Educational Disparities in Mortality Among Adults With Diabetes in the U.S.

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OBJECTIVE — To measure relative and absolute educational disparities in mortality among U.S. adults with diabetes and to compare their magnitude with disparities observed within the nondiabetic population.

RESEARCH DESIGN AND METHODS — A total of 85,867 individuals (5,007 with diabetes), aged 35–84 years, who participated in the National Health Interview Survey from 1986 to 1996 were followed for mortality through 31 December 2002. Relative and absolute educational disparities in all-cause, cardiovascular disease (CVD), and non-CVD mortality were measured.

RESULTS — In relative terms, the risk of all-cause mortality was 28% higher in diabetic adults with the lowest versus the highest position on the educational scale (relative index of inequality 1.28 [95% CI 1.08–1.53]). This inverse relationship reflected marked disparities in CVD mortality and was found in all age, sex, and race/ethnicity groups except Hispanics. Although substantial, this relative educational gradient in mortality among adults with diabetes was smaller than in the nondiabetic population. In absolute terms, diabetic adults with the lowest position on the educational scale suffered 503 excess deaths per 10,000 person-years of follow-up compared with those with the highest position. These absolute disparities were stronger than in the nondiabetic population. The results were even more striking for CVD mortality.

CONCLUSIONS — The risk of mortality differs substantially according to educational level among individuals with diabetes in the U.S. Although relative educational disparities in mortality are weaker in adults with versus without diabetes, their absolute impact is greater and translates into a major mortality burden.

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In the U.S., >20 million adults have diabetes, and the prevalence is expected to rise substantially in the coming decades (1,2). Diabetes complications impose an enormous burden on public health, and people with diabetes have an age-adjusted mortality rate approximately twice as high as those without (3).

The public health burden of diabetes is unevenly distributed across socioeconomic strata. First, diabetes is more common in ethnic minorities and people of low education and income level (4,5). Second, in people with diabetes, socioeconomic position (SEP) may influence major determinants of health, such as access to care, quality of care, and health behaviors (6). Correspondingly, SEP may have a profound impact on the morbidity and mortality associated with diabetes. In Europe, socioeconomic health disparities have been reported among people with diabetes in various settings (5,6); though, two large record linkage studies (7,8) found that the magnitude of socioeconomic differentials in survival was weaker in people with diabetes than in the general population, a result that has remained largely unexplained. In the U.S., only few studies have focused on SEP-related disparities among people with diabetes and then only in selected subpopulations (9–12), making it difficult to determine the impact of such disparities at the population level and their public health importance.

To fully monitor health disparities, the general consensus is that both relative and absolute measures are required (13,14). The objective of this study was to quantify relative and absolute educational disparities in mortality within the U.S. diabetic population according to cause of death and across age, sex, and race/ethnicity strata and to compare the magnitude of these disparities to those found in the nondiabetic population.

RESEARCH DESIGN AND METHODS

— We used data collected in the National Health Interview Survey (NHIS) from 1986 to 1996 and linked to the National Death Index (NDI) for mortality through 31 December 2002. The NHIS is a continuous, annual, household survey conducted by the National Center for Health Statistics. The survey uses a stratified cluster probability sampling design to collect information from a representative sample of the civilian, noninstitutionalized U.S. population. A complete description of NHIS procedures is available elsewhere (15). The NHIS sample is divided into six representative subsamples. Each subsample is administered one of six checklists of chronic conditions and respondents are asked to indicate the presence or absence of each condition specified on the particular list assigned to them. The present analyses were restricted to the subsample asked about the presence of diabetes. The NHIS and NDI are linked using a probabilistic matching algorithm to determine the vital status of all NHIS participants aged ≥18 years. It is estimated that the matching methods correctly identify >9% of all living NHIS respondents and 96% of those who died, with no substantial difference according to age, sex, race/ethnicity, or socioeconomic status (16).

Variables of interest

For each participant who died by 3 December 2002, available data included information on the quarter and year of

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death and on the underlying causes of death classified according to the ICD-10. Deaths caused by cardiovascular disease (CVD) were those coded as I00–I78.

Educational attainment was used as the main indicator of SEP because unlike income and occupation, education is unlikely to be affected by poor health in adulthood. Detailed information on the highest level of school completed was collected and the variable was categorized as "less than high school degree" (high school not completed), "high school degree" (high school diploma or general equivalency diploma), and "more than high school degree" (some college, vocational, or technical school; associate's degree; Bachelor's, Master's, or professional degree). Race/ethnicity was self-reported. Participants with diabetes were those who reported themselves or whose proxy reported that they had diabetes in the past 12 months.

