BMJ Open

Trends and socioeconomic disparities in all-cause mortality among adults with diagnosed diabetes by race/ethnicity: a population-based cohort study — United States, 1997-2015

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-044158
Article Type:	Original research
Date Submitted by the Author:	25-Aug-2020
Complete List of Authors:	Mercado, Carla; Centers for Disease Control and Prevention, Division of Diabetes Translation Beckles, Gloria; Centers for Disease Control and Prevention, Division of Diabetes Translation Cheng, Yiling; Centers for Disease Control and Prevention Bullard, Kai; Centers for Disease Control and Prevention Sayday, Sharon; National Center for Chronic Disease Prevention and Health Promotion, Gregg, Edward; Imperial College London, Imperatore, Giuseppina ; Centers for Disease Control and Prevention
Keywords:	DIABETES & ENDOCRINOLOGY, EPIDEMIOLOGY, STATISTICS & RESEARCH METHODS, PUBLIC HEALTH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Trends and socioeconomic disparities in all-cause mortality among adults with diagnosed diabetes by race/ethnicity: a population-based cohort study — United States, 1997-2015

Carla I. Mercado[1], PhD; Gloria L. Beckles[1], MD, MSc; Yiling Cheng[1], MD, PhD; Kai McKeever Bullard[1], PhD; Sharon H. Saydah[1], PhD, Edward W. Gregg[2], MD, PhD; Giuseppina Imperatore[1], MD, PhD

[1] Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

[2] School of Public Health, Imperial College London, London, UK

Corresponding author: Carla I. Mercado, Centers for Disease Control and Prevention, Mailstop F-75, 4770 Buford Highway NE, Atlanta, GA 30341. Tel: 770-488-8075, Fax: 770-488-8151, E-mail: CMercado@cdc.gov.

Running title: socioeconomic mortality disparity in diabetes

Keywords: socioeconomic disparity, mortality, race/ethnicity, trends, diabetes

Word count: 3660

Number of tables and figures: 5

The findings and conclusions in this manuscript are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Abstract

Objectives: By race/ethnicity and socioeconomic position (SEP) subgroups, to estimate and examine changes over time in 1) mortality rate; 2) mortality disparities, and 3) excess mortality risk attributed to diagnosed diabetes (DM).

Design: Population-based cohort study using National Health Interview Survey data linked to mortality status from the National Death Index from survey year up to December 31, 2015.

Participants: U.S. adults aged ≥25 years with (32,986) and without (347,927) DM.

Primary outcome: Age-adjusted 5-year all-cause mortality rate for U.S. adults with DM in each subgroup of SEP [education attainment and income to poverty ratio (IPR)] and time period (1997-2001, 2002-2006, and 2007-2011).

Results: Among adults with DM, mortality rates fell from 24.3/1000 person-years (p-y) in 1997-2001 to 17.9/1000 p-y in 2007-2011 with changes of -6.1/1000 p-y for non-Hispanic whites; -5.4/1000 p-y for non-Hispanic blacks; and -5.4/1000 p-y for Hispanics. Rates also significantly declined within SEP groups, measured as education attainment [<high school = -6.7/1000 p-y; high school grad = -5.0/1000 p-y; and >high school = -5.9/1000 p-y] and IPR group [<100% = -9.3/1000 p-y; 100-199% = -4.5/1000 p-y; 200-399% = -5.9/1000 p-y ; and ≥400% = -6.3/1000 p-y], but patterns in trends varied by race/ethnicity. For adults with DM, the statistically significant relative disparity in all-cause mortality was greater from the lowest to the highest SEP level for education attainment and for IPR in each time period. The excess mortality risk attributed to DM significantly decreased from 1997-2001 to 2007-2011, within SEP levels, and among Hispanic and non-Hispanic white adults; but no statistically significant changes among non-Hispanic black.

Conclusions: There were substantial improvements in all-cause mortality among U.S. adults. However, we observed SEP disparities in mortality across race/ethnic groups or for adults with and without DM despite targeted efforts to improve access and quality of care among vulnerable populations.

Strengths and Limitations

- A population-based study on multi-dimensional association and disparities between socioeconomic position (SEP), race/ethnicity, diabetes, and mortality along with whether any changes have occurred since 1997.
- A series of consecutive national representative surveys (1997-2011) were linked to latest available mortality data through December 31, 2015.
- Aside from investigating changes in mortality rates over time, this study measured the mortality disparity from lower to higher SEP rankings and how those disparities have changed over time.
- Since diabetes and SEP statuses were self-reported and only measured at baseline, misreporting and status changes during the course of the follow-up period may have occurred.

INTRODUCTION

Diabetes mellitus increased rapidly in the United States from mid-1990s that by 2015 an estimated 23.1 million people had diagnosed diabetes, or 9.4% of the total population.(1) Prevalence and incidence of diagnosed diabetes affects racial/ethnic groups disproportionately, with greater and plateauing estimates among non-Hispanic blacks and Hispanics than the lower declining ones for non-Hispanic whites.(2-4) Additionally, diabetes prevalence is greater at lower socioeconomic position (SEP) levels, measured by education attainment and income, than higher levels.(5, 6) Although several national, state and local programs and initiatives were developed to reduce diabetes and eliminate diabetes-associated disparities,(7) marked racial/ethnic and SEP disparities in prevalence of diabetes were reported between 2004 and 2010 with increased SEP disparities magnitude among adults with diagnosed diabetes over time.(8-10)

Diabetes socioeconomic patterning is associated with reduced access to care, poor quality of care, underuse of preventive health measures and health care behaviors that provide pathways to increased mortality risk.(11) SEP (measured by either education attainment, wealth, income, and/or income-to-poverty ratio) has been reported to be inversely associated all-cause mortality risk.(12-16) When the magnitudes of absolute educational disparities (slope index of inequality, SII) were assessed, adults with diabetes experienced a greater all-cause mortality burden associated with low levels of education than those without diabetes.(12-16) Additionally, the educational gradient in all-cause mortality rates was present in non-Hispanic white and non-Hispanic blacks but not among Hispanics.(12-16)

The SEP mortality association has typically been examined separately without examining the intersectionality of known related characteristics, such as race/ethnicity or diabetes. This approach ignores that individuals inhabit multiple social statuses simultaneously, that these statuses interact to shape the

health risk patterns experienced, and thereby the health disparities observed.(16) Investigation in population-level race/ethnic- and SEP-specific mortality rate changes among adults with diagnosed diabetes could inform national, state, and local efforts aimed at reducing diabetes-related disparities. Furthermore, examining changes in excess mortality risk attributed to diabetes could determine if diabetes-related disparity has narrowed. This study aims to examine whether and to what extent race/ethnic: 1) SEP-specific mortality rates have changed over time among adults with diagnosed diabetes, 2) SEP disparities in all-cause mortality exist and changed over time among adults with diagnosed diabetes, and 3) has the excess mortality risk attributed to diabetes (rate difference between those with and without diabetes) in SEP-specific groups changed over time.

METHODS

Data and population Data from the National Health Interview Surveys (NHIS) for the years 1997-2011 was linked with death certificates from the National Death Index (NDI) to obtain the most current mortality status through December 31, 2015.(17) NHIS is an annual ongoing cross-sectional household interview survey (about 35,000 households per year) of a nationally representative civilian, noninstitutionalized sample conducted by the CDC's National Center for Health Statistics (NCHS).(18, 19) Participation in NHIS is voluntary and confidentiality is assured under the Public Health Service Act Section 308(d). NHIS data from 1997 through 2011 had a final adult response rate ranging from 61% to 80%.(20) Most survey participants (a 94.8% average) were eligible for the mortality follow-up based on the following identifiable data combinations: 1) social security number, last name, and first name; 2) social security number, sex, and birthday (month, day, and year); and/or 3) last name, first name, and birth month and year.(17) Sampling weights adjusted for ineligible mortality linkage were used in all analyses.

Participants who responded "yes" to the question, "Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?" were classified as having diagnosed diabetes; otherwise, participants were classified as not having been diagnosed with diabetes. The analysis sample was restricted to the 381,246 adults aged ≥25 years interviewed in the 1997 to 2011 survey years and were eligible for the mortality follow-up. Of these, 32,986 reported having diagnosed diabetes, 347,927 did not report having diagnosed diabetes, and 333 were excluded due to missing diagnosed diabetes status.

Variables

Outcome. All-cause mortality was determined by vital status after data linkage with NDI. Person-time was calculated from exact survey interview date to date of death or December 31, 2015 (currently the latest

available mortality data) for those assumed alive. To reduce follow-up bias when assessing temporal changes in mortality rates, follow-up was right truncated at death or 5 years of follow-up (whichever came first). For example, for the 1997 cohort, mortality information was assessed up to 2001. Therefore, survey cycles after 2011 were not included since 5-year mortality rate is not available.

Social Economic Position. SEP was measured by 2 socioeconomic indicators: i) educational attainment [completion of grades <12 (<high school), high school graduate or equivalency (high school grad), any education beyond high school (>high school)]; and ii) the family income-to-poverty threshold ratio (IPR) (poor <100% federal poverty level [FPL]; near poor 100%-199% FPL; middle income 200%-399% FPL; and high income ≥400% FPL).(21) Education and income were self-reported. Due to missing income values of weighted percentage between 23-33% for survey years of 1997-2011, the NCHS CDC imputed missing values using reported multiple-imputation methodology(22) producing five data sets that accompany the data release of each survey year. Income estimates were calculated by averaging the estimates from the five data sets and estimating the variance by calculating the within and between imputation variance.

Other Covariates. Diabetes status, age, sex, and race-ethnicity were self-reported at baseline. Characteristics and demographics were described for adults with diagnosed diabetes according to three 5-year periods based on their interview date (1997-2001, 2002-2006, and 2007-2011) as counts, percentages, and estimated number in the population for: sex, age groups (25-49, 50-64, 65-79, and ≥80 years), race/ethnicity (non-Hispanic white, non-Hispanic black, and Hispanic), educational attainment categories, IPR categories, and diagnosed diabetes status. The counts for IPR were based on the imputed data set number five. Participants who identified as "other race/ethnicity" were included in total population ("All") analyses but not for race/ethnic specific estimates due to the limited sample size. Characteristics and demographics were also described separately for adults without diagnosed diabetes (supplemental table 1).

Statistical Analysis

Weighted Poisson regression accounting for survey design was used to calculate population-level 5-year mortality rates, weighted death number divided by the total weighted person-time and adjusted for baseline age and compare across the three survey time periods (1997-2001, 2002-2006, and 2007-2011). Estimates were expressed as deaths per 1000 person-years. Data was analyzed for all adults and by each race/ethnic subgroup using regression model containing a 3-way term for interaction between baseline diagnosed diabetes status*time period*SEP variable, including all lower order interactions and variables, and baseline age covariate was used. This modeling allowed comparison test between time periods, SEP levels, and diabetes status. Predictive margins were used to estimate adjusted mortality rates by SEP, time period, and diabetes status. Marginal effects were used to estimate strata-specific age-adjusted 5-year mortality rate differences (excess mortality risk) between those with and those without diagnosed diabetes and change in mortality rates between 1997-2001 cohort and 2007-2011 cohort. Both predictive margins and marginal effects test differences using t-test.

SEP disparity was examined by defining educational attainment and IPR groups ordered from the highest to the lowest ranks.(23, 24) A ridit score for each period was calculated for education attainment and for IPR based on the midpoint of the cumulative proportion of each rank from highest to lowest, ranging between 0 (highest) to 1 (lowest). The ridit score estimates the relative position of each socio-economic group in the social hierarchy considering their group size.(25) For all adults and by each race/ethnic subgroup, we used a Poisson regression model containing a 3-way term for interaction between baseline diagnosed diabetes status*time periods*SEP ridit score and the covariate of baseline age. Absolute Difference was obtained by fitting a straight line to the mortality rates ordered from the ridit score of educational attainment or IPR. The linear regression ridit slope, or Slope Index of Inequality (SII), was interpreted as the average absolute difference in the age-adjusted 5-year all-cause mortality rate from each

SEP indicator lowest to the highest rank. Relative Difference, Relative Index of Inequality (RII) expressed as a percent change, was obtained by dividing the Absolute Difference by the age-adjusted 5-year all-cause mortality rate for the total population. It is interpreted as the average percentage change in the age-adjusted mortality rate from the lowest to the highest rank of each SEP indicator. From the regression model, SII and RII for each time period and diabetes status subgroup was calculated. We assessed SII and RII magnitudes for the three time periods (1997-2001, 2002-2006, and 2007-2011) and direction of change over time as the simple differences between the 1st and 3rd time periods.

For adults with no diagnosed diabetes, the results for age-adjusted 5-year mortality, SII, and RII are provided in the supplemental materials. We used Stata 15.0 (StataCorp LP, College Station, Texas) in all analyses to take account of the complex multistage sampling design and to provide representative population estimates with 95% confidence intervals (CIs). Estimates for change from Poisson regression models were considered significant if 95% confidence intervals did not include the null value. Since different Poisson regression models were used for each race/ethnic subgroup, comparing estimates between race/ethnic subgroups were conservatively considered statistically significantly different if 95% confidence intervals did not overlap.(26) Although we understand that this approach is very conservative, it was a better option than fitting a 4-way interaction in these models which could lead to unstable or uninterpretable results.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

RESULTS

Between 1997-2001 and 2007-2011, the population of U.S. adults aged ≥25 years with diagnosed diabetes grew from 10.6 million to 19.1 million, mean age stayed steady at 60.2 years and 60.4 years, and the percentage in minority racial/ethnic group (non-Hispanic black and Hispanic) increased from 29.0% to 31.3% (Table 1). The percentage that had not completed high school fell from 33.1% to 24.8%, and percentage living below the federal poverty level fell from 15.6% to 14.5%.

Trends in all-cause mortality rates by socioeconomic position

Among all adults with diagnosed diabetes, age-adjusted 5-year all-cause mortality rates fell from 24.3/1000 person-years (p-y) in 1997-2001 to 17.9/1000 p-y in 2007-2011; a decline of 26% or 6.4/1000 p-y (Table 2). Within each racial/ethnic group, all-cause mortality rates also declined between 1997-2001 and 2007-2011: by 6.1/1000 p-y or 23% for non-Hispanic whites; 5.4/1000 p-y or 26% for non-Hispanic blacks; and 5.4/1000 p-y; or 34% for Hispanics. In each 5-year period, all-cause mortality rates were highest among non-Hispanic whites, lowest among Hispanics, and intermediate for non-Hispanic blacks based on non-overlapping confidence intervals.

At each level of SEP, overall mortality rates showed a significant decline between 1997-2001 and 2007-2011 in education attainment [<high school = -6.7/1000 p-y; high school grad = -5.0/1000 p-y; and >high school = -5.9/1000 p-y] and IPR group [poor = -9.3/1000 p-y; near poor = -4.5/1000 p-y; middle income = -5.9/1000 p-y ; and high income = -6.3/1000 p-y] (Tables 3 & 4). However, the pattern of mortality rate decline of educational attainment varied by racial/ethnic group where rates declined for all levels in non-Hispanic whites (ranging from -4.5 to -5.8/1000 p-y) but significantly only for the lowest educational attainment level in non-Hispanic black (-4.9/1000 p-y**)** and Hispanic (-5.3/1000 p-y) adults**.** For IPR, there were differences by race/ethnicity in the pattern of significant mortality rate decline occurring in the high

income (-7.7/1000 p-y) and middle income (-5.7/1000 p-y) groups, but not significantly in the two poorer groups, for non-Hispanic white adults. In contrast, mortality rates only declined significantly among the poor for non-Hispanic blacks (-11.2/1000 p-y) and Hispanics (-6.1/1000 p-y), and not among the more affluent groups.

Socioeconomic disparities in mortality

Among all adults with diagnosed diabetes, age-adjusted 5-year all-cause mortality rates showed an inverse gradient with educational attainment (Table 3) and IPR (Table 4) with greater rates in the lower levels than the higher ones. Overall, the absolute disparity in all-cause mortality (SII) in the lowest level than the highest was a 7.6/1000 p-y greater mortality rate for education attainment and 11.4/1000 p-y for IPR in 1997-2001 and a 6.6/1000 p-y for education attainment and 11.0/1000 p-y for IPR in 2007-2011. The relative disparity (RII) in the lowest than highest level showed a 31.8% higher mortality rate for education attainment and for IPR a 48.2% higher rate in 1997-2001 and a 37.1% for education attainment and 62.1% for IPR relative disparity in 2007-2011 (Tables 3 and 4).

When comparing each strata of SEP levels and time periods across race/ethnic groups, mortality rates were mostly greater for non-Hispanic white adults than non-Hispanic black and Hispanic adults based on non-overlapping confidence intervals. For non-Hispanic white adults, the absolute disparity (SII) in all-cause mortality ranged from 9.6 to 10.0/1000 p-y for education attainment and 10.1 to 16.1/1000 p-y for IPR across the three time periods; while relative disparity (RII) ranged from 38.6% to 46.9% for education attainment and 38.7% to 78.8% for IPR. For non-Hispanic blacks, there was a significant education attainment disparity in all-cause mortality observed only for the time period of 2002-2006 (SII=12.9/1000 p-y and RII=68.3%); while the IPR disparity was significant for all three time periods among non-Hispanic blacks (ranges: SII= 8.8 to 21.8/1000 p-y and RII= 57.1% to 107.2%). There were no statistically

significant absolute or relative education attainment or IPR disparity in all-cause mortality during these time periods for Hispanic adults with diagnosed diabetes. Additionally, no statistically significant change between 1997-2001 and 2007-2011 in the absolute and relative SEP disparity was observed overall or within race/ethnic groups.

Excess mortality risk for adults with diagnosed diabetes

The overall age-adjusted all-cause excess mortality risk among adults with diagnosed diabetes significantly decreased from 1997-2001 [11.6/1000 p-y (95% CI; 10.3, 12.8)] to 2007-2011 [7.6/1000 p-y (6.5, 8.7)], a decrease of 4.9/1000 p-y (3.2, 6.6) (supplemental table 3). The excess mortality risk tended to be greater among non-Hispanic white adults compared to non-Hispanic black and Hispanic adults. The decreased excess mortality risk for those with diabetes from 1997-2001 to 2007-2011 was only observed among non-Hispanic white [change= -4.4 (-6.7, -2.0)] and Hispanics [-4.7 (-8.2, -1.2)] adults, but no significant change for non-Hispanic black.

