Impact of Parental Socioeconomic Status on Excess Mortality in a Population-Based Cohort of Subjects With Childhood-Onset Type 1 Diabetes

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OBJECTIVE

The aim of this study was to analyze the possible impact of parental and individual socioeconomic status (SES) on all-cause mortality in a population-based cohort of patients with childhood-onset type 1 diabetes.

RESEARCH DESIGN AND METHODS

Subjects recorded in the Swedish Childhood Diabetes Registry (SCDR) from 1 January 1978 to 31 December 2008 were included (*n* = 14,647). The SCDR was linked to the Swedish Cause of Death Registry (CDR) and the Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA).

RESULTS

At a mean follow-up of 23.9 years (maximum 46.5 years), 238 deaths occurred in a total of 349,762 person-years at risk. In crude analyses, low maternal education predicted mortality for male patients only ($P = 0.046$), whereas parental income support predicted mortality in both sexes ($P < 0.001$ for both). In Cox models stratified by age-at-death group and adjusted for age at onset and sex, parental income support predicted mortality among young adults (≥18 years of age) but not for children. Including the adult patient's own SES in a Cox model showed that individual income support to the patient predicted mortality occurring at ≥24 years of age when adjusting for age at onset, sex, and parental SES.

CONCLUSIONS

Exposure to low SES, mirrored by the need for income support, increases mortality risk in patients with childhood-onset type 1 diabetes who died after the age of 18 years.

Despite marked improvements in diabetes care and a decrease in diabetes-related mortality, type 1 diabetes (T1D) is still associated with excess mortality in all ages (1–5). Although mortality in older ages is attributed to renal complications and cardiovascular disease, early mortality has been related to acute complications such as diabetic ketoacidosis (1–4,6,7). Time to diabetes complications and death in T1D depends on metabolic control that may associate with psychological as well as social stress. Parental socioeconomic status (SES), mirrored by parental educational level and economic resources, is shown to affect disease care and metabolic

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Table 1—Demographic data

	Male			Female		
Stratification variable	*n*	Living	Dead	*n*	Living	Dead
Number of patients	7,731	7,577 (98.0)	154 (2.0)	6,916	6,832 (98.8)	84 (1.2)
Decade at onset						
1978–1987	1,970	1,868 (94.8)	102 (5.2)	1,793	1,737 (96.9)	56 (3.1)
1988–1997	2,307	2,271 (98.4)	36 (1.6)	2,095	2,074 (99.0)	21 (1.0)
1998–2007	3,454	3,438 (99.5)	16 (0.5)	3,028	3,021 (99.8)	7 (0.2)
Age at onset						
0–4 years	1,452	1,435 (98.8)	17 (1.2)	1,210	1,199 (99.1)	11 (0.9)
5–9 years	2,590	2,545 (98.3)	45 (1.7)	2,607	2,581 (99.0)	26 (1.0)
10–14.99 years	3,689	3,597 (97.5)	92 (2.5)	3,099	3,052 (98.5)	47 (1.5)
Age at follow-up/death						
0–17 years	2,174	2,145 (98.7)	29 (1.3)	2,023	2,005 (99.1)	18 (0.9)
18–24 years	2,207	2,166 (98.1)	41 (1.9)	1,923	1,899 (98.8)	24 (1.2)
≥25 years	3,350	3,266 (97.5)	84 (2.5)	2,970	2,928 (98.6)	42 (1.4)

Data are *n* (%) unless otherwise indicated.

control in the child with diabetes (8,9). Numerous reports have shown that individuals with lower SES during childhood have increased morbidity and all-cause mortality at all ages (10–14). Although recent epidemiological studies have shown that all-cause mortality in patients with T1D increases with lower SES in the individuals themselves (15,16), the association between parental SES and mortality among patients with childhood-onset T1D has not been reported to the best of our knowledge. Our hypothesis was that low parental SES additionally increases mortality in subjects with childhood-onset T1D. In this study, we used large population-based Swedish databases to *1*) explore in a population-based study how parental SES affects mortality in a patient with childhood-onset T1D, *2*) describe and compare how the effect differs among various age-at-death strata, and *3*) assess whether the adult patient's own SES affects mortality independently of parental SES.

