Socioeconomic position and cardiovascular disease in adults with and without diabetes: United States trends, 1997-2005.

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Socioeconomic Position and Cardiovascular Disease in Adults With and Without Diabetes: United States Trends, 1997-2005

Running title: Diabetes, SEP and CVD

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Abstract (248 words)

Background: Diabetes and its cardiovascular complications are more common in adults of low socioeconomic position (SEP). In the US, the past decade saw the establishment of many programs to reduce cardiovascular risk in persons with diabetes, but their effect on socioeconomic disparities is uncertain.

Objective: We sought to investigate recent time trends in socioeconomic disparities in cardiovascular disease (CVD) among persons with and without diabetes.

Participants and Design: 255,966 individuals aged 25 years or older included in the National Health Interview Survey between 1997 and 2005.

Measurements: Educational attainment was used as a marker for SEP and self-reported history of CVD as the main outcome. Educational disparities were measured using prevalence rate ratios (PRR) and relative index of inequalities (RII).

Results: Among adults with diabetes, CVD prevalence was persistently higher in those who did not complete high school (HS) than in college graduates (adjusted PRR [aPRR] 1.20, 95% confidence interval [95%CI] 1.05-1.38 in 1997-1999, and aPRR 1.12, 95%CI 1.00-1.25 in 2003-2005). However, the HS vs. college graduates disparity in CVD declined from 1997-1999 (aPRR 1.20, 95%CI 1.04-1.37) to 2003-2005 (aPRR 1.01, 95%CI 0.90-1.12). Among adults without diabetes educational disparities in CVD widened markedly over time.

Conclusions: Concurrently with improvements in diabetes management, the widening of socioeconomic health disparities has remained limited in the diabetic population during the past decade. This provides evidence for the potential impact of

improvements in disparities in health care access and process, such as experienced among persons with diabetes, in limiting socioeconomic health disparities.

Keywords: Diabetes mellitus; Cardiovascular diseases; Socioeconomic factors; Health disparities

Introduction

In the US, over 20 million adults have diabetes and the prevalence is expected to rise substantially in the coming decades.[1, 2] Diabetic complications impose an enormous burden on public health: compared to their non-diabetic counterparts, adults with diabetes are two to four times more likely to develop cardiovascular disease (CVD), and their age-adjusted mortality rate is approximately twice higher.[3]

The public health burden of diabetes is unevenly distributed across socioeconomic strata. First, diabetes is more common in ethnic minorities and persons of low education and income level.[4] Second, among people with diabetes, low socioeconomic position (SEP) appears to increase risk of morbidity and mortality. Such disparities have been reported in Europe.[5-18] However, in the US only a few studies have focused on SEP-related disparities, and then only in selected subpopulations.[19-22]

Over the past decades, socioeconomic health disparities have widened in the general populations of the US and Europe.[23, 24] For persons with diabetes, major advances in disease process of care and control have occurred during the past decade.[25-27] Data from clinical trials suggest that programs of diabetes management may have the greatest benefit in people with low education or low literacy.[28, 29] However, the extent to which such improvements have benefited equally to all patients regardless of their SEP at the population level has not been studied. The present study aimed at investigating the time trends in socioeconomic health disparities among persons with and without diagnosed diabetes in the US over the past decade. We hypothesized that, concurrently with improvements in diabetes process of care and control, such disparities have increased to a lesser extent among persons with diabetes than among those without.

Methods

Data source

The NHIS is a continuous, annual, household survey conducted by the National Center for Health Statistics (NCHS). The survey uses a 3-stage stratified cluster probability sampling design to collect information from a representative sample of the civilian, noninstitutionalized US population. A complete description of NHIS procedures is available elsewhere.[30] Each year between 1997 and 2005, data from an average number of 32,190 (range: 30,801 to 36,116) adults aged 18 years or older have been collected through a face-to-face interview. The 9-year average response rate was 73.3% (range: 69.0% to 80.4%).

Variables of interest

The main dependent variable for this study was self-reported medical history of CVD. Respondents were classified as having a prevalent cardiovascular condition if they answered yes to at least one of the questions asking whether "they had ever been told by a doctor or other health professional that they had: coronary heart disease; angina pectoris; myocardial infarction; any other kind of heart disease or condition; or stroke".

Information on diabetes was collected using the question "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" Those reporting 'borderline' diabetes and women who had diabetes only during pregnancy were categorized as not having diabetes. Comorbidity was defined by the self-reported history of at least one of the following conditions: hypertension, asthma, emphysema, chronic bronchitis, kidney condition or cancer.