Statistical analysis

Analyses were restricted to participants aged 35–84 years. Participants were considered at risk for death during the period between the time of NHIS interview and either the quarter of their death, the quarter of their 85th birthday, or the fourth quarter of 2002, whichever occurred first. Direct standardization was used to estimate age- and sex-standardized mortality rates overall and according to educational level among subjects with and without diabetes, using the whole population (regardless of diabetes) as the standard.

Educational disparities in mortality were measured using multivariate Cox regression models controlling for time-updated age, sex, race/ethnicity, and survey year. Terms of interaction between education and diabetes status were included in the models to measure differences in the magnitude of educational disparities between subjects with and without diabetes.

Two indicators were used to estimate relative educational disparities in mortality. First, hazard ratios (HRs) associated with educational level were computed, using the highest level of education as reference. Whereas HRs are easy to interpret, comparisons of HRs across various groups of the population are complicated by different distributions of educational level across these subgroups. Indeed, the advantages conferred by, e.g., holding a high school degree probably differ across age, sex, or race/ethnicity strata. The use of the relative index of inequality (RII) as a measure of educational inequalities overcomes this problem by providing a continuous measure of inequalities that accounts simultaneously for the size and relative position of educational groups (13). It does so by using a specific measure of individuals' relative educational position (i.e., the mean proportion of the overall population that has an educational level higher than his/her own). For example, each individual in the lowest educational group is assigned a value corresponding to the proportion of the population with middle or high education, plus half of the proportion of the population with low education. This is therefore a continuous measure, taking the value 0 for someone at the top of the educational scale and 1 for someone at the bottom.

The RII, obtained by regressing mortality on this new indicator, is the predicted ratio of mortality rates at the two extremes of the educational scale. We calculated the RII overall (using individuals' educational position relative to the whole population as indicator of education) and separately across age, sex, and race/ethnicity strata (using individuals' educational position relative to the population within their strata as indicator of education).

Absolute educational disparities in mortality were estimated by the slope index of inequality (SII), corresponding to the slope coefficient obtained by regressing mortality on the indicator of relative educational position defined above. The SII is the predicted difference in mortality rates between the two extremes of the educational scale. CIs of RII and SII were estimated using a bootstrap procedure. We accounted for the complex sampling design and data weighting of NHIS in estimating standardized mortality rates but not in estimating associations between education and mortality. All statistical analyses were performed using Stata/SE 10.0 (Stata, College Station, TX).

RESULTS

Characteristics of the study population

We identified 86,817 adults aged 35–84 years at the time of the NHIS interview, who had been asked about the presence of diabetes and for whom NDI-linked data were available. Of these, we excluded 863 with missing data on educational attainment and 87 who died within the quarter following interview, yielding a final sample of 85,867 individuals. The median follow-up time was 10.5 years (range one-quarter to 16.8 years). At baseline, 5,007 (5.6%) participants reported having diabetes; they accounted for 43,295 person-years of follow-up. The 80,860 nondiabetic participants accounted for 851,223 person-years of follow-up.

Regardless of diabetes status, participants who did not complete high school and high school graduates were older and more likely to be women than those with more than a high school degree. Participants with less than a high school degree were also more likely to be non-Hispanic blacks or Hispanics (Table 1).

Mortality

Of 15,351 participants who died, 2,188 (14.0%) had diabetes at baseline. CVD accounted for 46.6% of the causes of death among participants with diabetes versus 40.2% among those without. Major non-CVD causes of death were cancers (17.6% of deaths), diabetes (14.7%), and respiratory conditions (5.9%) among participants with diabetes and cancers (29.7%) and respiratory conditions (10.1%) among those without. All-cause, CVD, and non-CVD mortality rates were 340.0, 150.7, and 189.3 per 10,000 person-years, respectively, in adults with diabetes versus 136.9, 52.1, and 84.8 per 10,000 person-years, respectively, in those without. As shown in Fig. 1, all-cause, CVD, and non-CVD mortality rates were inversely associated with educational level in both adults with and without diabetes.

Relative educational disparities in mortality

As shown in Table 2, the inverse relationship between education and mortality risk was statistically significant among adults with diabetes even after accounting for age, sex, race/ethnicity, and survey year. Overall, the risk of all-cause mortality was 28% higher in diabetic adults with the lowest versus the highest position on the educational scale, as measured by the RII. This inverse relationship between education and mortality risk in adults with diabetes reflected marked educational differences in the risk of CVD mortality. Conversely, the risk of non-CVD mortality did not differ significantly across education strata in adults with diabetes.

