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Socio-economic status and mortality in people with type 1 diabetes in Scotland 2006–2015: a retrospective cohort study

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What's new?

- The socio-economic gradient in mortality within the general population and in type 2 diabetes is established. Scandinavian population-based cohort studies of people with type 1 diabetes have reported an inverse association between socio-economic status and mortality but there are no contemporary data for the UK.
- This study found that socio-economic deprivation was associated with higher mortality in people with type 1 diabetes in Scotland, that the effect of deprivation was larger than in the general population and that inequalities appear to be widening over time.
- Effective interventions to reduce socio-economic inequalities in outcomes of type 1 diabetes are required.

Abstract

Aims To describe the association between socio-economic status and mortality in a nationwide cohort of people with type 1 diabetes in Scotland and to compare patterns over time and with the general population.

Methods A retrospective cohort study was performed using data for people with type 1 diabetes from a population-based register linked to mortality records. Socio-economic status was derived from quintiles of an area-based measure: the Scottish Index of Multiple Deprivation. Sex-specific directly age-standardized mortality rates for each Scottish Index of Multiple Deprivation quintile and rate ratios comparing the most vs least deprived quintile were calculated for two time periods: 2006–2010 and 2011–2015. Data for the population without type 1 diabetes between 2011 and 2015 were available for comparison.

Results Data for 3802 deaths among 33 547 people with type 1 diabetes were available.

The age-standardized mortality rate per 1000 person-years decreased over time (from 2006–2010 to 2011–2015) for men and women with type 1 diabetes: 24.8 to 20.2 and 22.5 to 17.6, respectively. Mortality in populations with and without type 1 diabetes was generally higher for men than women and was inversely associated with socio-economic status. Rate ratios for the most vs least deprived groups increased over time among people with type 1 diabetes (men: 2.49 to 2.81; women: 1.92 to 2.86) and were higher than among populations without type 1 diabetes in 2011–2015 (men: 2.06; women: 1.66).

Conclusions Socio-economic deprivation was associated with a steeper mortality gradient in people with type 1 diabetes than in the population without type 1 diabetes in Scotland. Age-standardized mortality has decreased over time but socio-economic inequalities may be increasing.

Introduction

Socio-economic gradients in morbidity and mortality within the general population and in type 2 diabetes mellitus are well established [1–3]. People from low socio-economic backgrounds have lower life expectancy and greater morbidity compared to more affluent peers, which has been attributed to a combination of financial, social and behavioural factors [4]. In the past two decades, improvements in life expectancy have occurred across the UK but the difference between the most and least affluent groups appears to be increasing [5,6]. It has been hypothesized that these inequalities may disproportionately affect those with chronic diseases, such as type 1 diabetes [7].

The evidence for an association between socio-economic status (SES) and outcome in type 1 diabetes is limited. Since the pathophysiology and management of type 1 and type 2 diabetes differ markedly, it cannot be assumed that the effects of SES will be similar.

Population-based studies of people with type 1 diabetes performed in Sweden and Finland found an inverse association between SES, measured using individual measures such as income and education level, and mortality [8,9]. Few studies have compared the SES gradient in mortality in populations with type 1 diabetes with those in populations with type 2 diabetes and in populations without diabetes. Studies from Italy and the USA have demonstrated larger SES gradients in mortality in people with type 1 diabetes than in these other populations, but a Finnish study found little difference [10–12]. The association between SES and outcomes of type 1 diabetes in the UK is unclear. Only a small number of studies have been conducted [13–16]. Most of these studies were small, cross-sectional studies from the late 1990s, and focused on aspects of morbidity or diabetic management. Only one study has investigated the association between SES and mortality in the UK in people with type 1 diabetes and this is now nearly 20 years old [17].

The aim of the present study was to investigate whether SES, determined by an area-based measure, was associated with mortality among people with type 1 diabetes over two time periods and to describe mortality relative to that of the population without type 1 diabetes using recent national data for Scotland

Participants and methods

Data sources

Population-based data for people with type 1 diabetes in Scotland were obtained from a 2016 extract of the Scottish Care Information – Diabetes (SCI-Diabetes) database. This national database contains demographic and clinical data relevant to diabetes care. It is populated by daily downloads from primary and secondary care databases across Scotland. Data from all hospital clinics and >99% of general practices have been included since 2004.

