Effect of socioeconomic status on survival in patients on the Diabetes Shared Care Program: Finding from a Taiwan nationwide cohort

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Abstract

Background: The Diabetes Shared Care Program (DSCP) is an integrated care model in Taiwan to improve the care quality of patients with diabetes. Socioeconomic status (SES) is one of the important factors affecting health, and it is confirmed as a predictor of various diseases and deaths.This study aimed to determine the relationship between survival rate and SES among patients who participated in the DSCP.

Methods: A cohort population-based study was conducted using the National Health Insurance Research Database of Taiwan from 2008 to 2013. The study subjects were type 2 diabetes. We defined individual SES and neighborhood SES by each patient's job category and household income, which were characterized as advantaged or disadvantaged. Then we compared the survival rates of SES groups by Cox proportional hazards model to adjust risk factors.

Results: This study included 16614 patients with type 2 diabetes who participated in the DSCP program. The DSCP cohort showed a high hospitalization rate in low individual SES. In terms of 10-year overall survival, DSCP participants with high individual SES living in advantaged and disadvantaged neighborhoods had lower risk of mortality than those with low SES living in advantaged and disadvantaged neighborhoods, after adjustment for age and comorbidity. DSCP participants with low individual SES living in disadvantaged neighborhoods had no significant difference of mortality as those with low individual SES living in advantaged neighborhoods.

Conclusion: In this study, we found that low individual SES, but not neighborhood SES, was associated with an increased mortality rate among DSCP participants.

Keywords: Diabetes mellitus, type 2; Hospitalization; Social class

1. INTRODUCTION

Type 2 diabetes mellitus (DM) is a complex metabolic disorder with a high prevalence of chronic complications and has, therefore, been recognized as a serious public health concern with a considerable impact on human life.[1–4] It affects individuals' functional capacities and quality of life, leading to significant morbidity and premature mortality.[5] Although adequate control of glycemia may prevent or slow the progression of diabetes complications,[6–9] the cost of treating patients with diabetes and the inpatient care has been a substantial economic burden on society and patients.[10] Diabetes prevalence is increasing in Taiwan and globally due to aging populations and rising prevalence rates of obesity and sedentary lifestyle.[11,12] Rapid economic development and urbanization in recent decades have also led to a rising burden of diabetes in many parts of the world including both developed and developing countries.[13]

Diabetes is the seventh leading cause of death in the world and the fifth in Taiwan, and over 90% of them are type 2 DM. Factors that influence the survival rate of patients with DM include socioeconomic status (SES), age, gender, lifestyle, and other environmental factors.[14–16] SES may influence access to quality of care, social support, and availability of community resources. It may also influence diabetes-related knowledge, communication with providers, treatment choices, and the ability to adhere to recommended medication, exercise, and dietary regimens.[17,18]

Thus, low SES is an important determinant that could be associated with multiple risks and worse care. Regional deprivation (often used as a proxy for individual SES) was shown to have an independent influence on the incidence and prevalence of DM.[19]

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The Diabetes Shared Care Program (DSCP) was implemented nationally in Taiwan in 2001 to increase the quality of diabetes care, to provide continuity of care, to achieve better glycemic control, and to reduce the occurrence of diabetes complications.[20] The combined effects of individual and neighborhood SES on survival rate in DSCP participants are still not clear. Therefore, we have designed a population-based study using data from the Taiwan National Health Insurance Administration to analyze the combined effects of neighborhood and individual SES on survival rate in DSCP participants.

2. METHODS

2.1. Ethics statement

The identity of all patients in the National Health Insurance Research Database (NHIRD) is concealed, a waiver of informed consent was obtained from the institutional review board (IRB). The IRB approved the protocol (VGHKS15-EM10-02).

2.2. Database

This data set is based on Taiwan's National Health Insurance Program, organized and managed by the National Health Research Institutes in Taiwan. The plan covers about 97% of the health care providers and 99% of Taiwan residents.[21] Data were collected from 2008 to 2013 using Taiwan's NHIRD. Individual patients enter the National Health Insurance (NHI) scheme when they are covered by Taiwan's mandatory NHI program and leave the program in case of death only.[22]

We enrolled 16 614 patients with type 2 DM who participated in the DSCP for more than 1 year. Patients were identified from the database through the presence of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM),[23] diagnostic code for type 2 DM (250) on there at least 3 outpatient claims or once during hospitalization records at any time from 2008 to 2013. Patients who had procedure codes P1401 to P1411 were defined as participants in the DSCP. We excluded type 1 DM and gestational DM.