Educational attainment was used as an indicator of SEP. Detailed information on the highest level of school completed was collected and the variable was categorized as: "high school (HS) not completed" (less than HS diploma); "HS completed" (HS diploma, general equivalency diploma, some college, vocational or technical school or associate's degree); and "college completed" (bachelor's, master's, or professional degree). Education was preferred to income as the main measure of SEP because unlike income, education is unlikely to be affected by poor health at adult ages.

Covariates included age, gender, race/ethnicity, and poverty status. NHIS participants were asked to self-identify their race/ethnicity as non-Hispanic White, non-Hispanic Black, Hispanic or other. Poverty status was based on family income and family size, and categorized using the US Census Bureau's poverty thresholds for the previous calendar year as follows: poor (below the poverty thresholds); near poor (100-200% of the poverty thresholds); and not poor (≥200% of the poverty thresholds).[30] The multiple imputations income files provided by the NCHS were used.[31]

Study sample

Because educational attainment is often still evolving in early adulthood, analyses were limited to participants aged 25 years or older. Individuals with missing data for education (n=2728), diabetes (n=292) or CVD (n=407) were excluded. These exclusion criteria yielded to a final sample of 255,966 individuals.

Statistical Analysis

The 1997-2005 overall study period was divided in three 3-year periods (1997-1999; 2000-2002; 2003-2005) to obtain robust estimates for each time period. Analyses were adjusted for age, sex, race/ethnicity, poverty status, comorbidity and survey year. Poisson regression models with robust estimation of variance were used.[32]

Age-, sex- and race-adjusted prevalences of CVD among persons with and without diabetes were calculated for each three-year period, overall and according to educational attainment. Educational disparities in CVD prevalence were measured for each three-year period among persons with and without diabetes. Two estimates were used: first, prevalence rate ratios (PRR) associated with education were computed for each three-year period, using the highest level of education as reference. Whereas PRRs are easy to interpret, comparisons of PRRs over time are complicated by possible changes over time in the distribution of educational level in the population. The use of the Relative Index of Inequality (RII) as a measure of educational inequalities overcomes this problem by providing a continuous measure of inequalities that accounts simultaneously for the size and relative position of educational groups.[33] It does so by using a specific measure of individuals' relative educational position, i.e. the proportion of the overall population that has an educational level higher than his/her own. This is therefore a continuous measure, taking the value 0 for someone at the top of the educational scale and 1 for a person at the bottom. Using the categorical measure of educational attainment described above, we assigned this new socioeconomic indicator to each individual and then obtained the RII by regressing CVD prevalence on this new indicator. The RII can be interpreted as the change in CVD prevalence when moving from the top to the bottom of the educational scale.

Additional analyses were conducted to measure educational disparities in CVD prevalence over time among persons with and without diabetes i) separately according to age, gender, race/ethnicity and poverty status, and ii) restricting the outcome to either coronary heart disease events (CHD, as defined by self-reported coronary heart disease, angina pectoris or myocardial infarction) or stroke. Lastly, for each time period, PRRs associated with diabetes were calculated separately by educational level. Changes over time in these diabetes-associated PRRs were compared across categories of educational level. Because the risk of CVD associated with diabetes differs according to gender,[34] these analyses were performed separately in men and women. Changes over time in the magnitude of the various associations of interest were measured using terms of interaction with time period treated as a continuous variable in the models.

All statistical analyses were performed using Stata 8.0® (Stata Corporation, College Station, TX) and accounted for the complex sampling design and data weighting of NHIS so that estimates are representative of the US population.

Results

Sample characteristics

The proportion of persons reporting diabetes increased from 5.9% to 7.9% over the period 1997-2005. As shown in Table 1, as compared to the non diabetic population persons with diabetes were older (median age: 60 vs. 45 years), more frequently of non-

Hispanic Black or Hispanic race/ethnicity, less educated and poorer. Adults with diabetes more frequently reported a medical history of CVD (more than one third vs. only 12%) and comorbidity.

The distribution of educational level showed substantial changes over the period 1997-2005. Regardless of diabetes status, the proportion of persons who had not completed HS significantly decreased over time (from 18.1% to 16.0% overall), whereas the proportion of those who had completed college increased (from 24.7% to 27.4%).