Evidence for the existence of an inverse educational gradient in all-cause and CVD mortality risk was found in both diabetic adults aged 35–64 years and in their older counterparts, in diabetic men

Table 1—*Characteristics of 85,867 participants with and without diabetes, according to educational level*

	Adults with diabetes (n = 5,007)			Adults without diabetes (n = 80,860)		
	Less than high school degree	High school degree	More than high school degree	Less than high school degree	High school degree	More than high school degree
n	2,179	1,699	1,129	18,969	30,013	31,878
Age at the time of interview (years)						
means ± SE	64.8 ± 0.27	61.3 ± 0.34	58.5 ± 0.40	59.8 ± 0.14	53.0 ± 0.12	49.9 ± 0.11
35–64	48.4	56.2	65.8	59.6	78.6	85.4
≥65	51.6	43.8	34.2	40.4	21.4	14.6
Sex						
Men	41.6	44.8	57.1	47.5	42.2	51.7
Women	58.4	55.2	42.9	52.5	57.8	48.3
Race/ethnicity						
Non-Hispanic whites	61.6	80.5	77.0	69.8	84.2	85.0
Non-Hispanic blacks	22.9	12.6	13.6	14.5	8.7	6.8
Hispanics	12.7	4.4	5.2	12.7	4.7	4.2
Other non-Hispanics	2.8	2.5	4.2	3.0	2.4	4.0

Data are %, unless otherwise indicated.

and women, and in white and black diabetic adults (Fig. 2). However, such a gradient was not found among Hispanic adults with diabetes. The magnitude of educational disparities in all-cause, CVD, and non-CVD mortality was significantly lower in adults with diabetes compared with their nondiabetic counterparts (Table 2).

Absolute educational disparities in mortality

As shown in Table 2, the difference in the estimated risk of all-cause mortality between diabetic adults with the lowest versus the highest position on the educational scale, as measured by the SII, was 503.0 deaths per 10,000 person-years. This difference was largely driven by educational disparities in CVD mortality, accounting for 401 excess deaths per 10,000 person-years of follow-up. These absolute educational disparities in all-cause and CVD mortality were greater in adults with diabetes than in their nondiabetic counterparts. In contrast, absolute educational disparities in non-CVD mortality did not differ in magnitude according to diabetes status.

CONCLUSIONS — Our results suggest that differences in educational position produce substantial disparities in mortality risk in U.S. adults with diagnosed diabetes regardless of age, sex, and race/ethnicity. In relative terms, these disparities are weaker than in nondiabetic adults. However, in absolute terms, adults with diabetes suffer the greatest mortality burden from low educational position, with a difference of over 500 deaths per 10,000 person-years of follow-up between the two extremes of the educational scale. These disparities are mainly driven by CVD mortality, a cause of death for which many effective preventive measures are available.

Strengths of this study, which lend weight to these conclusions, include a nationally representative cohort large enough to afford multiple stratified multivariate analyses and long-term follow-up that is nearly 100% complete. The main limitation of our study is reliance on self-report of diabetes. The accuracy of diabetes self-report has been reported to be high overall and improves with educational level (17). Moreover, approximately one-third of U.S. adults with diabetes are estimated to be undiagnosed (18), a rate possibly higher among people with low education (19). This suggests that self-reported cases of diabetes may underrepresent the milder cases (i.e., those either undiagnosed or diagnosed but underreported), especially among people with a low education. Consequently, educational health disparities measured within adults with diagnosed diabetes may be more marked than those occurring in the whole population of people with diabetes. Additionally, although

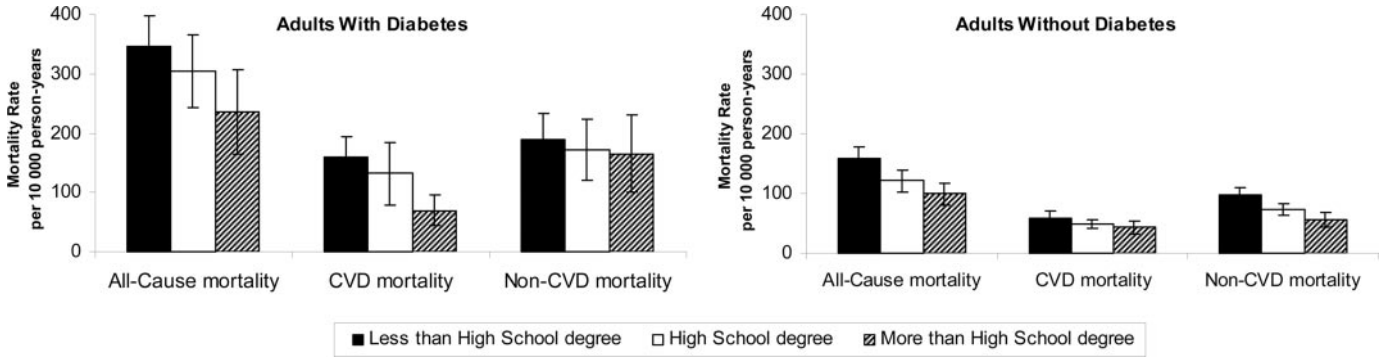

Figure 1—*Age- and sex-standardized all-cause, CVD, and non-CVD mortality rates (95% CIs) according to educational level among adults with and without diabetes.*

