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# Effect of Socioeconomic Status on Mortality Among People With Type 2 Diabetes

A study from the Scottish Diabetes Research Network  
Epidemiology Group

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**OBJECTIVE**—The study objective was to describe the effect of socioeconomic status (SES) on mortality among people with type 2 diabetes.

**RESEARCH DESIGN AND METHODS**—We used a population-based national electronic diabetes database for 35- to 84-year-olds in Scotland for 2001–2007 linked to mortality records. SES was derived from an area-based measure with Q5 and Q1 representing the most deprived and affluent quintiles, respectively. Poisson regression was used to estimate relative risks (RRs) for mortality among people with type 2 diabetes compared with the population without diabetes stratified by age (35–64 and 65–84 years), sex, duration of diabetes (<2 and ≥2 years), and SES.

**RESULTS**—Complete data were available for 210,994 eligible individuals (99.4%), and there were 33,842 deaths. Absolute mortality from all causes among people with type 2 diabetes increased with increasing age and socioeconomic deprivation and was higher for men than women. RR for mortality associated with type 2 diabetes was highest for women aged 35–64 years in Q1 with diabetes duration <2 years at 4.83 (95% CI 3.15–7.40) and lowest for men aged 65–84 years in Q5 with diabetes duration ≥2 years at 1.13 (1.03–1.24).

**CONCLUSIONS**—SES modifies the association between type 2 diabetes and mortality so that RR for mortality is lower among more deprived populations. Age, sex, and duration of diabetes also interact with type 2 diabetes to influence RR of mortality. Differences in prevalence of comorbidities may explain these findings.

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Prevalence of type 2 diabetes is higher in deprived than affluent areas of developed countries, and socioeconomic deprivation seems to have a more marked effect on diabetes prevalence among women than among men in several populations (1–4). Inequalities in morbidity and mortality from the complications of

both type 1 and type 2 diabetes by individual or area-based measures of socioeconomic status (SES) have been described in many studies (5). A review of data collected up to 1995 from a variety of populations concluded that mortality rates among people with diabetes were approximately double those of people in the general population (6). However, relative risks (RRs) of mortality associated with diabetes seem to have declined in more recent years (7).

There has been limited investigation of the role of SES in the association between type 2 diabetes and mortality. SES could confound the association between diabetes and mortality because it is associated with both diabetes prevalence and mortality. Previous studies have described higher mortality among people with diabetes from more deprived areas or of lower educational achievement than among people from more affluent areas or higher educational achievement, but they have not described whether the strength of the association between diabetes and mortality varied by SES (8,9).

We have used population-based data to investigate the relationships between SES and prevalence and mortality of type 2 diabetes in men and women in Scotland to test the hypothesis that SES confounds or modifies the association between type 2 diabetes and mortality.

## RESEARCH DESIGN AND METHODS

Population-based data are available for people with diagnosed diabetes in Scotland (population 5.1 million people) from the Scottish Care Information–Diabetes Collaboration (SCI-DC) dataset (10). In brief, the dataset has existed at a national level since 2000, contains demographic and clinical data relevant to diabetes care, and is populated by daily downloads from primary and secondary care databases across Scotland. Data are collated from 995 of the 1,000 general practices in Scotland

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\*A complete list of the members of the Scottish Diabetes Research Network Epidemiology Group can be found in the Supplementary Data.

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and from all hospital clinics. The use of a unique identifier for health records in Scotland, the Community Health Index number, allows the capture of data for all patients with a diagnosis of diabetes registered with a contributing practice and tracking of movements between practices, and permits linkage to mortality records.

An area-based measure of SES can be assigned to individual people with diabetes on the basis of where they live by using the Scottish Index of Multiple Deprivation (SIMD) 2006 (see <http://www.scotland.gov.uk/Topics/Statistics/SIMD> for more information). SIMD 2006 combines 31 indicators across seven domains of income—employment, health, education, housing, geographic access, and crime—and the overall index is generated from a weighted sum of the seven domain scores for each datazone, which contains a median of 769 people and can be identified from postcodes. Quintiles of the index are defined at a national level, and Q1 and Q5 were used to identify the most affluent and most deprived quintiles, respectively.

