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A Growing Disparity in Diabetes-Related Mortality: U.S. Trends 1989-2005

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Abstract

Background—Whether a disparity in diabetes-related death across education levels has widened, narrowed, or remained constant over the past 15 years is not known, and is the topic of this study. The analysis also examined concomitant trends by education levels in possible mechanisms that link education and diabetes-related mortality.

Methods—The first part of the analysis calculates diabetes-related mortality rates for adults age 40-64 and adults age 65-79 using U.S. Vital Statistics from 1989-2005 to provide the number of deaths per year in the U.S. (the numerator) and also from the U.S. Census to provide the population size (the denominator). The second part of the analysis uses the U.S. National Health and Nutrition Examination Surveys (NHANES) program in 1988-1994 and 1999-2004 to examine trends in diabetes prevalence and diabetes-related factors.

Results—A disparity in diabetes-related mortality across education levels widened substantially from the late 1980s to the present, an overall trend apparent in the subgroups of men, women, Blacks, Whites, and Hispanics. Analysis of NHANES data indicated that progress in diabetes care and management (as indicated by HbA1c levels less than 8%) has helped people of all educational levels but has been of greater benefit to those with higher education.

Conclusions—The widening disparity across education levels in diabetes-related mortality follows a classic, “early adoption” pattern. Societal advances in diabetes care and self-management – particularly in glucose control -- have benefited people in all social strata, but the pace of improvement has been quicker for people with higher educational attainment. Developing policies and interventions to speed up the pace among people with lower education represents a promising approach to reduce diabetes-related mortality further.

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BACKGROUND

In the year 2000 diabetes was the sixth leading cause of death in the United States,¹ contributing to approximately 3.6% of all deaths. Whether disparities in diabetes-related mortality by socioeconomic status have grown, diminished, or remain unchanged in recent decades is not known but is important to evaluate the success of recent efforts by the Department of Health and Human Services to reduce health disparities.²

To address this question the analysis examined trends over the past two decades in diabetes-related mortality and associated risk factors for adults age 40-64 and age 65-79 by education level. The analyses use two different, nationally-representative data sources. The first is mortality data from the U.S. National Vital Statistics, which allow calculation of the U.S. diabetes-related mortality rate by education level over time. The second data source is the U.S. National Health and Nutrition Examination Surveys (NHANES) collected in 1988-1994 and 1999-2004, which contain detailed information on diabetes status and related health information that is directly comparable across the two time periods.

The primary goal of this analysis is to test the hypothesis that there is a widening disparity in diabetes-related mortality. It is expected that over the past two decades the sum total of the new information and technology in diabetes prevention and management has benefited people in all social strata, but that a quicker pace of improvement among those in the upper social strata has resulted in a widening disparity in diabetes-related mortality. This expectation is based on the general observation that people in the upper social strata have more social and physical resources to protect themselves from diseases and outcomes that are preventable,^{3, 4} and are also more likely to be “early adopters” of new technologies and behaviors,⁵ including those that improve health. The secondary goal is to examine which specific diabetes-related resources or behaviors play a role in a widening disparity, if one is found. Candidate resources and behaviors include effective glucose control, diabetes prevalence, health insurance, use of oral hypoglycemics, and preventable cardiovascular risk factors.

METHODS

Surveys

The first analyses draw on the U.S. Vital Statistics, which provide the number of diabetes-related deaths per year in the U.S. (the numerator) and also from the U.S. Census to provide the population size (the denominator). This study uses data since 1989, the first year in which the mortality data contain information on educational attainment. All deaths that listed diabetes as the underlying cause or a contributing cause were coded as diabetes-related. Age, race/ethnicity, and sex came from death certificate information in analysis of the U.S. Vital Statistics data. To calculate mortality rates of demographic groups the analysis used the same race/ethnicity measures in the U.S. Vital Statistics and the U.S. Census: non-Hispanic white, non-Hispanic Black, and Hispanics (regardless of race).

Estimates of the total U.S. population come from the U.S. Census reports of the residential and ‘group quarters’ population, such as people living in military quarters or incarcerated in

prisons. The Census provides only decennial estimates of the size of the group quarters population. The analysis is based on an assumption of linear changes in the “group quarters” population between 1990 and 2000, and used a linear interpolation from 1989 to 2005 to add estimates of the “group quarters” population to the published, yearly estimates of residential population size.