2.3. Diabetes Shared Care Program

DSCP was initiated by Taiwan's Bureau of National Health Insurance in 2001, which is a health care management strategy that links the payment for services to desirable health outcomes. This program is based on a chronic model with multidisciplinary care team[23] that financially encourages the health care provider to provide patients with diabetes multiple laboratory tests annually (eg, HbA1c, total cholesterol, low-density lipoprotein, and other related health examinations, eg, for eyes or feet).[23] Participating patients are required to attend a clinic or hospital every 3 months for the adjustment of drugs by a physician and to receive diabetes education from a diabetes educator, as well as a diet consultation with a dietitian. In addition, the DSCP education model also includes appropriate lifestyle modification, encouragement of patients to exercise, frequent self-monitoring of blood sugar, proper foot care, use of subcutaneous insulin injection technique, and appropriate nutritional intake for diabetes according to clinical guidelines.[24]

2.4. Measurement

The 10-year survival rate is the key dependent variable of profits. Cause-specific survival was not used because it was not possible to determine the specific cause of death from the registry data used. Roohan et al have shown that when adapting a clinical morbidity index for use with ICD-9-CM administrative databases, the survival models for all-cause mortality and cancer-specific mortality did not differ significantly.[25]

We designed individual and neighborhood SES based on survival rate as the main independent variable of this study. The survival of DSCP participants was achieved by placing their 2008 to 2013 mortality data with claims data that indicated their start of first treatment for diabetes during the 10 years before the end of the study or death. Based on the above information, we can calculate the survival rate. Patient's characteristics included age, geographic region, comorbidities, and urbanization. The presence of comorbidities was based on the modified Charlson Comorbidity Index Score (CCIS)—a widely accepted measure for risk adjustment in the administrative claims data sets.[26]

2.5. Individual-level measures

In this study, we used the enrollee category, which defines a person's workplace and income-related insurance payment amount, as a proxy measure of individual SES, following validation of the use of this proxy by a previous studies.[4,27] Subjects were divided into three groups as follows: (1) high SES group, comprising civil servants, employees of privately owned institutions or full-time, or regularly paid personnel with government affiliation; income amount US $833 per month (New Taiwan Dollar NT$25001) or more; (2) moderate SES group, defined as members of the farmers' or fishermen's associations, and self-employed individuals, other employees; income amount between US $528 and US $833 per month (NT$15841–25 000); and (3) low SES group, the definition for veterans, families of those unemployed, and alternative service draftees; income amount lower than US $528 per month (NT$15840). We selected NT$15 840 as the low-income level cutoff point because this was the government-stipulated minimum wage for full-time employees in Taiwan in 2006.

2.6. Neighborhood-level SES

Neighborhood SES is a contextual factor of the 2001 census report based on the average family income and percentage of households in Taiwan. In that census, neighborhood household income of the township, per capita income, was determined by the Taiwan's Ministry of Finance announced on the basis of the 2001 tax statistics.[28] The advantaged or disadvantaged neighborhoods were sorted according to their median values as follows: advantaged neighborhoods had higher-than-median household incomes and disadvantaged neighborhoods had lower-than-median household incomes.

2.7. Other variables

We used population density, the percentage of residents with college-level or higher education, the percentage of residents working as agricultural workers, number of physicians per 100 000 residents, and urbanization level of residential areas divided into seven levels.[21] Urban areas were divided into level 1, the suburb areas were divided into levels 2 and 3, and rural areas were divided into levels 4 to 7. Taiwan is divided into 4 major geographic areas (Northern, Central, Southern, and Eastern) and has different medical resource distributions according to the different population densities. Hospitals also vary in their policies and treatment recommendations.