RESEARCH DESIGN AND METHODS

The Swedish Childhood Diabetes Registry (SCDR) is a dynamic population-based cohort reporting incident cases of T1D since 1 July 1977, which to date has collected >16,000 prospective cases. After parental informed consent, the SCDR enrolls children with T1D onset before 15 years of age and who resided in Sweden at the time of diagnosis. The level of coverage is 96–99% and is ascertained by internal revisions and matching to official population registries (17). For the present analyses, the SCDR database was linked to the Swedish Cause of Death Registry (CDR) at the National Board of Health, and the Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA) at Statistics Sweden using a unique personal identification number (18,19). Data from these registries have been found to be valid and have been used extensively in research. The LISA database contains individual- as well as household-level data using the personal identification number of the person for whom information is collected. The database accumulates information on demographics, education, employment, and income, including that from salaries and various benefits from social welfare. Data on educational level and requirement of income support through the Swedish social welfare system were anonymously retrieved for the parents and the patients for the years 1990–2010.

The Swedish educational system has 9 years of compulsory schooling followed by 3 years of voluntary high school. After high school, graduates can proceed to college and university. Low educational level is defined as no more than 9 years of school. In the Swedish social welfare system, income support is provided for those who totally lack financial resources of their own and are not entitled to unemployment pay/activity grant or sick pay/sickness benefit. Income support is means tested and granted after individual assessment by social services to people >18 years of age. Low economic resources are defined as any family member having received income support from social welfare from 1 January 1990 to 31 December 2010. Because other socioeconomic circumstances or health issues may be hidden behind a longstanding need for income support, we also performed a sensitivity analysis by excluding 10% of the cases with the highest accumulated sum of parental income support during follow-up (1990–2010). Mortality data were recorded as of 31 December 2010. The age and sex standardized mortality ratio was based on data from Statistics Sweden.

All children with diabetes included in the SCDR had parental informed consent, and patients/parents had an opportunity to opt out of this study. Data linkage was

Table 2—Living and dead patients with childhood-onset T1D by parental SES measures

			HR (95% CI)		
SES measure	Living	Dead	All	Male	Female
Maternal educational level (year 2010)	13,769	223			
Low <10 years	2,068 (15.0)	65 (29.1)	1.36 (1.02–1.82)	1.43 (1.00–2.04)	1.21 (0.72–2.02)
Intermediate or high	11,701 (85.0)	158 (70.9)	1	1	1
Paternal educational level (year 2010)	13,556	218			
Low <10 years	3,004 (22.2)	76 (34.9)	1.12 (0.85–1.49)	1.11 (0.78–1.57)	1.18 (0.73–1.90)
Intermediate or high	10,552 (77.8)	142 (61.5)	1	1	1
Income support to family (years 1990–2010)	13,518	212			
Any	4,406 (32.6)	96 (45.3)	2.03 (1.55–2.67)	1.89 (1.36–2.64)	2.30 (1.43–3.70)
None	9,112 (67.4)	116 (54.7)	1	1	1

Data are *n* (%) and by univariate and sex-stratified Cox regressions for each SES measure.

performed at Statistics Sweden, and only coded data were delivered to the researchers. The study was approved by the Regional Ethics Review Board at Umeå University and by the ethics committees at the National Board of Health and Statistics Sweden.