The algorithm used to define type of diabetes for research purposes has been described previously [18]. Annual estimates of the numbers of people with type 1 diabetes and of numbers of deaths for 2006–2015 by age, sex and five SES groups were obtained from SCI-Diabetes.

Socio-economic status was measured using the 2012 Scottish Index of Multiple Deprivation (SIMD), an area-based measure of SES [19]. It is a composite score that uses information from seven domains including income, education and crime to assign a deprivation score to each data zone. There are 6505 data zones across Scotland, with a median population of 769 people per data zone. These data zones are ranked according to their scores and divided into fifths, described as 'quintiles', with quintiles 1 and 5 representing the 20% most and least deprived areas, respectively.

Population and death data for the general population by age, sex, SIMD quintile and calendar year for the period 2011–2015 were obtained from the General Register Office for Scotland.

Participants

All people in the 2016 research extract of SCI-Diabetes with type 1 diabetes identified from the algorithm who were alive between 1 January 2006 and 31 December 2015 were included. Individuals were excluded if they had any of the following data missing: date of birth; sex; SIMD quintile; or date of type 1 diabetes diagnosis.

The numbers of people and deaths in the type 1 diabetes population were subtracted from mid-year population estimates and numbers of deaths for the whole of Scotland by age,

sex, SIMD quintile and calendar year between 2011 and 2015 to identify numerators and denominators for the population without type 1 diabetes.

Statistical analyses

The cohort of people with type 1 diabetes was split into two time periods: 2006–2010 and 2011–2015, in order to examine time trends with sufficiently large numbers of outcomes in age and sex subgroups. Descriptive data for each cohort are presented stratified by age (four categories: 0–39, 40–59, 60–79 and ≥ 80 years), sex and SIMD quintile.

Sex-specific directly age-standardized mortality rates were calculated using the above four age groups for each SIMD quintile in both time periods using the European Standard Population 2013. Sex-specific analysis was undertaken as differences in mortality by sex in populations with type 1 diabetes that have been described previously [8,20].

Rate differences and rate ratios for all-cause mortality between periods were calculated for each sex by subtraction of the age-standardized mortality rates for SIMD 1 and 5 and age-adjusted Poisson regression for SIMD 1 compared to SIMD 5, respectively. Absolute and relative mortality for the population without type 1 diabetes and their differences by SIMD quintile were calculated using the same methods. In addition, sex-specific rate differences and rate ratios were calculated to compare mortality between the population with type 1 diabetes and the population without type 1 diabetes for the period 2011–2015. Interaction terms were included in Poisson models where appropriate.

Ethics

Approval for use of anonymized linked data for research, with a waiver for individual consent, was obtained from the Scotland A Research Ethics Committee (reference

11/AL/0225) and the Privacy Advisory Committee of National Health Service (NHS) Scotland (reference 33/11).

Results

Participants

A total of 37 169 people with type 1 diabetes were identified in the SCI-Diabetes extract. Of these, 238 people (0.6%) were excluded due to missing data. A further 3384 (9.1%) were excluded as they died prior to the study period or were diagnosed after the study period. Data remained for 33 547 eligible participants. In the 2006–2010 period there were 1936 deaths during 130 972 person-years. In the 2011–2015 period there were 1866 deaths during 143 123 person-years. There were 271 356 deaths during 26 518 677 person-years of follow-up for the population without type 1 diabetes for 2011–2015.

Characteristics of the three study populations are given in Table 1. There were small differences in age distribution in the cohorts with type 1 diabetes between the two time periods. Sex and SIMD distribution was similar in the two type 1 diabetes cohorts, with a higher proportion of men than women in both. Compared to populations with type 1 diabetes, the population without type 1 diabetes had a more even balance of the sexes and a greater proportion of people in older age categories. There was a minor difference in SIMD distribution.