Within SEP, trends in the overall excess mortality risk for adults with diagnosed diabetes showed significant decrease at each level of educational attainment and among the poor, middle income, and high income categories between 1997-2001 and 2007-2011 (Figure 1). By race/ethnicity, significant excess mortality risk decreases were only observed in those with <high school and >high school education attainment and in the high income group for non-Hispanic white and among the poor group in non-Hispanic black adults.

DISCUSSION

In this study of a nationally representative sample of adults with diagnosed diabetes, we found age-adjusted all-cause 5-year mortality rates declined from 1997 to 2011 overall and within each racial/ethnic group, and mortality rates were lower among racial/ethnic minority groups than non-Hispanic whites in each 5-year period. Age-adjusted mortality rates were inversely associated with SEP measures and significant SEP disparities in all-cause mortality rates were present overall but varied by racial/ethnic group and SEP measure. Regardless of declining mortality trends in adults with diagnosed diabetes, SEP disparity (SIIs and RIIs) did not change significantly over time meaning that the magnitude of the inverse association between SEP and all-cause mortality has remained constant from 1997-2011. When considering the excess mortality risk of U.S. adults with diagnosed diabetes, we found that the excess risk has decreased between 1997-2011 overall and in non-Hispanic white and Hispanic adults, but not among non-Hispanic black adults. Additionally, the excess mortality risk for adults with diagnosed diabetes has decreased within SEP level, but the changes varied throughout race/ethnic groups and SEP levels.

Our finding that age-adjusted all-cause mortality rates in adults with diagnosed diabetes were lower for non-Hispanic blacks and Hispanics than the rates for non-Hispanic whites is consistent with reports from studies that used U.S. nationally representative [12-15] or large convenient [27-30] samples and even after adjustment for multiple covariates. This racial/ethnic patterning of all-cause mortality in diabetic populations is not consistent with that of the general population's 2-fold greater risk reported for minority racial/ethnic groups compared to whites.[28, 31] Several factors may account for these different patterns. First, in the general population the prevalence of diabetes is higher among minority racial groups than whites, so that racial/ethnic-specific mortality rates are attributable to the distribution of diabetes across the different racial/ethnic subgroups in the general population. In contrast, mortality rates in diabetic populations are estimated conditional on individuals having diabetes which removes the effect of

racial/ethnic differences in prevalence. Second, despite the decline during the time period of interest, undiagnosed diabetes remained more prevalent among racial/ethnic minority groups than among non-Hispanic whites, accounting for as much as 50% of diabetes cases in racial/ethnic minority populations;[32] consequently, the lower rates in the diagnosed population may reflect missed undiagnosed cases and higher rates among racial/ethnic minority groups in the general population. Third, mortality rates may be lower among non-Hispanic blacks and Hispanics because they may be in better health than non-Hispanic whites at older ages when diabetes occurs.[33, 34] Non-Hispanic blacks are more likely to have higher mortality rates at younger ages than non-Hispanic whites;(33) the high proportion of foreign-born among the current Hispanic population may contribute the assets (younger, healthier, and better educated) of the 'healthy migrant'.[34] Based on all these reasons, we chose to use all-cause mortality instead of disease-specific mortality to minimize bias and have a comprehensive clear outcome.

The results of this study confirm earlier reports of no excess mortality risk among racial/ethnic minority groups with diagnosed diabetes but inverse relationships between SEP measures (educational attainment, income, wealth) and mortality risk within these groups.[12, 13, 15] However, we document that within racial/ethnic groups, adults with diabetes exposed to the greatest socioeconomic disadvantage experienced significantly greater mortality burden than their more affluent peers despite declining trends in mortality. We are not aware of other evidence that SEP-mortality relationships persist despite secular improvement in the health of the diabetic population, as measured by declining mortality risk. Additional analyses (supplemental tables) showed that among adults without diagnosed diabetes age-adjusted all-cause mortality rates were half as high as those for adults with diagnosed diabetes; yet, they experienced improvements to a much lesser degree during this period, especially by SEP measures (Supplementary Tables 2, 4, and 5).

Although greater improvements in all-cause mortality among adults with diagnosed diabetes compared to adults without diabetes were noted, the underlying diabetic population has experienced marked changes in the distribution of the SEP indicators. For example, the proportion of adults with diagnosed diabetes reporting greater than high school education attainment increased and those with less than high school graduation decreased by 8 percentage points while only high school graduation remained at 31% between 1997-2001 and 2007-2011. Additionally, those with IPR ≥ 400% increased by almost 3 percentage points while the proportion living below the federal poverty level remained at about 15%. Surprisingly, the population of adults without diagnosed diabetes also experienced an increased in those who reported greater than high school education attainment by about 6 percentage points but the IPR distribution remained fairly the same with a slight suggestion of an increase shift towards poorer levels. Therefore, in adults with diabetes, not only has the SEP distribution shifted towards higher SEP levels but the shape of the distribution has changed suggesting that the underlying diabetic population in 1997-2001 is not the same as the more recent 2007-2011 population. The population of adults without diagnosed diabetes seems to have experienced a different pattern in SEP distribution changes. Considering the inverse relationship between SEP and mortality, the distribution changes in SEP observed in the underlying populations of adults with and without diabetes can explain why greater improvements were seen in those with diabetes than those without. If health improvements are responsible for the decreasing mortality rates rather than the changes in the SEP distribution, then these improvements have not benefited adults at the highest risk (lower SEP levels) since SEP disparity gap in all-cause mortality did not significantly change during this time.

Limitations & Strengths

First, diabetes status was self-reported and ascertained only at baseline. It is possible that individuals had the disease at baseline but were undiagnosed or that they developed diabetes through the course of the

follow-up time. Therefore, the number of diagnosed cases may have been subject to recall and social desirability bias. However, self-reported diagnosed diabetes has been shown to have high reliability.(32) These findings do not reflect disparities in the prevalence of all diabetes (diagnosed plus undiagnosed); approximately 28% of all diabetes is undiagnosed(32) and might vary by SEP as well as race/ethnicity. To avoid bias related to the high nonresponse to survey questions on income, NHIS datasets with imputed income were used in all analyses. However, when using imputed data, there is the potential for misclassification. Furthermore, SEP measures (education attainment and IPR) were measured only at baseline; although education attainment did not likely change for many in this cohort of adults aged ≥25 years, their income may have fluctuated. Also, SEP measures were self-reported and if income was misreported it could have a bias effect on the imputed values. In this study, we were unable to further stratify by sex or age groups due to sample size constraints. However, all analyses were adjusted for sex and age. Finally, although there is potential for bias based on the exclusion of those ineligible for mortality linkage, the majority of NHIS participants were linkage eligible and we used sampling weights adjusted for ineligible linkage.

Conclusions

During the period 1997 to 2011, age-adjusted 5-year all-cause mortality rates improved across all levels of SEP, measured as education attainment and income-to-poverty ratio. We observed no change in the magnitude of the SEP disparities in mortality during the time period of interest across race/ethnic groups or for adults with and without diabetes. More research that investigates and identifies potential modifiable system-level factors that contribute to SEP disparity in all-cause mortality beyond diabetes and race/ethnicity is needed.

Acknowledgments

CIM, GLB, YC, KMB, SHS, EWG, and GI contributed to the design of this study. is the guarantor of this work and, as such, has primary responsibility over the integrity and accuracy of the data sets, data analyses, writing the paper, and the final content of this project. All authors read, reviewed, and approved the final manuscript. **Competing Interests:** CIM, GLB, YC, KMB, SHS, EWG, and GI have no potential competing interest relevant to this article. **Funding:** None. **Participants informed consent:** Not required.

REFERENCES

1. Centers for Disease Control and Prevention. National Diabetes Statistic Report, 2020. Atlanta, GA: Centers for Disease Control and Prevention, US Department of Health and Human Services; 2020.
2. Geiss LS, Wang J, Cheng YJ, Thompson TJ, Barker L, Li Y, et al. Prevalence and incidence trends for diagnosed diabetes among adults aged 20 to 79 years, United States, 1980-2012. Jama. 2014;312(12):1218-26.
3. Selvin E, Ali MK. Declines in the Incidence of Diabetes in the U.S.-Real Progress or Artifact? Diabetes Care. 2017;40(9):1139-43.
4. Benoit SR, Hora I, Albright AL, Gregg EW. New directions in incidence and prevalence of diagnosed diabetes in the USA. BMJ open diabetes research & care. 2019;7(1):e000657.
5. Agardh E, Allebeck P, Hallqvist J, Moradi T, Sidorchuk A. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. Int J Epidemiol. 2011;40(3):804-18.
6. Maty SC, James SA, Kaplan GA. Life-course socioeconomic position and incidence of diabetes mellitus among blacks and whites: the Alameda County Study, 1965-1999. Am J Public Health. 2010;100(1):137-45.
7. Centers for Disease Control and Prevention. State, Local, and National Partner Diabetes Programs 2019 [Available from: https://www.cdc.gov/diabetes/programs/stateandlocal/index.html.
8. Beckles GL, Chou CF. Diabetes - United States, 2006 and 2010. MMWR supplements. 2013;62(3):99-104.
9. Beckles GL, Zhu J, Moonesinghe R. Diabetes - United States, 2004 and 2008. MMWR supplements. 2011;60(1):90-3.
10. Beckles GL, Chou CF. Disparities in the Prevalence of Diagnosed Diabetes - United States, 1999-2002 and 2011-2014. MMWR Morbidity and mortality weekly report. 2016;65(45):1265-9.
11. Brown AF, Ettner SL, Piette J, Weinberger M, Gregg E, Shapiro MF, et al. Socioeconomic position and health among persons with diabetes mellitus: a conceptual framework and review of the literature. Epidemiologic reviews. 2004;26:63-77.
12. Dray-Spira R, Gary-Webb TL, Brancati FL. Educational disparities in mortality among adults with diabetes in the U.S. Diabetes Care. 2010;33(6):1200-5.
13. Dupre ME, Silberberg M, Willis JM, Feinglos MN. Education, glucose control, and mortality risks among U.S. older adults with diabetes. Diabetes Res Clin Pract. 2015;107(3):392-9.
14. McEwen LN, Kim C, Karter AJ, Haan MN, Ghosh D, Lantz PM, et al. Risk factors for mortality among patients with diabetes: the Translating Research Into Action for Diabetes (TRIAD) Study. Diabetes Care. 2007;30(7):1736-41.
15. Saydah SH, Imperatore G, Beckles GL. Socioeconomic status and mortality: contribution of health care access and psychological distress among U.S. adults with diagnosed diabetes. Diabetes Care. 2013;36(1):49-55.
16. Williams DR, Kontos EZ, Viswanath K, Haas JS, Lathan CS, MacConaill LE, et al. Integrating multiple social statuses in health disparities research: the case of lung cancer. Health services research. 2012;47(3 Pt 2):1255-77.
17. Office of Analysis and Epidemiology NCfHS. The Linkage of National Center for Health Statistics Survey Data to the National Death Index - 2015 Linked Mortality File: Methodology Overview and Analytic Considerations. Hyattsville, MarylandMarch 2019.
18. Design and estimation for the National Health Interview Survey, 1995-2004. Vital and health statistics Series 2, Data evaluation and methods research. 2000(130):1-31.
19. Parsons VL, Moriarity C, Jonas K, Moore TF, Davis KE, Tompkins L. Design and estimation for the national health interview survey, 2006-2015. Vital and health statistics Series 2, Data evaluation and methods research. 2014(165):1-53.
20. National Center for Health Statistics. Survey Description, National Health Interview Survey, 2011. Hyattsville, Maryland; 2012.
21. Krieger N, Williams DR, Moss NE. Measuring social class in US public health research: concepts, methodologies, and guidelines. Annu Rev Public Health. 1997;18:341-78.

22. National Center for Health Statistics and Department of Health Information Security. Multiple Imputation of Family Income and Personal Earnings in the National Health Interview Survey: Methods and Examples. Hyattsville, Maryland: National Center for Health Statistics, Centers for Disease Control and Prevention; 2012.
23. Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. Soc Sci Med. 1997;44(6):757-71.
24. Moreno-Betancur M, Latouche A, Menvielle G, Kunst AE, Rey G. Relative index of inequality and slope index of inequality: a structured regression framework for estimation. Epidemiology. 2015;26(4):518-27.
25. Irwin DJB. How to Use Ridit Analysis. Biometrics. 1958;14(1):18-38.
26. Payton ME, Greenstone MH, Schenker N. Overlapping confidence intervals or standard error intervals: what do they mean in terms of statistical significance? Journal of insect science (Online). 2003;3:34.
27. Conway BN, May ME, Blot WJ. Mortality among low-income African Americans and whites with diabetes. Diabetes Care. 2012;35(11):2293-9.
28. Hunt BR, Whitman S, Henry CA. Age-adjusted diabetes mortality rates vary in local communities in a metropolitan area: racial and spatial disparities and correlates. Diabetes Care. 2014;37(5):1279-86.
29. Lynch CP, Gebregziabher M, Echols C, Gilbert GE, Zhao Y, Egede LE. Racial disparities in all-cause mortality among veterans with type 2 diabetes. J Gen Intern Med. 2010;25(10):1051-6.
30. Zhao W, Katzmarzyk PT, Horswell R, Wang Y, Li W, Johnson J, et al. Body mass index and the risk of all-cause mortality among patients with type 2 diabetes mellitus. Circulation. 2014;130(24):2143-51.
31. Rosenstock S, Whitman S, West JF, Balkin M. Racial disparities in diabetes mortality in the 50 most populous US cities. Journal of urban health : bulletin of the New York Academy of Medicine. 2014;91(5):873-85.
32. Menke A, Casagrande S, Geiss L, Cowie CC. Prevalence of and Trends in Diabetes Among Adults in the United States, 1988-2012. Jama. 2015;314(10):1021-9.
33. Olshansky SJ, Antonucci T, Berkman L, Binstock RH, Boersch-Supan A, Cacioppo JT, et al. Differences in life expectancy due to race and educational differences are widening, and many may not catch up. Health affairs (Project Hope). 2012;31(8):1803-13.
34. Medina-Inojosa J, Jean N, Cortes-Bergoderi M, Lopez-Jimenez F. The Hispanic paradox in cardiovascular disease and total mortality. Progress in cardiovascular diseases. 2014;57(3):286-92.

Table 1. Selected characteristics of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** for three time period cohorts (1997-2001, 2002-2006, and 2007-2011) - National Health Interview Survey, 1997-2015

	1997-2001			2002-2006			2007-2011		
	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)
Total	9660	100.0	10.6	10864	100.0	14.3	12462	100.0	19.1
Gender									
Men	4077	48.0 (46.7, 49.3)	5.1	4840	49.7 (48.6, 50.8)	7.1	5630	49.9 (48.8, 51.1)	9.5
Women	5583	52.0 (50.7, 53.3)	5.5	6024	50.3 (49.2, 51.4)	7.2	6832	50.1 (48.9, 51.2)	9.6
Age groups (years)									
25-49	2132	23.6 (22.6, 24.7)	2.5	2314	23.2 (22.2, 24.3)	3.3	2390	21.4 (20.4, 22.4)	4.1
50-64	3241	35.2 (34.0, 36.5)	3.7	3865	37.3 (36.1, 38.5)	5.3	4665	39.9 (38.9, 41.0)	7.6
65-79	3426	33.4 (32.3, 34.6)	3.5	3624	31.0 (29.9, 32.1)	4.4	4125	29.9 (28.9, 30.9)	5.7
≥80	861	7.7 (7.1, 8.4)	0.8	1061	8.5 (7.9, 9.2)	1.2	1282	8.8 (8.3, 9.4)	1.7
Age (years): mean (se)		60.2 (0.2)			60.1 (0.2)			60.4 (0.2)	
Race/ethnicity									
Non-Hispanic white	5677	71.0 (69.5, 72.4)	7.3	6477	71.6 (70.4, 72.7)	9.8	6694	68.6 (67.5, 69.8)	12.4
Non-Hispanic black	1998	17.2 (15.9, 18.5)	1.8	2129	16.2 (15.2, 17.1)	2.2	2745	16.4 (15.5, 17.4)	3.0
Hispanic	1716	11.8 (11.0, 12.8)	1.2	1847	12.3 (11.5, 13.1)	1.7	2303	14.9 (14.0, 15.8)	2.7
Education									
<High School	3615	33.1 (31.9, 34.2)	3.5	3412	27.0 (26.0, 28.0)	3.9	3554	24.8 (23.8, 25.9)	4.7
High School Grad	2873	31.7 (30.6, 32.9)	3.4	3262	31.5 (30.4, 32.6)	4.5	3661	31.3 (30.2, 32.4)	6.0
>High School	3172	35.2 (33.9, 36.5)	3.7	4190	41.5 (40.3, 42.8)	5.9	5247	43.8 (42.7, 45.0)	8.4
Income-to-Poverty Ratio									
Poor (<100%)	2047	15.6 (14.6, 16.5)	1.6	2244	15.1 (14.3, 15.9)	2.2	2496	14.5 (13.6, 15.3)	2.8
Near poor (100-199%)	2617	24.6 (23.5, 25.8)	2.6	2823	23.8 (22.7, 24.8)	3.4	3217	23.8 (22.7, 24.9)	4.5
Middle income (200-399%)	2927	33.2 (32.1, 34.4)	3.5	3210	31.8 (30.7, 33.0)	4.5	3796	32.5 (31.4, 33.7)	6.2
High income (≥400%)	2069	26.6 (25.4, 27.8)	2.8	2587	29.3 (28.1, 30.5)	4.2	2953	29.2 (28.0, 30.5)	5.6

Five data files with imputed income data were provided by the Centers for Disease Control and Prevention's National Center for Health Statistics. Multiple imputation methodology was used to calculate all estimates related to income to poverty ratio threshold; N's based on imputed income data file number 5.