Table 2—*Relative and absolute educational disparities in all-cause, CVD, and non-CVD mortality among adults with and without diabetes

	Relative disparities			Absolute disparities
	HR			
	Less than High School degree	High School degree	RII	SII
Adults with diabetes				
All-cause mortality	1.22 (1.08–1.38)†	1.17 (1.02–1.33)	1.28 (1.08–1.53)†	503.0 (302.4–697.2)†
CVD mortality	1.41 (1.17–1.69)†	1.19 (0.98–1.36)	1.55 (1.16–2.05)	401.3 (260.5–536.5)†
Non-CVD mortality	1.07 (0.91–1.26)†	1.15 (0.97–1.36)	1.06 (0.85–1.33)†	101.7 (−48.0 to 248.9)
Adults without diabetes				
All-cause mortality	1.71 (1.63–1.80)†	1.30 (1.23–1.36)	1.84 (1.70–2.01)†	291.4 (262.4–321.0)†
CVD mortality	1.82 (1.67–1.97)†	1.33 (1.22–1.44)	1.99 (1.74–2.31)	125.6 (107.1–145.6)†
Non-CVD mortality	1.65 (1.55–1.76)†	1.28 (1.20–1.36)	1.75 (1.57–1.95)†	165.8 (142.0–187.5)

Data are HR/RII/SII (95% CI). HR: hazard ratio of death (reference category: individuals with more than a high school degree). RII: ratio of mortality rates of individuals with the highest and lowest educational level in the population. SII: difference between mortality rates of individuals with the highest and lowest educational level in the population. *All measures are adjusted for age, sex, race/ethnicity, and survey year; †$P < 0.05$ for interaction between educational level and diabetes status.

educational health disparities may differ according to diabetes type (7), NHIS does not attempt to distinguish between type 1 and type 2 diabetes. However, since type 2 diabetes accounts for the large majority (90–95%) of cases in the U.S., our results mostly pertain to type 2 diabetes (1).

Mortality rates provided in the study were estimated accounting for sampling weights, thus they are representative of the U.S. population. However, we could not account for data weighting in estimating associations between education and mortality because we were unable to calculate correct sampling weight for bootstrap analyses and thus unable to provide an accurate estimate of RII and SII variances. Complementary analyses show that regardless of diabetes status, point estimates of HRs and RII do no substantially differ whether calculations are based on weighted or unweighted data. Though, SII estimates in adults with diabetes appear greater using weighted rather than unweighted data (600.3 vs. 503.0 deaths per 10,000 person-years for all-cause mortality), suggesting that absolute educational disparities in mortality among U.S. adults with diabetes may be underestimated in our study.

By showing that the risk of mortality differs according to educational attainment, both in relative and in absolute terms, our results provide strong evidence for the existence of educational disparities in mortality in U.S. adults with diagnosed diabetes. Thereby, the present study suggests that socioeconomic disparities in health previously reported among people with diabetes in Europe (5,6) occur in the U.S. context as well. Underlying pathways may involve a large range of factors, including patient factors (e.g., health behaviors, material conditions, or psychosocial factors) as well as characteristics of the providers, the community, and the health care system (6). Given the major burden of diabetes in the U.S. across the various socioeconomic strata of the population, such disparities may have a major public health impact at the national level.

In relative terms, our findings indicate that educational disparities in mortality among U.S. adults with diabetes are mainly driven by differences in the risk of death from CVD causes. Including deaths with diabetes as the underlying cause in the definition of CVD deaths did not change this finding (data available on request). In addition, such disparities among adults with diabetes are substantial in all age, sex, and race/ethnicity strata except Hispanic adults. The absence of educational health disparities among Hispanics has been reported among the general population as well (20), suggesting that its underlying mechanisms are likely to be independent of diabetes status.