Mortality data

Age-standardized mortality rates for populations with type 1 diabetes, stratified by SIMD and calendar periods, are shown for men (Fig. 1) and women (Fig. 2). Age-standardized mortality rates for the population without type 1 diabetes for 2011–2015 are also presented. In all populations, the age-standardized mortality rate increased with increasing

deprivation. Within the population of people with type 1 diabetes, the age-standardized mortality rate decreased over time in every SES quintile, in both sexes. Smaller reductions in age-standardized mortality rate between time periods were seen in the most deprived quintile (13% for men and women), than in the least deprived quintile (24% for men and 47% for women). Age-standardized mortality rates were higher for men than women in most SIMD quintiles. Compared to the population without type 1 diabetes, age-standardized mortality rates were higher in the population with type 1 diabetes in every SIMD quintile, in both sexes.

Absolute differences in age-standardized mortality rate between SIMD 1 and 5 in the populations, along with rate ratios are shown in Table 2. The age-standardized mortality rate was statistically significantly higher in the most deprived compared with the least deprived quintile for both sexes in all populations. In men with type 1 diabetes, the absolute rate difference between extreme SIMD quintiles decreased over time, with no evidence of a statistically significant interaction ($P=0.422$) despite increases in rate ratios over time. In women with type 1 diabetes, both absolute and relative differences in mortality by SES increased over time ($P=0.018$ for interaction between SIMD and period).

Absolute rate differences and rate ratios between the most and least deprived SES groups were larger in the population with type 1 diabetes for 2011–2015 for both sexes than among the population without type 1 diabetes.

Absolute differences in age-standardized mortality rate and rate ratios between the population with type 1 diabetes and population without type 1 diabetes for 2011–2015 for each SIMD quintile and sex are shown in Table 3. There were higher age-standardized mortality rates in the population with type 1 diabetes compared to the population without type 1 diabetes in all SES groups for both sexes. Rate ratios of mortality for type 1 diabetes compared to the population without type 1 diabetes were higher in the most deprived than

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in the least deprived quintile (P for interaction <0.001) and were higher in women than men, with no evidence of an interaction ($P=0.257$).

Discussion

We found that mortality among people with type 1 diabetes declined over time and that socio-economic deprivation was positively associated with mortality in people with type 1 diabetes in Scotland. Socio-economic inequalities in mortality among women with type 1 diabetes appear to be widening over time. The socio-economic gradient in mortality was stronger in people with type 1 diabetes than in the general population.

The finding of a mortality gradient according to SES is consistent with previous studies of populations with type 1 diabetes. A register-based study in Sweden conducted between 2006 and 2012 found that people with type 1 diabetes in the lowest SES quintile had a relative risk of death of 2.60 (2.03–3.34) compared to people in the highest quintile [8].

Mortality gradients by SES have also been found in Finnish, US and Italian cohorts [9–11], with estimates ranging from 1.96 (1.78–2.17) [9] to 3.0 (1.2–7.8) [11] for comparisons between the lowest vs highest income groups or those without vs with college degrees, respectively. By comparison, our 2011–2015 estimate of the relative risks of mortality for people with type 1 diabetes from the most compared to the least deprived fifths of areas of Scotland was 2.81 (2.27–3.47) for men and 2.86 (2.22–3.69) for women. The studies from other countries used individual-level data on educational attainment, income and unemployment status to measure SES, whereas we used an area-based composite measure.

These different approaches may contribute to the variation among results. Other differences among studies include healthcare systems, distributions of ethnicity within study populations and time period. Nevertheless, the consistent finding of a mortality gradient supports an inverse association between SES and mortality.

Numerous mechanisms may explain these findings. Known risk factors that are associated with increased mortality in type 1 diabetes include HbA_{1c}, cholesterol, hypertension and microalbuminuria [21]. People with type 1 diabetes from low SES backgrounds are known to have higher HbA_{1c} levels than their less deprived peers [21]. Socio-economic deprivation is also associated with unhealthy lifestyles such as smoking [22] and higher prevalence of elevated cholesterol levels, hypertension and microalbuminuria [8]. Intensive insulin regimes, involving tight management of blood glucose levels through frequent testing and multiple injections of insulin daily, reduce morbidity and mortality in type 1 diabetes [23]. Uptake of these regimes is higher among more affluent SES groups [21]. Studies that have adjusted for risk factors have noted a decrease in the strength of association between SES and mortality compared to unadjusted analyses [8,11].

Nevertheless, the persistence of a relationship despite the adjustment suggests SES is an independent predictor of mortality in type 1 diabetes.