Time Trends in CVD Prevalence

As shown in Figure 1, throughout the study period the overall age, sex and race-adjusted prevalence of CVD was substantially higher among persons with vs. without diabetes. The adjusted CVD prevalence decreased from 24.0% to 20.5% (p=0.01) between 1997 and 2005 among diabetic adults, while no significant trend was observed among those non diabetic. However, such time trends were not homogeneous across categories of educational attainment: among persons with diabetes, CVD prevalence significantly decreased among HS graduates (from 24.1% to 19.9%; p=0.002) but remained stable in the other educational groups. In contrast, in non-diabetic adults, CVD prevalence decreased in college graduates, increased in HS graduates, and remained stable in those who did not complete HS.

Time Trends in Socioeconomic Disparities

Table 2 shows the various measures of educational disparities in CVD prevalence over time, according to diabetes status. Among persons with diabetes, the RII was significantly greater than one in 1997-1999 and 2003-2005, suggesting that CVD prevalence was 10-20% higher when moving from the top to the bottom of the educational scale. These disparities remained stable between 1997 and 2005 (p for time trend: 0.58). The PRRs suggested that CVD prevalence was persistently higher in adults who did not complete HS than in college graduates (adjusted PRR [aPRR] 1.21, 95%CI [1.06-1.38], 1.06 [0.94-1.21], and 1.14 [1.02-1.27], respectively, for periods 1997-1999, 2000-2002 and 2003-2005; p for time trend: 0.64). In contrast, the PRR for HS graduates decreased significantly over time (p for time trend: 0.03). Consequently, the HS vs. college graduates disparity in CVD prevalence resolved between 1997-1999 (aPRR 1.22, 95%CI [1.07-1.40]) and 2003-2005 (aPRR 1.01, 95%CI [0.91-1.13]).

In adults without diabetes, socioeconomic disparities in CVD prevalence as measured by RII and aPRR increased markedly over time (Table 2). The magnitude of these disparities did not differ between adults with and without diabetes in 1997-1999. However, during the subsequent time periods the RII and the aPRRs for those who did not complete HS and for HS graduates became significantly higher among non-diabetic than among diabetic adults.

As shown in Figure 2, regardless of diabetes status time trends in educational disparities in CVD prevalence as measured by RII were consistent across gender, race/ethnicity and poverty status. However, such trends differed according to age and diabetes status: among adults aged 25-64 years, a significant increase in educational disparities in CVD prevalence was observed in those non-diabetic (p for time trend: 0.004) but not in those with diabetes (p for time trend: 0.18); among older adults, no significant time trend was observed regardless of diabetes status. Additional analyses showed similar trends in educational disparities by diabetes status whether the health outcome was restricted to either CHD or stroke.

Time Trends in the Relative Prevalence of CVD in Adults With vs. Without Diabetes

Overall, the age and race-adjusted prevalence of CVD was approximately 2.5 times higher in adults with vs. without diabetes, regardless of sex (aPRR 2.44, 95%CI [2.18-2.73] and 2.47 [2.20-2.77], respectively, in men and women). As shown in Figure 3, this association was not homogeneous across time and educational attainment, even after adjustment for potential confounders including poverty status and comorbidity. Among men, the adjusted PRR associated with diabetes overall significantly decreased over time between 1997 and 2005, from 2.11 (95%CI [1.89-2.36]) in 1997-1999 to 1.81 (95%CI [1.63-2.01]) in 2003-2005 (p for time trend: 0.03). However, this overall trend reflected different patterns according to education: whereas in HS graduate men the aPRR significantly decreased over time, from 2.23 (95%CI [1.97-2.52]) in 1997-1999 to 1.73 (95%CI [1.55-1.94]) in 2003-2005 (p for time trend: <0.001), no significant trend was observed in the other educational groups. Among women, no significant change over time was observed in the aPRR associated with diabetes overall as well as among those who did not complete HS or college graduates. However, in HS graduate women the aPRR significantly decreased over time, from 2.16 (95%CI [1.91-2.45]) in 1997-1999 to 1.70 (95%CI [1.51-1.92]) in 2003-2005 (p for time trend: 0.01).

Discussion

Our results provide evidence for the existence of educational disparities in CVD prevalence among persons with diagnosed diabetes in the US, suggesting that socioeconomic health disparities reported among persons with diabetes in Europe occur as well in this population. Furthermore, our results suggest that the increase in educational health disparities reported among the US general population has not occurred among the population diagnosed with diabetes over the past decade, a period during which major advances in diabetes process of care and control have occurred. Indeed, while educational health inequalities remained stable in adults with diabetes, they widened markedly in the non diabetic population, a feature particularly salient in middle-aged adults.