Statistical Analyses

All patients recorded in the SCDR from 1 January 1978 to 31 December 2008 were followed until death or 31 December 2010. The cohort was subjected to crude analyses and stratified analyses by age-at-death groups (0–17, 18–24, and ≥25 years). Time at risk was calculated from date of birth until death or 31 December 2010. Kaplan-Meier analyses and log-rank tests were performed to compare the effect of low maternal educational level, low paternal educational level, and family income support (any/none). Cox regression analyses were performed to estimate and compare the hazard ratios (HRs) for the socioeconomic variables and to adjust for the potential confounding variables age at onset and sex. For patients who died at ≥18 years of age, these patients' own need of income support was included in the model as a potential independent risk factor. The level of missing data for each parental socioeconomic variable was <6.5% for the whole cohort. However, among the patients who died during follow-up, 10.9% had missing values on income support to parents. To check whether the analysis of the effect of income support on mortality is sensitive to the missing data, we performed two separate Cox regressions with two different scenarios: one "max" scenario by replacing all missing terms with data as if the parents had received income support and one "min" scenario with all missing terms with data as if the parents had not received income support. Neither scenario implied a change in the conclusions drawn from the initial original Cox regression analysis. Patients with missing values were not included in the survival analyses. Ninety-five percent CIs are given for HRs. SPSS Statistics for Windows version 20.0 was used for the statistical analyses.

RESULTS

The study included 14,647 patients with childhood-onset T1D. A total of 238 deaths (male 154, female 84) occurred in 349,762 person-years at risk. The majority of mortalities occurred among the oldest age-group (≥25 years of age), and most of the deceased subjects had onset of T1D at the ages of 10–14.99 years (Table 1). Mean follow-up was 23.9 years and maximum 46.5 years. The overall standardized mortality ratio