Table 2. Age adjusted all-cause 5-year mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** by race/ethnicity - National Health Interview Survey, 1997-2015

	5-year Mortality at Each Time Period with Potential Follow-up Through 2015			
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2007-2011
All	24.3 (23.0, 25.6)	20.2 (19.1, 21.4)	17.9 (16.8, 18.9)	-6.4 (-8.1, -4.8)
Non-Hispanic white	26.7 (25.0, 28.5)	22.9 (21.4, 24.5)	20.6 (19.1, 22.1)	-6.1 (-8.4, -3.8)
Non-Hispanic black	20.8 (17.8, 23.8)	19.2 (16.6, 21.9)	15.4 (13.5, 17.2)	-5.4 (-8.9, -1.9)
Hispanic	15.8 (13.0, 18.7)	10.4 (8.4, 12.4)	10.5 (8.7, 12.3)	-5.4 (-8.7, -2.1)

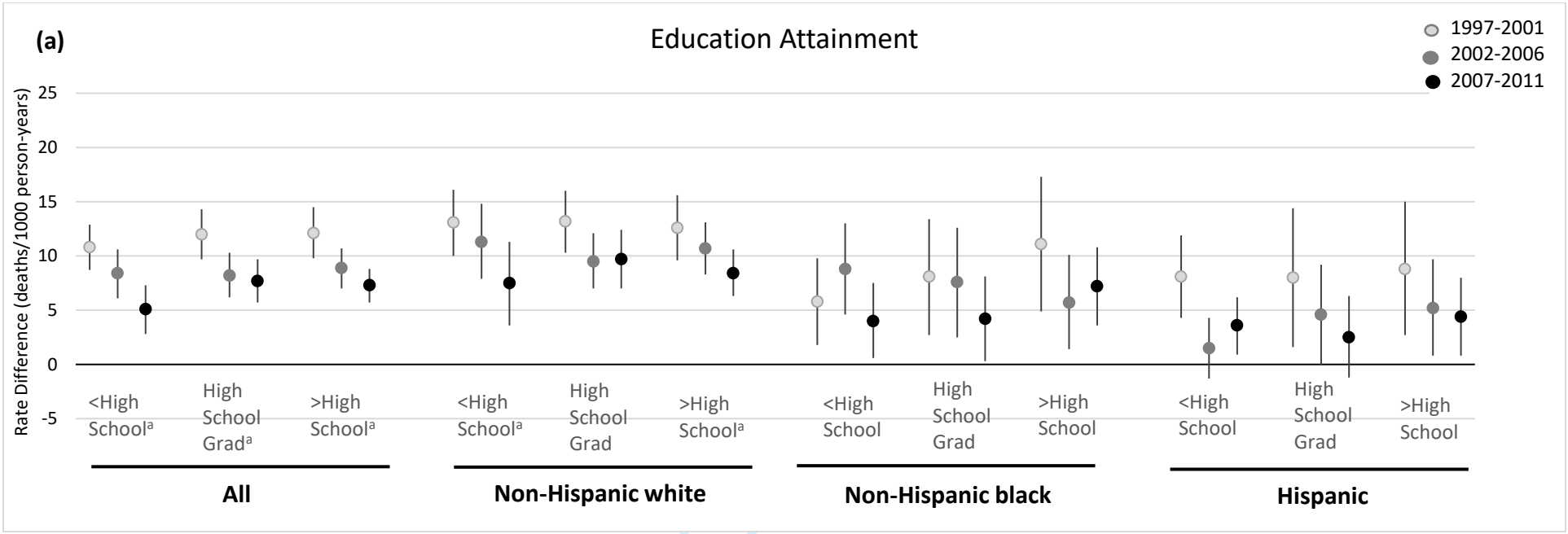
Table 3. Age adjusted all-cause 5-year mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different **Education Attainment** and by race/ethnicity - National Health Interview Survey, 1997-2015

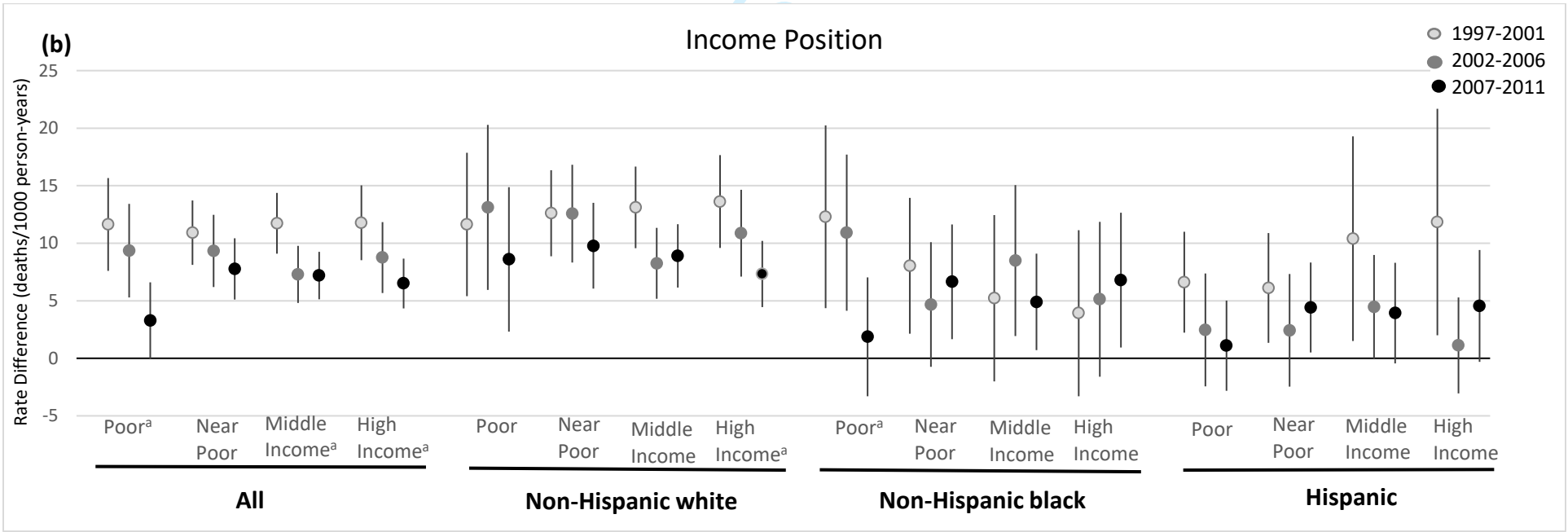
	5-year Mortality at Each Time Period with Potential Follow-up Through 2015			
	1997-2001	**2002-2006**	**2007-2011**	**Change 1997-2001 to 2007-2011**
All				
<High School	26.7 (24.8, 28.7)	23.8 (21.6, 25.9)	20.0 (17.9, 22.1)	-6.7 (-9.5, -3.9)
High School Grad	23.6 (21.3, 25.9)	19.6 (17.5, 21.6)	18.6 (16.8, 20.5)	-5.0 (-7.9, -2.1)
>High School	21.8 (19.4, 24.1)	17.7 (15.9, 19.5)	15.8 (14.3, 17.3)	-5.9 (-8.7, -3.2)
SII (95% CI)	7.6 (3.0, 12.1)	8.7 (4.6, 12.9)	6.6 (3.0, 10.2)	-1.0 (-6.8, 4.8)
RII (95% CI)	31.8 (12.1, 51.4)	43.8 (22.7, 64.9)	37.1 (16.7, 57.6)	5.4 (-23.0, 33.7)
Non-Hispanic white				
<High School	30.4 (27.5, 33.3)	27.8 (24.5, 31.1)	24.6 (21.0, 28.1)	-5.8 (-10.4, -1.2)
High School Grad	25.9 (23.1, 28.7)	22.0 (19.4, 24.5)	21.4 (18.8, 23.9)	-4.5 (-8.2, -0.7)
>High School	23.4 (20.6, 26.3)	20.4 (18.0, 22.8)	17.9 (15.9, 19.9)	-5.5 (-9.0, -2.0)
SII (95% CI)	10.0 (3.9, 16.1)	9.6 (3.9, 15.4)	9.56 (4.3, 14.8)	-0.5 (-8.5, 7.6)
RII (95% CI)	38.6 (14.6, 62.5)	42.5 (16.9, 68.2)	46.9 (21.2, 72.5)	8.3 (-26.7, 43.3)
Non-Hispanic black				
<High School	21.7 (18.1, 25.3)	23.4 (19.6, 27.2)	16.8 (13.9, 19.7)	-4.9 (-9.5, -0.4)
High School Grad	20.0 (14.8, 25.2)	17.2 (12.3, 22.2)	15.2 (11.3, 19.2)	-4.8 (-11.3, 1.7)
>High School	20.9 (14.8, 27.0)	15.2 (10.9, 19.4)	14.5 (11.0, 18.0)	-6.4 (-13.4, 0.7)
SII (95% CI)	1.4 (-9.0, 11.8)	12.9 (4.3, 21.6)	3.4 (-4.0, 10.7)	1.9 (-10.7, 14.6)
RII (95% CI)	6.8 (-43.1, 56.7)	68.3 (21.1, 115.6)	21.7 (-26.1, 69.4)	14.9 (-54.0, 83.8)
Hispanic				
<High School	16.7 (13.1, 20.3)	10.7 (8.1, 13.2)	11.4 (8.8, 14.0)	-5.3 (-9.7, -1.0)
High School Grad	15.6 (9.4, 21.7)	10.6 (6.0, 15.2)	9.5 (6.3, 12.7)	-6.1 (-13.0, 0.9)
>High School	14.0 (8.0, 20.0)	10.2 (5.8, 14.6)	9.8 (6.3, 13.2)	-4.2 (-11.1, 2.7)
SII (95% CI)	4.3 (-6.4, 15.0)	0.7 (-6.7, 8.1)	3.0 (-3.6, 9.7)	-1.3 (-13.8, 11.3)
RII (95% CI)	27.0 (-41.8, 95.9)	7.0 (-63.4, 77.4)	28.8 (-35.0, 92.6)	1.8 (-91.7, 95.2)

Table 4. Age adjusted all-cause 5-year mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different Income-to-Poverty Ratio and by race/ethnicity - National Health Interview Survey, 1997-2015

	5-year Mortality at Each Time Period with Potential Follow-up Through 2015			
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2007-2011
All				
Poor (<100%)	29.7 (25.8, 33.5)	26.0 (22.3, 29.8)	20.4 (17.5, 23.3)	-9.3 (-14.2, -4.3)
Near poor (100-199%)	25.7 (23.1, 28.4)	23.1 (20.2, 26.2)	21.3 (18.8, 23.7)	-4.5 (-8.1, -0.9)
Middle income (200-399%)	23.6 (20.9, 26.2)	18.5 (16.1, 20.8)	17.7 (15.7, 19.7)	-5.9 (-9.2, -2.5)
High income (≥400%)	20.0 (16.8, 23.2)	16.5 (13.5, 19.4)	13.7 (11.6, 15.8)	-6.3 (-10.1, -2.6)
SII (95% CI)	11.4 (6.0, 16.8)	12.5 (7.0, 17.9)	11.0 (6.6, 15.4)	-0.4 (-7.1, 6.3)
RII (95% CI)	48.2 (24.7, 71.7)	63.0 (34.5, 91.6)	62.1 (36.9, 87.4)	14.0 (-19.3, 47.2)
Non-Hispanic white				
Poor (<100%)	31.6 (25.8, 37.4)	31.3 (24.6, 38.0)	27.7 (22.0, 33.4)	-3.9 (-12.3, 4.5)
Near poor (100-199%)	28.6 (25.0, 32.2)	26.8 (22.8, 30.9)	24.8 (21.3, 28.3)	-3.9 (-8.8, 1.0)
Middle income (200-399%)	26.0 (22.5, 29.5)	20.6 (17.7, 23.5)	20.4 (17.7, 23.0)	-5.7 (-10.1, -1.2)
High income (≥400%)	23.1 (19.1, 27.1)	19.6 (15.9, 23.2)	15.4 (12.6, 18.2)	-7.7 (-12.5, -2.9)
SII (95% CI)	10.1 (3.0, 17.3)	13.3 (5.5, 21.2)	16.1 (9.2, 22.9)	5.9 (-3.7, 15.6)
RII (95% CI)	38.7 (10.8, 66.6)	59.2 (23.9, 94.4)	78.8 (45.2, 112.4)	40.1 (-2.6, 82.7)
Non-Hispanic black				
Poor (<100%)	28.7 (21.6, 35.9)	26.6 (20.6, 32.7)	17.5 (13.2, 21.9)	-11.2 (-19.6, -2.8)
Near poor (100-199%)	22.0 (16.7, 27.4)	18.7 (13.8, 23.6)	18.2 (13.6, 22.8)	-3.8 (-10.8, 3.2)
Middle income (200-399%)	17.7 (11.1, 24.2)	17.7 (11.1, 24.3)	13.6 (9.8, 17.4)	-4.1 (-11.5, 3.4)
High income (≥400%)	12.0 (5.3, 18.6)	11.7 (4.9, 18.5)	11.9 (6.4, 17.4)	-0.1 (-8.7, 8.6)
SII (95% CI)	21.8 (8.8, 34.8)	17.7 (6.5, 29.0)	8.8 (0.4, 17.3)	-13.0 (-28.7, 2.7)
RII (95% CI)	107.2 (42.2, 172.2)	94.6 (33.3, 156.0)	57.1 (0.9, 113.3)	-50.1 (-136.7, 36.5)
Hispanic				
Poor (<100%)	16.3 (12.2, 20.3)	11.0 (6.6, 15.4)	10.2 (6.8, 13.6)	-6.1 (-11.4, -0.7)
Near poor (100-199%)	15.2 (10.7, 19.7)	12.2 (7.8, 16.7)	11.7 (8.1, 15.3)	-3.5 (-9.1, 2.1)
Middle income (200-399%)	16.6 (7.9, 25.4)	10.5 (6.2, 14.9)	10.1 (6.1, 14.1)	-6.5 (-16.1, 3.1)
High income (≥400%)	16.2 (6.5, 25.9)	5.3 (1.5, 9.1)	9.6 (5.0, 14.1)	-6.6 (-17.5, 4.2)
SII (95% CI)	-0.5 (-11.7, 10.7)	5.5 (-2.5, 13.5)	1.2 (-5.8, 8.3)	1.8 (-11.5, 15.0)
RII (95% CI)	-3.2 (-72.7, 66.4)	54.5 (-24.7, 133.7)	11.8 (-56.2, 79.7)	15.0 (-82.5, 112.6)

Figure 1. Age-adjusted 5-year all-cause mortality rate difference between U.S. adults aged ≥25 years with diagnosed diabetes and those without diagnosed diabetes for three time period cohorts (1997-2001, 2002-2006, and 2007-2011) - National Health Interview Survey, 1997-2015. [a]P-value <0.05 for rate difference change from 1997-2001 cohort to 2007-2011 cohort.


(a)
Education Attainment
1997-2001
2002-2006
2007-2011
Rate Difference (deaths/1000 person-years)
25
20
15
10
5
0
-5
<High School[a]
High School Grad[a]
>High School[a]
<High School[a]
High School Grad
>High School[a]
<High School
High School Grad
>High School
<High School
High School Grad
>High School
All
Non-Hispanic white
Non-Hispanic black
Hispanic


(b)
Income Position
1997-2001
2002-2006
2007-2011
Rate Difference (deaths/1000 person-years)
25
20
15
10
5
0
-5
Poor[a]
Near Poor
Middle Income[a]
High Income[a]
Poor
Near Poor
Middle Income
High Income[a]
Poor[a]
Near Poor
Middle Income
High Income
Poor
Near Poor
Middle Income
High Income
All
Non-Hispanic white
Non-Hispanic black
Hispanic

Supplemental Table 1. Selected characteristics of U.S. adults aged >=25 years with **NO diagnosed diabetes** for three time period cohorts (1997-2001, 2002-2006, and 2007-2011) - National Health Interview Survey, 1997-2015

	1997-2001 N= 130357			**2002-2006** N= 113328			**2007-2011** N= 104242		
	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)
Gender									
Men	56348	47.8 (47.5, 48.1)	73.7	49512	47.8 (47.4, 48.1)	76.6	45800	47.9 (47.5, 48.3)	83.6
Women	74009	52.2 (51.9, 52.5)	80.6	63816	52.2 (51.9, 52.6)	83.7	58442	52.1 (51.7, 52.5)	90.8
Age groups (years)									
25-49	76940	61.0 (60.5, 61.4)	94.1	64075	58.4 (57.9, 58.8)	93.5	56177	55.6 (55.1, 56.2)	97.0
50-64	27536	21.8 (21.5, 22.1)	33.6	27192	24.8 (24.5, 25.1)	39.8	27129	27.3 (26.9, 27.7)	47.6
65-79	19211	13.1 (12.9, 13.4)	20.3	15546	12.3 (12.0, 12.5)	19.7	14739	12.4 (12.1, 12.7)	21.6
≥80	6670	4.1 (3.9, 4.2)	6.3	6515	4.6 (4.4, 4.7)	7.3	6197	4.7 (4.5, 5.0)	8.2
Age (years): mean (se)		47.7 (0.1)			48.3 (0.1)			48.8 (0.1)	
Race/ethnicity									
Non-Hispanic white	89725	79.6 (79.0, 80.2)	118.2	75248	77.2 (76.6, 77.7)	118.4	63878	74.7 (74.0, 75.4)	123.0
Non-Hispanic black	17016	10.7 (10.3, 11.2)	15.9	15182	10.9 (10.5, 11.4)	16.7	15534	11.6 (11.1, 12.1)	19.1
Hispanic	19467	9.7 (9.2, 10.1)	14.4	18540	11.9 (11.5, 12.3)	18.3	17860	13.7 (13.3, 14.2)	22.6
Education									
<High School	26895	17.3 (16.9, 17.7)	26.7	21313	16.1 (15.7, 16.5)	25.8	17307	14.2 (13.8, 14.6)	24.8
High School Grad	37774	29.9 (29.5, 30.4)	46.2	32099	29.0 (28.6, 29.4)	46.5	27417	26.8 (26.3, 27.2)	46.7
>High School	65688	52.8 (52.1, 53.4)	81.4	59916	54.9 (54.4, 55.5)	88.0	59518	59.0 (58.4, 59.7)	102.9
Income to Poverty Ratio									
Poor (<100%)	17494	9.6 (9.3, 9.9)	14.8	15099	9.9 (9.6, 10.2)	15.8	14882	10.5 (10.1, 10.8)	18.2
Near poor (100-199%)	25123	16.7 (16.4, 17.1)	25.8	22154	17.1 (16.8, 17.5)	27.4	20429	17.3 (16.9, 17.8)	30.2
Middle income (200-399%)	41584	32.7 (32.3, 33.0)	50.4	35255	31.4 (31.0, 31.8)	50.3	31409	30.6 (30.2, 31.0)	53.4
High income (≥400%)	46156	41.0 (40.4, 41.6)	63.3	40820	41.6 (41.0, 42.2)	66.7	37522	41.6 (40.9, 42.3)	72.5

Five data files with imputed income data were provided by the Centers for Disease Control and Prevention's National Center for Health Statistics. Multiple imputation methodology was used to calculate all estimates related to income-to-poverty ratio threshold; N's are based on imputed income data file number 5.