SEP may influence major determinants of the health of persons with diabetes including health behaviors, access to and process of care.[35] Underlying pathways probably involve a large range of factors including individual (e.g., social support, mental health, comorbidity, health literacy), provider, communities, and health care system characteristics.[35] Socioeconomic health disparities have been reported to be attenuated in adults with diabetes as compared to those without in Finland[36] and in Italy.[37] Our findings of lower educational disparities in CVD prevalence in adults with vs. without diabetes beginning in 2000-2002 suggest that such a salutary role of diabetes management may have occurred as well in the US context as diabetes process of care and control have improved. In addition, the age heterogeneity we found suggests that this salutary effect may be particularly salient in adults aged below 65 years, i.e. those who don't benefit from universal Medicare health coverage and thus encounter the highest health care disparities in the US.[38] This suggests that such a salutary effect may be related to the leveling off of socioeconomic disparities in health care as a result of diabetes management. Thereby our results provide evidence for the potential impact of improvements in disparities in health care access and process, such as experienced among persons with diabetes in the past decade, in limiting socioeconomic health disparities.

We also found that the gap between persons with and without diagnosed diabetes regarding CVD prevalence has shown heterogeneous time trends across educational groups between 1997 and 2005. Indeed, HS graduates constitute the only group among whom such a gap significantly decreased during this period of improvement in diabetes process of care and control. This is consistent with data from clinical trials showing that the magnitude of improvements in glycemic control following an intensification of diabetes management are not homogeneous across the subgroups of patients, those with high levels of education or literacy benefiting to a lesser extent than the others.[28, 29] Our findings additionally suggest that, while improvements in diabetes management may have been beneficial to HS graduates, this is not true for the lowest educated groups of the population who may face additional barriers that are probably independent of the offer of care.

To our knowledge, this is one of few studies to provide an overview of educational health disparities among persons with diagnosed diabetes at the population level in the US. The NHIS, thanks to its large nationally representative sample and stable design and questionnaire since 1997, allowed us to estimate the magnitude and time trends of such disparities among various subgroups of the population, controlling for potential confounders. Diabetes diagnosis criteria have remained constant since 1997, suggesting that the time trends we show are unlikely to result from changes in disease classification. Furthermore, the use of the RII as a measure of health disparities allowed us to account for the changing socioeconomic composition of the population over time.

Nonetheless, the interpretation of our findings must remain cautious due to several limitations. First, NHIS data on diabetes and CVD are based entirely on self-report; therefore, they should not be interpreted as estimates of the true burden of disease in the population. However, agreement between self-report and medical record has been reported to be substantial for these conditions;[39-42] furthermore, our estimates of diagnosed diabetes prevalence, time trend in CVD among diabetic adults and diabetes-associated CVD risk are consistent with reports using other sources of data including NHANES,[43] the National Hospital Discharge Survey[44] and the Framingham Heart Study.[45]

Reliable estimates of educational disparities in self-reported diabetes require two conditions: 1) adequate self-report of diabetes if it has been diagnosed, regardless of educational level; and 2) comparable diagnosed/undiagnosed ratio across educational groups. Although the accuracy of diabetes self-report may improve with educational level,[39, 42] the SEP gradient in diabetes frequency has been shown to appear with equal force when using either self-reported or biological (i.e., glycosylated hemoglobin A_{1C}) data.[46] Moreover, approximately one third of US adults with diabetes are estimated to be undiagnosed.[43] The extent to which individuals with undiagnosed diabetes differ from those diagnosed with regard to education is not clear.[47, 48] In complementary analyses, we found that our estimation of educational disparities among persons with diabetes remained unchanged when analyses were restricted to the most advanced cases of diabetes, i.e. those treated or those diagnosed prior to 1997 - that is, previous to the lowering of the diagnostic fasting plasma glucose level from 7.8 to 7.0 mmol/L. This suggests that differences in diabetes detection are unlikely to explain the disparities we found.

Second, the health indicator we used, i.e. prevalent CVD, is difficult to interpret because it reflects both CVD incidence and survival following a diagnosis of CVD. Our data do not allow us to disentangle the contribution of each of these two phenomena in explaining the time trends we report. Moreover, a cross-sectional study of prevalent CVD excludes the most severe cases, i.e. those fatal. Because education is inversely associated with CVD case-fatality,[49] educational disparities in CVD may have been underestimated in our study.