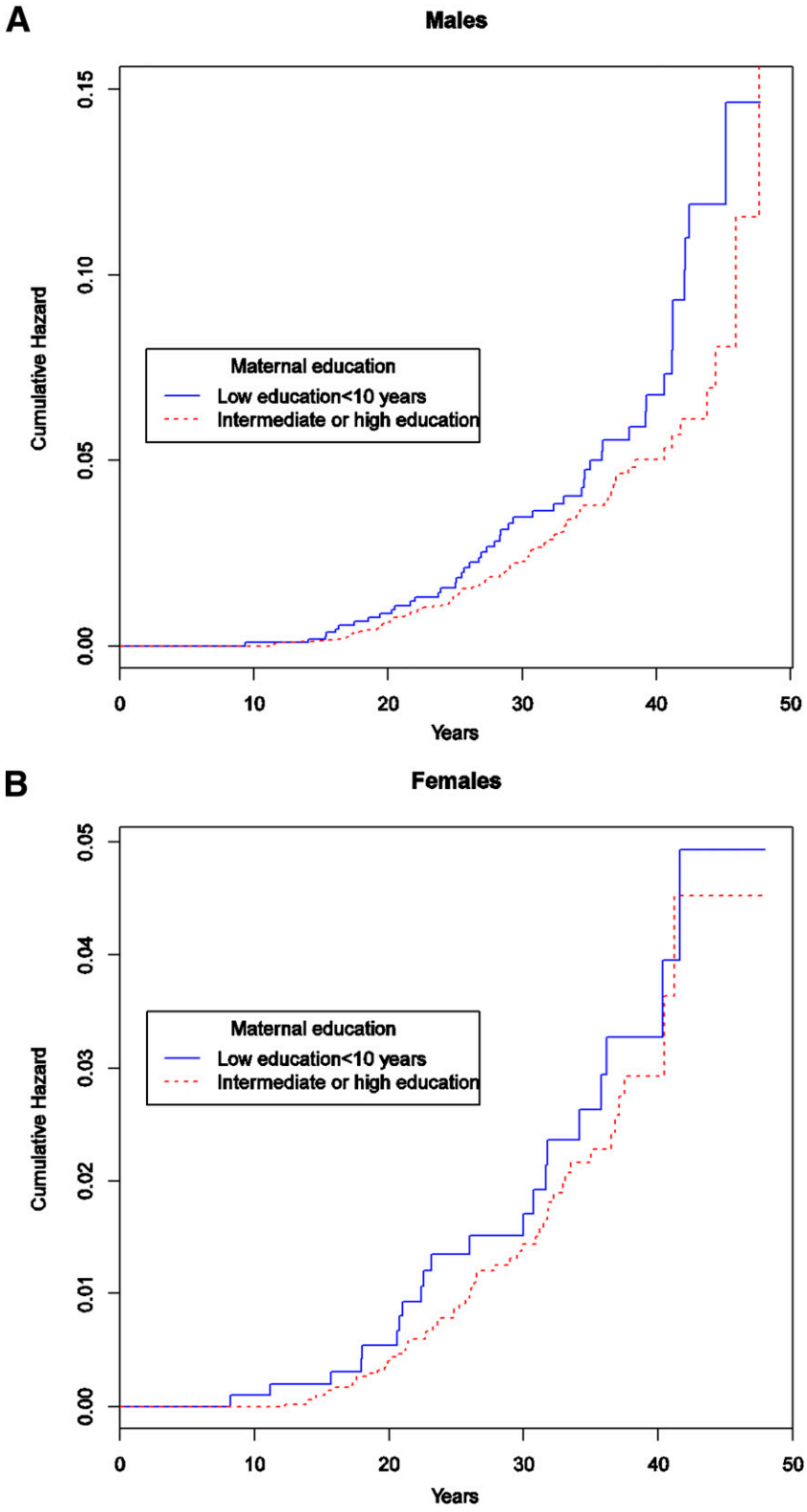

Figure 1—Crude cumulative mortality in male (*A*) and female (*B*) patients with T1D according to level of maternal education. Time at risk from birth until death or 31 December 2010.

up to the age of 47 years was 2.3 (95% CI 1.35–3.63); for females, it was 2.6 (1.28–4.66) and for males, 2.1 (1.27–3.49).

Effect of Parental SES on Time to Death

Analyses on the effect of low maternal educational level showed an increased mortality for male patients (HR 1.43 [95% CI 1.01–2.04], $P = 0.048$) and a nonsignificant increased mortality for female patients (1.21 [0.722–2.018], $P = 0.472$). Paternal educational level had no significant effect on mortality (Table 2 and Fig. 1*A* and *B*).

Having parents who ever received income support was associated with an increased risk of death in both males (HR 1.89 [95% CI 1.36–2.64], $P < 0.001$) and females (2.30 [1.43–3.67], $P = 0.001$) (Table 2 and Fig. 2*A* and *B*). Excluding the 10% of patients with the highest accumulated income support to parents during follow-up showed that having parents who ever received income support still was a risk factor for mortality.

A Cox model including maternal educational level together with parental income support, adjusting for age at onset and sex, showed that having parents who received income support was associated with a doubled mortality risk (HR 1.96 [95% CI 1.49–2.58], $P < 0.001$), whereas low maternal educational level was no longer a significant risk factor.

Effect of Parental SES on Time to Death in Different Age-at-Death Groups

Stratified analysis according to age at death (0–17, 18–24, and ≥25 years), adjusting for age at onset and sex, showed significant effects of having parents who received income support in the two oldest age-at-death groups (HR 3.16 [95% CI 1.87–5.32], $P < 0.001$; 1.93 [95% CI 1.31–2.83], $P = 0.001$) (Table 3).

Effect of the Patient's Own SES on Time to Death

In a Cox model including the adult patient's own SES, having parents who received income support was still an independent risk factor in the younger age-at-death group (18–24 years). Among those who died at age ≥25 years of age, the patient's own SES was a stronger predictor for mortality (HR 2.46 [95% CI 1.54–3.93], $P < 0.001$) (Table 3).