An extract of SCI-DC data was performed in May 2008. The Information and Statistics Division of the National Health Service National Services Scotland (NHS NSS) assigned SIMD using postcode and linked the SCI-DC extract to mortality records provided by the General Register Office for Scotland. A research database containing no identifiable information was used for analysis. Approval for the generation and analysis of the linked dataset was obtained from the SCI-DC steering committee, the Scottish multicenter research ethics committee, the Privacy Advisory Committee of NHS NSS, and the Caldicott guardians of all 14 Health Boards in Scotland.

The dataset used for this analysis contained information on people with type 2 diabetes (confirmed by an algorithm using age at diagnosis and use and timing of treatment with oral hypoglycemic agents and insulin) who were alive and aged 35–84 years during the period 2001–2007. An individual's data were included if complete information on date of birth, sex, SES, and date of death (if appropriate) were available. The numbers of people and of deaths in the whole population of Scotland by age, sex, calendar year, and quintile of SES were obtained from the General Register Office for Scotland.

The European Standard Population for 35- to 84-year-olds was used to

estimate age-standardized prevalence of type 2 diabetes for 2007 by sex and SIMD quintile. The denominator for estimates of prevalence was the total population minus the number of people with type 1 diabetes. The denominators for estimates of mortality were generated from the total Scottish population minus the numbers of people with type 1 diabetes and type 2 diabetes at the midpoint of each year. Associations between prevalence and SES were investigated using Poisson regression with stratification by sex and adjustment for age. Relationships between diabetes and all-cause mortality for 2001–2007 among people with type 2 diabetes stratified by age (35–64 and 65–84 years), sex, duration of diabetes (<2 and  $\geq 2$  years), and SES were also investigated using Poisson models to investigate whether interactions were present. The strata for age and duration of diabetes were chosen after combining larger numbers of strata into groups with similar effects. For example, RRs were similar for strata of duration of diabetes of 2–5, 6–9, and 10+ years, so data were combined to give a group with duration  $\geq 2$  years. Likelihood ratio tests were used to compare a model without interaction between type 2 diabetes and SES with a model with interaction in each age, sex, and duration stratum.

**RESULTS**—Data were available for 212,227 people with type 2 diabetes who were aged between 35 and 84 years during 2001–2007. Information on SES was not available for 1,233 individuals (0.6%) who were excluded from the analysis. The numbers of people with prevalent diabetes and population denominators and their distribution by sex and SES quintile are given in Table 1. People in the most deprived quintile and men were younger among prevalent cases and deaths than those in the most affluent quintile and women.

Age-standardized prevalence of type 2 diabetes by SES quintile and sex is shown in Fig. 1. Prevalence of type 2 diabetes was higher in men than in women and in deprived populations compared with affluent populations. SES had a more marked effect on diabetes prevalence among women than men: age-adjusted RR for Q5 versus Q1: 2.00 (95% CI 1.52–2.62) for women and 1.58 (1.20–2.07) for men.

There were 33,842 deaths among people with type 2 diabetes and 241,200 deaths among people with neither type 1

nor type 2 diabetes in Scotland in 2001–2007. Age-standardized mortality was 19.47 (95% CI 19.08–19.85) per 1,000 person-years among men with type 2 diabetes and 13.40 (13.33–13.47) per 1,000 person-years among men who did not have diabetes. Comparable estimates for women were 15.83 (15.43–16.24) and 8.45 (8.39–8.50), respectively. Age-standardized mortality rates for people with type 2 diabetes and the population without diabetes by sex, SES, and duration of diabetes are shown in Fig. 2. The highest absolute mortality rates were observed among men in the first 2 years after diagnosis of type 2 diabetes. There was a marked socioeconomic gradient in mortality across all strata of duration of diabetes and in the nondiabetic population. In most strata, mortality was significantly higher among people with diabetes than those without diabetes. Death rates among men in the two most deprived quintiles who had had type 2 diabetes for 2–4 years were not significantly different from those among the population of nondiabetic men. Men without diabetes in the two most deprived quintiles have particularly high mortality.