To consider potential explanations for trends observed in the U.S. Vital Statistics analyses, the analysis also includes examination of the U.S. National Health and Nutrition Examination Surveys (NHANES) program.⁶ Survey information includes self-reported interview data as well as physical examination data collected at mobile examination centers, including blood samples. The analysis used data from NHANES III, collected in 1988-1994, and from NHANES 1999-2004.

Outcome Measures in NHANES

The analysis considers separately adults age 40-64 and adults age 65-79. The cutoff is at age 65 because age-based eligibility for Medicare introduces a host of confounding and mediating factors that may lead to different results across these two age groups. The data is bottom-coded at age 40 because diabetes-related mortality before this age is rare (albeit becoming more frequent), and age is top-coded at age 79 because in certain years population size data is topcoded at age 80, which leads to severe problems in age-standardization in analysis of people age 80 and over.

“Any Diabetes” is coded 1 for respondents who are positive for either diagnosed or undiagnosed diabetes. Information on diagnosed diabetes comes from respondents’ self-report that a doctor told them they have diabetes. Respondents who reported that they did not have diabetes but had a fasting blood glucose level >125 mg/dl were scored positive for undiagnosed diabetes.

“No Health Insurance” is coded 1 for respondents who reported that they did not have health insurance from any source and 0 otherwise. “Poor glucose control” is coded 1 for respondents for whom blood analysis of data collected at the mobile examination clinic showed a HbA1c level greater than 8% and 0 otherwise. The 8% level is a strong indicator of uncontrolled glucose; of all major medical organizations that provide HbA1c guidelines none recommend a level higher than 8%.⁷

Among people who self-reported that they had diabetes, people are recorded positive for oral hypoglycemics if they answered yes to the question “Are you now taking diabetes pills to lower your blood sugar? These are sometimes called oral agents or oral hypoglycemic agents.” It is coded 0 for those who responded no.

The analysis examined four of the major behavioral risk factors for cardiovascular disease.⁸ “Currently smoking” is coded 1 for respondents who reported in the interview stage of the survey that they are currently smoking and 0 otherwise. “High cholesterol” is coded 1 for respondents whose measured total cholesterol level was 240 or higher.

“High blood pressure” is coded 1 for respondents with a systolic pressure greater than 130 or a diastolic pressure greater than 80,⁹ as measured at the mobile examination clinic.

“Overweight” is coded 1 for respondents with a body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) greater than or equal to 25 and 0 otherwise. Information for overweight status comes from the mobile examination clinic, in which respondents’ weight and height were measured by trained technicians who used standardized procedures and equipment. The variable “Had heart attack” is coded 1 for respondents who reported in the interview stage of the survey that a doctor or other health professional had told them they had experienced a heart attack and 0 otherwise.

Data Analysis and Statistical Methods

Data were analyzed using STATA version 9.0.¹⁰ The NHANES surveys used a complex sampling design and drew individuals from pre-selected strata and primary sampling units. All analyses used the NHANES-provided sampling weights that were calculated to take into account unequal probabilities of selection resulting from the sample design, nonresponse, and planned oversampling of selected subgroups. Standard errors were calculated with STATA version 9.0 using Taylor series linearization.

Mortality rates are based on direct age-standardization,¹¹ with year 2000 as the reference population.¹² The large overall sample size of the U.S. Vital Statistics allowed calculation of diabetes-related mortality rates for all five-year age groups from age 40 to 79 for every educational subgroup considered in this analysis.

The analysis includes calculation of overall changes during the study period in the mortality rate gap across education levels. These calculations are a comparison of the size of the gap at the most recent survey (in 2005) with the size of the gap at the initial survey of this study (in 1989). Calculation of the absolute change over the study period is the size of the gap in 2005 minus the size of the gap in 1989. Calculation of the relative change over the study period is the size of the gap in 2005 divided by the size of the gap in 1989. The results reported are based on predicted mortality rates, which come from models that use mortality rates from all seventeen time points in the study and include a quadratic term to take into account possible non-linearity.