The mechanisms behind the mortality disadvantage associated with socio-economic deprivation are therefore complex. These inequalities may be widening, as suggested by the increase in the relative risk of mortality between the most vs least deprived groups over time reported in the present study and in studies of the general population [5,6]. Although our results demonstrate the SES gradient in mortality and this trend over time in people with type 1 diabetes, further studies are required to delineate the underlying mechanisms, for example, by describing differences by SES in risk factor patterns and cause-specific mortality.

Our demonstration that socio-economic inequalities in mortality appear to be greater in populations with type 1 diabetes than in the general population supports the findings of previous studies [10,11]. Explanatory hypotheses for socio-economic inequalities in

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health in the general population may be emphasized in type 1 diabetes. For example, levels of health literacy, defined as a person's knowledge, motivation and competences to access, understand and apply information in order to make judgements in everyday life concerning healthcare, disease prevention and health promotion to maintain or improve quality of life during the life course, are lower in lower SES groups [24]. As a chronic condition that requires extensive self-care and lifestyle management, health literacy is key for successful management of type 1 diabetes. Interventions at both system and practitioner level can impact positively on health behaviours in those with low health literacy [25].

Initiatives such as access to structured education and to new technologies such as insulin pumps and flash glucose monitoring have the potential to improve management of type 1 diabetes. However, their benefits may be more apparent in higher SES groups who possess the resources to facilitate their use [26]. A recent systematic review found that fewer than one-third of quality improvement trials included equity-relevant considerations, limiting their application to disadvantaged groups [27]. Ensuring that quality improvement initiatives consider their effects across socio-economic groups will help to ensure interventions are appropriate and will not inadvertently exacerbate inequalities.

Interventions tailored towards disadvantaged populations may reduce disparities in diabetes care, however, a recent review was unable to draw strong conclusions about the potential benefits [28]. Furthermore, most of these studies were conducted in populations with type 2 diabetes and in the USA, whose health service is markedly different from that of the UK [27,28]. Further research to identify effective interventions to reduce socio-economic inequalities in UK-based populations with type 1 diabetes are required to permit informed policy-making.

Relative risks of all-cause mortality associated with type 1 diabetes in Scotland may have declined over time; overall rate ratios for 2005–2007 were 2.6 (95% CI 2.2–3.0) in men and 2.7 (95% CI 2.2–3.4) in women, whereas our estimates were 1.6 (95% CI 1.5–1.8) and 1.8 (95% CI 1.7–2.0) for 2011–2015 [29]. These estimates are not directly comparable as the earlier study was limited to people aged >20 years and excluded those with type 2 diabetes from the comparison population. Type 2 diabetes confers increased mortality relative to the general population [18]. Including people with type 2 diabetes in the population without type 1 diabetes will have resulted in underestimation of rate difference and rate ratios that would have been obtained if a population without either type of diabetes was used for comparison.

We found that, among people with type 1 diabetes, men had a greater absolute risk of mortality than women at all SES levels; however, when compared to the population without type 1 diabetes, relative risks of death were greater for women than men, consistent with findings of previous studies [8,20].

The present study has a number of strengths. The SCI-Diabetes database provides a nationwide cohort, for which data completeness is excellent, and mortality data for the whole study population are available from data linkage to national records.

Misclassification of type of diabetes could be a source of information bias, particularly if this were differential by SES. However, data on the type of diabetes have been validated using the algorithm previously described. The nationwide cohort provides a large number of participants and power to detect differences, thus limiting the potential for type 2 errors.

Limitations of this study include the fact that data on risk factors were not available from the population without diabetes to permit adjusted analyses. This would have allowed evaluation of the contribution of risk factors to the observed differences in mortality.

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Although age standardization helped to reduce confounding due to age differences between populations, the use of broad age categories may mean residual confounding was still present.

The use of an area-based measure of deprivation, rather than an individual-based measure is a potential limitation as area-based measures may not fully reflect the SES of individuals [30]. Other measures of inequalities (such as the slope and relative index of inequality) are available, but we chose to present absolute and relative measures that are more familiar to a clinical audience.

Our results provide a snapshot of the situation prior to the widespread implementation of new technologies such as insulin pumps. It would be interesting to repeat this study in the future to assess any impact on inequalities in mortality. Further research is also required to investigate the mechanisms underlying inequalities in populations with type 1 diabetes and to identify effective interventions to reduce socio-economic inequalities.

