Disparities in Vision Impairment among Adults in the United States

Carmen J. Wilson, MD; George Rust, MD, MPH; Robert Levine, MD; Ernest Alema-Mensah, PhD

Background: This study aimed to determine the prevalence and severity of vision impairment by race in the United States by analyzing the population-based prevalence of corrected distance visual acuities in non-Hispanic Whites, Hispanics, and African Americans.

Methods: This is a nationally representative, population-based, cross-sectional study. Data from the National Health and Nutrition Examination Survey (NHANES) 2001–2002 were analyzed to investigate the epidemiologic features of corrected distance visual acuities among non-Hispanic Whites (n=3034), Hispanic Americans (n=1532), and African Americans (n=1183) aged 18–85 years.

Results: Prevalence rates of overall impairment were 5.0%, 2.1%, and 1.6% for non-Hispanic Whites, Hispanic Americans, and African Americans, respectively (P=.1015).

Conclusions: The prevalence of vision impairment based on corrected distance visual acuity is higher in non-Hispanic Whites than in Hispanic and African Americans. The magnitude of this racial difference is not statistically significant and is less than that of previous studies that were based on comparisons of uncorrected visual acuities. (*Ethn Dis*. 2008;18 [Suppl 2]:S2-242–S2-246)

Key Words: Vision, Impairment, Disparities, Race

From the Clinical Research Center (CJW, EAM), National Center for Primary Care (GR), Department of Community and Preventive Medicine (RL), Morehouse School of Medicine, Atlanta, Georgia.

Reprints will not be available from the author. Address correspondence to: Carmen J. Wilson, MD; Morehouse Medical Associates; 75 Piedmont Ave, Ste 700; Atlanta, GA 30303; 404-756-1410; (404) 756-1494 (fax); cwilson@msm.edu

Introduction

Vision impairment is a result of abnormalities in the physiology of the eye or the visual pathways. This impairment can manifest in three predominant ways: a decrease in visual acuity, a constriction of peripheral visual field, or an alteration in contrast sensitivity.[1] Eye problems have been associated with self-reported visual function impairment and impairment in other activities of daily living.[2]

Ocular complications are more common and disabling in underrepresented minority populations. Several population-based surveys of visual acuity in African American and non-Hispanic White adults have been conducted. Only uncorrected visual acuities were measured, probably because of the lack of an accurate objective measure of refraction at that time. In addition, instead of binocular visual acuities, each eye was tested separately, thus eliminating the visual cues of depth perception and stereopsis provided with binocularity.

The National Health and Nutrition Examination Survey (NHANES) 2001–2002 used the advanced technology of automated refraction to provide both uncorrected and corrected visual acuities for a sample of Hispanic Americans, African Americans, and non-Hispanic White Americans. These monocular measurements and determination of the laterality of vision loss were conducted to provide a more useful assessment of severity of functional visual impairment. In this study, we determined the prevalence of visual impairment on the basis of best-corrected distance visual acuities in Hispanic Americans, African Americans and non-Hispanic White Americans from NHANES 2001–2002.

Methods

Study Sample

NHANES 2001–2002 used a complex multistage sampling design, obtaining a nationally representative sample of the civilian noninstitutionalized population of the continental United States. Informed consent was obtained from all participants. Data collection for the survey took place in two phases. Participants were first administered a household interview. Next, those participants who completed the interview were scheduled to receive a comprehensive physical examination at centrally located examination trailers where visual acuity was tested.

The current analysis was limited to adults 18–85 years of age. The classification of Hispanic Americans includes those who classified themselves as Mexican American or other Hispanic. Those classified in race/ethnicity as ''other'' were excluded. This group included all remaining single-race responses, those who indicated more than one race but did not select a main race, those who indicated a verbatim response to nonspecific multiracial heritage (eg, multiracial, Mulatto), and those with missing values on race. After accounting for these exclusions, visual acuity data were available on 1559 Hispanic Americans, 1203 African Americans, and 3054 non-Hispanic White Americans.

Visual Acuity Assessment

In NHANES 2001–2002, visual acuity was measured with an autorefractor. An objective refractor performs the refractive measurements automatically by using infrared light, requiring .2–10 seconds for the actual measurement. It may have spherocylindrical optics, visual acuity charts, and subjective refinement capability. Most automated refraction is based on the op-

Table 1. Demographic chararacteristics of 5791 participants in NHANES 2001–2002 with visual acuity data available

Characteristic	Whites *n* (%)	Hispanics *n* (%)	African Americans *n* (%)	Total *n* (%)
Number	3034 (52.8)	1532 (26.7)	1183 (20.6)	5719 (100)
Age, years				
18–39	1046 (34.5)	804 (52.5)	537 (45.4)	2387 (41.5)
40–62	948 (31.3)	453 (29.6)	397 (33.6)	1798 (31.3)
63–85	1040 (34.3)	275 (18.0)	249 (21.1)	1564 (27.2)
Education				
Less than high school	566 (18.7)	851 (55.6)	477 (40.3)	1894 (33.0)
High school	848 (28.0)	277 (18.1)	295 (24.9)	1420 (24.7)
More than high school	1620 (53.4)	403 (26.3)	411 (34.7)	2434 (42.4)
Annual Income				
<$25,000	562 (20.2)	377 (27.7)	350 (33.5)	1289 (24.8)
$25,000–$45,000	761 (27.3)	514 (37.8)	370 (35.4))	1645 (31.7)
$45,000–$75,000	647 (23.2)	306 (22.5)	173 (16.5)	1126 (21.7)
>$75,000	819 (29.4)	163 (12.0)	153 (14.6)	1135 (21.9)
Insurance Status				
Insured	329 (11.0)	570 (38.1)	218 (18.8)	1117 (38.1)
Uninsured	2669 (89.0)	926 (61.9)	944 (81.2)	4539 (61.9)

