Education and Diabetes in a Racially and Ethnically Diverse Population

Luisa N. Borrell, DDS, PhD, Florence J. Dallo, PhD, MPH, and Kellee White, MPH

Objectives. We used data from the National Health Interview Survey (1997–2002) to examine the association between education and the prevalence of diabetes in US adults and whether this relation differs by race/ethnicity.

Methods. The analyses were limited to non-Hispanic Blacks, non-Hispanic Whites, and Hispanics. SUDAAN was used to account for the complex sampling design.

Results. Educational attainment was inversely associated with the prevalence of diabetes. Individuals with less than a high-school diploma were 1.6 (95% confidence interval [CI] = 1.4, 1.8) times more likely to have diabetes than those with at least a bachelor's degree. Whites and Hispanics exhibited a significant relation between diabetes and having less than a high-school education (odds ratio [OR] = 1.7; 95% CI = 1.5, 2.0; and OR = 1.6; 95% CI = 1.1, 2.3, respectively). In addition, the odds of having diabetes was stronger for women (OR = 1.9; 95% CI = 1.6, 2.4) than for men (OR = 1.4; 95% CI = 1.1, 1.6)

Conclusions. Educational attainment was inversely associated with diabetes prevalence among Whites, Hispanics, and women but not among Blacks. Education may have a different effect on diabetes health among different racial/ethnic groups. (*Am J Public Health.* 2006;96:1637–1642. doi:10.2105/AJPH.2005.072884)

Type 2 diabetes (hereafter "diabetes") is an increasing public health problem and among the leading causes of death[1] and disability[2] in the United States. Recent studies using national data consistently show that diabetes prevalence has been increasing over the past years.[3,4] This increase has been disproportionate in the American population, with studies showing higher prevalences of diabetes among minority groups.[4–6] The prevalence of diabetes was higher among African Americans and Hispanics, specifically Mexican Americans, than among Whites.[6] A similar pattern has been observed for socioeconomic status, with those at the lower end exhibiting the highest prevalence, regardless of the indicator used.[7–9] Specifically, studies focusing on education show that less-educated people have a higher prevalence of diabetes than their more-educated counterparts.[7]

These studies suggest that educational attainment may promote the adoption of health behaviors such as adequate nutrition and compliance with medications. Therefore, it is possible that educational attainment acts as a fundamental cause of disease by utilizing resources such as knowledge that strongly influence people's ability to reduce risks that may prevent or delay diabetes or better control the disease once it occurs.[10] Moreover, although the interplay between race/ethnicity and education has been underscored in previous studies,[11–13] the impact of this relation on diabetes has seldom been investigated.

The National Health Interview Survey (NHIS), an annual survey of US households, affords the opportunity to aggregate several years of data, 1997 to 2002, to examine the association between education and the prevalence of diabetes in US adults aged 18 years and older before and after adjusting for selected covariates. We investigated whether the association between education and the prevalence of diabetes differs by race/ethnicity.

METHODS

The NHIS is an annual face-to-face interview of the civilian, noninstitutionalized household population of the United States that uses a 3-stage stratified cluster probability sampling design. A complete description of the plan and operation for the NHIS has been given elsewhere.[14–16] Briefly, the NHIS comprised a core set of questions (questions that are repeated yearly) and supplemental questions/modules. The survey oversampled Black and Hispanic persons to obtain reliable estimates for these groups. The interview sample for NHIS consisted of persons of all ages in families within households; those older than 85 years were labeled as 85 years of age. Data for these analyses were extracted from the Person and Sample Adult files and included the records of adults aged 18 years or older for years 1997 to 2002, yielding a total sample size of 196 101.

These analyses were limited to non-Hispanic Blacks, non-Hispanic Whites, and Hispanics (henceforth, non-Hispanic Blacks and Whites will be referred to as Blacks and Whites). Records of individuals with missing data for race/ethnicity (n = 67), education (n = 1888), and diabetes (n = 194), and those who self-identified their race as Other (n = 6719) were excluded. Those classified as Other were excluded because they may represent a heterogeneous group, making findings difficult to interpret. These exclusion criteria yielded a final sample of 187 233 adults.