2.8. Statistical analysis

The study of statistical operations were made using the SPSS software (version 15; SPSS Inc., Chicago, IL, USA). Pearson's chi-square test was used for categorical variables including level of urbanization, gender, category, and geographic region of residence and characteristics of the hospital such as ownership, teaching level, and workload.

Cox proportional hazards regression model was used to compare the results of different SES categories and after adjusting patient characteristics (including age, urbanization, CCIS, and

area of residence) and hospital characteristics (including medical center, district, and regional). Diabetes patients with low individual SES from disadvantaged communities were taken as the reference group. A two-sided p value of <0.05 was considered statistically significant.

3. RESULTS

3.1. Demographic data and SES characteristics

Table 1 shows the distribution of demographic and social variables, selected causes of hospitalization and mortality, and how they differ depending on SES. Among the 16 614 DSCP participants in the study, most of the cases (n = 6851) were in the low SES group. DSCP participants with low individual SES were more likely to be older, female, and had a significantly worse 10-year survival rate than those with high SES. Moreover, they lived in suburban and rural areas of Northern, Central, and Southern regions of Taiwan.

All causes of hospitalization and mortality rates were higher in DSCP participants with low individual SES. Heart failure, coronary heart disease, cerebrovascular disease, and pneumonia were among the most causes of hospitalization ($p < 0.001$). There were statistically significant differences in age, comorbidities, geographic regions, and neighborhood SES among different SES status.

3.2. Univariate survival analysis

As can be seen in Table 2, among the DSCP participants, those categorized as low SES group residing in disadvantaged neighborhoods had significantly worse survival rates than all comparison groups (all $p < 0.001$). The 10-year survival rates for DSCP participants with low and moderate individual SES living in disadvantaged neighborhoods were lower than those living in advantaged neighborhoods.

Multivariate analysis using Cox proportional-hazard regression model showed that the combined effects of individual and neighborhood SES on patient's survival rates still present

Table 1

Baseline characteristics (n = 16 614)

Variable	Low SES (n = 6851) n (%)	Moderate SES (n = 6187) n (%)	High SES (n = 3576) n (%)	*p*
Mean age, y (±SD)	63.27 ± 11.15	58.91 ± 10.86	50.73 ± 10.44	<0.001
Gender				<0.001
Male	3008 (43.91)	2792 (45.13)	2346 (65.60)	
Female	3843 (56.09)	3395 (54.87)	1230 (34.40)	
CCIS				<0.001
1–3	3914 (57.13)	3745 (60.53)	262 (73.27)	
4–6	2316 (33.81)	2003 (32.37)	828 (23.15)	
≥7	621 (9.06)	439 (7.10)	128 (3.58)	
Neighborhood SES				<0.001
Disadvantaged	2935 (42.84)	382 (61.74)	1532 (42.84)	
Advantaged	3916 (57.16)	2367 (38.26)	2044 (57.16)	
Urbanization				<0.001
Urban	1472 (21.49)	643 (10.39)	993 (27.77)	
Suburban	3404 (49.69)	2413 (39.00)	1639 (45.83)	
Rural	1975 (28.83)	3131 (50.61)	944 (26.40)	
Geographic regions				<0.001
Northern	3357 (49.00)	1788 (28.90)	1770 (59.50)	
Central	1657 (24.19)	2386 (38.56)	938 (26.23)	
Southern	1664 (24.29)	1815 (29.34)	798 (22.32)	
Eastern	173 (2.52)	198 (3.20)	70 (1.96)	
Hospital characteristics				<0.001
Medical center	1401 (20.45)	1030 (16.65)	780 (21.81)	
Regional	2294 (33.48)	2165 (34.99)	1194 (33.39)	
District	1210 (17.66)	1096 (17.71)	592 (16.55)	
Clinic	1946 (28.40)	1896 (30.64)	1010 (28.24)	
All cause of hospitalization	4675 (68.24)	3902 (63.07)	1700 (47.54)	<0.001
Coronary heart disease	1090 (15.91)	744 (12.03)	253 (7.07)	<0.001
Cerebrovascular disease	959 (14.00)	672 (10.86)	174 (4.87)	<0.001
Heart failure	1181 (17.24)	771 (12.46)	188 (5.26)	<0.001
Peripheral vascular disease	134 (1.96)	83 (1.34)	22 (0.62)	<0.001
Chronic kidney disease	271 (3.96)	148 (2.39)	31 (6.87)	<0.001
Infection				
Central nervous	19 (0.28)	25 (0.40)	3 (0.08)	<0.001
Pneumonia and influenza	997 (14.55)	679 (10.97)	151 (4.22)	<0.001
Gastrointestinal	190 (2.77)	145 (2.34)	44 (1.23)	<0.001
Genitourinary	236 (3.44)	209 (3.38)	47 (1.31)	<0.001
Cellulitis	493 (7.20)	442 (7.14)	153 (4.28)	<0.001
Primary bacteremia	172 (2.51)	136 (2.20)	32 (0.89)	<0.001
All cause of mortality	919 (13.41)	547 (8.84)	109 (3.05)	<0.001