Because diabetes is common in all populations in industrialized nations and affects persons at all levels of the society, tackling socioeconomic health disparities among persons with diabetes is likely to have a major public health impact. Our study suggests that improvements in diabetes management over the past decade may have resulted in limiting the widening of socioeconomic health disparities in this population, probably through the leveling off of disparities in health care access and process. This provides evidence for the potential beneficial impact of programs of universal health insurance on socioeconomic health disparities in the US. However, health disparities are probably only partially explained by differential access to health care; a wider understanding of underlying pathways should guide any attempt to their reduction.

Acknowledgments

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Conflict of interest

None

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Figures legends

Figure 1

Title:

Figure 1: Age, sex, and race-adjusted prevalence of CVD over time among adults with diabetes (plain lines) and without diabetes (dotted lines), overall and by education

Legends:

* Time trend: $p<0.05$

HS: High school

Figure 2

Title:

Figure 2: Relative Index of Inequality† (and 95% confidence intervals) over time among adults with and without diabetes, by gender, age, race/ethnicity and poverty status

Legends:

† Adjusted for age, race/ethnicity, poverty status, comorbidity and survey year.

Figure 3

Title:

Figure 3: Adjusted† prevalence rate ratios of CVD associated with diabetes (and 95% confidence intervals) over time, by gender and educational attainment

Legends:

† Adjusted for age, race/ethnicity, poverty status, comorbidity and survey year. The "Overall" model is additionally adjusted for educational attainment.

* Time trend: $p<0.05$

Table 1. Characteristics* of US adults with and without diabetes by time period - NHIS 1997-2005 (N=255,966).

	1997-1999		2000-2002		2003-2005	
	With diabetes N=5,681	Without diabetes N=82,441	With diabetes N=6,362	Without diabetes N=78,798	With diabetes N=7,062	Without diabetes N=75,622
Age						
25-44 yrs	15.0 (0.6)	50.5 (0.3)	15.1 (0.6)	48.6 (0.3)	13.7 (0.6)	46.7 (0.3)
45-64 yrs	43.6 (0.8)	32.4 (0.2)	45.1 (0.8)	34.6 (0.2)	46.8 (0.7)	36.8 (0.2)
>=65 yrs	41.5 (0.8)	17.2 (0.2)	39.8 (0.7)	16.8 (0.2)	39.4 (0.8)	16.6 (0.2)
Males	46.7 (0.8)	47.7 (0.2)	50.4 (0.8)	47.4 (0.2)	49.6 (0.6)	47.6 (0.2)
Race/Ethnicity						
Non-Hispanic Whites	68.1 (0.9)	76.8 (0.3)	68.7 (0.8)	75.4 (0.2)	68.8 (0.7)	73.6 (0.4)
Non-Hispanic Blacks	16.7 (0.7)	10.4 (0.2)	16.1 (0.6)	10.5 (0.3)	15.5 (0.6)	10.4 (0.3)
Hispanics	11.7 (0.6)	9.1 (0.2)	11.3 (0.5)	9.9 (0.3)	11.6 (0.5)	11.7 (0.3)
Other	3.5 (0.4)	3.7 (0.1)	3.9 (0.3)	4.2 (0.1)	4.1 (0.4)	4.3 (0.1)
Educational attainment						
High school not completed	33.4 (0.8)	17.1 (0.2)	30.0 (0.7)	15.8 (0.2)	26.0 (0.7)	15.2 (0.2)
High school completed	53.2 (0.8)	57.5 (0.3)	55.4 (0.7)	57.3 (0.3)	57.1 (0.7)	56.5 (0.3)
College completed	13.4 (0.6)	25.4 (0.3)	14.6 (0.5)	26.9 (0.3)	16.9 (0.6)	28.3 (0.3)
Poverty status †						
Poor	16.6 (0.6)	9.8 (0.2)	14.5 (0.5)	9.4 (0.2)	14.8 (0.5)	9.7 (0.2)
Near poor	23.7 (0.7)	16.8 (0.2)	24.5 (0.6)	16.4 (0.2)	23.9 (0.6)	17.1 (0.2)
Not poor	59.7 (0.9)	73.4 (0.3)	61.0 (0.7)	74.2 (0.3)	61.3 (0.8)	73.2 (0.3)
Self-reported CVD	38.7 (0.8)	12.1 (0.1)	37.0 (0.7)	11.9 (0.2)	36.0 (0.7)	12.2 (0.1)
Comorbidity	72.2 (0.7)	35.1 (0.2)	73.3 (0.7)	36.5 (0.2)	75.9 (0.6)	37.3 (0.3)