Rrs for all-cause mortality associated with type 2 diabetes stratified by age, sex, duration of diabetes, and SES are shown in Table 2. RRs were generally higher in groups with lower absolute mortality risk and were higher for younger than older people, for women than for men, and for more affluent people than more deprived people. The results of likelihood ratio tests indicate that models that include an interaction term between type 2 diabetes and SES fit the data better than models that do not include an interaction term for men <65 years of age with duration of diabetes of <2 years and all groups with duration of diabetes of  $\geq 2$  years regardless of sex or age-group.

**CONCLUSIONS**—Our findings of increasing prevalence of diabetes associated with increasing deprivation and a more marked effect in women than men are consistent with other studies (1,3,4,11). These associations reflect differences in obesity prevalence (12). As expected, marked gradients in mortality by SES were found regardless of diabetes status, and absolute risks of mortality were higher in people with type 2 diabetes than people without diabetes in most subgroups. Type 2 diabetes is associated with increased risk of mortality not only because it increases the risk of life-threatening

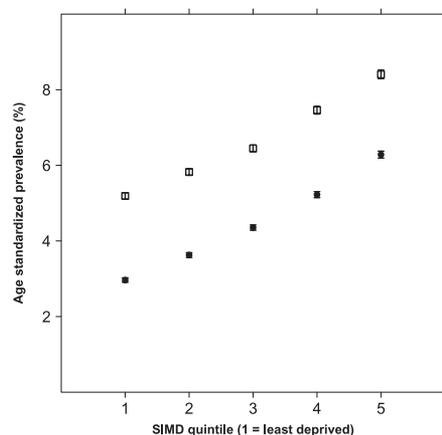
**Table 1—Crude prevalence, mortality, numerators, and denominators for each estimate for type 2 diabetes in Scotland 2001–2007 for people aged 35–84 years by sex**

	Sex	SIMD quintile				
		1 (least deprived)	2	3	4	5 (most deprived)
Population of Scotland 2007	M	282,617	293,471	285,773	262,888	238,700
	F	307,790	318,857	313,689	302,185	282,955
No. of people with type 2 diabetes 2007	M	15,309	18,349	19,962	21,142	21,086
	F	10,241	13,296	15,941	18,535	19,872
Crude prevalence 2007 (%)	M	5.4	6.3	7.0	8.0	8.8
	F	3.3	4.2	5.1	6.1	7.0
Mean (SD) age of people with type 2 diabetes in 2007 (years)	M	64.6 (10.7)	64.7 (10.8)	64.4 (10.9)	64.0 (11.0)	62.8 (11.2)
	F	66.8 (10.9)	66.8 (11.0)	66.3 (11.1)	66.3 (11.2)	65.2 (11.5)
Proportion (%) of people with type 2 diabetes aged <65 years in 2007	M	48.4	47.0	47.6	48.8	52.6
	F	38.7	38.3	39.4	39.5	42.9
Mean (SD) duration of diabetes among whole cohort (years)	M	7.7 (6.8)	7.7 (6.8)	7.6 (6.6)	7.6 (6.6)	7.4 (6.3)
	F	7.5 (6.7)	7.7 (6.8)	7.7 (6.6)	7.8 (6.6)	7.6 (6.3)
No. of deaths among people with type 2 diabetes 2001–2007	M	2,441	3,309	3,922	4,470	4,838
	F	1,583	2,302	3,017	3,670	4,290
Mean (SD) age at death of people with type 2 diabetes 2001–2007 (years)	M	73.2 (8.2)	73.1 (8.3)	72.2 (8.6)	71.8 (8.6)	70.3 (9.0)
	F	75.2 (7.6)	74.5 (7.6)	74.0 (8.1)	73.4 (8.5)	72.5 (8.6)
Proportion (%) of deaths at age <65 years among people with type 2 diabetes 2001–2007	M	15.0	15.1	17.8	19.2	23.8
	F	10.2	10.8	12.5	14.4	16.7

Duration describes time from diagnosis to end of 2007 or death.

complications but also because risk factors such as obesity increase the risk of cardiovascular disease and cancer, as well as diabetes.