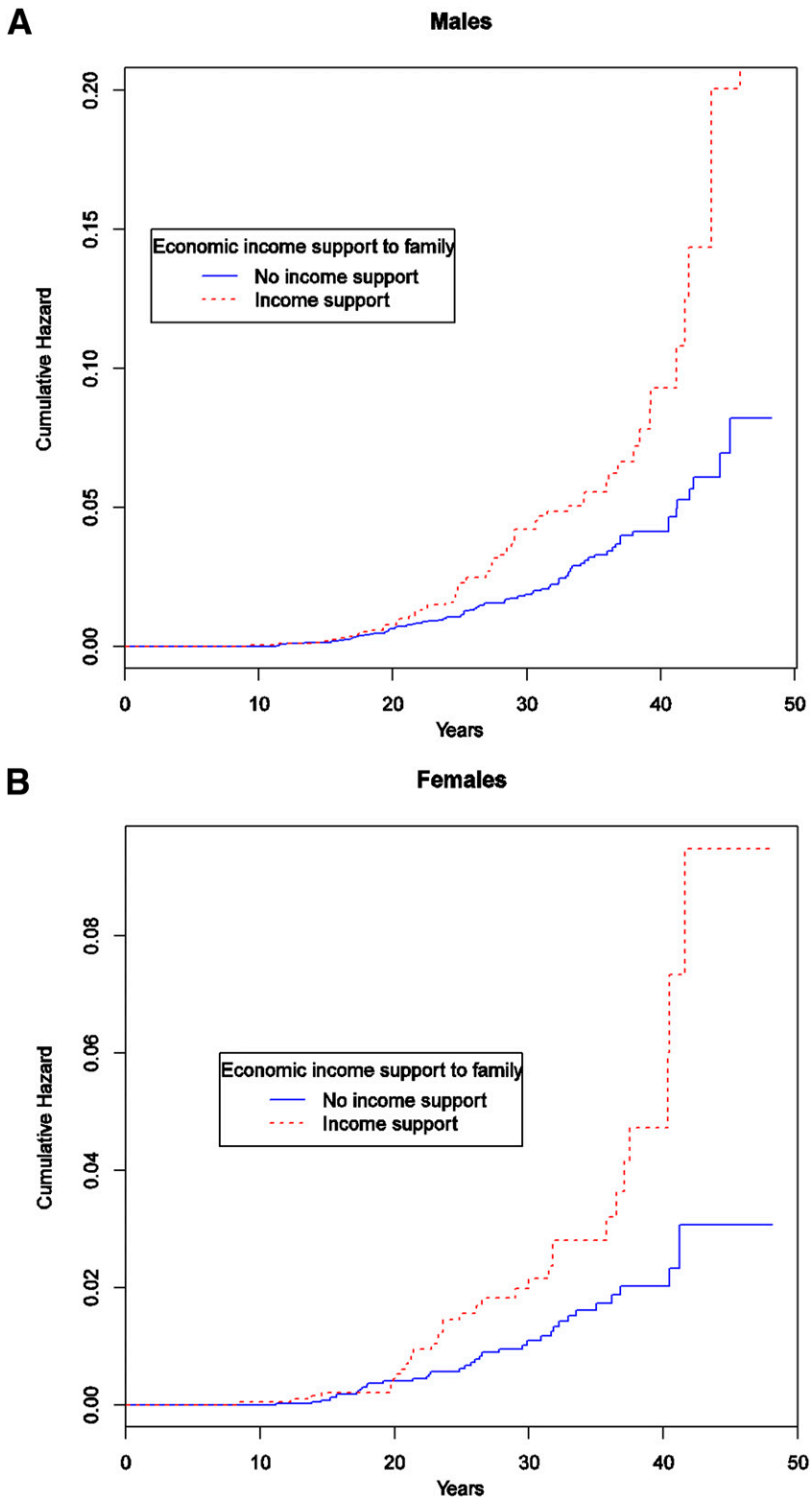

Figure 2—Crude cumulative mortality in male (*A*) and female (*B*) patients with T1D according to parental requirement for income support. Time at risk from birth until death or 31 December 2010.