Analyses using NHANES data used a cutoff of $p < .05$ to indicate statistical significance. Analyses using the U.S. Vital Statistics did not consider statistical significance due to the large sample size; all observable trends were due to more than sampling error.

RESULTS

Figure 1 graphically presents trends in diabetes-related mortality over the past 17 years by four education levels and age group. Among both age groups a disparity in diabetes-related mortality was present in 1989 and widened through 2005, as indicated by a widening gap between the mortality rates of the lowest and highest educated. In the lowest educational category (less than a high school education) the rate of diabetes-related mortality increased for both age groups, by 75% among those age 40-64 and by 40% among those age 65-79. In contrast, in the highest educational category (at least a college degree) the rate decreased for both age groups, by 7% among those age 40-64 and by 15% among those age 65-79.

Figure 1 shows important differences across the age groups. As expected, the baseline mortality rates for all educational groups are higher among the older group. In addition, among those with a high school education diabetes-related mortality rates increased among those age 40-64 but showed little overall gain among those age 65-79.

Table 1 disaggregates the overall trend presented in Figure 1 by demographic groups and indicates that the widening disparity was present among both age groups across men, women, Blacks, Whites, and Hispanics. The columns in Table 1 entitled “Absolute Increase” and “Relative Increase” present an overall summary of the change in the diabetes-related mortality disparity across education levels, and the positive value for each and every demographic group indicates that the widening disparity was not isolated to any group or groups.

Table 1 shows that the four educational levels considered in this study contributed to the widening disparity in different proportions across demographic groups. For example, in some cases the group without a high school education contributed substantially to the widening disparity, as it did among Whites age 40-64, while in other cases it did not, as among most of the demographic groups age 65-79. Also, a declining mortality rate among the group with at least a high school education contributed substantially to the widening disparity among all demographic groups among those age 65-79, but not among Blacks in the younger age category.

The analysis next turned to NHANES data to determine if trends in diabetes-related factors were consistent with the trend in diabetes-related mortality. Table 2 presents results from an analysis examining the possibility that the widening disparity in diabetes-related mortality reflects a widening disparity in diabetes prevalence. The results indicate that this possibility is unlikely. While the overall prevalence of any diabetes – diagnosed or undiagnosed -- increased substantially from the late 1980s to the present, the results in Table 2 show that the gap in the diabetes prevalence rate across education levels actually narrowed, by 21% among respondents age 40-64 and by 29% among those age 65-79.

Table 3 presents analysis by educational level, age group, and time period of poor glucose control, as indicated by HbA1c levels greater than 8%. As with diabetes-related mortality, a disparity in this outcome significantly increased over the study period. In the earlier NHANES surveys of 1988-1994 glucose control was actually worse for people with high v. low education in both age groups 40-64 and 65-79. During the following years HbA1c levels improved for all groups, but a faster pace of improvement among those with higher education led to a significant disparity that disadvantaged respondents with lower education by the 1999-2004 surveys.

The analysis considered additional factors (not presented in the Tables). A disparity in health insurance by education level actually decreased over the study period for those age 40-64. While the overall prevalence of uninsured increased for all education groups, it increased faster among those with high education and the disparity consequently decreased by 73% -- from 260% in 1988-1994 (13.93% with low education v. 3.87% with high

education) to 69% in 1999-2004 (20.16% v. 11.96%). Respondents age 65-79 all had Medicare insurance at both time periods.

The analysis considered trends across educational levels in the use of oral hypoglycemics. Among people who self-reported diabetes, use did not significantly differ by educational level in either the NHANES 1988-1994 or 1999-2004 waves.