The outcome for this study was self-reported diabetes. Diabetes information was collected using the question "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" For women, the phrase, "Other than pregnant" was added before the question for diabetes to exclude cases of gestational diabetes. Consistent with NHIS analyses, responses from survey participants who said they had "borderline" diabetes were treated as unknown with respect to diabetes and were included among those reporting not having diabetes.[17–19]

The main independent variable was education. Education was collected as a continuous variable from 0 to 21 and congruent with other studies[20] categorized as (1) less than high-school diploma, (2) high-school diploma or general equivalency diploma (GED),

(3) some college, vocational, or technical school or associate's degree, or (4) bachelor's, master's, or professional degree.

Variables considered as risk factors or potential confounders in studies of diabetes[7–9,19–22] were included in these analyses. These variables were age, gender, marital status, race/ethnicity, place of birth, region of residence, health insurance, income, and body mass index (BMI). Age, collected as a continuous variable, was coded as 18 to 44 years, 45 to 64 years, 65 to 75 years, and 75 years of age and older. Gender (male/female) was included in the analysis as collected during the interview. Marital status, collected as married, divorced, widowed, separated, single, living with partner, and unknown, was classified into a dichotomous variable (married or unmarried). The term *married* encompasses the categories married and separated, and unmarried comprises individuals indicating single, living with a partner, widowed, or divorced.

Race/ethnicity was used in the analysis as collected: non-Hispanic White, non-Hispanic Black, non-Hispanic Other, and Hispanic, with the exception of survey year 1997. For 1997, mutually exclusive race/ethnicity categories were created by cross-classifying information on an individual's ethnicity ("Do any of these groups represent your national origin or ancestry—Hispanic ethnicity?") and the categories for race (White, Black, and Other). Foreign-born status was ascertained from 1997 to 2001 with the question "Were you born in the US (excluding US territories)?" In 2002, foreign-born status was derived from a question with regard to the geographic place of birth. Region of residence was included in the analyses as collected (Northeast, South, West, and Midwest). Health insurance was collected with a detailed question regarding multiple sources of insurance and recoded as private, public, and noncoverage.

Income was collected by asking each participant to select his or her total annual income from 12 categories (ranging from $0 to $75 000 and over as well as a refusal category) and, on the basis of the sample distribution, was categorized as <$20 000, $20 000–$49 999, and ≥$50 000. Because of the large number of missing values, the multiple imputations income files provided by the National Center for Health Statistics were used for these analyses.[23] BMI, a risk factor for diabetes, was included in the analyses. BMI (kg/m^2) was calculated with self-reported weight and height and was categorized as less than 18.5 kg/m^2 (underweight), 18.5 kg/m^2 to less than 25.0 kg/m^2 (healthy weight), and greater than 25.0 kg/m^2 (overweight including obese).[24]

Descriptive statistics for the characteristics of the population and prevalence of diabetes were calculated by education. To determine significant differences, χ^2 (discrete variables) and *t* tests (continuous variables) were used. We used χ^2 tests to assess significant differences in the prevalence of diabetes between groups.

Logistic regression was used to estimate the strength of the association between education and the prevalence of diabetes before and after control for other covariates. Specifically, 4 sets of analyses were performed: (1) odds ratios adjusted for survey year (model 1), (2) odds ratios adjusted for survey year, age, and gender (model 2), (3) odds ratios additionally adjusted for race/ethnicity (model 3), and (4) odds ratios additionally adjusted for marital status, nativity, BMI, insurance, and income (model 4).

To determine whether the strength of the association between education and diabetes differed by race/ethnicity, an interaction between race/ethnicity and education was tested. In addition, an interaction between education and gender was tested. A test for trends for education was performed with the variable used as ordinal rather than the categorical. The number of records available for the multivariable logistic regression varied according to the covariates included in the model.

Data management procedures were carried out with SAS,[25] and the statistical analyses were conducted with SUDAAN.[26] SUDAAN takes into account the complex sampling design yielding unbiased standard error estimates. In order to adjust the population size across the 6 years of the NHIS surveys used in these analyses, first, data from the 6 survey years were combined, and then a new weight variable was created that averaged the population size across the 6 years (telephone communication with Zakia Coriaty Nelson, epidemiologist, Centers for Disease Control and Prevention, National Center for Health Statistics, July 17, 2004; information was verified on May 18, 2006). In the tables, the sample sizes were unweighted. However, estimates for means, proportions, standard errors, and odds ratios with their 95% confidence intervals were weighted.