Previous studies suggesting that diabetes confers approximately double the risk of mortality compared with a population without diabetes took place before



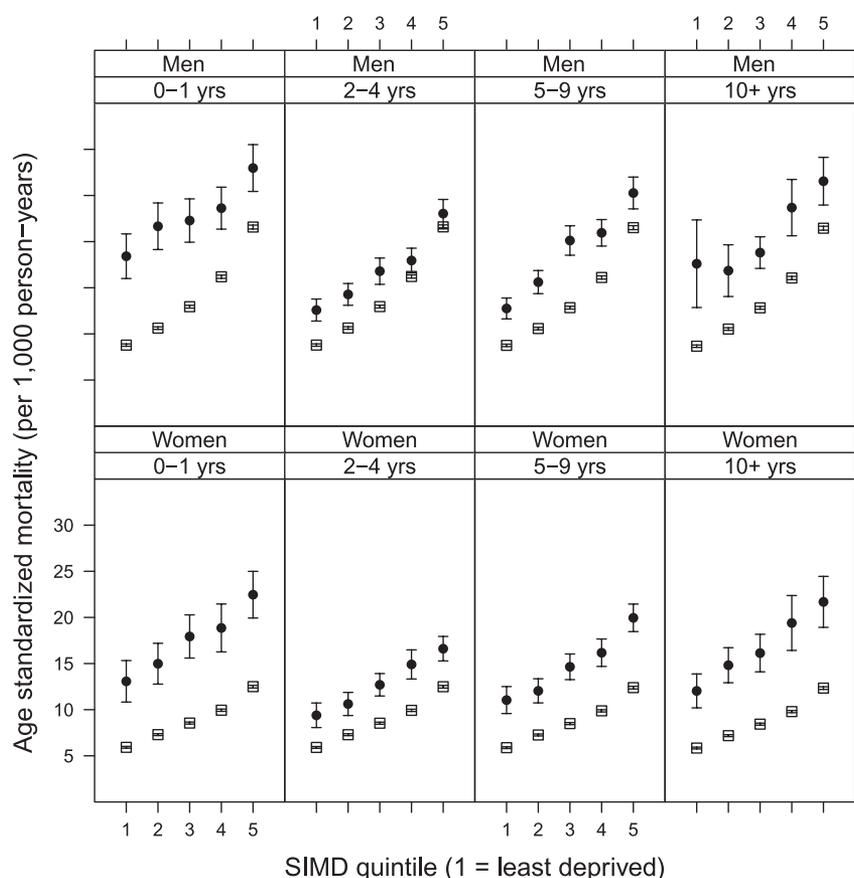
**Figure 1—Age-standardized prevalence (and 95% CI) for type 2 diabetes for 35- to 84-year-olds by sex and quintile of SIMD (1 = most affluent, 5 = most deprived) for 2001 to 2007. □, Men; ■, women.**

the widespread use of effective approaches to prevention of cardiovascular disease. For example, the Nurses' Health Study reported age-adjusted RRs of all-cause mortality among women aged 30–55 years for 1976–1996 of 3.39 (95% CI 3.08–3.73) for women with a history of diabetes and no coronary heart disease (CHD) at baseline compared with women with neither diabetes nor CHD at baseline (13). Among 44,230 patients aged 35–89 years in 1992 with prevalent type 2 diabetes identified from the General Practice Research Database in the U.K. who were followed up until October 1999, hazard ratios for all-cause mortality compared with a matched cohort with no record of diabetes at any time were 1.77 (1.72–1.83) for men and 2.13 (2.06–2.20) for women (14).

Adjusting for age, as these studies did, obscures the effect of any interaction, although age-stratified analyses indicate lower hazard ratios among older than younger people in the General Practice Research Database study (14). We have shown that age, sex, duration of diabetes, and SES all modify the effect of type 2 diabetes on RR of mortality. These

multiple interactions make summary measures of the effect of diabetes on mortality specific to each study population. Differences in such summary measures across populations and time periods may be partially explained by differences in population structures. Age-adjusted RRs for mortality associated with type 2 diabetes in the Scottish population for 2001–2007 were 1.38 (95% CI 1.28–1.48) for men and 1.67 (1.58–1.77) for women, with further adjustment for SES having little effect: 1.35 (1.30–1.40) for men and 1.62 (1.57–1.67) for women.