The analysis next examined if trends in cardiovascular risk factors may have played a role in the widening disparity in diabetes-related mortality. The cardiovascular factors considered were past heart attack, currently smoking, high cholesterol, high blood pressure, and overweight. For people age 40-64 a disparity that disadvantages people with lower education widened in each and every one of these risk factors among people who self-reported diabetes. The widening was largest for the outcomes of “currently smoking” and self-reported “past heart attack,” which showed emergent disparities that were present in the most recent NHANES survey but not the earlier one in 1988-1994. Specifically, the prevalence of a past heart attack was 140% higher for people with low v. high education in the NHANES 1999-2004 (9.30% v. 3.87%, a difference that is statistically significant at the .05 level), which increased from the earlier increased risk of 74% in the 1988-1994 NHANES survey (13.35% for those with low education and 7.68% with high education). The prevalence of smoking was 43% higher for people with low v. high education in the most recent NHANES wave (30.91% among those with low education v. 21.58% with high education, a difference that is statistically significant at the .05 level), which was an increase from the earlier wave when it was 14.13% (24.31% v. 21.30%). Disparities by education level increased for all other cardiovascular risk factors, but these disparities in the 1999-2004 wave were not statistically significant at the .05 level.

Among the group age 65-79, the same cardiovascular factors did not parallel the widening disparity in diabetes-related mortality. In this group the prevalence of these outcomes did not significantly differ across low and high educational status, in either the 1988-1994 or the 1999-2004 NHANES surveys. Also, they did not uniformly follow any trend over historical time. Disparities by education level slightly increased for three of the outcomes (self-reported past heart attack, smoking, and high blood pressure), but decreased for the other two (high cholesterol and overweight).

COMMENT

To our knowledge, this study is the first to document a widening disparity in diabetes-related mortality across education levels in recent years. Among both the 40-64 and age 65-79 age groups the mortality rate increased for those with lower education and decreased for those with higher education. A substantial, widening disparity in diabetes-related mortality across education levels was present among the demographic subgroups of men, women, Blacks, Whites, and Hispanics.

We hypothesized that that this widening disparity was explained by a quicker rate of improvement in diabetes-related factors among people with higher v. lower education, in light of the fact that people with higher education are more likely to be ‘early adopters’ of

new health technologies and behaviors, or old ones newly rediscovered.⁵ The strongest evidence for this hypothesis was a parallel widening across education levels in glucose control, as measured by HbA1c levels > 8% in the NHANES surveys. For both age groups 40-64 and 65-79 glucose control improved for all educational groups, but it increased substantially faster for people with high v. low education. Glucose control is a plausible contributor to the widening disparity in diabetes-related mortality because it is a predictor of mortality,¹³⁻¹⁵ with one estimate that an increase of 1% in HbA1c is associated with a 26% increase in risk of death.¹⁶

Widening disparities across educational levels in other cardiovascular risk factors also appear to have played a role, at least among the age group 40-64. In this age group disparities in past heart attack and smoking emerged over the study period to disadvantage people with low education. These findings, however, were isolated to the 40-64 age group and were not present among the 65-79 group.

While the main findings are the same across the two age groups – the widening disparity in diabetes-related mortality and glucose control – important differences are also present. Across age groups the four educational levels considered in this study contributed to the widening disparity in diabetes-related mortality in different proportions. Further, emerging disparities in cardiovascular-related risk factors across education levels were present in the age 40-64 group but not in the group 65-79. Finally, Medicare eligibility for the group age 65-79 strongly suggests that the growing disparity in diabetes-related mortality cannot be explained by health care access alone for this age group.

This study has some limitations. Vital Statistics data underestimate the true number of deaths that are related to diabetes, because some deaths that are a result of diabetes are not recorded as such. However, to the extent that underestimation was constant during the study period, changes in trends over time – the main research question of this study -- are attributable to “signal” and are not a methodological artifact. During the time period of this analysis there was no substantial improvement in the percentage of deaths recorded as diabetes-related on death certificates among decedents known to have diabetes,^{17, 18} reducing the threat of this potential bias.

A second limitation is that none of the data sets in this study differentiate type 1 and type 2 diabetes. The observed trends in diabetes are most likely driven by type 2 diabetes, which accounts for 90 to 95% of diabetes prevalence in the United States.¹⁹

A third limitation is that while this study contains measures of many factors that may be involved in the widening disparity, it does not include all of them. For example, the NHANES data do not contain directly comparable measures of physical exercise across waves. The data also do not contain information on differences across educational levels in medical treatment for people during and after a heart attack, a factor that surely contributes to the widening mortality disparity documented in this study.²⁰