RESULTS

Table 1 presents the distribution of selected covariates by educational attainment. In general, older people, Hispanics, those with low income, those with public health insurance coverage, and those living in the South were more likely to have less than a high-school diploma (all *P*s<.001). By contrast, those with at least a bachelor's degree were more likely to be male, White, have an income of at least $50 000, be married, and live in the Northeast. Finally, the foreign-born were more likely to have less than a high-school diploma and less likely to have a bachelor's degree or more than the US-born.

The overall prevalence of diabetes was 5.8% for individuals aged 18 years and older who participated in NHIS from 1997 to 2002 (data not shown). Table 2 shows that the overall prevalence of diabetes was associated with education, with the least educated exhibiting the highest prevalence (10.2%) and those with at least a bachelor's degree the lowest (3.4%; *P*<.001). This pattern was consistently observed for age, race/ethnicity, gender, marital status, country of birth, insurance, and region of residence (all *P* values<.001).

However, people aged 65 to 74 years, Blacks, those reporting being married or living with someone, those born in the United States, and those having public health insurance coverage exhibited the highest prevalence of diabetes regardless of their education. Interestingly, women with at least a high-school diploma or GED had a higher prevalence of diabetes, whereas men with at least some college had a higher prevalence.

Table 3 presents the unadjusted and adjusted odds ratios with their 95% confidence intervals for the prevalence of diabetes by educational attainment. In the crude analysis, the odds of having diabetes among NHIS participants with less than a high-school diploma was 3.2 times higher (95% CI=3.0, 3.5) than among their counterparts with at least a bachelor's degree. The odds of having

TABLE 1—Distribution (SE) According to Education of Selected Characteristics of the National Health Interview Survey Study Population (n = 187 233): United States, 1997–2002

	Less Than High School (n = 39 729)	High School or GED (n = 55 208)	Some College (n = 52 424)	Less than Bachelor's Degree (n = 39 872)	*P*
Mean age, y	49.4 (0.20)	45.9 (0.12)	41.6 (0.16)	44.7 (0.12)	<.001
Gender, %					<.001
Male	18.3 (0.23)	29.7 (0.27)	27.9 (0.21)	24.1 (0.28)	
Female	17.9 (0.22)	31.4 (0.24)	29.6 (0.20)	21.0 (0.26)	
Race/ethnicity, %					<.001
Non-Hispanic White	13.5 (0.21)	31.3 (0.26)	29.6 (0.18)	25.6 (0.30)	
Non-Hispanic Black	24.5 (0.52)	31.4 (0.44)	30.0 (0.50)	14.1 (0.40)	
Hispanic	44.2 (0.59)	24.6 (0.34)	21.7 (0.37)	9.6 (0.29)	
Marital status, %					<.001
Married	16.0 (0.22)	30.9 (0.25)	27.6 (0.18)	25.5 (0.31)	
Not married	21.4 (0.25)	30.1 (0.27)	30.6 (0.30)	17.9 (0.26)	
Country of birth, %					<.001
US-born	15.5 (0.19)	31.6 (0.23)	29.9 (0.17)	23.0 (0.26)	
Foreign-born	39.2 (0.63)	22.5 (0.36)	20.1 (0.35)	18.2 (0.40)	
Region, %					<.001
Northeast	15.8 (0.29)	33.2 (0.46)	25.4 (0.34)	25.6 (0.56)	
Midwest	14.2 (0.30)	33.5 (0.49)	30.6 (0.31)	21.7 (0.51)	
South	21.3 (0.39)	30.1 (0.36)	27.8 (0.27)	20.8 (0.42)	
West	19.6 (0.49)	24.8 (0.35)	31.9 (0.35)	23.6 (0.44)	
Income, %					<.001
< $20 000	20.8 (0.32)	34.9 (0.35)	31.9 (0.36)	12.4 (0.24)	
$20 000–$49 999	9.1 (0.19)	31.2 (0.32)	34.0 (0.29)	25.7 (0.33)	
≥ $50 000	3.5 (0.15)	17.2 (0.35)	27.1 (0.34)	52.2 (0.47)	
Health insurance, %					<.001
Private	13.2 (0.17)	30.0 (0.24)	30.4 (0.17)	26.4 (0.28)	
Public	47.6 (0.60)	30.5 (0.54)	17.6 (0.41)	4.4 (0.23)	
None	32.9 (0.44)	33.9 (0.39)	24.7 (0.33)	8.5 (0.23)	