Rrs of mortality associated with type 2 diabetes seem to be declining over time. It is not clear whether changes in distribution of age, sex, duration of diabetes, and SES may have contributed to these apparent time trends. RR of mortality among people with diabetes compared with mortality in the U.K. population as a whole was 26% (95% CI 8–40) lower in 2006 than in 2001 (7). The decline described in this study may partly be due to the use of the whole population rather than the nondiabetic population as the comparison group and the increasing prevalence of diabetes over this period,



**Figure 2**—Age-standardized mortality for people with type 2 diabetes and for the population of Scotland without diabetes for 2001–2007 stratified by sex and duration of diabetes. □, General population (no diabetes); ●, type 2 diabetes.

resulting in a higher proportion of people with diabetes in the denominator. However, a Danish study describing mortality associated with diabetes between 1995 and 2006 also described declines in standardized mortality ratios with comparison of mortality in the diabetic

population with that of the nondiabetic population over time (15). Changes in diagnostic criteria for diabetes and increased opportunistic screening for diabetes might have contributed to lower RRs of mortality associated with diabetes in recent years. Increased prescribing of

effective treatments for control of diabetes, hypertension, and dyslipidemia may also have contributed to increasing survival of people with diabetes over time (16).

Our findings that RR of mortality among people with diabetes were lower at older age are consistent with the findings of other studies (7,15,17). We found a higher RR of diabetes for mortality among women than men, as have most other studies, although the Danish study reported virtually identical standardized mortality ratios for men and women (15). These findings may relate to differences by age, sex, and between countries in distribution of cardiovascular disease risk factors and comorbidities between people with and without diabetes. Hypertension, dyslipidemia, and obesity are strongly associated with diabetes but are also most prevalent in older men and least prevalent in younger women in many countries. In contrast, prevalence of smoking is more similar in men and women in Denmark than in other countries. A meta-analysis of 16 studies that included risk factor data suggests that sex differences in both all-cause and cardiovascular disease mortality do not persist after adjusting for classic risk factors for coronary heart disease (age, hypertension, total cholesterol level, and smoking) (18). This suggests that differences between people with type 2 diabetes compared with people without diabetes in prevalence of cardiovascular risk factors may be more marked among women than men, but further data are needed to confirm this hypothesis.

The Danish population-based study also reported higher relative mortality in people with recently diagnosed diabetes

**Table 2**—RRs for all-cause mortality for people with type 2 diabetes compared with the Scottish population without type 2 diabetes aged 35–84 years for the period 2001–2007 stratified by age, sex, duration of diabetes, and socioeconomic status

Quintile of SES	Duration of diabetes <2 years			
	Men aged 35–64 years	Men aged 65–84 years	Women aged 35–64 years	Women aged 65–84 years
Q1 (most affluent)	3.74 (2.57–5.44)	1.88 (1.34–2.64)	4.83 (3.15–7.40)	1.91 (1.40–2.60)
Q2	4.08 (3.08–5.40)	1.72 (1.28–2.31)	4.36 (3.09–6.17)	1.74 (1.34–2.26)
Q3	2.99 (2.27–3.94)	1.48 (1.12–1.95)	4.28 (3.24–5.67)	1.64 (1.29–2.08)
Q4	2.17 (1.67–2.81)	1.37 (1.05–1.78)	3.84 (3.01–4.90)	1.40 (1.15–1.76)
Q5 (most deprived)	1.75 (1.40–2.18)	1.23 (0.94–1.60)	3.13 (2.52–3.89)	1.48 (1.21–1.82)
P (LR test)	< 0.0001	0.29	0.23	0.48
Quintile of SES	Duration of diabetes ≥2 years			
	Men aged 35–64 years	Men aged 65–84 years	Women aged 35–64 years	Women aged 65–84 years
Q1 (most affluent)	3.43 (2.89–4.07)	1.53 (1.34–1.73)	3.85 (3.15–4.69)	1.84 (1.64–2.06)
Q2	2.69 (2.32–3.13)	1.46 (1.31–1.63)	3.51 (2.99–4.12)	1.62 (1.47–1.78)
Q3	2.75 (2.43–3.11)	1.32 (1.20–1.47)	3.25 (2.85–3.70)	1.59 (1.46–1.73)
Q4	2.26 (2.03–2.53)	1.19 (1.08–1.31)	3.10 (2.78–3.46)	1.46 (1.35–1.58)
Q5 (most deprived)	1.75 (1.59–1.92)	1.13 (1.03–1.24)	2.72 (2.47–2.99)	1.43 (1.33–1.54)
P (LR test)	< 0.0001	0.0002	0.006	0.003