A fourth limitation is that the criteria for diabetes and diabetes-related mortality changed over the study period, in two ways. First, the classification of death in the U.S. Vital Statistics changed from the ICD-9 to the ICD-10²¹ in the year 1999. While this change could

potentially lead to a shift in the diabetes-related mortality rate in the year 1999 that resulted from measurement artifact, the results of Figure 1 show that no dramatic shift is apparent in the year 1999. Second, the diagnostic criteria for diabetes changed in 1997²² which again introduces the potential for the results to be driven by measurement artifact. However, in the study results no sudden shift in the diabetes mortality rate is present in 1997. In addition, the NHANES data address this limitation because they contain a measure of fasting blood glucose, which allowed this study to use one cutoff level (per the post-1997 criteria) to indicate diabetes prevalence across the two NHANES waves.

Finally, it is important to note that there is a lag time between diabetes-related mortality and the earlier development/implementation of new diabetes management techniques and behaviors. Most likely the widening of the disparity in diabetes-related mortality will continue to grow at least in the near future as the result of the momentum of the trends identified in this study.

Counterbalancing these limitations are multiple strengths of this study. To our knowledge, few data sources other than the Vital Statistics provide the opportunity to track current, national trends in diabetes-related mortality across education levels. Furthermore, the NHANES is well suited to examine possible reasons for the trends because it provides a sample of people with diabetes that is nationally-representative, it is large enough to support detailed statistical analysis, it contains measures that are directly comparable across a 15 year time span, and these measures include a rich assortment of both self-reported outcomes and objective lab tests.

In conclusion, disparities in diabetes-related mortality have widened across educational levels in recent years. This widening occurred in large part because improvements related to glucose control occurred faster among those with higher vs. lower education. Identifying why these improvements have occurred quicker among those with higher education – and developing appropriate policies and interventions to speed up the pace among people with lower education – represents a promising approach to reduce diabetes-related mortality further.

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Source: U.S. Vital Statistics and U.S. Census.

Note: All deaths coded to ICD9 in years 1989 to 1998, and to ICD10 in 1999 and later years

Figure 1.

Diabetes-Related Annual Death Rate by Year and Age Group, Results Standardized to 2000 Population

Source: U.S. Vital Statistics and U.S. Census.

Note: All deaths coded to ICD9 in years 1989 to 1998, and to ICD10 in 1999 and later years

Table 1

Year	----- decedents age 40-64 -----						----- decedents age 65-79 -----					
	1989	1995	2000	2005	Absolute Increase ^a	Relative Increase ^b	1989	1995	2000	2005	Absolute Increase ^a	Relative Increase ^b
Overall (n=670,621)												
low educ.	62.52	83.47	93.16	109.68	22.62	89.06%	101.76	130.18	143.14	142.64	28.98	98.20%
High school	50.32	59.25	63.98	67.30			110.42	116.99	117.53	112.98		
any college	36.52	31.74	34.29	40.23			80.51	63.54	67.01	71.19		
college+	23.07	24.18	23.45	21.42			69.31	71.39	69.30	58.83		
Men (n=378,905)												
low educ.	68.56	91.09	105.77	121.56	30.50	106.68%	102.02	137.52	153.72	172.09	46.12	181.08%
High school	62.51	74.40	81.58	83.45			139.03	146.05	151.06	140.74		
any college	43.77	39.75	41.46	50.67			100.48	80.34	86.76	94.23		
college+	27.32	27.92	28.71	26.20			85.51	85.65	81.72	68.64		
Women (n=291,709)												
low educ.	57.06	76.26	81.55	91.05	13.66	55.44%	102.00	124.67	134.59	133.40	18.93	51.16%
High school	41.68	47.88	50.07	50.42			94.32	99.86	98.38	91.80		
any college	29.88	24.65	27.91	28.62			65.46	50.59	52.89	52.95		
college+	16.26	18.76	16.95	14.19			51.18	53.10	51.33	42.91		
Whites (n=432,029)												
low educ.	52.24	76.82	97.13	119.78	24.46	123.47%	91.23	121.23	136.06	148.38	26.74	98.60%
High school	39.53	48.74	53.77	57.91			96.15	105.61	107.49	100.10		
any college	29.76	26.76	29.34	32.70			70.97	57.80	60.75	63.71		
college+	18.92	20.30	20.15	17.57			60.68	64.58	64.55	53.03		
Blacks (n=150,467)												
low educ.	90.41	128.71	141.30	165.10	38.70	167.03%	117.80	165.41	178.33	182.84	102.43	88.98%
High school	123.86	130.23	141.24	121.80			294.91	248.06	234.57	232.53		
any college	75.21	69.25	69.28	83.19			163.07	166.30	158.43	142.44		
college+	70.51	71.26	66.29	61.24			181.91	235.90	199.51	137.03		
Hispanics (n=58,123)												
low educ.	55.82	61.57	64.54	71.92	15.27	77.12%	128.13	137.36	152.49	152.33	33.25	143.20%