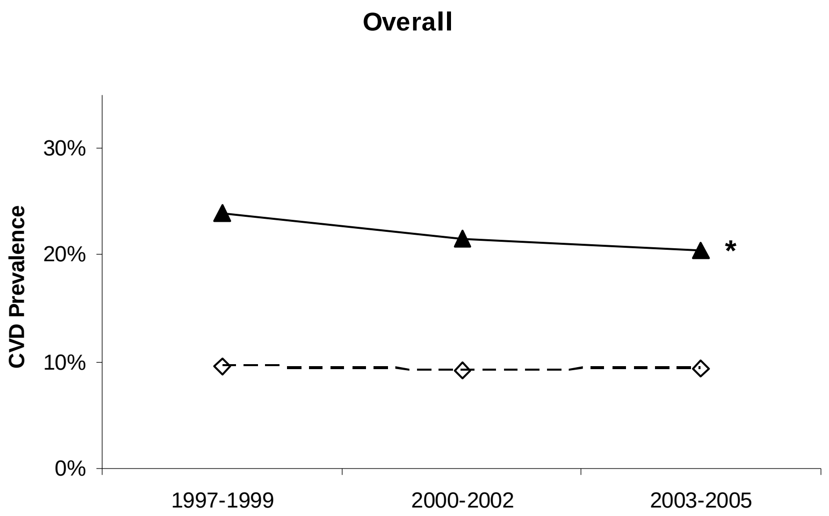
* Values are weighted percentages (Standard Error)

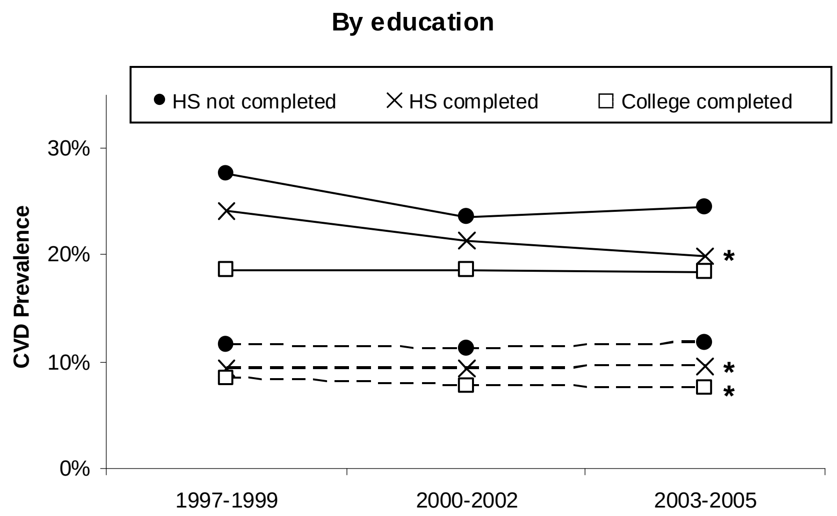
† Based on family income and family size using the US Census Bureau's poverty thresholds for the previous calendar year. "Poor" persons are defined as below the poverty threshold. "Near poor" persons have incomes of 100% to less than 200% of the poverty threshold. "Not poor" persons have incomes that are 200% of the poverty threshold or greater.

Table 2. Educational disparities in the prevalence of self-reported CVD over time among US adults with and without diabetes. NHIS 1997-2005.

	1997-1999	2000-2002	2003-2005	p (time trend)
Adults with diabetes				
RII [95% CI]*	1.17 [1.02-1.34]	1.06 [0.92-1.23]¶	1.21 [1.05-1.38]¶	0.58
PRR [95% CI]*				
High school not completed	1.21 [1.06-1.38]	1.06 [0.94-1.21]¶	1.14 [1.02-1.27]¶	0.64
High school completed	1.22 [1.07-1.40]	1.06 [0.94-1.19]	1.01 [0.91-1.13]¶	0.03
College completed	1	1	1	
Adults without diabetes				
RII [95% CI]*	1.30 [1.19-1.41]	1.39 [1.27-1.52]¶	1.47 [1.35-1.59]¶	0.005
PRR [95% CI]*				
High school not completed	1.22 [1.14-1.31]	1.30 [1.21-1.39]¶	1.35 [1.26-1.44]¶	0.006
High school completed	1.06 [1.00-1.13]	1.15 [1.08-1.23]	1.20 [1.13-1.26]¶	0.002
College completed	1	1	1	