Note. GED = general equivalency diploma.

diabetes was higher among people with a high-school diploma or a GED (OR=1.9; 95% CI=1.7, 2.0) or among those with some college (OR=1.3; 95% CI=1.2, 1.4) than among people with at least a bachelor's degree. Although the magnitude of the association decreased, these patterns persisted after adjustment for age, gender, race/ethnicity, survey year, marital status, BMI, health insurance, and income.

The odds of having diabetes among those with less than a high-school diploma was 1.6 (95% CI=1.4, 1.8) times higher than that of their counterparts with at least a bachelor's degree. Those with a high-school diploma or GED (OR=1.3; 95% CI=1.2, 1.4) or with some college (OR=1.3; 95% CI=1.1, 1.4) had similar odds of having diabetes as their counterparts with at least a bachelor's degree. Additional adjustment for the region of the country did not change the estimates presented here (data not shown).

The association between education and the prevalence of diabetes varied by race/ethnicity (*P* for interaction<.001; Table 4). The association between education and the prevalence of diabetes was significant among Whites and Hispanics, with the highest odds for those with less than a high-school diploma (OR=1.7; 95% CI=1.5, 2.0; and OR=1.6; 95% CI=1.1, 2.3, respectively) compared with their counterparts with at least a bachelor's degree. There was no association between education and the prevalence of diabetes for Blacks.

In addition, the association between education and the prevalence of diabetes differed by gender (*P* for interaction=.01) (data not shown). Specifically, men and women with less than a high-school diploma had higher odds of diabetes than their peers with more than a bachelor's degree. However, the odds of having diabetes was stronger for women (OR=1.9; 95% CI=1.6, 2.4) than it was for men (OR=1.4; 95% CI=1.1, 1.6; data not shown).

DISCUSSION

Educational attainment was associated with the prevalence of diabetes in the US adult population. People with less than a high-school diploma were almost twice as likely to report having diabetes as those with at least a bachelor's degree. This association persisted after adjustment for age, gender, marital status, race/ethnicity, income, country of birth, insurance, and BMI. Furthermore, this association varied by race/ethnicity and gender. Whites and Hispanics exhibited a stronger association between education and the prevalence of diabetes than Blacks. Among those with less than a high-school diploma, the odds of having diabetes was greater for women than for men.

Very few studies have examined the association between educational attainment and the prevalence of diabetes. In addition, these studies did not compare Whites, Blacks, and Hispanics. However, these studies found an inverse association between education and the prevalence of diabetes.[20,27] For example, Tang et al.[20] examined the association between education and diabetes by gender, and Leonetti et al.[27] examined this association among Japanese American men. After adjusting for age, area of residence, BMI, and physical activity, Tang et al. found that women in the lowest income category or with the least

TABLE 2—Prevalence (SE) of Diabetes by Educational Attainment for Selected Characteristics (n = 187 233): National Health Interview Survey, 1997–2002