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Year	decedents age 40-64					decedents age 65-79				
	1989	1995	2000	2005	Absolute Increase ^a	Relative Increase ^b	1989	1995	2000	2005
High school	56.25	74.12	63.83	64.99			123.79	166.23	139.08	133.37
any college	46.93	35.52	42.28	41.15			189.51	70.76	79.25	88.79
college+	31.78	29.14	30.68	26.87			91.33	82.19	91.83	65.75

Note: Data from the U.S. Vital Statistics and the U.S. Census. Death rates per 100,000, age-standardized to 2000 Population.

^aSee text for description of this statistic.

^bSee text for description of this statistic.

Table 2

Prevalence of Any Diabetes (Diagnosed or Undiagnosed^d), by Year and Educational Attainment (Linearized Standard Errors in Parentheses)

Year of survey	----- respondents age 40-64 -----				----- respondents age 65-79 -----			
	Overall prevalence	Prevalence, low education	Prevalence, high education	Relative Change in disparity over time ^c	Overall prevalence	Prevalence, low education	Prevalence, high education	Relative Change in disparity over time ^c
1999-2004	12.81 (.0082)	15.94 ^b (.013)	10.37 (.012)	-21%	26.22 ^a (.020)	29.88 ^{a,b} (.022)	21.07 (.027)	-29%
1988-1994	10.90 (.0078)	13.24 ^b (.0096)	7.88 (.012)		19.86 (.015)	22.16 ^b (.017)	13.74 (.024)	

Note: Data come from the National Health and Nutrition Examination Survey (NHANES). This analysis includes only the randomly-selected half of the sample that was asked to fast before attending the Mobile Examination Clinic (people with known diabetes were excluded from the fast). For ages 40-64 n=2443 in 1999-2004 and n=2720 in 1988-1994. For ages 65-79 n=1173 in 1999-2004 and n=1387 in 1988-1994.

^a p .05 for change in prevalence across NHANES waves.

^b p .05 for difference in prevalence across educational attainment, within the NHANES wave

^c Calculated as change in relative difference across education from NHANES 1988-1994 to 1999-2004

^d Undiagnosed diabetes is defined as people who report that they do not have diabetes but have a fasting blood glucose level > 125mg/dl.

Table 3

Prevalence of Poor Glucose Control (HbA1c > 8%) Among Respondents Who Report that they Have Diabetes, by Year and Educational Attainment (Linearized Standard Errors in Parentheses)

Year of survey	----- respondents age 40-64 -----					----- respondents age 65-79 -----				
	Overall prevalence	Prevalence, low education	Prevalence, high education	Relative Increase in disparity over time ^c		Overall prevalence	Prevalence, low education	Prevalence, high education	Relative Increase in disparity over time ^c	
1999-2004	30.02 ^a (.019)	35.07 ^{a,b} (.027)	24.61 ^a (.029)	+70%		18.39 ^a (.023)	21.81 ^{a,b} (.030)	11.38 ^a (.027)	+194%	
1988-1994	41.37 (.037)	39.33 (.038)	47.01 (.094)			34.34 (.036)	31.38 ^b (.035)	48.18 (.088)		

Note: Data come from the subgroup of National Health and Nutrition Examination Survey (NHANES) that was asked to fast. For ages 40-64 n=665 in 1999-2004 and n=528 in 1988-1994. For ages 65-79 n=582 in 1999-2004 and n=460 in 1988-1994.

^a p .05 for change in prevalence across NHANES waves.

^b p .05 for difference in prevalence across educational attainment, within the NHANES wave