Supplemental Table 2. Age adjusted all-cause 5-year mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **NO** DIAGNOSED DIABETES by race/ethnicity - National Health Interview Survey, 1997-2015

	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2007-2011
All	12.1 (11.8, 12.5)	11.2 (10.9, 11.6)	10.6 (10.2, 11.0)	-1.5 (-2.0, -1.1)
Non-Hispanic white	13.2 (12.7, 13.7)	12.1 (11.6, 12.5)	11.5 (11.0, 11.9)	-1.7 (-2.3, -1.1)
Non-Hispanic black	13.1 (12.1, 14.0)	11.4 (10.4, 12.5)	10.0 (9.1, 10.9)	-3.1 (-4.3, -1.8)
Hispanic	7.5 (6.7, 8.3)	7.3 (6.6, 8.1)	6.9 (6.1, 7.6)	-0.7 (-1.7, 0.4)

Supplemental Table 3. Age adjusted all-cause 5-year mortality **RATE DIFFERENCE** (deaths/1000 person-years) between U.S. adults aged ≥25 years with and without diagnosed diabetes by race/ethnicity - National Health Interview Survey, 1997-2015

	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2007-2011
All	11.6 (10.3, 12.8)	9.0 (7.8, 10.2)	7.6 (6.5, 8.7)	-4.9 (-6.6, -3.2)
Non-Hispanic white	12.6 (10.9, 14.2)	10.9 (9.3, 12.6)	9.7 (8.1, 11.3)	-4.4 (-6.7, -2.0)
Non-Hispanic black	7.4 (4.3, 10.5)	7.7 (4.9, 10.5)	5.6 (3.4, 7.7)	-2.4 (-6.2, 1.4)
Hispanic	8.3 (5.3, 11.3)	3.0 (0.9, 5.1)	3.7 (1.7, 5.6)	-4.7 (-8.2, -1.2)

Supplemental Table 4. Age adjusted all-cause 5-year mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **NO DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different education attainment and by gender and race/ethnicity - National Health Interview Survey, 1997-2015

	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2007-2011
All				
<High School	16.0 (15.3, 16.7)	15.4 (14.6, 16.2)	15.0 (14.1, 15.9)	-1.0 (-2.1, 0.1)
High School Grad	11.6 (11.1, 12.2)	11.3 (10.7, 12.0)	11.0 (10.3, 11.6)	-0.7 (-1.5, 0.2)
>High School	9.6 (9.1, 10.1)	8.9 (8.4, 9.3)	8.6 (8.1, 9.0)	-1.1 (-1.7, -0.4)
SII (95% CI)	9.1 (7.8, 10.4)	9.3 (8.0, 10.6)	8.8 (7.4, 10.2)	-0.3 (-2.2, 1.6)
RII (95% CI)	75.2 (64.6, 85.7)	81.8 (70.9, 92.8)	81.1 (68.6, 93.7)	6.0 (-10.1, 22.1)
Non-Hispanic white				
<High School	17.3 (16.4, 18.2)	16.5 (15.4, 17.5)	17.1 (15.8, 18.4)	-0.2 (-1.8, 1.4)
High School Grad	12.7 (12.1, 13.3)	12.5 (11.7, 13.2)	11.7 (10.9, 12.5)	-1.0 (-2.0, 0.02)
>High School	10.8 (10.2, 11.4)	9.7 (9.1, 10.3)	9.5 (8.9, 10.0)	-1.4 (-2.2, -0.6)
SII (95% CI)	8.7 (7.2, 10.2)	9.2 (7.6, 10.7)	9.1 (7.3, 10.9)	0.4 (-1.9, 2.7)
RII (95% CI)	66.4 (55.0, 77.8)	75.3 (62.7, 87.9)	78.0 (63.4, 92.5)	11.6 (-6.5, 29.7)
Non-Hispanic black				
<High School	15.9 (14.3, 17.6)	14.6 (12.7, 16.5)	12.8 (11.1, 14.5)	-3.1 (-5.4, -0.8)
High School Grad	12.0 (10.2, 13.7)	9.7 (8.1, 11.2)	11.0 (9.1, 12.9)	-0.9 (-3.5, 1.6)
>High School	9.8 (8.5, 11.1)	9.4 (8.0, 10.9)	7.3 (6.1, 8.6)	-2.5 (-4.3, -0.7)
SII (95% CI)	9.7 (6.0, 13.4)	7.6 (4.0, 11.1)	8.9 (5.6, 12.3)	-0.8 (-5.8, 4.2)
RII (95% CI)	74.5 (47.2, 101.9)	66.0 (35.8, 96.1)	86.9 (54.3, 119.4)	12.3 (-30.2, 54.8)
Hispanic				
<High School	8.6 (7.6, 9.7)	9.2 (8.1, 10.3)	7.8 (6.7, 8.9)	-0.8 (-2.3, 0.7)
High School Grad	7.6 (5.9, 9.2)	6.0 (4.6, 7.3)	7.0 (5.4, 8.5)	-0.6 (-2.8, 1.6)
≥High School	5.2 (4.0, 6.3)	4.9 (3.8, 6.1)	5.4 (4.2, 6.5)	0.2 (-1.4, 1.8)
SII (95% CI)	5.7 (2.8, 8.6)	7.8 (4.6, 10.9)	4.0 (1.3, 6.7)	-1.7 (-5.7, 2.2)
RII (95% CI)	76.2 (37.7, 114.7)	105.1 (64.0, 146.2)	57.9 (18.9, 96.9)	-18.3 (-72.4, 35.9)

Supplemental Table 5. Age adjusted all-cause 5-year mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **NO DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different income to poverty ratio and by gender and race/ethnicity - National Health Interview Survey, 1997-2015

	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2007-2011
Income to Poverty Ratio				
All				
Poor (<100%)	18.0 (16.8, 19.3)	16.7 (15.3, 18.0)	17.1 (15.5, 18.8)	-0.9 (-3.1, 1.3)
Near poor (100-199%)	14.8 (14.0, 15.6)	13.8 (12.9, 14.7)	13.5 (12.5, 14.5)	-1.3 (-2.6, -0.1)
Middle income (200-399%)	11.8 (11.2, 12.5)	11.2 (10.5, 11.9)	10.5 (9.8, 11.2)	-5.9 (-7.3, -4.5)
High income (≥400%)	8.2 (7.6, 8.9)	7.7 (7.0, 8.4)	7.2 (6.7, 7.7)	-1.1 (-1.8, -0.3)
SII (95% CI)	12.1 (10.6, 13.7)	11.3 (9.7, 13.0)	12.3 (10.6, 13.9)	0.1 (-2.2, 2.5)
RII (95% CI)	100.6 (-4.0, 205.2)	100.3 (-11.4, 212.0)	112.0 (-7.0, 230.9)	113.6 (-84.3, 311.4)
Non-Hispanic white				
Poor (<100%)	20.0 (18.1, 21.9)	18.1 (16.3, 20.0)	19.1 (16.5, 21.7)	-0.9 (-4.3, 2.5)
Near poor (100-199%)	16.0 (15.1, 17.0)	14.2 (13.2, 15.3)	15.0 (13.7, 16.3)	-1.0 (-2.6, 0.5)
Middle income (200-399%)	12.9 (12.1, 13.7)	12.3 (11.5, 13.2)	11.5 (10.6, 12.3)	-5.7 (-7.6, -3.8)
High income (≥400%)	9.5 (8.7, 10.2)	8.7 (7.8, 9.5)	8.1 (7.4, 8.7)	-1.4 (-2.4, -0.4)
SII (95% CI)	12.0 (10.0, 13.9)	10.7 (8.6, 12.7)	12.7 (10.7, 14.8)	0.8 (-2.1, 3.7)
RII (95% CI)	91.2 (-3.8, 186.1)	88.5 (-11.1, 188.1)	107.8 (-6.9, 222.5)	166.3 (-60.2, 392.8)
Non-Hispanic black				
Poor (<100%)	16.4 (14.0, 18.9)	15.7 (12.8, 18.6)	15.7 (13.4, 18.0)	-0.8 (-4.1, 2.6)
Near poor (100-199%)	14.0 (12.0, 16.0)	14.0 (11.3, 16.8)	11.5 (9.5, 13.6)	-2.4 (-5.2, 0.4)
Middle income (200-399%)	12.5 (10.3, 14.6)	9.2 (7.3, 11.1)	8.7 (6.7, 10.7)	-4.1 (-7.4, -0.7)
High income (≥400%)	8.0 (5.9, 10.2)	6.6 (4.6, 8.6)	5.1 (3.5, 6.7)	-3.0 (-5.6, -0.3)
SII (95% CI)	10.5 (6.2, 14.8)	13.4 (9.2, 17.6)	14.3 (10.5, 18.1)	3.8 (-2.1, 9.7)
RII (95% CI)	81.0 (-13.4, 175.3)	116.3 (-18.9, 251.6)	137.6 (-7.6, 282.9)	566.7 (60.2, 1073.2)
Hispanic				
Poor (<100%)	9.6 (7.8, 11.5)	8.5 (6.6, 10.5)	9.1 (6.9, 11.3)	-0.5 (-3.4, 2.4)
Near poor (100-199%)	9.1 (7.2, 10.9)	9.8 (8.0, 11.6)	7.3 (5.8, 8.7)	-1.8 (-4.1, 0.5)
Middle income (200-399%)	6.2 (4.7, 7.8)	6.1 (4.7, 7.4)	6.2 (4.7, 7.7)	-6.5 (-9.8, -3.2)
High income (≥400%)	4.4 (2.4, 6.3)	4.2 (2.7, 5.8)	5.0 (3.4, 6.7)	0.7 (-1.9, 3.2)
SII (95% CI)	7.3 (4.2, 10.5)	6.7 (3.5, 9.8)	5.0 (1.5, 8.5)	-2.3 (-7.1, 2.4)
RII (95% CI)	97.0 (-7.2, 201.2)	90.2 (-17.6, 198.0)	72.0 (-20.5, 164.4)	-250.4 (-895.5, 394.6)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page and/or Line Numbers
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Pg 1 and 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Pg 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Pg 4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	Pg 5
Methods			
Study design	4	Present key elements of study design early in the paper	Pg 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Pg 6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Pg 6-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Pg 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pg 6-9
Bias	9	Describe any efforts to address potential sources of bias	Pg 6-9
Study size	10	Explain how the study size was arrived at	Pg 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pg 6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pg 8-9
		(*b*) Describe any methods used to examine subgroups and interactions	Pg 8-9
		(*c*) Explain how missing data were addressed	Pg 6-7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods	9

		taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			**Page and/or Line Numbers**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pg 6
		(b) Give reasons for non-participation at each stage	Pg 6
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Pg 10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Pg. 10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	Pg 10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pg 10-12
		(*b*) Report category boundaries when continuous variables were categorized	Pg 10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Pg 10-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	Pg 13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pg 15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pg 13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	Pg 15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Pg 1 Pg 17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Trends and socioeconomic disparities in all-cause mortality among adults with diagnosed diabetes by race/ethnicity: a population-based cohort study — United States, 1997-2015

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-044158.R1
Article Type:	Original research
Date Submitted by the Author:	27-Feb-2021
Complete List of Authors:	Mercado, Carla; Centers for Disease Control and Prevention, Division of Diabetes Translation Beckles, Gloria; Centers for Disease Control and Prevention, Division of Diabetes Translation Cheng, Yiling; Centers for Disease Control and Prevention Bullard, Kai; Centers for Disease Control and Prevention Sayday, Sharon; National Center for Chronic Disease Prevention and Health Promotion, Gregg, Edward; Imperial College London, Imperatore, Giuseppina ; Centers for Disease Control and Prevention
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Diabetes and endocrinology, Public health, Epidemiology
Keywords:	DIABETES & ENDOCRINOLOGY, EPIDEMIOLOGY, STATISTICS & RESEARCH METHODS, PUBLIC HEALTH

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Trends and socioeconomic disparities in all-cause mortality among adults with diagnosed diabetes by race/ethnicity: a population-based cohort study — United States, 1997-2015

Carla I. Mercado[1], PhD; Gloria L. Beckles[1], MD, MSc; Yiling Cheng[1], MD, PhD; Kai McKeever Bullard[1], PhD; Sharon H. Saydah[1], PhD, Edward W. Gregg[2], MD, PhD; Giuseppina Imperatore[1], MD, PhD

[1] Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

[2] School of Public Health, Imperial College London, London, UK

Corresponding author: Carla I. Mercado, Centers for Disease Control and Prevention, Mailstop F-75, 4770 Buford Highway NE, Atlanta, GA 30341. Tel: 770-488-8075, Fax: 770-488-8151, E-mail: CMercado@cdc.gov.

Running title: socioeconomic mortality disparity in diabetes

Keywords: socioeconomic disparity, mortality, race/ethnicity, trends, diabetes

Word count: 4063

Number of tables and figures: 5

The findings and conclusions in this manuscript are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Abstract

Objectives: By race/ethnicity and socioeconomic position (SEP), to estimate and examine changes over time in 1) mortality rate; 2) mortality disparities, and 3) excess mortality risk attributed to diagnosed diabetes (DM).

Design: Population-based cohort study using National Health Interview Survey data linked to mortality status from the National Death Index from survey year up to December 31, 2015 with 5 years person-time.

Participants: U.S. adults aged ≥25 years with (31,586) and without (332,451) DM.

Primary outcome: Age-adjusted all-cause mortality rate for U.S. adults with DM in each subgroup of SEP [education attainment and income to poverty ratio (IPR)] and time (1997-2001, 2002-2006, and 2007-2011).

Results: Among adults with DM, mortality rates fell from 23.5/1000 person-years (p-y) in 1997-2001 to 18.1/1000 p-y in 2007-2011 with changes of -5.2/1000 p-y for non-Hispanic whites; -5.2/1000 p-y for non-Hispanic blacks; and -5.4/1000 p-y for Hispanics. Rates significantly declined within SEP groups, measured as education attainment [<high school = -5.7/1000 p-y; high school grad = -4.2/1000 p-y; and >high school = -4.8/1000 p-y] and IPR group [poor= -7.9/1000 p-y, middle income = -4.7/1000 p-y, and high income = -6.2/1000 p-y; but not for near poor]. For adults with DM, statistically significant all-cause mortality disparity showed greater mortality rates for the lowest than the highest SEP level (education attainment and IPR) in each time period. However, patterns in mortality trends and disparity varied by race/ethnicity. The excess mortality risk attributed to DM significantly decreased from 1997-2001 to 2007-2011, within SEP levels, and among Hispanics and non-Hispanic whites; but no statistically significant changes among non-Hispanic blacks.

Conclusions: There were substantial improvements in all-cause mortality among U.S. adults. However, we observed SEP disparities in mortality across race/ethnic groups or for adults with and without DM despite targeted efforts to improve access and quality of care among vulnerable populations.

Strengths and Limitations

- A population-based study on multi-dimensional association and disparities between socioeconomic position (SEP), race/ethnicity, diabetes, and mortality along with whether any changes have occurred since 1997.
- A series of consecutive national representative surveys (1997-2011) were linked to latest available mortality data through December 31, 2015.
- Aside from investigating changes in mortality rates over time, this study measured the mortality disparity from lower to higher SEP rankings and how those disparities have changed over time.
- Since diabetes and SEP statuses were self-reported and only measured at baseline, misreporting and status changes during the course of the follow-up period may have occurred.

INTRODUCTION

From mid-1990s, diabetes mellitus has increased rapidly in the United States with an estimated 23.1 million people had diagnosed diabetes, 9.4% of the total population, in 2015 (1). Prevalence and incidence of diagnosed diabetes affects racial/ethnic groups disproportionately, with greater and plateauing estimates among non-Hispanic blacks and Hispanics than the lower declining ones for non-Hispanic whites (2-4). Additionally, diabetes prevalence is greater at lower socioeconomic position levels, measured by education attainment and income, than higher levels (5, 6). Although several national, state and local programs and initiatives were developed to reduce diabetes and eliminate diabetes-associated disparities,(7) marked racial/ethnic and socioeconomic disparities in prevalence of diabetes were reported between 2004 and 2010 with increased socioeconomic disparities magnitude among adults with diagnosed diabetes over time (8-10).

Diabetes socioeconomic patterning is associated with reduced access to care, poor quality of care, underuse of preventive health measures and health care behaviors that provide pathways to increased mortality risk (11). Socioeconomic position (measured by either education attainment, wealth, income, and/or income-to-poverty ratio) has been reported to be inversely associated all-cause mortality risk (12-16). When the magnitudes of absolute educational disparities (slope index of inequality, SII) were assessed, adults with diabetes experienced a greater all-cause mortality burden associated with low levels of education than those without diabetes (12-16). Additionally, the educational gradient in all-cause mortality rates was present in non-Hispanic white and non-Hispanic blacks but not among Hispanics (12-16).