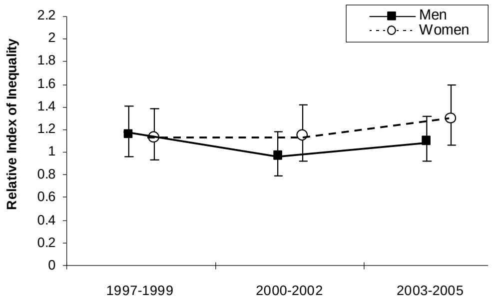
RII: Relative Index of Inequality, PRR: Prevalence Rate Ratio, 95% CI: 95% confidence interval
* Adjusted for age, sex, race/ethnicity, poverty status, comorbidity and survey year
¶ Interaction between education and diabetes status in the regression model: $p<0.05$

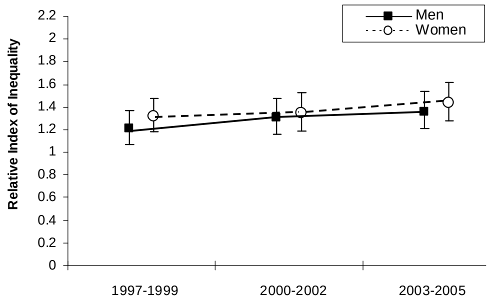

Overall
CVD Prevalence
30%
20%
10%
0%
1997-1999
2000-2002
2003-2005
*


By education
HS not completed
HS completed
College completed
CVD Prevalence
30%
20%
10%
0%
1997-1999
2000-2002
2003-2005
*
*
*

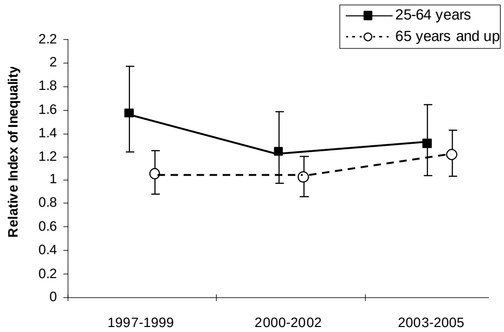
ADULTS WITH DIABETES | **ADULTS WITHOUT DIABETES**