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Competing interests

None declared.

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FIGURE 1 Age-standardized mortality rate (DSR) per Scottish Index of Multiple Deprivation (SIMD) quintile in Scotland for men with type 1 diabetes in the period 2006–2010, men with type 1 diabetes in 2011–2015 and men without type 1 diabetes in 2011–2015.

FIGURE 2 Age-standardized mortality rate (DSR) per Scottish Index of Multiple Deprivation (SIMD) quintile in Scotland for women with type 1 diabetes in the period 2006–2010, women with type 1 diabetes in 2011–2015 and women without type 1 diabetes in 2011–2015.

Accepted Article

Table 1 Distribution within Scotland of sociodemographic characteristics for people with type 1 diabetes between 2006 and 2010, people with type 1 diabetes between 2011 and 2015 and people without type 1 diabetes between 2011 and 2015

	Type 1 diabetes		Population without type 1 diabetes	
	2006–2010	2011–2015	<i>P</i> (Type 1 diabetes 2006–2010 vs 2011–2015)	<i>P</i> (Type 1 diabetes vs population without type 1 diabetes for 2011–2015)
Total person-years	130 972	143 123		26 518 677
Men, <i>n</i> (%)	73 277 (56)	80 91 (56)	0.43	12 860 978 (49)
Women, <i>n</i>	57 695	62 832		13 657 699
Age category, <i>n</i> (% of total)				
0–39 years	64 012 (49)	66 275 (46)		12 679 896 (48)
40–59 years	47 566 (36)	53 616 (38)	<0.001	7 532 359 (28)
60–79 years	17 611 (13)	21 076 (15)		5 100 259 (19)
≥80 years	1783 (1.4)	2156 (1.5)		1 206 163 (4.5)

SIMD, *n* (%)

1	26 426 (20)	28 791 (20)		5 329 014 (20)	
2	26 962 (21)	29 288 (21)		5 324 426 (20)	
3	27 581 (21)	29 945 (21)	0.45	5 306 098 (20)	<0.001
4	26 085 (20)	28 605 (20)		5 287 384 (20)	
5	23 918 (18)	26 494 (19)		5 271 755 (20)	

SIMD, Scottish Index of Multiple Deprivation.

P values are presented for chi-squared tests comparing differences between populations.

Table 2 Absolute differences and rate ratios for comparisons of age-standardized or age-adjusted mortality rates between SIMD 1 and SIMD 5 in the study populations