The socioeconomic mortality association has typically been examined separately without examining the intersectionality of known related characteristics, such as race/ethnicity or diabetes. This approach ignores

that individuals inhabit multiple social statuses simultaneously, that these statuses interact to shape the health risk patterns experienced, and thereby the health disparities observed (16). Investigation in population-level race/ethnic- and socioeconomic position-specific mortality rate changes among adults with diagnosed diabetes could inform national, state, and local efforts aimed at reducing diabetes-related disparities. Furthermore, examining changes in excess mortality risk attributed to diabetes could determine if diabetes-related disparity has narrowed. This study aims to examine whether and to what extent race/ethnic: 1) socioeconomic position-specific mortality rates have changed among U.S. adult population during 1997-2011 with diagnosed diabetes, 2) socioeconomic position disparities in all-cause mortality exist and changed from 1997-2011 among adults with diagnosed diabetes, and 3) has the excess mortality risk attributed to diabetes (rate difference between those with and without diabetes) in socioeconomic position-specific groups changed during 1997-2011.

METHODS

Data and population Data from the National Health Interview Surveys (NHIS) for the years 1997-2011 was linked with death certificates from the National Death Index (NDI) to obtain the most current mortality status through December 31, 2015 (17). NHIS is an annual ongoing cross-sectional household interview survey (about 35,000 households per year) of a nationally representative civilian, noninstitutionalized sample conducted by the CDC's National Center for Health Statistics (NCHS) (18, 19). Participation in NHIS is voluntary and confidentiality is assured under the Public Health Service Act Section 308(d). NHIS data from 1997 through 2011 had a final adult response rate ranging from 61% to 80% (20). Most survey participants (a 94.8% average) were eligible for the mortality follow-up based on the following identifiable data combinations: 1) social security number, last name, and first name; 2) social security number, sex, and birthday (month, day, and year); and/or 3) last name, first name, and birth month and year (17). Sampling weights adjusted for ineligible mortality linkage were used in all analyses.

Participants who responded "yes" to the question, "Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?" were classified as having diagnosed diabetes; otherwise, participants were classified as not having been diagnosed with diabetes. The analysis sample was restricted to the 381,247 adults aged ≥25 years interviewed in the 1997 to 2011 survey years and were eligible for the mortality follow-up. Of these, 32,986 reported having diagnosed diabetes and 347,928 did not report having diagnosed diabetes. The analysis excluded those missing diagnosed diabetes status (n=333) and persons of other race or multiple race (n=16,894). Therefore, the analytical sample size was 364,037 (diabetes=31,586 and no diabetes=332,451).

Variables

Outcome. All-cause mortality was determined by vital status after data linkage with NDI. Person-time was calculated from survey interview date to date of death or December 31, 2015 (currently the latest available mortality data) for those assumed alive. To reduce follow-up bias when assessing temporal changes in mortality rates, follow-up was right truncated at death or 5 years of follow-up (whichever came first). For example, for the 1997 cohort, mortality information was assessed up to 2001. Therefore, survey cycles after 2011 were not included since mortality rate for a 5-year period is not available. All-cause mortality rates presented in this study are based on data of a 5-year period from the survey interview date.

Social Economic Position (SEP). SEP was measured by 2 socioeconomic indicators: i) educational attainment [completion of grades <12 (<high school), high school graduate or equivalency (high school grad), any education beyond high school (>high school)]; and ii) the family income-to-poverty threshold ratio (IPR) (poor <100% federal poverty level [FPL]; near poor 100%-199% FPL; middle income 200%-399% FPL; and high income ≥400% FPL) (21). Education and income were self-reported. Due to missing income values of weighted percentage between 23-33% for survey years of 1997-2011, the NCHS CDC imputed missing values using reported multiple-imputation methodology producing five data sets that accompany the data release of each survey year (22). Income estimates were calculated by averaging the estimates from the five data sets and estimating the variance by calculating the within and between imputation variance.

Other Covariates. Diabetes status, age, sex, and race-ethnicity were self-reported at baseline. Characteristics and demographics were described for adults with diagnosed diabetes according to three 5-year periods based on their interview date (1997-2001, 2002-2006, and 2007-2011) as counts, percentages, and estimated number in the population for: sex, age groups (25-49, 50-64, 65-79, and ≥80 years), race/ethnicity (non-Hispanic white, non-Hispanic black, and Hispanic), educational attainment categories, IPR categories, and diagnosed diabetes status. The counts for IPR were based on the imputed data set

number five. Participants who identified as "other race/ethnicity" were excluded from race/ethnic specific estimates due to the limited sample size. Characteristics and demographics were also described separately for adults without diagnosed diabetes (supplemental table 1).

Statistical Analysis

Weighted Poisson regression accounting for survey design was used to calculate population-level mortality rates, weighted death number divided by the total weighted person-time and adjusted for baseline age and compare across the three survey time periods (1997-2001, 2002-2006, and 2007-2011). The mortality-linked adult person-level sample weights were used in the analyses to calculate U.S. population-level estimates. Estimates were expressed as deaths per 1000 person-years. Data was analyzed for all adults and by each race/ethnic subgroup using regression model containing a 3-way term for interaction between baseline diagnosed diabetes status*time period*SEP variable, including all lower order interactions and variables, and baseline age covariate was used. This modeling allowed comparison test between time periods, SEP levels, and diabetes status. Predictive margins were used to estimate adjusted mortality rates by SEP, time period, and diabetes status. Marginal effects were used to estimate strata-specific age-adjusted mortality rate differences (excess mortality risk) between those with and those without diagnosed diabetes and change in mortality rates between cohorts (1997-2001 vs 2002-2006, 2002-2006 vs 2007-2011, and 1997-2001 vs 2007-2001). Both predictive margins and marginal effects test differences using t-test.

SEP disparity was examined by defining educational attainment and IPR groups ordered from the highest to the lowest ranks (23, 24). A ridit score for each period was calculated for education attainment and for IPR based on the midpoint of the cumulative proportion of each rank from highest to lowest, ranging between 0 (highest) to 1 (lowest). The ridit score estimates the relative position of each socio-economic group in the social hierarchy considering their group size (25). For all adults and by each race/ethnic

subgroup, we used a Poisson regression model containing a 3-way term for interaction between baseline diagnosed diabetes status*time periods*SEP ridit score and the covariate of baseline age. Absolute Difference was obtained by fitting a straight line to the mortality rates ordered from the ridit score of educational attainment or IPR. The linear regression ridit slope, or Slope Index of Inequality (SII), was interpreted as the average absolute difference in the age-adjusted all-cause mortality rate from each SEP indicator lowest to the highest rank. Relative Difference, Relative Index of Inequality (RII) expressed as a percent change, was obtained by dividing the Absolute Difference by the age-adjusted all-cause mortality rate for the total population. It is interpreted as the average percentage change in the age-adjusted mortality rate from the lowest to the highest rank of each SEP indicator. From the regression model, SII and RII for each time period and diabetes status subgroup was calculated. We assessed SII and RII magnitudes for the three time periods (1997-2001, 2002-2006, and 2007-2011) and direction of change over time as the simple differences between the time periods (1st and 2rd, 2nd and 3rd, and 1st and 3rd).

For adults with no diagnosed diabetes, the results for age-adjusted mortality, SII, and RII are provided in the supplemental materials (supplemental tables 2-4). We used Stata 15.0 (StataCorp LP, College Station, Texas) in all analyses to take account of the complex multistage sampling design and to provide representative population estimates with 95% confidence intervals (CIs). Estimates for change from Poisson regression models were considered significant if 95% confidence intervals did not include the null value. Since different Poisson regression models were used for each race/ethnic subgroup, comparing estimates between race/ethnic subgroups were conservatively considered statistically significantly different if 95% confidence intervals did not overlap (26). Although we understand that this approach is very conservative, it was a better option than fitting a 4-way interaction in these models which could lead to unstable or uninterpretable results.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

RESULTS

Between 1997-2001 and 2007-2011, the population of U.S. adults aged ≥25 years with diagnosed diabetes grew from 10.2 million to 18.0 million, mean age stayed steady at 60.2 years and 60.4 years, and the percentage in minority racial/ethnic group (non-Hispanic black and Hispanic) increased from 29.0% to 31.3% (Table 1). The percentage that had not completed high school fell from 33.3% to 25.2%, and percentage living below the federal poverty level fell from 15.5% to 14.3%.

Trends in all-cause mortality rates by socioeconomic position

Among all adults with diagnosed diabetes, age-adjusted all-cause mortality rates steadily declined by 14% from 1997-2001 to 2002-2006 and 10% from 2002-2006 to 2007-2011, a net decline from 23.5/1000 person-years (p-y) in 1997-2001 to 18.1/1000 p-y in 2007-2011 or 5.4/1000 p-y (Table 2). In each 5-year period, all-cause mortality rates in adults with diagnosed diabetes were highest among non-Hispanic whites (20.1-25.3 p-y), lowest among Hispanics (10.3-15.7 p-y), and intermediate for non-Hispanic blacks (15.0-20.2 p-y) based on non-overlapping confidence intervals. Within each racial/ethnic group, all-cause mortality rates also declined between 1997-2001, 2002-2006, and 2007-2011, but in different patterns. In non-Hispanic white adults with diagnosed diabetes, there was steady decline in mortality rates by 13% from 1997-2001 to 2002-2006 and 9% from 2002-2006 to 2007-2011 5.2/1000 p-y. In non-Hispanic blacks, there was no statistically significant change in mortality rate from 1997-2001 to 2002-2006, but a 19% decline from 2002-2006 to 2007-2011. In Hispanics, there was a 34% decline in mortality rate from 1997-2001 to 2002-2006 and no statistically significant difference from 2002-2006 to 2007-2011.

Overall mortality rates among adults with diagnosed diabetes showed a significant decline between 1997-2001 and 2007-2011 in education attainment [<high school = -5.7/1000 p-y (22%); high school grad = -4.2/1000 p-y (19%); and >high school = -4.8/1000 p-y (23%)] (Table 3). However, the pattern of

mortality rate decline of educational attainment varied by racial/ethnic group where rates declined for all levels in non-Hispanic whites [ranging from -3.7 to -4.9/1000 p-y (15-22%)] but significantly only for the lowest educational attainment level in non-Hispanic black [-5.0/1000 p-y (23%)] and Hispanic [-5.6/1000 p-y (34%)] adults.

For all adults with diagnosed diabetes, there were IPR mortality rate declines for poor = -7.9/1000 p-y (28%), middle income = -4.7/1000 p-y (21%), and high income = -6.2/1000 p-y (31%); but no statistically significant change for the near poor group (Tables 4). There were differences by race/ethnicity in the pattern of significant IPR mortality rate decline occurring in the high income [-7.5/1000 p-y (33%)] and middle income [-4.5/1000 p-y (18%)] groups, but not significantly in the two poorer groups, for non-Hispanic white adults. In contrast, mortality rates only declined significantly among the poor for non-Hispanic blacks [-10.8/1000 p-y (38%)] and Hispanics [-6.1/1000 p-y (37%)], and not among the more affluent groups.

Socioeconomic disparities in mortality

Among all adults with diagnosed diabetes, age-adjusted all-cause mortality rates showed an inverse gradient with educational attainment (Table 3) and IPR (Table 4) with greater rates in the lower levels than the higher ones. Overall, the absolute education attainment disparity in all-cause mortality (SII) across the three time periods in the lowest level (<high school) than the highest (>high school) ranged from 5.9 to 7.4/1000 p-y greater mortality rate with no statistically significant change in the disparity over time (Table 3). The relative disparity (RII) in the <high school than >high school showed a 32.3% higher mortality rate in 1997-2001, and no statistically significant difference in the RII from the 42.0% in 2002-2006, and 33.0% in 2007-2011. The overall absolute IPR disparity in all-cause mortality (SII) in the poor than the high-income group ranged from 10.5 to 12.7/1000 p-y greater mortality rate across the three time

periods, with no statistically significant change in the disparity over time (Table 4). The relative IPR disparity (RII) in the poor than the high-income group showed a 46.0% higher mortality rate in 1997-2001, 64.3% in 2002-2006, and 64.4% in 2007-2011; but no statistical difference between the three time periods.

When comparing each strata of SEP levels and time periods across race/ethnic groups, mortality rates were mostly greater for non-Hispanic white adults than non-Hispanic black and Hispanic adults based on non-overlapping confidence intervals (Tables 3 and 4). For non-Hispanic white adults, the absolute disparity (SII) in all-cause mortality did not significantly change across the three time periods and ranged from 9.2 to 10.0/1000 p-y for education attainment and 9.0 to 15.9/1000 p-y for IPR. While the relative disparity (RII) for education attainment in non-Hispanic whites did not statistically significantly change and ranged from 37.1% to 45.9%, the IPR RII increased from 36.3% to 79.9%, a significant increase of 43.5%. For non-Hispanic blacks, there was a significant education attainment disparity in all-cause mortality observed only for 2002-2006 (SII=11.3/1000 p-y and RII=61.5%). While the IPR SII was significant across all three time periods for non-Hispanic blacks (range= 8.4 to 21.6/1000 p-y), the IPR RII was only significant in 1997-2001 (107.6%) and in 2002-2006 (97.4%). There were no statistically significant absolute or relative education attainment or IPR disparity in all-cause mortality during these time periods for Hispanic adults with diagnosed diabetes.

Excess mortality risk for adults with diagnosed diabetes

The overall all-cause excess mortality risk in adults with diagnosed diabetes steadily decreased from 11.3/1000 p-y in 1997-2001, 8.9/1000 p-y in 2002-2006, and 7.3/1000 p-y 2007-2011, a net decrease of 4.0/1000 p-y (supplemental table 5). The excess mortality risk tended to be greater among non-Hispanic white adults compared to non-Hispanic black and Hispanic adults. The decreased excess mortality risk for

those with diabetes from 1997-2001 to 2007-2011 was only observed among non-Hispanic white (change= -3.8/1000 p-y) and Hispanics (-4.9/1000 p-y) adults, but no significant change for non-Hispanic black.

Within SEP, trends in the overall excess mortality risk for adults with diagnosed diabetes showed significant decrease at each level of educational attainment and among the poor, middle income, and high income categories between 1997-2001 and 2007-2011 (Figure 1). By race/ethnicity, significant excess mortality risk decreases were only observed in those with <high school and >high school education attainment and in the high income group for non-Hispanic white and among the poor group in non-Hispanic black adults. Among Hispanics, there were significant decreases in excess mortality risk observed for those with <high school and high income groups.

DISCUSSION

In this study of a nationally representative sample of adults with diagnosed diabetes, we found age-adjusted all-cause mortality rates declined from 1997 to 2011 overall and within each racial/ethnic group, and mortality rates were lower among racial/ethnic minority groups than non-Hispanic whites in each 5-year period. Age-adjusted mortality rates were inversely associated with SEP measures and significant SEP disparities in all-cause mortality rates were present overall but varied by racial/ethnic group and SEP measure. Regardless of declining mortality trends in adults with diagnosed diabetes, SEP disparity (SIIs and RIIs) did not change significantly over time meaning, for the most part, that the magnitude of the inverse association between SEP and all-cause mortality has remained constant from 1997-2011. The one exception was the significant increase in the IPR relative disparity (RII) of 43.5% from 1997-2011 for non-Hispanic white adults with diagnosed diabetes. When considering the excess mortality risk of U.S. adults with diagnosed diabetes, we found that the excess risk has decreased between 1997-2011 overall and in non-Hispanic white and Hispanic adults, but not among non-Hispanic black adults. Additionally, the excess mortality risk for adults with diagnosed diabetes has decreased within SEP level, but the changes varied throughout race/ethnic groups and SEP levels.

Our finding that age-adjusted all-cause mortality rates in adults with diagnosed diabetes were lower for non-Hispanic blacks and Hispanics than the rates for non-Hispanic whites is consistent with reports from studies that used U.S. nationally representative (12-15) or large convenient (27-30) samples and even after adjustment for multiple covariates. This racial/ethnic patterning of all-cause mortality in diabetic populations is not consistent with that of the general population's 2-fold greater risk reported for minority racial/ethnic groups compared to whites (28, 31). Several factors may account for these different patterns. First, in the general population the prevalence of diabetes is higher among minority racial groups than whites, so that racial/ethnic-specific mortality rates are attributable to the distribution of diabetes across

the different racial/ethnic subgroups in the general population. In contrast, mortality rates in diabetic populations are estimated conditional on individuals having diabetes which removes the effect of racial/ethnic differences in prevalence. Second, despite the decline during the time period of interest, undiagnosed diabetes remained more prevalent among racial/ethnic minority groups than among non-Hispanic whites, accounting for as much as 50% of diabetes cases in racial/ethnic minority populations(32); consequently, the lower rates in the diagnosed population may reflect missed undiagnosed cases and higher rates among racial/ethnic minority groups in the general population. Third, mortality rates may be lower among non-Hispanic blacks and Hispanics because they may be in better health than non-Hispanic whites at older ages when diabetes occurs (33, 34). Non-Hispanic blacks are more likely to have higher mortality rates at younger ages than non-Hispanic whites(33); the high proportion of foreign-born among the current Hispanic population may contribute the assets (younger, healthier, and better educated) of the 'healthy migrant'(34). In this study, we observed the age distribution of U.S. adults with diagnosed diabetes varied by race/ethnicity with an older distribution for non-Hispanic whites (43% aged ≥65 years) compared to non-Hispanic blacks (33% aged ≥65 years) and Hispanics (30% aged ≥65 years). Based on all these reasons, we chose to use all-cause mortality instead of disease-specific mortality to minimize bias and have a comprehensive clear outcome.

The results of this study confirm earlier reports of no excess mortality risk among racial/ethnic minority groups with diagnosed diabetes but inverse relationships between SEP measures (educational attainment, income, wealth) and mortality risk within these groups (12, 13, 15). However, we document that within racial/ethnic groups, adults with diabetes exposed to the greatest socioeconomic disadvantage experienced significantly greater mortality burden than their more affluent peers despite declining trends in mortality. We are not aware of other evidence that SEP-mortality relationships persist or worsened despite secular improvement in the health of the diabetic population, as measured by declining mortality risk. Additional

analyses (supplemental tables) showed that among adults without diagnosed diabetes age-adjusted all-cause mortality rates were half as high as those for adults with diagnosed diabetes; yet, they experienced improvements to a much lesser degree during this period, especially by SEP measures, and SEP disparity in mortality was more consistently persistent across race/ethnic groups (Supplementary Tables 2, 4, and 5).