The results of likelihood ratio tests for interaction between presence of diabetes and SIMD quintile are given in the rows labeled “P (LR test).” LR, likelihood ratio.

than for people with diabetes of moderate duration, as we did (15). This could be explained by increased detection of diabetes in people receiving treatment for other medical conditions (e.g., cardiovascular disease) that increase mortality.

Educational disparities in mortality have been found to be lower among adults with diabetes than adults without diabetes in Italy, Finland, and the U.S. (9,19,20). It is possible that better control of cardiovascular risk factors among deprived people with diabetes when compared with deprived people without diabetes could account for this effect by reducing the risk of comorbidity among people with diabetes. Our previous work suggests control of blood pressure, cholesterol levels, and glycemia among people with type 2 diabetes are similar across socioeconomic groups in Scotland (21). These patterns contrast with unfavorable trends in risk factor profiles by SES observed in the general population. Smoking prevalence in Q1 in people with diagnosed diabetes (15%) is similar to that of participants in the Scottish Health Survey 2008 (15% in men and 14% in women in Q1), whereas smoking prevalence in Q5 is considerably lower among people with diagnosed diabetes (33% in both men and women) than among Scottish Health Survey 2008 participants (40% in men and 39% in women) (22). Consequently, the lower RR of mortality associated with diabetes in deprived populations may be related to markedly higher prevalence of life-shortening comorbidity among deprived than affluent people without diabetes.

The strengths of this study include the population-based nature of the electronic record of diagnosed diabetes that captures data from all but 5 of the 1,000 primary care practices in Scotland. Data completeness in the SCI-DC dataset is excellent, and mortality data for the whole study population are available from data linkage. Data on type of diabetes have been validated using age at diagnosis and prescribing data for insulin and oral antidiabetic drugs. The use of an area-based measure of SES rather than an individual-based measure is a potential limitation of the study. However, the small average population size of each datazone used to create the SIMD (median <800 people) makes it preferable to previous area-based measures. The inclusion of the health domain in the measure of SES does not seem to have a major effect on the pattern of health inequalities

by SES (23). At present, we have insufficient data to examine time trends in mortality associated with diabetes.

In conclusion, both socioeconomic deprivation and type 2 diabetes were associated with increased absolute mortality risk, but relative mortality associated with type 2 diabetes was lower among deprived than affluent populations. Data on the prevalence of risk factors and their management and comorbidity are available for people with diabetes in Scotland, but similar information from the nondiabetic population is required to explore the role of these factors in explaining the excess mortality associated with diabetes. Further research is required to develop effective interventions to reduce socioeconomic inequalities in the prevalence of type 2 diabetes and its complications, including mortality.

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No potential conflicts of interest relevant to this article were reported.

J.J.W. performed the analyses and prepared the tables and graphs. S.J.L. and H.M.C. generated the algorithm to validate the type of diabetes. R.S.L., J.A.M., A.D.M., J.R.P., S.P., and N.S. contributed to SCI-DC data collection through their clinical work. S.H.W. wrote the article and incorporated the comments provided by all other authors.

These data are available for analysis by members of the Scottish Diabetes Research Network Epidemiology Group because of the hard work of numerous NHS staff who enter the data as well as the individuals and organizations (the SCI-DC Steering Group, the Scottish Diabetes Group, the Scottish Diabetes Survey Monitoring Group, and the managed clinical network managers and staff in each Health Board) involved in setting up, maintaining, and overseeing the SCI-DC database.

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