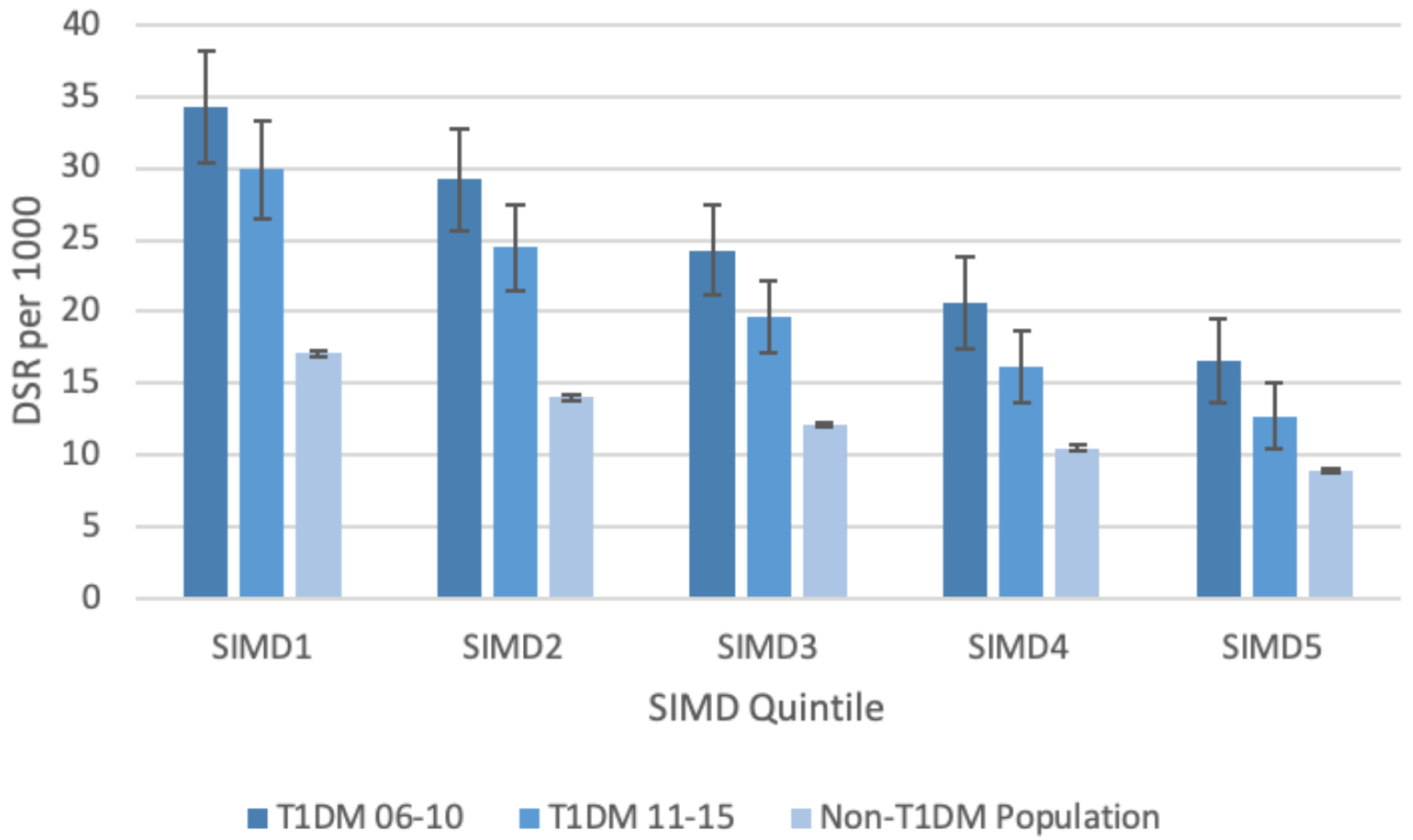
	Type 1 diabetes		Population without type 1 diabetes
	2006–2010	2011–2015	2011–2015
Men			
Rate difference (95% CI) per 1000 person-years, DSR SIMD1 – DSR SIMD5	17.7 (16.3–19.1)	17.2 (15.9–18.5)	8.20 (7.20–9.20)
Rate ratio (95% CI), SIMD1 vs SIMD5	2.49 (2.02–3.06)	2.81 (2.27–3.47)	2.06 (2.03–2.10)
Women			
Rate difference (95% CI) per 1000 person-years, DSR SIMD1 – DSR SIMD5	11.0 (9.6–12.4)	16.3 (15.1–17.5)	5.1 (4.2–6.0)
Rate ratio (95% CI), SIMD1 vs SIMD5	1.92 (1.52–2.39)	2.86 (2.22–3.69)	1.66 (1.63–1.69)

DSR, age-standardized mortality rate; SIMD, Scottish Index of Multiple Deprivation.

Table 3 Absolute rate differences and rate ratios for comparisons of age-standardized mortality rates between the Type 1 diabetes population and the population without type 1 diabetes for 2011–2015, stratified by Scottish Index of Multiple Deprivation quintile