Although greater improvements in all-cause mortality among adults with diagnosed diabetes compared to adults without diabetes were noted, the underlying diabetic population has experienced marked changes in the distribution of the SEP indicators. For example, the proportion of adults with diagnosed diabetes reporting greater than high school education attainment increased and those with less than high school graduation decreased by 8 percentage points while only high school graduation remained at 31% between 1997-2001 and 2007-2011. Additionally, those with IPR ≥ 400% increased by almost 3 percentage points while the proportion living below the federal poverty level remained at about 15%. Surprisingly, the population of adults without diagnosed diabetes also experienced an increased in those who reported greater than high school education attainment by about 6 percentage points but the IPR distribution remained fairly the same with a slight suggestion of an increase shift towards poorer levels. Therefore, in adults with diabetes, not only has the SEP distribution shifted towards higher SEP levels but the shape of the distribution has changed suggesting that the underlying diabetic population in 1997-2001 is not the same as the more recent 2007-2011 population. The population of adults without diagnosed diabetes seems to have experienced a different pattern in SEP distribution changes. Considering the inverse relationship between SEP and mortality, the distribution changes in SEP observed in the underlying populations of adults with and without diabetes can explain why greater improvements were seen in those with diabetes than those without. If health improvements are responsible for the decreasing mortality rates rather than the changes in the SEP distribution, then these improvements have not benefited adults at the

highest risk (lower SEP levels) since SEP disparity gap in all-cause mortality did not significantly change during this time.

Limitations & Strengths

First, diabetes status was self-reported and ascertained only at baseline. It is possible that individuals had the disease at baseline but were undiagnosed or that they developed diabetes through the course of the follow-up time. Therefore, the number of diagnosed cases may have been subject to recall and social desirability bias. However, self-reported diagnosed diabetes has been shown to have high reliability (32). These findings do not reflect disparities in the prevalence of all diabetes (diagnosed plus undiagnosed); approximately 28% of all diabetes is undiagnosed(32) and might vary by SEP as well as race/ethnicity. Additionally, we only considered self-reported diagnosed diabetes and were unable to assess diabetes management; related to quality of care, medication adherence, and hemoglobin A1c levels, which may differ by SEP and race/ethnicity and associated with increase mortality. Also, to avoid bias related to the high nonresponse to survey questions on income, NHIS datasets with imputed income were used in all analyses. However, when using imputed data, there is the potential for misclassification. Furthermore, SEP measures (education attainment and IPR) were measured only at baseline; although education attainment did not likely change for many in this cohort of adults aged ≥25 years, their income may have fluctuated. Also, SEP measures were self-reported and if income was misreported it could have a bias effect on the imputed values. In this study, we were unable to further stratify by sex or age groups due to sample size constraints. Finally, although there is potential for bias based on the exclusion of those ineligible for mortality linkage, the majority of NHIS participants were linkage eligible and we used sampling weights adjusted for ineligible linkage.

Conclusions

During the period 1997 to 2011, age-adjusted all-cause mortality rates improved across all levels of SEP, measured as education attainment and income-to-poverty ratio. We observed no change or, in a few instances, worsening in the magnitude of the SEP disparities in mortality during the time period of interest across race/ethnic groups or for adults with and without diabetes. More research that investigates and identifies potential modifiable system-level factors that contribute to SEP disparity in all-cause mortality beyond diabetes and race/ethnicity is needed.

Contributorship statement: CIM, GLB, YC, KMB, SHS, EWG, and GI contributed to the design of this study. is the guarantor of this work and, as such, has primary responsibility over the integrity and accuracy of the data sets, data analyses, writing the paper, and the final content of this project. All authors read, reviewed, and approved the final manuscript.

Competing Interests: CIM, GLB, YC, KMB, SHS, EWG, and GI have no potential competing interest relevant to this article.

Funding: None.

Participants informed consent: Not required.

Data sharing statement: The National Health and Nutrition Examination Survey (NHANES) data are publicly available, NHANES Questionnaires, Datasets, and Related Documentation (cdc.gov). NHANES restricted data could be accessed through the Research Data Centers at National Center for Health Statistics, RDC - Research Data Center Homepage (cdc.gov).

REFERENCES

1. Centers for Disease Control and Prevention. National Diabetes Statistic Report, 2020. Atlanta, GA: Centers for Disease Control and Prevention, US Department of Health and Human Services; 2020.
2. Geiss LS, Wang J, Cheng YJ, Thompson TJ, Barker L, Li Y, et al. Prevalence and incidence trends for diagnosed diabetes among adults aged 20 to 79 years, United States, 1980-2012. Jama. 2014;312(12):1218-26.
3. Selvin E, Ali MK. Declines in the Incidence of Diabetes in the U.S.-Real Progress or Artifact? Diabetes Care. 2017;40(9):1139-43.
4. Benoit SR, Hora I, Albright AL, Gregg EW. New directions in incidence and prevalence of diagnosed diabetes in the USA. BMJ open diabetes research & care. 2019;7(1):e000657.
5. Agardh E, Allebeck P, Hallqvist J, Moradi T, Sidorchuk A. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. Int J Epidemiol. 2011;40(3):804-18.
6. Maty SC, James SA, Kaplan GA. Life-course socioeconomic position and incidence of diabetes mellitus among blacks and whites: the Alameda County Study, 1965-1999. Am J Public Health. 2010;100(1):137-45.
7. Centers for Disease Control and Prevention. State, Local, and National Partner Diabetes Programs 2019 [Available from: https://www.cdc.gov/diabetes/programs/stateandlocal/index.html.
8. Beckles GL, Chou CF. Diabetes - United States, 2006 and 2010. MMWR supplements. 2013;62(3):99-104.
9. Beckles GL, Zhu J, Moonesinghe R. Diabetes - United States, 2004 and 2008. MMWR supplements. 2011;60(1):90-3.
10. Beckles GL, Chou CF. Disparities in the Prevalence of Diagnosed Diabetes - United States, 1999-2002 and 2011-2014. MMWR Morbidity and mortality weekly report. 2016;65(45):1265-9.
11. Brown AF, Ettner SL, Piette J, Weinberger M, Gregg E, Shapiro MF, et al. Socioeconomic position and health among persons with diabetes mellitus: a conceptual framework and review of the literature. Epidemiologic reviews. 2004;26:63-77.
12. Dray-Spira R, Gary-Webb TL, Brancati FL. Educational disparities in mortality among adults with diabetes in the U.S. Diabetes Care. 2010;33(6):1200-5.
13. Dupre ME, Silberberg M, Willis JM, Feinglos MN. Education, glucose control, and mortality risks among U.S. older adults with diabetes. Diabetes Res Clin Pract. 2015;107(3):392-9.
14. McEwen LN, Kim C, Karter AJ, Haan MN, Ghosh D, Lantz PM, et al. Risk factors for mortality among patients with diabetes: the Translating Research Into Action for Diabetes (TRIAD) Study. Diabetes Care. 2007;30(7):1736-41.
15. Saydah SH, Imperatore G, Beckles GL. Socioeconomic status and mortality: contribution of health care access and psychological distress among U.S. adults with diagnosed diabetes. Diabetes Care. 2013;36(1):49-55.
16. Williams DR, Kontos EZ, Viswanath K, Haas JS, Lathan CS, MacConaill LE, et al. Integrating multiple social statuses in health disparities research: the case of lung cancer. Health services research. 2012;47(3 Pt 2):1255-77.
17. Office of Analysis and Epidemiology, National Center for Health Statistics. The Linkage of National Center for Health Statistics Survey Data to the National Death Index - 2015 Linked Mortality File: Methodology Overview and Analytic Considerations. Hyattsville, MarylandMarch 2019.
18. Design and estimation for the National Health Interview Survey, 1995-2004. Vital and health statistics Series 2, Data evaluation and methods research. 2000(130):1-31.
19. Parsons VL, Moriarity C, Jonas K, Moore TF, Davis KE, Tompkins L. Design and estimation for the national health interview survey, 2006-2015. Vital and health statistics Series 2, Data evaluation and methods research. 2014(165):1-53.
20. National Center for Health Statistics. Survey Description, National Health Interview Survey, 2011. Hyattsville, Maryland; 2012.
21. Krieger N, Williams DR, Moss NE. Measuring social class in US public health research: concepts, methodologies, and guidelines. Annu Rev Public Health. 1997;18:341-78.
22. National Center for Health Statistics and Department of Health Information Security. Multiple Imputation of Family Income and Personal Earnings in the National Health Interview Survey: Methods and Examples. Hyattsville, Maryland: National Center for Health Statistics, Centers for Disease Control and Prevention; 2012.

23. Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. Soc Sci Med. 1997;44(6):757-71.
24. Moreno-Betancur M, Latouche A, Menvielle G, Kunst AE, Rey G. Relative index of inequality and slope index of inequality: a structured regression framework for estimation. Epidemiology. 2015;26(4):518-27.
25. Irwin DJB. How to Use Ridit Analysis. Biometrics. 1958;14(1):18-38.
26. Payton ME, Greenstone MH, Schenker N. Overlapping confidence intervals or standard error intervals: what do they mean in terms of statistical significance? Journal of insect science (Online). 2003;3:34.
27. Conway BN, May ME, Blot WJ. Mortality among low-income African Americans and whites with diabetes. Diabetes Care. 2012;35(11):2293-9.
28. Hunt BR, Whitman S, Henry CA. Age-adjusted diabetes mortality rates vary in local communities in a metropolitan area: racial and spatial disparities and correlates. Diabetes Care. 2014;37(5):1279-86.
29. Lynch CP, Gebregziabher M, Echols C, Gilbert GE, Zhao Y, Egede LE. Racial disparities in all-cause mortality among veterans with type 2 diabetes. J Gen Intern Med. 2010;25(10):1051-6.
30. Zhao W, Katzmarzyk PT, Horswell R, Wang Y, Li W, Johnson J, et al. Body mass index and the risk of all-cause mortality among patients with type 2 diabetes mellitus. Circulation. 2014;130(24):2143-51.
31. Rosenstock S, Whitman S, West JF, Balkin M. Racial disparities in diabetes mortality in the 50 most populous US cities. Journal of urban health : bulletin of the New York Academy of Medicine. 2014;91(5):873-85.
32. Menke A, Casagrande S, Geiss L, Cowie CC. Prevalence of and Trends in Diabetes Among Adults in the United States, 1988-2012. Jama. 2015;314(10):1021-9.
33. Olshansky SJ, Antonucci T, Berkman L, Binstock RH, Boersch-Supan A, Cacioppo JT, et al. Differences in life expectancy due to race and educational differences are widening, and many may not catch up. Health affairs (Project Hope). 2012;31(8):1803-13.
34. Medina-Inojosa J, Jean N, Cortes-Bergoderi M, Lopez-Jimenez F. The Hispanic paradox in cardiovascular disease and total mortality. Progress in cardiovascular diseases. 2014;57(3):286-92.

Table 1. Selected characteristics of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** for three time period cohorts (1997-2001, 2002-2006, and 2007-2011) - National Health Interview Survey, 1997-2015

	1997-2001			2002-2006			2007-2011		
	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)
Total	9391	100.0	10.2	10453	100.0	13.6	11742	100.0	18.0
Gender									
Men	3939	47.7 (46.3, 49.0)	4.9	4628	49.4 (48.3, 50.5)	6.7	5274	49.7 (48.5, 50.9)	9.0
Women	5452	52.3 (51.0, 53.7)	5.3	5825	50.6 (49.5, 51.7)	6.9	6468	50.3 (49.1, 51.5)	9.1
Age groups (years)									
25-49	2057	23.4 (22.4, 24.4)	2.4	2211	23.0 (21.9, 24.1)	3.1	2245	21.3 (20.3, 22.3)	3.8
50-64	3130	35.0 (33.7, 36.3)	3.6	3713	37.2 (36.0, 38.3)	5.1	4420	39.9 (38.8, 41.0)	7.2
65-79	3351	33.7 (32.6, 34.9)	3.4	3501	31.3 (30.1, 32.4)	4.3	3869	29.8 (28.8, 30.9)	5.4
≥80	853	7.9 (7.2, 8.6)	0.8	1028	8.6 (8.0, 9.3)	1.2	1208	9.0 (8.4, 9.6)	1.6
Age (years): mean (se)		60.2 (0.2)			60.2 (0.2)			60.4 (0.2)	
Race/ethnicity									
Non-Hispanic white	5677	71.0 (69.5, 72.4)	7.3	6477	71.6 (70.4, 72.7)	9.8	6694	68.6 (67.5, 69.8)	12.4
Non-Hispanic black	1998	17.2 (15.9, 18.5)	1.8	2129	16.2 (15.2, 17.1)	2.2	2745	16.4 (15.5, 17.4)	3
Hispanic	1716	11.8 (11.0, 12.8)	1.2	1847	12.3 (11.5, 13.1)	1.7	2303	14.9 (14.0, 15.8)	2.7
Education									
<High School	3546	33.3 (32.1, 34.5)	3.4	3306	27.2 (26.1, 28.2)	3.7	3395	25.2 (24.1, 26.3)	4.5
High School Grad	2805	32.0 (30.8, 33.2)	3.3	3169	31.8 (30.7, 33.0)	4.3	3487	31.6 (30.4, 32.7)	5.7
>High School	3040	34.7 (33.4, 36.0)	3.5	3978	41.0 (39.7, 42.3)	5.6	4860	43.2 (42.0, 44.4)	7.8
Income-to-Poverty Ratio									
Poor (<100%)	1987	15.5 (14.6, 16.5)	1.6	2144	14.9 (14.1, 15.7)	2.0	2346	14.3 (13.5, 15.2)	2.6
Near poor (100-199%)	2561	24.8 (23.7, 26.0)	2.5	2737	24.0 (22.9, 25.0)	3.2	3052	23.9 (22.8, 25.0)	4.3
Middle income (200-399%)	2853	33.2 (32.1, 34.4)	3.4	3108	32.1 (30.9, 33.2)	4.4	3598	32.6 (31.4, 33.8)	5.9
High income (≥400%)	1990	26.4 (25.1, 27.6)	2.7	2464	29.1 (27.9, 30.3)	4.0	2746	29.2 (27.9, 30.5)	5.3

Five data files with imputed income data were provided by the Centers for Disease Control and Prevention's National Center for Health Statistics. Multiple imputation methodology was used to calculate all estimates related to income to poverty ratio threshold; N's based on imputed income data file number 5.

Table 2. Age adjusted all-cause mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** by race/ethnicity - National Health Interview Survey, 1997-2015

	Mortality at Each Time Period with 5 Years Follow-up Through 2015					
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2002-2006	Change 2002-2006 to 2007-2011	Change 1997-2001 to 2007-2011
All	23.5 (22.2, 24.8)	20.2 (19.0, 21.4)	18.1 (17.0, 19.2)	-3.3 (-5.0, -1.6)	-2.1 (-3.6, -0.6)	-5.4 (-7.1, -3.7)
Non-Hispanic white	25.3 (23.6, 27.0)	22.1 (20.6, 23.6)	20.1 (18.7, 21.5)	-3.2 (-5.5, -1.0)	-2.0 (-3.9, 0.01)	-5.2 (-7.4, -3.0)
Non-Hispanic black	20.2 (17.3, 23.2)	18.6 (16.0, 21.1)	15.0 (13.2, 16.9)	-1.7 (-5.2, 1.9)	-3.5 (-6.5, -0.5)	-5.2 (-8.6, -1.8)
Hispanic	15.7 (12.9, 18.6)	10.4 (8.4, 12.4)	10.3 (8.5, 12.1)	-5.3 (-9.0, -1.6)	-0.1 (-2.9, 2.6)	-5.4 (-8.8, -2.1)

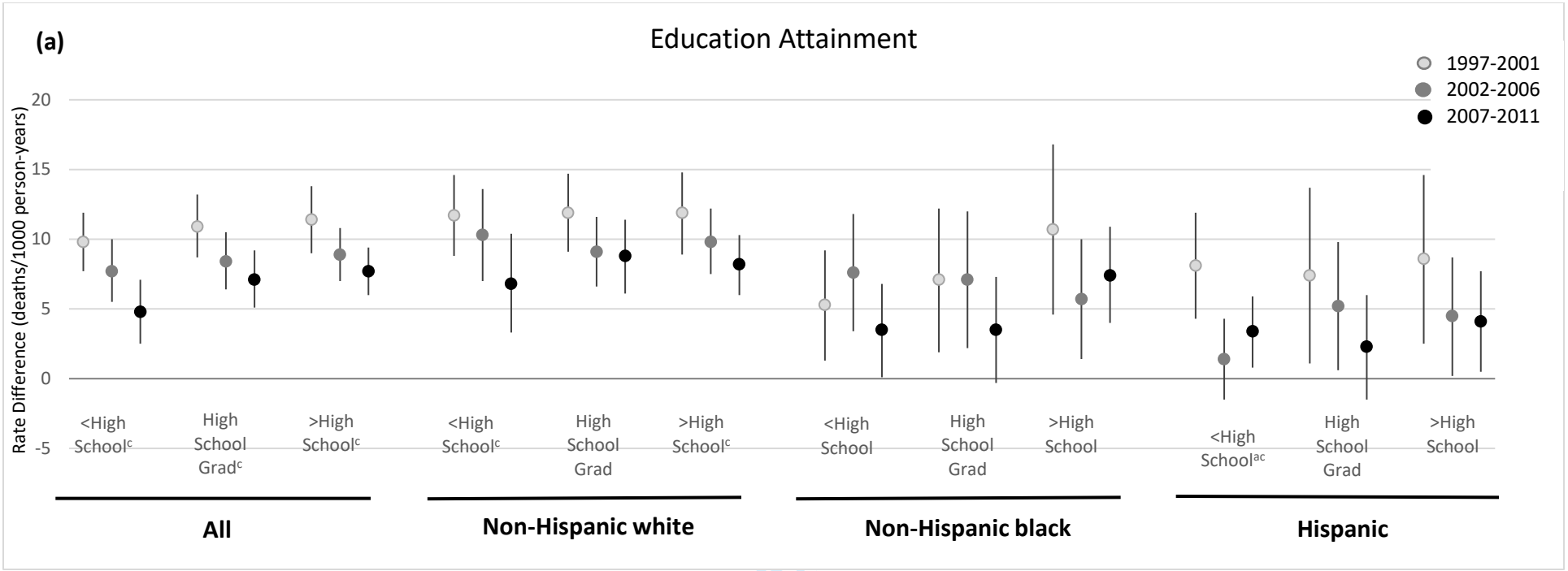
Table 3. Age adjusted all-cause mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different **Education Attainment** and by race/ethnicity - National Health Interview Survey, 1997-2015