CCIS = Charlson Comorbidity Index score; SES = socioeconomic status.

Table 2

Ten-year overall survival rates in patients with diabetes mellitus

	Survival rate	95% CI	*p*
Individual SES			<0.001
Low	0.77	0.75–0.78	
Moderate	0.83	0.81–0.84	
High	0.94	0.92–0.95	
Neighborhood SES			<0.001
Disadvantaged	0.80	0.79–0.81	
Advantaged	0.83	0.82–0.85	
Individual* neighborhood SES			<0.001
High SES advantaged	0.75	0.72–0.77	
High SES disadvantaged	0.78	0.76–0.79	
Moderate SES advantaged	0.80	0.78–0.82	
Moderate SES disadvantaged	0.87	0.85–0.90	
Low SES advantaged	0.95	0.93–0.96	
Low SES disadvantaged	0.92	0.90–0.95	
Hospital characteristics			0.012
Medical center	0.81	0.79–0.83	
Regional	0.81	0.79–0.82	
District	0.80	0.77–0.82	
Clinic	0.84	0.83–0.86	

SES = socioeconomic status.

Table 3

aHR SES and neighborhood SES for mortality

	aHR	95% CI	*p*
Model 1			
Low SES disadvantage	1		
Low SES advantage	0.89	0.78–1.02	0.083
Moderate SES disadvantage	0.86	0.75–0.99	0.034
Moderate SES advantage	0.72	0.59–0.89	0.002
High SES disadvantage	0.56	0.41–0.76	<0.001
High SES advantage	0.57	0.43–0.75	<0.001
Model 2			
Individual SES			
Low	1		
Moderate	0.85	0.76–0.95	0.005
High	0.60	0.49–0.75	<0.001
Neighborhood SES			
Disadvantage	1		
Advantage	0.88	0.79–0.99	0.026
Model 3			
Low SES disadvantage	1		
Low SES advantage	0.89	0.77–1.03	0.107
Moderate SES disadvantage	0.87	0.75–1.00	0.044
Moderate SES advantage	0.73	0.59–0.90	0.003
High SES disadvantage	0.56	0.41–0.76	<0.001
High SES advantage	0.57	0.43–0.76	<0.001

Models 1 and 2 adjust for age group, geographic regions, and comorbidities. Model 3 adjusts for age group, geographic regions, comorbidities, hospital characteristics, and urbanization. This table shows the *p* values for pairwise comparisons with log-rank test between the survival curves of different SES. There was statistical significance between individual low SES status and high SES. aHR = adjusted hazard ratio; SES = socioeconomic status.

significant survival rate after making adjustment in other factors. After adjusting age, CCIS, and geographic region, hazard ratios (HRs) reveal that the individuals with high SES living in disadvantaged neighborhoods had 0.56× lower risk of death (95% CI, 0.41–0.76; $p < 0.001$) than those with low and moderate SES living in disadvantaged neighborhoods.

Regression model 2 showed that the individuals with high SES living in disadvantaged neighborhoods had 0.60× lower risk of death (95% CI, 0.49–0.75) than those with low and moderate SES living in disadvantaged neighborhoods and 0.88× lower risk (95% CI, 0.79–0.99) than those with low SES living in advantaged neighborhoods.