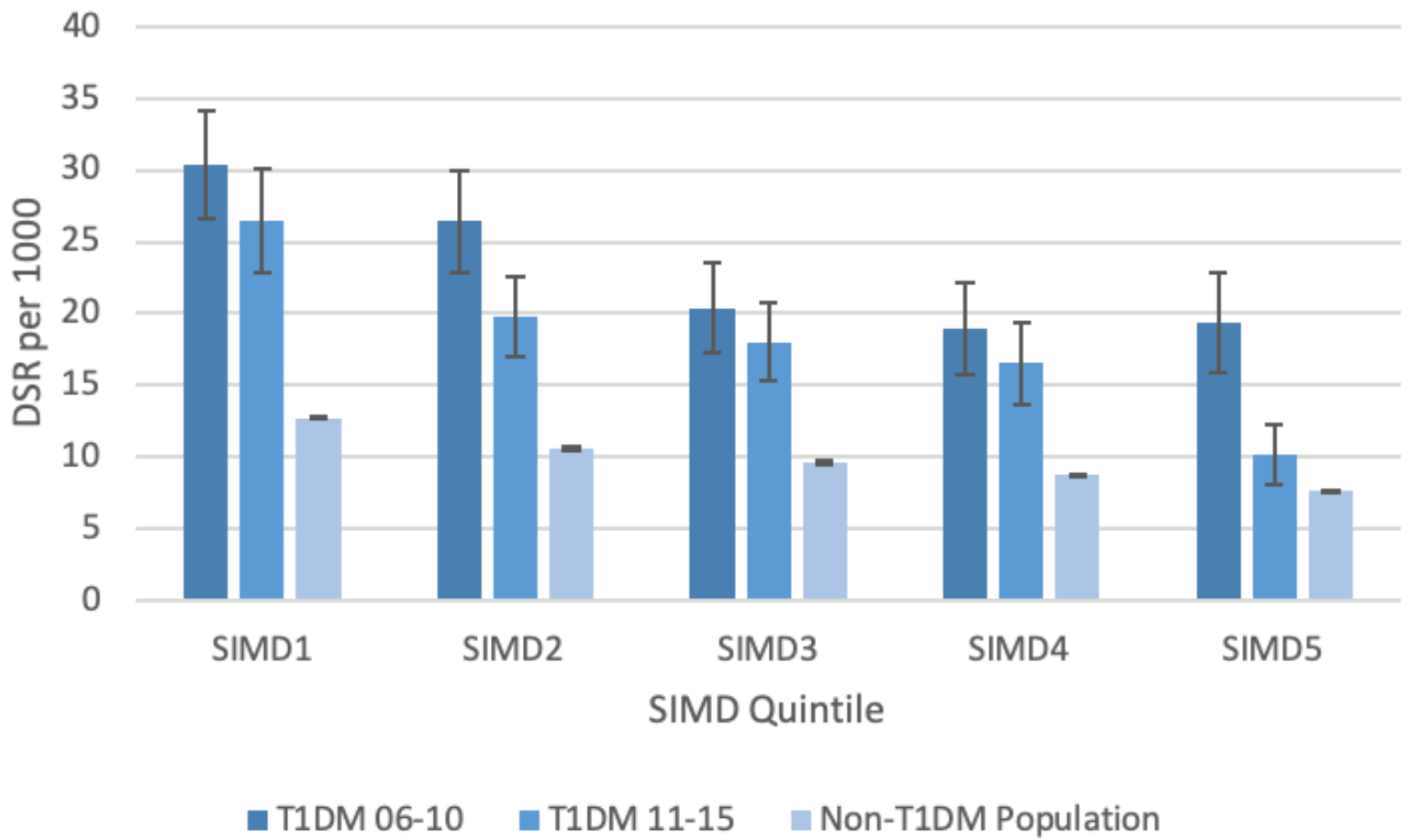
	Men	Women
SIMD 1 (most deprived)		
Rate difference (95% CI) per 1000 person-years	12.8 (11.5–14.1)	13.8 (12.6–15.0)
Rate ratio (95% CI)	1.98 (1.77–2.22)	2.41 (2.11–2.77)
SIMD 2		
Rate difference (95% CI) per 1000 person-years	10.5 (9.3–11.7)	9.2 (8.1–10.3)
Rate ratio (95% CI)	2.04 (1.61–2.31)	2.29 (1.99–2.64)
SIMD 3		
Rate difference (95% CI) per 1000 person-years	7.5 (6.4–8.6)	8.4 (7.4–9.4)
Rate ratio (95% CI)	1.96 (1.72–2.24)	2.26 (1.94–2.62)
SIMD 4		
Rate difference (95% CI) per 1000 person-years	5.7 (4.7 - 6.7)	7.8 (6.8–8.8)
Rate ratio (95% CI)	1.95 (1.68–2.28)	2.20 (1.86– 2.60)
SIMD 5 (least deprived)		
Rate difference (95% CI) per 1000 person-years	3.8 (2.9–4.7)	2.6 (1.8–3.4)
Rate ratio (95% CI)	1.64 (1.37–1.95)	1.56 (1.26–1.93)

SIMD, Scottish Index of Multiple Deprivation.



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