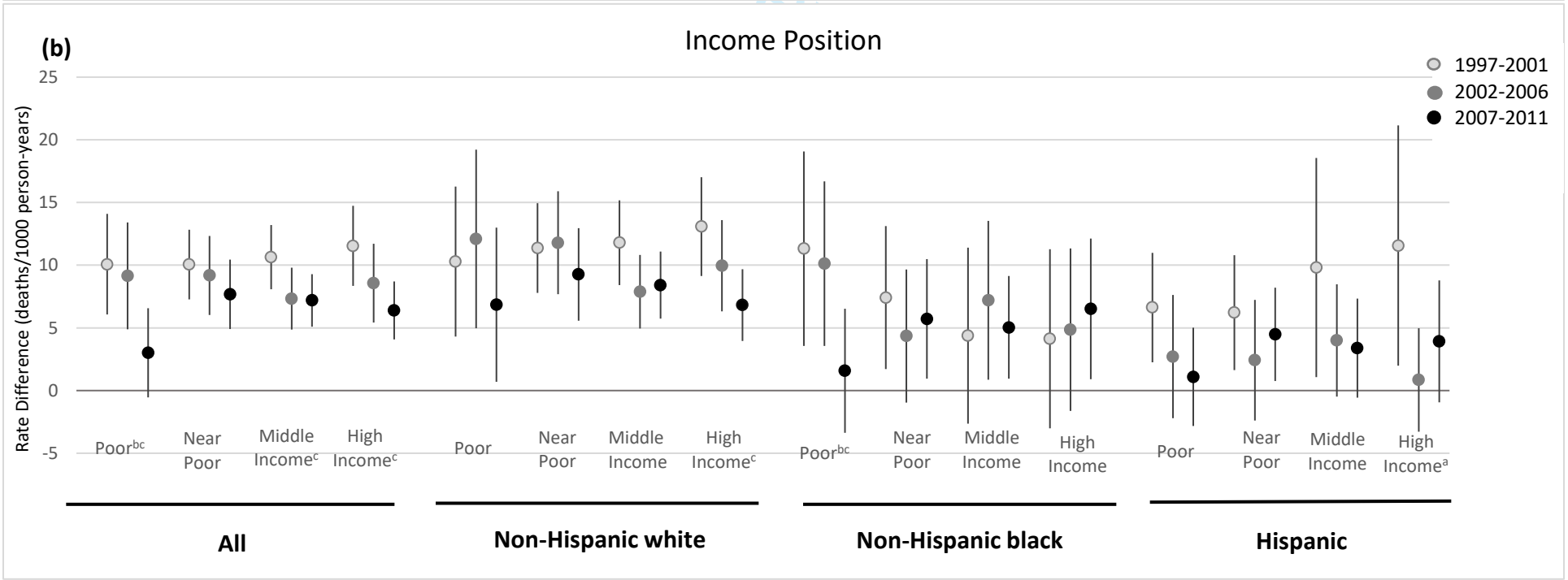
	Mortality at Each Time Period with Potential Follow-up Through 2015					
	1997-2001	**2002-2006**	**2007-2011**	**Change 1997-2001 to 2002-2006**	**Change 2002-2006 to 2007-2011**	**Change 1997-2001 to 2007-2011**
All						
<High School	26.1 (24.2, 28.0)	23.5 (21.4, 25.6)	20.3 (18.3, 22.4)	-2.5 (-5.4, 0.3)	-3.2 (-6.1, -0.3)	-5.7 (-8.5, -3.0)
High School Grad	22.6 (20.3, 24.8)	19.7 (17.7, 21.8)	18.4 (16.5, 20.3)	-2.8 (-5.7, 0.1)	-1.4 (-4.1, 1.4)	-4.2 (-7.1, -1.3)
>High School	21.1 (18.8, 23.5)	17.8 (15.9, 19.6)	16.4 (14.7, 18.0)	-3.4 (-6.4, -0.3)	-1.4 (-3.9, 1.1)	-4.8 (-7.6, -1.9)
SII (95% CI)	7.4 (3.0, 11.9)	8.4 (4.3, 12.5)	5.9 (2.2, 9.7)	0.9 (-5.2, 7.1)	-2.5 (-8.1, 3.2)	-1.5 (-7.3, 4.3)
RII (95% CI)	32.3 (12.3, 52.2)	42.0 (20.9, 63.1)	33.0 (11.8, 54.3)	9.7 (-19.6, 39.1)	-9.0 (-39.2, 21.2)	0.8 (-28.4, 29.9)
Non-Hispanic white						
<High School	28.9 (26.2, 31.7)	27.0 (23.9, 30.1)	24.3 (20.9, 27.6)	-1.9 (-6.2, 2.4)	-2.8 (-7.3, 1.7)	-4.7 (-9.0, -0.4)
High School Grad	24.3 (21.5, 27.0)	21.4 (18.9, 23.8)	20.6 (18.1, 23.0)	-2.9 (-6.4, 0.6)	-0.8 (-4.3, 2.7)	-3.7 (-7.3, -0.1)
>High School	22.5 (19.7, 25.3)	19.4 (17.1, 21.7)	17.6 (15.6, 19.6)	-3.1 (-6.8, 0.7)	-1.8 (-4.9, 1.3)	-4.9 (-8.3, -1.4)
SII (95% CI)	9.2 (3.3, 15.0)	10.0 (4.5, 15.5)	9.2 (4.0, 14.3)	0.8 (-7.5, 9.1)	-0.9 (-8.4, 6.7)	-0.03 (-7.8, 7.7)
RII (95% CI)	37.1 (12.8, 61.4)	45.8 (20.2, 71.4)	45.9 (20.2, 71.6)	8.7 (-27.6, 45.0)	0.1 (-36.3, 36.6)	8.8 (-26.5, 44.1)
Non-Hispanic black						
<High School	21.4 (18.0, 24.9)	22.3 (18.6, 26.1)	16.4 (13.5, 19.3)	0.9 (-3.6, 5.4)	-5.9 (-10.7, -1.2)	-5.0 (-9.4, -0.6)
High School Grad	19.0 (14.1, 24.0)	16.9 (12.0, 21.8)	14.6 (10.8, 18.4)	-2.1 (-9.3, 5.1)	-2.3 (-8.2, 3.6)	-4.4 (-10.6, 1.8)
>High School	20.5 (14.5, 26.5)	15.1 (10.9, 19.3)	14.6 (11.2, 18.1)	-5.4 (-12.9, 2.1)	-0.5 (-5.8, 4.9)	-5.8 (-12.7, 1.1)
SII (95% CI)	1.8 (-8.3, 11.9)	11.3 (3.0, 19.6)	2.5 (-4.6, 9.6)	9.5 (-4.1, 23.2)	-8.8 (-20.3, 2.7)	0.7 (-11.6, 13.0)
RII (95% CI)	8.7 (-41.1, 58.6)	61.5 (14.5, 108.4)	16.3 (-30.6, 63.3)	52.7 (-19.2, 124.7)	-45.1 (-114.1, 23.9)	7.6 (-60.7, 75.9)
Hispanic						
<High School	16.7 (13.2, 20.3)	10.7 (8.2, 13.2)	11.2 (8.6, 13.7)	-6.0 (-10.5, -1.6)	0.5 (-3.1, 4.0)	-5.6 (-9.9, -1.3)
High School Grad	15.0 (9.0, 21.1)	11.4 (6.8, 15.9)	9.4 (6.2, 12.5)	-3.7 (-11.0, 3.6)	-2.0 (-7.6, 3.6)	-5.7 (-12.5, 1.2)
>High School	13.6 (7.7, 19.6)	9.4 (5.3, 13.6)	9.7 (6.3, 13.1)	-4.2 (-12.4, 4.0)	0.2 (-5.2, 5.7)	-4.0 (-10.8, 2.9)
SII (95% CI)	5.1 (-5.5, 15.7)	1.5 (-5.8, 8.7)	2.8 (-3.7, 9.2)	-3.7 (-16.6, 9.3)	1.3 (-8.3, 10.9)	-2.4 (-14.7, 10.0)
RII (95% CI)	32.9 (-36.4, 102.1)	13.8 (-55.7, 83.3)	26.7 (-36.2, 89.6)	-19.1 (-119.2, 81.0)	12.9 (-80.4, 106.3)	-6.1 (-99.3, 87.0)

Table 4. Age adjusted all-cause mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different Income-to-Poverty Ratio and by race/ethnicity - National Health Interview Survey, 1997-2015

	Mortality at Each Time Period with Potential Follow-up Through 2015					
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2002-2006	Change 2002-2006 to 2007-2011	Change 1997-2001 to 2007-2011
All						
Poor (<100%)	28.7 (25.0, 32.5)	26.1 (22.2, 30.0)	20.8 (17.7, 23.9)	-2.6 (-8.3, 3.1)	-5.3 (-10.1, -0.5)	-7.9 (-13.0, -2.8)
Near poor (100-199%)	25.0 (22.4, 27.6)	23.1 (20.2, 26.0)	21.7 (19.2, 24.3)	-1.9 (-6.0, 2.1)	-1.4 (-4.8, 2.1)	-3.3 (-7.0, 0.4)
Middle income (200-399%)	22.5 (19.9, 25.1)	18.6 (16.3, 20.9)	17.8 (15.8, 19.9)	-3.9 (-7.4, -0.4)	-0.8 (-3.8, 2.3)	-4.7 (-8.0, -1.3)
High income (≥400%)	19.8 (16.7, 23.0)	16.3 (13.3, 19.2)	13.7 (11.4, 15.9)	-3.6 (-7.9, 0.8)	-2.6 (-6.3, 1.1)	-6.2 (-9.9, -2.4)
SII (95% CI)	10.5 (5.2, 15.8)	12.7 (7.1, 18.2)	11.7 (7.0, 16.4)	2.2 (-5.5, 9.8)	-1.0 (-8.2, 6.1)	1.1 (-5.7, 8.0)
RII (95% CI)	46.0 (22.2, 69.9)	64.3 (35.4, 93.3)	65.4 (38.4, 92.4)	18.3 (-19.4, 56.0)	1.1 (-37.9, 40.1)	19.4 (-15.3, 54.1)
Non-Hispanic white						
Poor (<100%)	30.3 (24.8, 35.9)	30.3 (23.6, 37.0)	26.3 (20.8, 31.8)	-0.03 (-9.3, 9.2)	-4.0 (-12.3, 4.3)	-4.1 (-12.3, 4.2)
Near poor (100-199%)	27.1 (23.6, 30.5)	25.9 (22.0, 29.8)	24.5 (21.1, 27.9)	-1.2 (-6.6, 4.3)	-1.4 (-6.1, 3.4)	-2.5 (-7.3, 2.3)
Middle income (200-399%)	24.5 (21.2, 27.8)	20.1 (17.3, 22.9)	19.9 (17.4, 22.5)	-4.4 (-8.6, -0.2)	-0.2 (-4.0, 3.7)	-4.5 (-8.8, -0.3)
High income (≥400%)	22.4 (18.5, 26.3)	18.6 (15.1, 22.1)	14.9 (12.1, 17.7)	-3.8 (-9.1, 1.5)	-3.7 (-8.0, 0.6)	-7.5 (-12.2, -2.8)
SII (95% CI)	9.0 (2.2, 15.9)	13.4 (5.9, 20.9)	15.9 (9.1, 22.7)	4.3 (-6.1, 14.7)	2.5 (-7.3, 12.3)	6.8 (-2.5, 16.2)
RII (95% CI)	36.3 (8.1, 64.6)	61.5 (26.5, 96.6)	79.9 (45.4, 114.3)	25.2 (-21.1, 71.5)	18.3 (-29.7, 66.3)	43.5 (0.3, 86.7)
Non-Hispanic black						
Poor (<100%)	28.1 (21.1, 35.1)	25.9 (20.0, 31.8)	17.3 (13.1, 21.5)	-2.2 (-11.1, 6.7)	-8.6 (-16.0, -1.2)	-10.8 (-18.9, -2.8)
Near poor (100-199%)	21.5 (16.3, 26.6)	18.4 (13.6, 23.2)	17.5 (13.1, 21.9)	-3.1 (-9.6, 3.5)	-0.9 (-6.9, 5.1)	-4.0 (-10.6, 2.6)
Middle income (200-399%)	16.8 (10.5, 23.2)	16.6 (10.2, 22.9)	13.7 (9.9, 17.4)	-0.3 (-9.2, 8.7)	-2.9 (-10.2, 4.4)	-3.2 (-10.3, 4.0)
High income (≥400%)	12.0 (5.4, 18.5)	11.5 (4.9, 18.1)	11.6 (6.3, 16.8)	-0.5 (-10.2, 9.3)	0.1 (-8.7, 8.9)	-0.4 (-8.8, 8.0)
SII (95% CI)	21.6 (8.9, 33.7)	17.6 (6.7, 28.6)	8.4 (0.2, 16.7)	-3.7 (-19.9, 12.6)	-9.2 (-23.2, 4.8)	-12.9 (-27.9, 2.2)
RII (95% CI)	107.6 (44.0, 171.2)	97.4 (35.6, 159.2)	55.6 (-0.4, 111.7)	-10.2 (-97.6, 77.2)	-41.8 (-126.5, 43.0)	-52.0 (-137.2, 33.3)
Hispanic						
Poor (<100%)	16.3 (12.3, 20.3)	11.2 (6.8, 15.6)	10.2 (6.8, 13.6)	-5.1 (-11.6, 1.4)	-1.0 (-6.4, 4.4)	-6.1 (-11.4, -0.7)
Near poor (100-199%)	15.4 (11.0, 19.7)	12.3 (7.9, 16.6)	11.7 (8.2, 15.2)	-3.1 (-9.4, 3.2)	-0.6 (-6.1, 4.9)	-3.7 (-9.0, 1.7)
Middle income (200-399%)	16.1 (7.5, 24.6)	10.3 (6.0, 14.6)	9.5 (6.0, 13.1)	-5.8 (-15.3, 3.8)	-0.7 (-6.3, 4.9)	-6.5 (-15.8, 2.7)
High income (≥400%)	15.8 (6.4, 25.2)	5.3 (1.5, 9.0)	9.5 (4.9, 14.0)	-10.6 (-20.7, -0.4)	4.2 (-1.7, 10.2)	-6.4 (-16.9, 4.2)
SII (95% CI)	0.3 (-10.8, 11.4)	6.1 (-1.7, 13.9)	1.8 (-4.9, 8.4)	5.8 (-8.0, 19.6)	-4.3 (-14.5, 5.9)	1.5 (-11.5, 14.5)
RII (95% CI)	1.9 (-68.7, 72.5)	60.4 (-17.2, 138.0)	17.2 (-47.9, 82.2)	58.5 (-48.5, 165.4)	-43.2 (-144.1, 57.6)	15.3 (-81.0, 111.5)

Figure 1. Age-adjusted all-cause mortality rate difference between U.S. adults aged ≥25 years with diagnosed diabetes and those without diagnosed diabetes for three time period cohorts (1997-2001, 2002-2006, and 2007-2011) - National Health Interview Survey, 1997-2015. [a]P-value <0.05 for rate difference change from 1997-2001 cohort to 2002-2006 cohort. [b]P-value <0.05 for rate difference change from 2002-2006 cohort to 2007-2011 cohort. [c]P-value <0.05 for rate difference change from 1997-2001 cohort to 2007-2011 cohort.


(a)
Education Attainment
1997-2001
2002-2006
2007-2011
Rate Difference (deaths/1000 person-years)
20
15
10
5
0
-5
<High School[c]
High School Grad[c]
>High School[c]
<High School[c]
High School Grad
>High School[c]
<High School
High School Grad
>High School
<High School[ac]
High School Grad
>High School
All
Non-Hispanic white
Non-Hispanic black
Hispanic


(b)
Income Position
1997-2001
2002-2006
2007-2011
Rate Difference (deaths/1000 person-years)
25
20
15
10
5
0
-5
Poor[bc]
Near Poor
Middle Income[c]
High Income[c]
Poor
Near Poor
Middle Income
High Income[c]
Poor[bc]
Near Poor
Middle Income
High Income
Poor
Near Poor
Middle Income
High Income[a]
All
Non-Hispanic white
Non-Hispanic black
Hispanic

Supplemental Table 1. Selected characteristics of U.S. adults aged ≥25 years with **NO diagnosed diabetes** for three time period cohorts (1997-2001, 2002-2006, and 2007-2011) - National Health Interview Survey, 1997-2015

	1997-2001 N= 126209			**2002-2006** N= 108970			**2007-2011** N= 97272		
	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)	n	% (95% CI)	N in pop (in millions)
Gender									
Men	54481	47.7 (47.4, 48.1)	70.9	47468	47.7 (47.3, 48.1)	73.2	42662	48.0 (47.6, 48.4)	79.0
Women	71728	52.3 (51.9, 52.6)	77.6	61502	52.3 (51.9, 52.7)	80.2	54610	52.0 (51.6, 52.4)	85.7
Age groups (years)									
25-49	73992	60.6 (60.1, 61.0)	89.9	61141	57.9 (57.4, 58.3)	88.8	51760	55.1 (54.6, 55.7)	90.9
50-64	26797	21.9 (21.6, 22.2)	32.6	26310	25.0 (24.6, 25.3)	38.3	25607	27.5 (27.1, 27.9)	45.3
65-79	18830	13.3 (13.1, 13.6)	19.8	15125	12.5 (12.2, 12.7)	19.1	13989	12.6 (12.3, 12.9)	20.7
≥80	6590	4.2 (4.0, 4.3)	6.2	6394	4.7 (4.5, 4.9)	7.2	5916	4.8 (4.6, 5.1)	7.9
Age (years): mean (se)		47.8 (0.1)			48.4 (0.1)			48.9 (0.1)	
Race/ethnicity									
Non-Hispanic white	89725	79.6 (79.0, 80.2)	118.2	75248	77.2 (76.6, 77.7)	118.4	63878	74.7 (74.0, 75.4)	123.0
Non-Hispanic black	17017	10.7 (10.3, 11.2)	15.9	15182	10.9 (10.5, 11.4)	16.7	15534	11.6 (11.1, 12.1)	19.1
Hispanic	19467	9.7 (9.2, 10.1)	14.4	18540	11.9 (11.5, 12.3)	18.3	17860	13.7 (13.3, 14.2)	22.6
Education									
<High School	26247	17.4 (17.0, 17.8)	25.8	20723	16.2 (15.8, 16.6)	24.8	16468	14.3 (13.9, 14.8)	23.6
High School Grad	36985	30.4 (29.9, 30.8)	45.1	31238	29.4 (29.0, 29.8)	45.1	26207	27.3 (26.9, 27.8)	45.0
>High School	62977	52.3 (51.6, 52.9)	77.6	57009	54.4 (53.9, 55.0)	83.5	54597	58.3 (57.7, 59.0)	96.1
Income to Poverty Ratio									
Poor (<100%)	16869	9.5 (9.2, 9.8)	14.1	14560	9.9 (9.6, 10.1)	15.1	13904	10.4 (10.1, 10.7)	17.1
Near poor (100-199%)	24407	16.7 (16.4, 17.1)	24.9	21414	17.2 (16.8, 17.5)	26.3	19213	17.4 (17.0, 17.8)	28.6
Middle income (200-399%)	40410	32.8 (32.4, 33.2)	48.7	34022	31.5 (31.1, 31.9)	48.3	29551	30.8 (30.3, 31.2)	50.8
High income (≥400%)	44523	41.0 (40.3, 41.6)	60.8	38974	41.5 (40.9, 42.1)	63.7	34604	41.4 (40.7, 42.2)	68.3

Five data files with imputed income data were provided by the Centers for Disease Control and Prevention's National Center for Health Statistics. Multiple imputation methodology was used to calculate all estimates related to income-to-poverty ratio threshold; N's are based on imputed income data file number 5.