Although they are substantial, educational disparities in mortality in adults with diabetes appear to be smaller than disparities in nondiabetic adults. Such difference has also been reported in Italy (7) and in Finland (8), two countries with equitable access to health services. One possible explanation is that diabetes management levels off disparities in health care and health behaviors across the various educational groups. Our findings suggest that such a salutary role of diabetes management may occur as well in the context of the U.S. health care system, a hypothesis supported by a recent study (21) showing that concurrently with major improvement in diabetes management over the past decade, there has been limited widening of educational health disparities in the U.S. diabetic population. Whether this arises from the specificities of diabetes management itself or from its beneficial consequences in terms of enhancing health care access and use deserves further studies.

We found that in diabetic adults absolute disparities in mortality are strong, specifically from CVD-related causes, and, in contrast to relative disparities, greater than in the nondiabetic population. Indeed, we found that diabetic adults who hold the lowest position on the educational scale suffer 503 excess deaths per 10,000 person-years of follow-up than those with the highest position, a gap 73% higher than in the nondiabetic population. The results were even more striking for CVD mortality, with a gap 319% higher in the diabetic versus the nondiabetic population. The contrasted results we obtained using either relative or absolute measures of disparities stem from the fact that the burden of CVD mortality is dramatically higher in adults with versus without diabetes. This finding highlights the relevance of using both relative and absolute measures of inequalities to adequately assess health disparities and suggests that educational health disparities among adults with diabetes have a major public health impact.

In summary, we have shown that the risk of mortality differs substantially according to educational level among people with diabetes in the U.S. Although

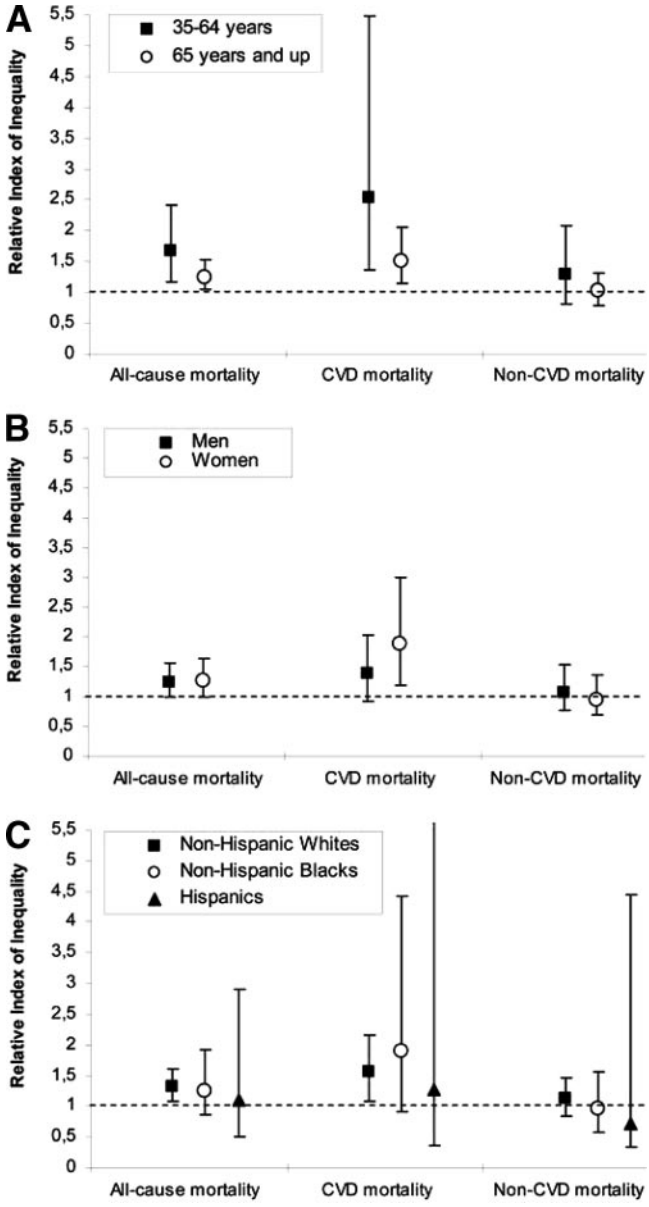

Figure 2—*Relative index of inequality (adjusted for survey year and, if appropriate, for age, sex, and race/ethnicity) (95% CIs) in all-cause, CVD, and non-CVD mortality among adults with diabetes by age* (A)*, sex* (B)*, and race/ethnicity* (C)*.*

relative educational disparities in mortality are less marked in adults with diabetes than in those without, their absolute impact is greater and translates into a major mortality burden. Considering the major burden of diabetes in the U.S., especially among the most deprived categories of the population, this suggests that reducing social health inequalities among people with diabetes is likely to have a major public health impact. Future research should determine pathways underlying these educational disparities with an eye toward developing strategies to eliminate them.

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