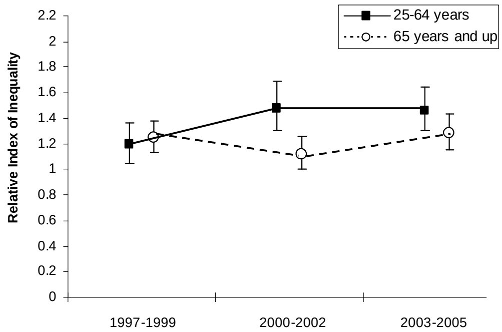
Gender



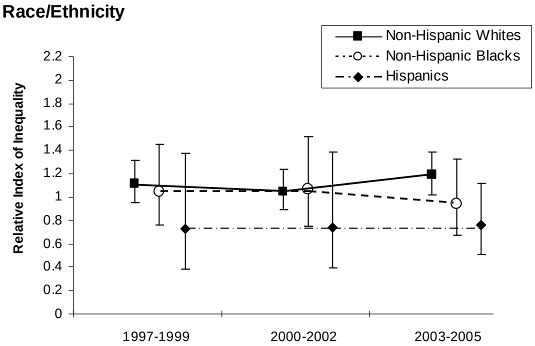


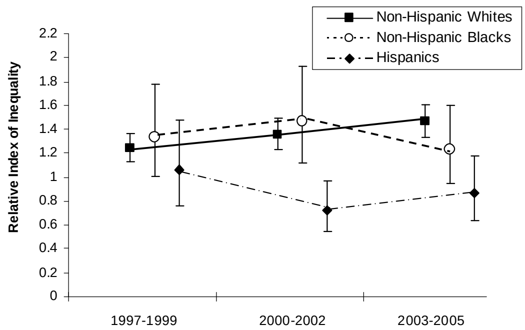
Age



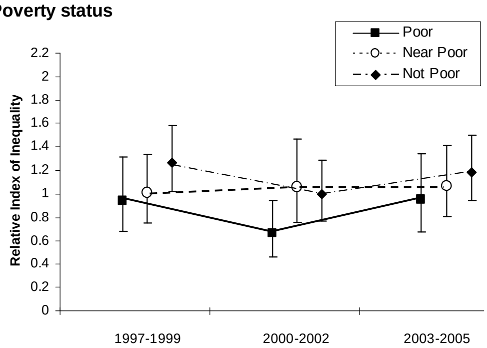


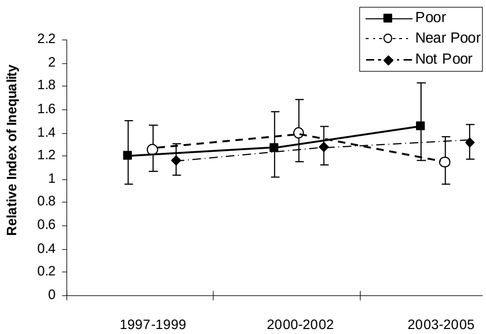
Race/Ethnicity

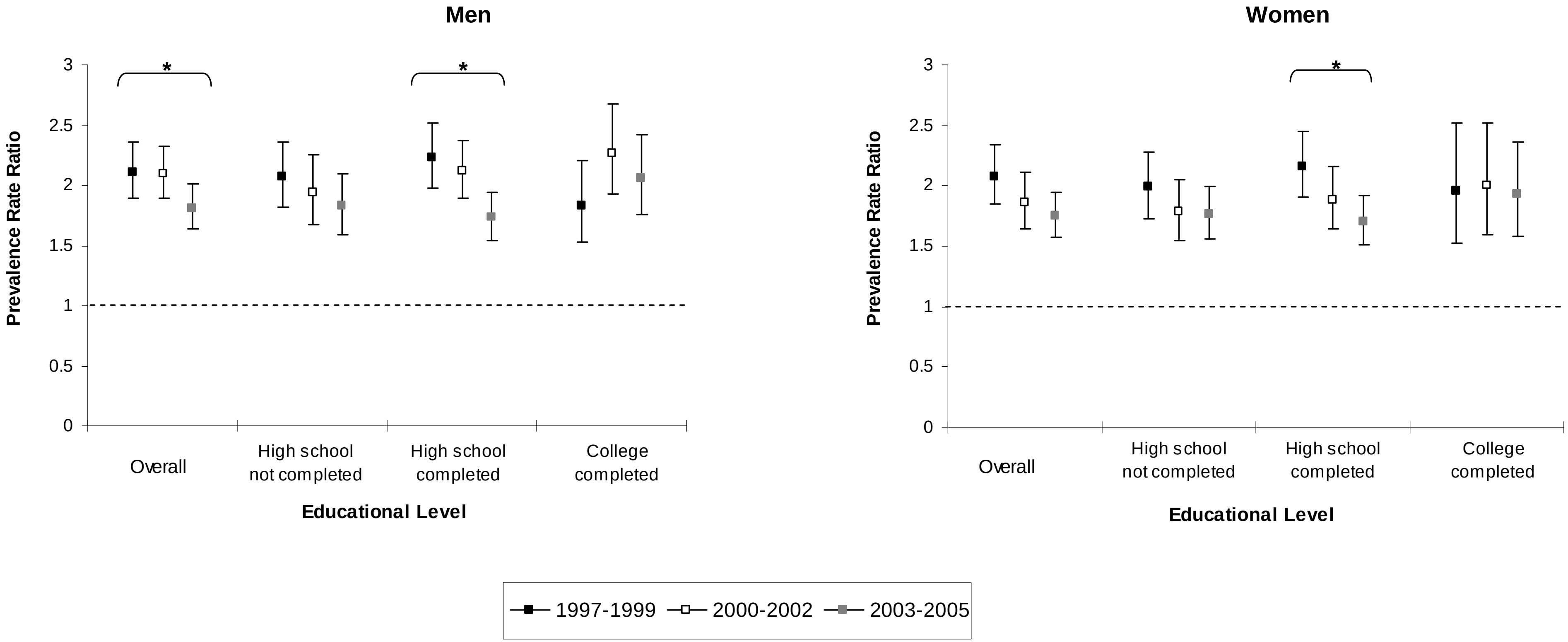




Poverty status







Men
Women
3
2.5
2
1.5
1
0.5
0
Prevalence Rate Ratio
*
Overall
High school not completed
High school completed
College completed
Educational Level
1997-1999
2000-2002
2003-2005