Regression model 3, in which we added variables including hospital characteristics, teaching level, and urbanization, indicates that diabetes patients with high individual SES living in disadvantaged neighborhoods had a lower mortality rate than those with low and moderate individual SES (HR, 0.56; 95% CI, 0.41 ± 0.76) as shown in Table 3.

The 10-year Kaplan-Meier survival curve is demonstrated in Fig. 1. Among the DSCP participants, those categorized as low individual SES had significantly worse survival rates than all comparison groups ($p < 0.001$). There is a difference between low SES patients who lived in advantaged and disadvantaged neighborhoods. Overall, a worse survival rate was seen in the disadvantaged group.

4. DISCUSSION

The results of the present study indicated that DSCP participants with low individual SES living in disadvantaged neighborhoods were at a higher risk of mortality and hospitalization than those with high SES living in disadvantaged neighborhoods, after age-adjusted CCIS. To our knowledge, this study is the first effort to examine the combined effect of individual and neighborhood SES in a population-based study on the risk of death using data provided by the current health care system in Taiwan (NHI System). Although SES has been indicated to have a significant impact on the survival of DM patients,[29] its role in DSCP participants' survival rate has not yet been valued. Some previous studies reported participation in the DSCP had better adherence to guideline-recommended examinations, better clinical process of care, and was associated with reduction of all-cause mortality and the complications of diabetes compared with nonparticipants. But SES may influence multiple aspects of diabetes management including the quality of health care, availability of community resources, acquisition of diabetes-related knowledge, communication with health care providers, adherence to recommended medication, exercise intensity, and dietary regimens.[17]

Few research reports have focused on the correlation between SES and DM comorbidity and mortality.[30,31] Walker et al noticed a significant association between low individual SES, greater comorbidity, and a high mortality rate. Another study carried by Lee et al found that individuals with low SES have a higher incidence and prevalence rate of DM.[32,33] However, no reports investigated whether both individual- and neighborhood-level SES contribute to DSCP participants' survival rates.

Neighborhood features that may affect the survival rate of DM patients can be physical or social characteristics of the neighborhood environment. Whether a patient lives in an advantaged or disadvantaged community may influence the accessibility of health care services or the frequency with which patients undertake beneficial behaviors.

Pay-for-performance program with the DSCP was established by Taiwan's Ministry of Health and Welfare in 2001 to reduce the medical costs of diabetes and improve diabetes management and glycemic control. It has been proven to be cost-effective, especially in patients with type 2 DM with hypertension and hyperlipidemia. This program provides financial incentives for providers to increase regular follow-up visits, self-education, and comprehensive diabetes-specific assessment.[23] The DSCP team members, including physicians, nurses, and dietitians, are required to participate in clinical training to become certified in the Taiwan Diabetes Shared Care System. Hao et al showed that patients enrolled in the DSCP program had significantly