	Less Than High School (n = 39 729), %	High School or GED (n = 55 208), %	Some College (n = 52 424), %	≥ Bachelor's Degree (n = 39 872), %	P[a]
Overall	10.2 (0.19)	6.2 (0.13)	4.5 (0.11)	3.4 (0.10)	<.001
Age, y					<.001
18–44	2.3 (0.14)	2.1 (0.10)	1.7 (0.08)	1.2 (0.09)	
45–64	15.2 (0.48)	8.8 (0.26)	7.5 (0.25)	4.9 (0.20)	
65–74	19.9 (0.66)	14.6 (0.48)	13.8 (0.66)	10.1 (0.65)	
≥75	16.1 (0.53)	12.3 (0.50)	10.9 (0.73)	9.4 (0.72)	
Gender					.45
Male	9.1 (0.27)	6.0 (0.19)	4.9 (0.18)	4.2 (0.17)	
Female	11.2 (0.26)	6.3 (0.17)	4.2 (0.12)	2.6 (0.12)	
Race/ethnicity					<.001
Non-Hispanic White	10.1 (0.24)	6.0 (0.14)	4.3 (0.12)	3.2 (0.11)	
Non-Hispanic Black	13.3 (0.58)	7.8 (0.37)	5.9 (0.32)	6.3 (0.45)	
Hispanic	8.4 (0.33)	5.6 (0.33)	4.5 (0.31)	3.5 (0.49)	
Marital status					<.001
Married	10.9 (0.27)	6.6 (0.17)	5.1 (0.16)	3.5 (0.13)	
Not married	9.3 (0.25)	5.4 (0.17)	3.7 (0.13)	3.3 (0.15)	
Country of birth					<.0158
US-born	11.0 (0.23)	6.2 (0.13)	4.6 (0.11)	3.5 (0.11)	
Foreign-born	7.6 (0.31)	5.5 (0.40)	3.3 (0.31)	2.9 (0.35)	
Region					<.001
Northeast	10.8 (0.43)	6.2 (0.26)	4.0 (0.25)	3.3 (0.22)	
Midwest	10.6 (0.42)	5.6 (0.25)	4.2 (0.18)	3.1 (0.16)	
South	10.9 (0.30)	6.5 (0.22)	4.8 (0.18)	3.9 (0.19)	
West	7.6 (0.39)	6.1 (0.29)	4.7 (0.27)	3.2 (0.26)	
Income					.48
<$20 000	5.1 (0.23)	3.9 (0.17)	2.9 (0.15)	3.3 (0.28)	
$20 000–$49 999	4.8 (0.41)	3.6 (0.19)	3.3 (0.16)	2.4 (0.18)	
≥$50 000	5.5 (0.93)	3.9 (0.34)	3.5 (0.28)	2.6 (0.17)	
Health insurance					<.001
Private	11.6 (0.27)	6.5 (0.14)	4.6 (0.12)	3.4 (0.11)	
Public	15.4 (0.51)	10.3 (0.64)	9.1 (0.68)	10.0 (1.49)	
None	4.2 (0.22)	3.2 (0.22)	2.8 (0.22)	2.2 (0.32)	

Note. GED = general equivalency diploma.
[a]*P* for χ^2 test of independence.

education were approximately 2 times more likely to have diabetes than those with high income or educational attainment. However, the association was not significant for men.[20] Our findings are consistent with the results of Tang et al., in which women with less than a high-school diploma had almost twice the odds of diabetes than their peers with more than a bachelor's degree. The association for men, although significant, was of a lower magnitude (OR = 1.4).

Other studies have included diabetes as a risk factor for cardiovascular disease and have examined the clustering of cardiovascular risk factors as related to education.[11–13,28] These studies also found an inverse association between education and the cumulative number of risk factors.[11–13] Furthermore, these studies found that among persons with high educational attainment, Mexican Americans and Blacks had a higher risk of cardiovascular disease than Whites.[28]

Finally, studies examining the association between diabetes and race/ethnicity have included education as a control variable.[12,28] For example, Winkleby et al.[12] found that after adjustment for years of education, there were significant differences in the prevalence of diabetes among both Black and Mexican American women compared with White women ($P < .001$). In contrast to the study of Winkleby et al., our study focuses on the association between education and the prevalence of diabetes. However, our findings show that in general, Blacks and Hispanics had a higher prevalence of diabetes, regardless of their education, than Whites.

According to the 2000 US Census, educational attainment differs among racial/ethnic groups.[29] Moreover, the economic return of education varies by race/ethnicity.[30–33] For example, Blacks and Hispanics tend to earn a lower income for the same level of education than Whites after adjustment for age and occupation. This difference is further increased for gender, with women receiving lower income returns than men regardless of their race/ethnicity.[30,31]

Our study found that the association between education and the prevalence of diabetes varied by race/ethnicity and gender. Specifically, education seems to be strongly associated with diabetes among Whites and Hispanics but not among Blacks. This finding confirms that education may have a different translation for health across racial/ethnic groups. In addition, there was a difference in the association between education and the prevalence of diabetes by gender, with women exhibiting a stronger association than men when we compared those with less than a high-school diploma with those with more than a bachelor's degree.