CONCLUSIONS

Data from this large population-based cohort study indicate that parental SES affects mortality within the diabetes cohort when adjusting for age at onset (duration) and sex. Despite a well-developed health-care system in Sweden, overall mortality up to the age of 47 years is doubled in both males and females with childhood-onset T1D. These results are in accordance with

Table 3—Effect of parental and the adult patient's own SES on time to death

	Parental SES by age at death			Including adult patient's own SES	
	0–17 years	18–24 years	≥25 years	18–24 years	≥25 years
Male sex	1.61 (0.86–3.02)	1.61 (0.94–2.74)	1.96 (1.30–2.94)	1.43 (0.82–2.49)	2.00 (1.33–3.02)
Low age at onset	0.68 (0.46–1.01)	0.96 (0.67–1.38)	0.89 (0.64–1.24)	0.86 (0.59–1.25)	0.88 (0.63–1.22)
Low maternal education	1.61 (0.78–3.30)	1.09 (0.60–2.0)	1.26 (0.84–1.88)	1.17 (0.62–2.2)	1.23 (0.82–1.84)
Family received income support	1.01 (0.53–1.93)	3.16 (1.87–5.32)	1.93 (1.31–2.83)	3.75 (1.91–7.36)	1.13 (0.70–1.82)
Patient's own income support	—	—	—	0.86 (0.44–1.68)	2.46 (1.54–3.93)

Data are HR (95% CI). Cox model adjusted for age at onset and sex and stratified by age-at-death groups.

previous Swedish studies and reports from other comparable countries (1–3,5). Previous studies indicated that low SES during childhood is associated with low glycemic control and diabetes-related morbidity in patients with T1D (8,9), and the current study implies that mortality in adulthood is also affected by parental SES.

A number of studies have assessed the effects of SES on general health and mortality using various SES measures, including income, educational level, occupation, wealth, and various composite indices. In the current study, parental income support, as a proxy for low income, predicted excess mortality. Because the benefit of income support is means tested and takes the individual's complete economic situation into account (i.e., individual annual income, including benefits from social welfare, pension, annual household income, wealth), this variable seems to be a robust proxy for low income and limited economic self-sufficiency.

A couple of studies assessing how socioeconomic disadvantage in childhood affects mortality and health across the life course showed that low SES experienced during childhood significantly contributes to excess mortality in adulthood (10,11). Furthermore, one of these studies reported that the negative impact of low SES during childhood persists into adulthood, regardless of the individual's SES in adulthood (11). Having a chronic disease such as diabetes that requires extensive self-care may add to this risk, or alternatively, the regular health-care visits may compensate for it. We also know from previous studies on T1D and mortality that causes of death differ by disease duration and age at death. Although early mortality is mainly caused by acute diabetes complications and accidents, late mortality is also attributed to late complications, such as renal and cardiovascular disease (1–5). Hence, we analyzed the effect of parental SES and the adult patient's own SES by various age-at-death groups. The findings, when stratified by age-at-death group, show that adult patients' own need of income support independently predicted mortality in those who died at ≥25 years of age, whereas among those who died in the younger age-group (18–24 years), parental requirement of income support was still a strong independent risk factor. None of the present SES measures seem to predict mortality in the ages 0–17 years perhaps due to low numbers and, thus, power.

A possible limitation in using income support in an dichotomized way (any/none during the entire follow-up) may be that it does not distinguish the most extreme cases of poverty, with high and longstanding need for income support, from that requiring episodic income support. However, a sensitivity analysis showed that the current method was unbiased. The strength of this study is that it was large and that it was possible to link data on SES from official administrative registries at an individual level. It might have been of interest to study SES in relation to causes of death. Previous studies as well as our own experience, however, indicate that cause of death in diabetes may be misclassified when underlying cause of death from official statistics is used (20,21). We would need further information from hospital records to which we have had no access.

In conclusion, the current study indicates that having parents with low SES leads to additional excess mortality among young adults with childhood-onset T1D in Sweden. Diabetes care teams should be aware of this problem and make efforts to minimize these effects. Social workers should preferentially be involved on the diabetes team during both childhood and adulthood.

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