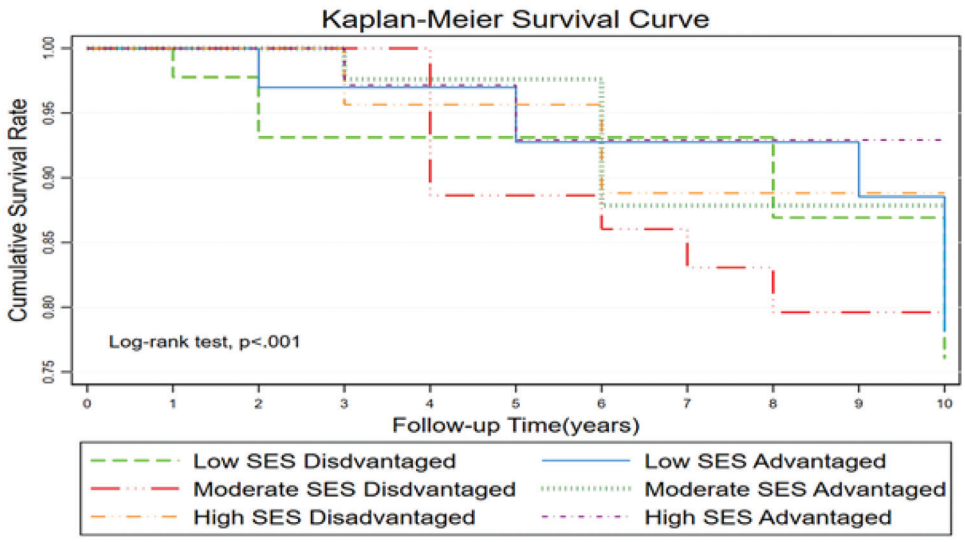

Fig. 1 Survival curve according to individual-level and neighborhood-level socioeconomic status (SES) for Diabetes Shared Care Program participants.

improved blood pressure and lipid profiles, including high- and low-density lipoprotein.[34] Another study by Kornelius et al also reported that patients engaged in the DSCP program had a 14% reduction in cardiovascular disease events, a 16% reduction in stroke risk, and a 22% reduction in all-cause mortality.[35] Chen et al demonstrated that participation in the DSCP programe was associated particularly with a lower risk of hospital mortality for infectious diseases than non-DSCP participants (2.18% vs 4.82%; $p < 0.001$).[36]

Among the DSCP participants in our study, those with low individual SES had the highest risk of mortality, regardless of whether they lived in an advantaged or a disadvantaged neighborhood. Patients with low individual SES tended to live in rural and suburban areas or live in northern, central, and southern areas of Taiwan. In this study, we also discovered an increase in the number of hospitalization and found that heart failure, coronary heart disease, cerebrovascular disease, and pneumonia were the most causes of hospitalization ($p < 0.001$).

Our study found no significant association between lower neighborhood SES and the mortality rate among DSCP participants after adjusting some of the hospital characteristics, including teaching level and urbanization. Millstein et al also found no significant relationship between these two variables among low-income and urban African American populations.[37] The possible reasons for the above findings among this group may be caused by their increased competing mortality and food environments. Socioeconomic inequality is an independent factor influencing the prognosis of diabetes patients with participation in the DSCP. Our results evaluating the effect of individual and neighborhood SES on mortality in DSCP participants emphasize that the evaluation of SES is necessary for every type 2 DM patient, as it appears to be a risk factor for diabetes complications and plays a significant role on the survival rate of DM patients. In addition, doctors who treat patients with diabetes should understand the impact of SES on clinical outcomes, particularly for those with low individual SES, to improve the survival rate in this population.

One limitation of our study is that the diagnosis of DSCP participants and comorbidity was obtained from ICD-9-CM codes based on NHI claims. Taiwan's NHI Bureau regularly updates by conducting random checks of charts and interviews patients to confirm the accuracy of their diagnoses in the database. Another issue is our inability to obtain detailed information of participants in study from the database of insurance claims on their regularity of physical exercise, dietary patterns, smoking habits, body mass index, and other risk factors that may affect survival rate in those with diabetes, such as alcohol consumption. Therefore, future studies should be designed to review the mortality and survival rates of those with diabetes in terms of these variables, using questionnaires to garner more information on the effect of lifestyle and diet. However, given the demonstrated soundness of the statistical analyses used here, these restrictions do not compromise the validity of our study results.

In conclusion, DSCP participants with low individual SES have a high mortality rate, regardless of living in an advantaged or disadvantaged neighborhood. This association suggests that attempts should be encouraged to address the existing divergence in SES patients with diabetes and to manage their disease

Table 4

Pairwise comparison

	Low SES disadvantaged	Low SES advantaged	Mooerate SES disadvantaged	Moderate SES advantaged	High SES advantaged	High SES advantaged
Low SES disadvantaged						
Low SES advantaged	0.588					
Moderate SES disadvantaged	0.017	0.433				
Moderate SES advantaged	<0.001	<0.001	<0.001			
High SES advantaged	<0.001	<0.001	<0.001	0.066		
High SES advantaged	<0.001	<0.001	<0.001	0.042	1.000	

p value for pairwise comparison with the log-rank test between the survival curves of different socioeconomic status.
SES = socioeconomic status.

based on the patient's SES status. The cause of the high mortality rate in DSCP participants with low individual SES status needs further study to delineate.

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