Among the strengths of this study are the use of multiple years of a national representative sample and the large sample size, which allowed us to control for numerous potential confounders while also examining interactions. In addition, this study afforded the opportunity to assess this association among Hispanics, the fastest growing segment of the

TABLE 3—Unadjusted and Adjusted Odds Ratios for Diabetes by Educational Attainment Categories: National Health Interview Survey, 1997–2002

Education	Unadjusted Model, OR (95% CI)	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)
Less than high school	3.2 (3.0, 3.5)	2.4 (2.2, 2.6)	2.0 (1.9, 2.2)	1.6 (1.4, 1.8)
High-school diploma or GED	1.9 (1.7, 2.0)	1.7 (1.6, 1.8)	1.6 (1.5, 1.7)	1.3 (1.2, 1.4)
Some college	1.3 (1.2, 1.4)	1.5 (1.4, 1.6)	1.4 (1.3, 1.5)	1.3 (1.1, 1.4)
Bachelor's degree or more	1.0	1.0	1.0	1.0

Note. OR = odds ratio; CI = confidence interval; GED = general equivalency diploma. Unadjusted model: education (adjusted for survey year). Model 1: crude model additionally adjusted for age and gender. Model 2: model 1 additionally adjusted for race/ethnicity. Model 3: model 2 additionally adjusted for marital status, nativity, BMI, income, and health insurance.

TABLE 4—Odds Ratios for the Prevalence of Diabetes by Race/Ethnicity: National Health Interview Survey, 1997–2002

Education	Non-Hispanic White, OR (95% CI)	Non-Hispanic Black, OR (95% CI)	Hispanic, OR (95% CI)
Less than high school	1.7 (1.5, 2.0)	1.1 (0.8, 1.4)	1.6 (1.1, 2.3)
High-school diploma or GED	1.3 (1.2, 1.5)	1.0 (0.8, 1.2)	1.6 (1.1, 2.4)
Some college	1.3 (1.2, 1.5)	1.1 (0.8, 1.2)	1.4 (0.9, 2.1)
Bachelor's degree or more	1.0	1.0	1.0

Note. OR = odds ratio; CI = confidence interval; GED = general equivalency diploma; BMI = body mass index. Adjusted for survey year, age, gender, marital status, nativity, BMI, income, and health insurance. *P* for interaction for education and race/ethnicity = .01.

US population[34] and a group with a higher prevalence of diabetes than that found among Whites.[6]

Important limitations are the cross-sectional nature of the data that precluded making inferences regarding cause and effect and the self-reported nature of diabetes. However, self-reported data for this condition are highly correlated with physicians' records.[35,36] Another limitation is the lack of disaggregate data to present Hispanics by subgroup. Because Mexican Americans represent the largest Hispanic subgroup and have the highest prevalence of diabetes among Hispanics, it is possible that the estimates presented here are a better reflection of the prevalence of diabetes among Mexican Americans than among Hispanics as a whole.

In summary, this study shows that education was significantly associated with the prevalence of self-reported diabetes in the US adult population during 1997 to 2002. Furthermore, this association varied by race/ethnicity and gender, with Whites, Hispanics, and women exhibiting a stronger association between education and diabetes than Blacks and men. Although the cross-sectional nature of the NHIS survey precluded any causal inference, our findings suggest that educational attainment is not only associated with diabetes, but it also may interact with race/ethnicity and gender to promote or prevent diabetes. ■

About the Authors

Luisa N. Borrell is with the Department of Epidemiology, Mailman School of Public Health and College of Dentistry, Columbia University, New York, NY. Florence J. Dallo is with the Institute for Social Research, University of Michigan, Ann Arbor. Kellee White is with the Department of Epidemiology, Mailman School of Public Health, Columbia University.

Requests for reprints should be sent to Luisa N. Borrell, DDS, PhD, Department of Epidemiology, Mailman School of Public Health, School of Dental and Oral Surgeons, Columbia University, 722 West 168th St, New York, NY 10032 (e-mail: lnb2@columbia.edu).

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Contributors

L.N. Borrell and F.J. Dallo planned the study and the analyses, interpreted the results, and wrote the article. K. White analyzed the data and contributed to interpreting the analyses and reviewing and writing the article.

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Human Participant Protection

The data were collected with the informed consent of the respondents of the NHIS following procedures approved by the institutional review board of the National Center for Health Statistics.

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