher socioeconomic class, he or she had higher risk of mortality than did a subject without diabetes who was in a low SES. This finding demonstrated that diabetes was a stronger risk factor for mortality than was a low SES.

Increased CVD mortality with a low SES was well documented in subjects with and without diabetes. Generally, CVD or metabolic diseases closely related to CVD need to be managed with long-term medical care to decrease the mortality risk. Therefore, subjects with a low SES are in an unfavorable situation to manage CVD risk factors due to limited access to medical care and a lack of sufficient time for self-care, including exercise.^[6] We also observed low physical activity levels in people with a low SES regardless of diabetes status (Table 1), and a large amount of evidence has indicated that physical activity itself is an independent contributor to traditional CVD risk factors and mortality.^[24,25] In addition, access to specialized cardiac services after the onset of coronary artery disease was limited in subjects with a low SES.^[26] Our study also showed that individuals with a low SES did not have enough time to exercise compared to those with higher SES, regardless of diabetes status. Moreover, we found that cancer mortality was also affected by SES, DM, and their combined effects. Previous epidemiological studies have shown disparities in

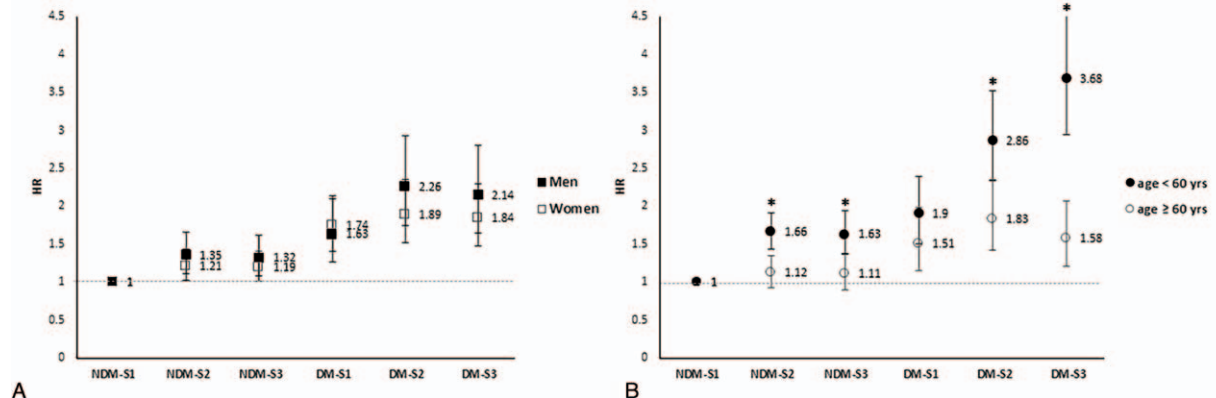


Figure 2. HRs for all-cause mortality according to SES and diabetes, stratified by gender and age (* P -interaction < 0.01).

the incidence of cancer in individuals based on their diabetes status and SES. Diabetes has been associated with an increased incidence of and mortality from various types of cancer, including colon and pancreatic cancer,^[27,28] and hyperglycemia has been associated with a higher risk of incident cancer even in the nondiabetic population.^[29] Other studies have observed that there are disparities in the incidence of cancer by race, ethnicity, and SES.^[30] Limited opportunities to participate in cancer prevention programs, including general health workups, and the resultant failure in the early detection of cancer explain the higher cancer mortality rate in the low SES group. Therefore, logically, these 2 risk factors could have contributed to the increase in cancer mortality in people with a low SES.

In the subgroups, remarkable disparities in mortality rates based on differences in DM status and SES were found in individuals younger than 60 years of age. Younger subjects in the DM-S3 group had more than a 3 times greater risk of all-cause mortality compared to younger subjects in the NDM-S1 group. Similar results have been reported for patients with diabetes in Canada^[22] and in US studies.^[13] These findings have consistently suggested the importance of intensive medical and social interventions for patients with diabetes, particularly those with a low SES.

Finally, we found discrepancies in the CVD incidence and mortality rate in subjects with DM in different SESs. The CVD incidence rates were comparable in all 3 SES groups in subjects with DM; however, CVD mortality was inversely associated with a decreasing SES, indicating that CVD mortality was higher in the lower SES group than in the higher SES group. In addition, we observed that metabolic parameters, including serum glucose level and blood pressure, were better controlled in the high SES group with DM than the low SES group. These findings suggested that well-managed CVD risk factors in the high SES group with DM could somewhat explain the lower mortality from CVD.

The overall findings of this study consistently showed health disparities according to SES and indirectly indicate the need for social action to improve health care in people with a low SES. Limited access to the medical care system and limited time for healthy behavior in people with a low SES resulted in poorer metabolic parameters (shown in Supplementary Table 1, <http://links.lww.com/MD/B153>) and eventually increased the mortality risk of CVD. Considering that population-wide interventions, including tobacco and alcohol taxes, have effectively reduced the burden of common diseases,^[17] we need more social interventions to reduce the burden of cardiometabolic diseases on government and society,^[31] such as a sugar tax for industry, and to strengthen access to health care, particularly in low- and middle-income populations.^[32] However, issues on health disparity are a global problem and are not confined to developing countries or local areas. The current structure of health in terms of the public area is complex and consists of multiple factors, including social inequalities, economy, settings, environments, and medical systems.^[32] Therefore, we need national and international health policy programs to improve health and to reduce the gap of health inequalities, such as WHO's "healthy cities" project.^[33,34]

This study has several limitations and strengths. We did not obtain some important information, including education levels and marital status, and did not adjust the changes in SES that may have influenced health outcomes. The subjects selected for this study from the original cohort were limited to those who participated in regular health examination programs; therefore, this study likely included subjects who were healthier or more

concerned about their health. However, we could correctly determine the SES of the subjects by their income based on their medical insurance premiums. In addition, the identification of DM status was objective and used various measures, including laboratory findings, which differed from other major studies that generally used self-reporting. Above all, this study produced strong evidence of income- and diabetes-related health inequality as it was performed on a large representative longitudinal cohort.

In conclusion, low SES and diabetes, individually and combined, affect individuals' mortality. Subjects with diabetes and a low SES had a significantly increased risk of mortality from various causes; therefore, effective interventions are needed for such patients.

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