Supplemental Table 2. Age adjusted all-cause mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **NO** DIAGNOSED DIABETES by race/ethnicity - National Health Interview Survey, 1997-2015

	Mortality at Each Time Period with 5 Years Follow-up Through 2015					
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2002-2006	Change 2002-2006 to 2007-2011	Change 1997-2001 to 2007-2011
All	12.2 (11.9, 12.6)	11.3 (11.0, 11.7)	10.8 (10.4, 11.2)	**-0.9 (-1.4, -0.4)**	-0.5 (-1.0, 0.02)	**-1.4 (-1.9, -0.9)**
Non-Hispanic white	13.0 (12.5, 13.4)	12.0 (11.5, 12.4)	11.5 (11.1, 12.0)	**-1.0 (-1.6, -0.4)**	-0.4 (-1.0, 0.2)	**-1.4 (-2.0, -0.8)**
Non-Hispanic black	13.1 (12.2, 14.0)	11.5 (10.4, 12.5)	10.0 (9.1, 11.0)	**-1.6 (-3.1, -0.2)**	**-1.5 (-2.8, -0.1)**	**-3.1 (-4.4, -1.8)**
Hispanic	7.5 (6.7, 8.3)	7.4 (6.7, 8.2)	6.9 (6.2, 7.7)	-0.1 (-1.2, 1.0)	-0.5 (-1.5, 0.5)	-0.6 (-1.7, 0.5)

Supplemental Table 3. Age adjusted all-cause mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **NO DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different education attainment and by gender and race/ethnicity - National Health Interview Survey, 1997-2015

	Mortality at Each Time Period with 5 Years Follow-up Through 2015					
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2002-2006	Change 2002-2006 to 2007-2011	Change 1997-2001 to 2007-2011
All						
<High School	16.3 (15.5, 17.0)	15.8 (15.0, 16.6)	15.5 (14.6, 16.5)	-0.5 (-1.6, 0.6)	-0.3 (-1.5, 1.0)	-0.7 (-1.9, 0.4)
High School Grad	11.6 (11.1, 12.2)	11.3 (10.7, 12.0)	11.2 (10.6, 11.9)	-0.3 (-1.2, 0.5)	-0.1 (-1.0, 0.8)	-0.4 (-1.2, 0.5)
>High School	9.7 (9.2, 10.2)	8.9 (8.4, 9.4)	8.7 (8.2, 9.2)	**-0.8 (-1.5, -0.2)**	-0.2 (-0.9, 0.5)	**-1.0 (-1.7, -0.4)**
SII (95% CI)	**9.3 (8.0, 10.6)**	**9.7 (8.4, 11.0)**	**9.4 (7.9, 10.8)**	0.4 (-1.4, 2.1)	-0.3 (-2.3, 1.7)	0.1 (-1.9, 2.0)
RII (95% CI)	**76.5 (65.9, 87.1)**	**84.4 (73.2, 95.6)**	**84.6 (71.8, 97.3)**	7.9 (-6.8, 22.6)	0.2 (-16.7, 17.1)	8.1 (-8.2, 24.4)
Non-Hispanic white						
<High School	17.2 (16.3, 18.1)	16.7 (15.6, 17.7)	17.4 (16.1, 18.8)	-0.5 (-1.9, 0.9)	0.8 (-1.0, 2.5)	0.2 (-1.3, 1.8)
High School Grad	12.4 (11.8, 13.0)	12.3 (11.5, 13.0)	11.8 (11.0, 12.6)	-0.1 (-1.1, 0.9)	-0.5 (-1.5, 0.6)	-0.6 (-1.5, 0.4)
>High School	10.6 (10.0, 11.2)	9.6 (9.0, 10.1)	9.5 (8.9, 10.1)	**-1.1 (-1.8, -0.3)**	-0.1 (-0.9, 0.7)	**-1.2 (-2.0, -0.4)**
SII (95% CI)	**8.7 (7.3, 10.2)**	**9.4 (7.9, 11.0)**	**9.5 (7.7, 11.2)**	0.7 (-1.4, 2.8)	0.02 (-2.3, 2.4)	0.7 (-1.5, 3.0)
RII (95% CI)	**67.6 (56.0, 79.3)**	**78.2 (65.5, 90.8)**	**80.4 (65.8, 95.0)**	10.5 (-5.8, 26.9)	2.2 (-16.7, 21.2)	12.8 (-5.4, 30.9)
Non-Hispanic black						
<High School	16.1 (14.5, 17.8)	14.7 (12.8, 16.7)	12.9 (11.2, 14.7)	-1.4 (-3.9, 1.1)	-1.8 (-4.3, 0.8)	**-3.2 (-5.6, -0.9)**
High School Grad	11.9 (10.2, 13.7)	9.8 (8.3, 11.3)	11.1 (9.2, 13.0)	-2.1 (-4.7, 0.5)	1.3 (-1.1, 3.7)	-0.8 (-3.4, 1.8)
>High School	9.8 (8.4, 11.1)	9.4 (8.0, 10.8)	7.2 (6.0, 8.4)	-0.4 (-2.3, 1.5)	**-2.2 (-4.0, -0.4)**	**-2.6 (-4.4, -0.7)**
SII (95% CI)	**10.2 (6.4, 13.9)**	**7.8 (4.2, 11.5)**	**9.4 (6.0, 12.7)**	-2.3 (-7.6, 3.0)	1.5 (-3.3, 6.3)	-0.8 (-5.8, 4.2)
RII (95% CI)	**77.8 (50.3, 105.4)**	**68.0 (37.6, 98.5)**	**91.0 (58.5, 123.5)**	-9.8 (-50.8, 31.2)	23.0 (-19.9, 65.8)	13.2 (-29.3, 55.7)
Hispanic						
<High School	8.7 (7.6, 9.8)	9.3 (8.1, 10.5)	7.8 (6.7, 8.9)	0.6 (-1.1, 2.4)	-1.5 (-3.1, 0.01)	-0.9 (-2.4, 0.6)
High School Grad	7.7 (6.1, 9.3)	6.2 (4.8, 7.5)	7.1 (5.5, 8.7)	-1.5 (-3.7, 0.6)	0.9 (-1.2, 3.0)	-0.6 (-2.8, 1.7)
≥High School	5.1 (3.9, 6.2)	5.0 (3.9, 6.1)	5.6 (4.4, 6.8)	-0.1 (-1.6, 1.5)	0.6 (-1.1, 2.3)	0.5 (-1.2, 2.2)
SII (95% CI)	**5.9 (3.0, 8.8)**	**7.8 (4.6, 11.0)**	**3.6 (0.8, 6.3)**	1.9 (-2.6, 6.5)	**-4.3 (-8.4, -0.1)**	-2.3 (-6.3, 1.7)
RII (95% CI)	**78.2 (39.8, 116.7)**	**104.2 (63.9, 144.6)**	**51.0 (11.2, 90.8)**	26.0 (-31.7, 83.8)	-53.3 (-108.5, 2.0)	-27.2 (-82.1, 27.6)

Supplemental Table 4. Age adjusted all-cause mortality rate (deaths/1000 person-years) of U.S. adults aged ≥25 years with **NO DIAGNOSED DIABETES** and slope index of inequality (SII) and relative index of inequality (RII) for different income to poverty ratio and by gender and race/ethnicity - National Health Interview Survey, 1997-2015

	Mortality at Each Time Period with 5 Years Follow-up Through 2015					
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2002-2006	Change 2002-2006 to 2007-2011	Change 1997-2001 to 2007-2011
Income to Poverty Ratio						
All						
Poor (<100%)	18.6 (17.3, 20.0)	17.0 (15.6, 18.4)	17.8 (16.1, 19.5)	-1.7 (-3.7, 0.34)	0.8 (-1.3, 3.0)	-0.8 (-3.1, 1.4)
Near poor (100-199%)	14.9 (14.2, 15.7)	13.9 (13.0, 14.8)	14.0 (13.0, 15.1)	-1.1 (-2.3, 0.16)	0.2 (-1.2, 1.5)	-0.9 (-2.2, 0.4)
Middle income (200-399%)	11.9 (11.2, 12.5)	11.3 (10.5, 12.0)	10.7 (9.9, 11.4)	-0.6 (-1.6, 0.43)	-0.6 (-1.7, 0.4)	**-1.2 (-2.1, -0.3)**
High income (≥400%)	8.3 (7.6, 8.9)	7.7 (7.0, 8.4)	7.3 (6.7, 7.8)	-0.6 (-1.6, 0.40)	-0.4 (-1.3, 0.5)	**-1.0 (-1.8, -0.2)**
SII (95% CI)	**12.5 (10.9, 14.1)**	**11.6 (9.9, 13.3)**	**13.0 (11.3, 14.7)**	-0.9 (-3.3, 1.45)	1.4 (-0.9, 3.8)	0.5 (-1.9, 2.9)
RII (95% CI)	102.8 (-4.3, 209.9)	101.6 (-12.0, 215.1)	115.9 (-6.8, 238.5)	-1.2 (-21.6, 19.2)	14.3 (-6.1, 34.7)	13.0 (-6.9, 33.0)
Non-Hispanic white						
Poor (<100%)	20.1 (18.2, 21.9)	18.2 (16.4, 20.0)	19.4 (16.9, 22.0)	-1.8 (-4.5, 0.8)	1.2 (-1.9, 4.3)	-0.6 (-4.0, 2.7)
Near poor (100-199%)	15.7 (14.8, 16.6)	14.1 (13.1, 15.1)	15.2 (14.0, 16.5)	**-1.6 (-2.9, -0.3)**	1.2 (-0.4, 2.7)	-0.4 (-2.0, 1.1)
Middle income (200-399%)	12.7 (11.9, 13.4)	12.2 (11.3, 13.1)	11.5 (10.7, 12.4)	-0.5 (-1.6, 0.7)	-0.7 (-1.9, 0.5)	**-1.1 (-2.3, -0.03)**
High income (≥400%)	9.3 (8.5, 10.1)	8.6 (7.8, 9.5)	8.1 (7.4, 8.7)	-0.7 (-1.8, 0.5)	-0.6 (-1.6, 0.5)	**-1.2 (-2.2, -0.3)**
SII (95% CI)	**11.9 (9.9, 13.8)**	**10.6 (8.5, 12.7)**	**13.1 (11.1, 15.2)**	-1.3 (-4.1, 1.6)	2.5 (-0.2, 5.2)	1.3 (-1.6, 4.1)
RII (95% CI)	92.1 (-4.1, 188.4)	88.5 (-11.9, 188.9)	110.0 (-6.9, 227.0)	-3.6 (-26.8, 19.7)	21.5 (-7.9, 43.8)	17.9 (-4.3, 40.2)
Non-Hispanic black						
Poor (<100%)	16.8 (14.3, 19.2)	15.7 (12.8, 18.7)	15.7 (13.5, 17.9)	-1.0 (-4.67, 2.60)	-0.1 (-3.7, 3.6)	-1.1 (-4.4, 2.21)
Near poor (100-199%)	14.1 (12.0, 16.1)	14.0 (11.3, 16.7)	11.8 (9.7, 13.8)	-0.03 (-3.65, 3.59)	-2.3 (-5.6, 1.0)	-2.3 (-5.1, 0.53)
Middle income (200-399%)	12.5 (10.3, 14.6)	9.4 (7.5, 11.2)	8.7 (6.6, 10.7)	**-3.1 (-6.17, -0.01)**	-0.7 (-3.5, 2.1)	**-3.8 (-6.7, -0.89)**
High income (≥400%)	7.8 (5.7, 9.9)	6.6 (4.6, 8.7)	5.0 (3.5, 6.6)	-1.2 (-4.13, 1.73)	-1.6 (-4.3, 1.1)	**-2.8 (-5.4, -0.16)**
SII (95% CI)	**11.2 (7.0, 15.4)**	**13.3 (9.0, 17.6)**	**14.5 (10.8, 18.3)**	2.1 (-4.06, 8.22)	1.3 (-4.6, 7.1)	3.3 (-2.4, 9.08)
RII (95% CI)	86.1 (-12.6, 184.7)	114.7 (-20.2, 249.7)	139.7 (-6.9, 286.4)	28.7 (-20.9, 78.2)	25.0 (-27.0, 77.0)	**53.7 (4.2, 103.2)**
Hispanic						
Poor (<100%)	9.6 (7.8, 11.5)	8.5 (6.6, 10.4)	9.1 (6.9, 11.4)	-1.2 (-4.0, 1.7)	0.6 (-2.2, 3.4)	-0.5 (-3.4, 2.4)
Near poor (100-199%)	9.2 (7.3, 11.0)	9.8 (8.0, 11.7)	7.2 (5.8, 8.6)	0.7 (-1.9, 3.2)	**-2.6 (-4.9, -0.4)**	-2.0 (-4.3, 0.4)
Middle income (200-399%)	6.2 (4.7, 7.8)	6.3 (4.9, 7.7)	6.2 (4.7, 7.7)	0.03 (-2.2, 2.2)	-0.1 (-2.1, 1.9)	-0.1 (-2.3, 2.1)
High income (≥400%)	4.3 (2.4, 6.2)	4.4 (2.8, 6.0)	5.5 (3.7, 7.4)	0.1 (-2.5, 2.8)	1.1 (-1.3, 3.6)	1.3 (-1.4, 4.0)
SII (95% CI)	**7.5 (4.3, 10.6)**	**6.3 (3.1, 9.5)**	**4.4 (0.8, 8.0)**	-1.1 (-6.2, 3.9)	-1.9 (-6.7, 2.9)	-3.1 (-7.9, 1.8)
RII (95% CI)	98.8 (-7.0, 204.7)	84.3 (-17.2, 185.9)	62.9 (-22.5, 148.3)	-14.5 (-81.6, 52.7)	-21.4 (-86.1, 43.3)	-35.9 (-101.7, 29.9)

Supplemental Table 5. Age adjusted all-cause mortality **RATE DIFFERENCE** (deaths/1000 person-years) between U.S. adults aged ≥25 years with and without diagnosed diabetes by race/ethnicity - National Health Interview Survey, 1997-2015

	Mortality at Each Time Period with 5 Years Follow-up Through 2015					
	1997-2001	2002-2006	2007-2011	Change 1997-2001 to 2002-2006	Change 2002-2006 to 2007-2011	Change 1997-2001 to 2007-2011
All	11.3 (9.9, 12.6)	8.9 (7.6, 10.1)	7.3 (6.2, 8.4)	**-2.4 (-4.2, -0.6)**	**-1.6 (-3.2, -0.03)**	**-4.0 (-5.7, -2.3)**
Non-Hispanic white	12.3 (10.6, 14.0)	10.1 (8.6, 11.6)	8.6 (7.1, 10.0)	-2.2 (-4.5, 0.02)	-1.6 (-3.6, 0.5)	**-3.8 (-6.0, -1.6)**
Non-Hispanic black	7.1 (4.0, 10.3)	7.1 (4.3, 9.8)	5.0 (3.0, 7.0)	-0.1 (-3.8, 3.7)	-2.1 (-5.3, 1.2)	-2.1 (-5.8, 1.6)
Hispanic	8.2 (5.2, 11.2)	3.0 (0.8, 5.1)	3.3 (1.4, 5.3)	**-5.2 (-9.1, -1.4)**	0.4 (-2.6, 3.3)	**-4.9 (-8.4, -1.4)**

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page and/or Line Numbers
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Pg 1 and 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Pg 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Pg 4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	Pg 5
Methods			
Study design	4	Present key elements of study design early in the paper	Pg 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Pg 6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	Pg 6-7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Pg 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pg 6-9
Bias	9	Describe any efforts to address potential sources of bias	Pg 6-9
Study size	10	Explain how the study size was arrived at	Pg 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pg 6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pg 8-9
		(*b*) Describe any methods used to examine subgroups and interactions	Pg 8-9
		(*c*) Explain how missing data were addressed	Pg 6-7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods	9

		taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			**Page and/or Line Numbers**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pg 6
		(b) Give reasons for non-participation at each stage	Pg 6
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Pg 10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Pg. 10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	Pg 10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Pg 10-12
		(*b*) Report category boundaries when continuous variables were categorized	Pg 10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Pg 10-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	Pg 13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pg 15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pg 13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	Pg 15-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Pg 1 Pg 17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.