NHANES = National Health and Nutrition Examination Survey.

tometer principle, providing smoothly variable change in vergence for the neutralization of refractive error.

The vision exam included measurements of 1) eyeglass prescription for glasses used to view distant objects, 2) presenting visual acuity with current correction, 3) objective refraction, 4) visual acuity incorporating objective refraction, and 5) near vision acuity.

Definitions of Visual Impairment Levels

Overall impairment was defined as 20/50 or worse because visual acuity below this level represents minimal impairment, and the binocular visual acuity criterion for obtaining a passenger car driver's license is 20/40 or better in most states. We added laterality to the measurement of severity of visual impairment. This additional component is categorized into three groups: none, unilateral (only one eye is impaired), or bilateral (both eyes are impaired).

Data Analysis

The main outcome variable of this cross-sectional study was vision impairment. If present, this variable was further classified as either unilateral or bilateral. The predictor variable was race, which was self-classified. The means and standard deviations (SD) for the continuous variables were reported. The percentages or proportions were reported for categorical variables. Comparisons between categorical variables were analyzed by using the χ^2 test with significance at $P<.05$.

Prevalence of visual impairment (percentage), standard errors, and 95% confidence intervals were reported for all comparisons. Ninety-five percent confidence intervals were calculated by using standard error estimates with a precision level of 100. Prevalence and confidence intervals were reported rounded to the nearest tenth. P values $\leq .05$ were considered significant.

Bivariate analysis was conducted to examine the association among the predictor and outcome variables. Multiple logistic regression analyses were performed to identify the most influential variables on vision impairment and to account for potential confounding variables, such as age, income, and educational level.

Because of the multistage sampling design, all analyses were performed with adjustments for sample weights and design effects with the SAS version 9.0 (SAS Institute, Inc., Cary, NC) and Stata version 9.2 (StataCorp LP, College Station, Texas) statistical packages for analysis of complex sample surveys.

RESULTS

Demographics of Study Sample

Of the 11,039 participants in NHANES 2001–2002, 5719 participants were selected after applying the inclusion criteria, including available visual acuity data. Fifty-two percent of this group were female. The mean age of the population was 47 (SD 20.8) years. Because of oversampling by NHANES, 52.8% were White, 26.7% were Hispanic, and 20.6% were African American. Table 1 provides a racial comparison of the study sample's demographic profile. No significant differences were seen between the races with regard to education, household income, or insurance status.

Prevalence of Vision Impairment

Table 2 specifies the prevalence rates of overall vision impairment, as defined

Table 2. Prevalence of vision impairment by ethnicity among 5791 participants in NHANES 2001–2002 with visual acuity data available

Characteristic	Whites *n* (%)	Hispanics *n* (%)	African Americans *n* (%)	Total *n* (%)	P value
Vision Impaired					
No	2747 (90.5)	1409 (92.0)	1092 (92.3)	5248 (91.3)	.1015
Yes	287 (9.5)	123 (8.0)	91 (7.7)	501 (8.7)	
Impairment Severity					
Unilateral	199 (69.3)	92 (74.8)	63 (69.2)	359 (71.7)	.2104
Bilateral	88 (30.7)	31 (25.2)	28 (30.8)	147 (29.3)	

NHANES = National Health and Nutrition Examination Survey.

by a best corrected visual acuity of 20/50 or worse, and severity of impairment based on whether it was unilateral or bilateral. Vision impairment was found in 501 participants (8.7%). Among the visually impaired, 359 (71.7%) had unilateral impairment, and 147 (29.3%) had bilateral impairment. Whites tended to have a higher prevalence rate for overall impairment (9.5%), unilateral impairment (69.3%), and bilateral impairment (30.7%) than did either Hispanics (8.0%, 74.8%, and 25.2%, respectively) or African Americans (7.7%, 69.2%, and 30.8%, respectively). However, these differences were not statistically significant.

In multivariate logistic regression analyses, the association between various characteristics and socioeconomic factors and vision impairment was also evaluated (Table 3). These results indicated a significant association between older age and overall vision impairment, unilateral impairment, and bilateral impairment. Higher educational attainment and household incomes >$75,000 tended to be protective for overall vision impairment and severity of vision impairment.

DISCUSSION

The results of this study indicate that after correcting for refractive error, race is not associated with the presence or severity of vision impairment. This finding is not consistent with

Table 3. Multivariate regression analysis showing association between prevalence and severity of vision impairment and selected variables among 5791 participants in NHANES 2001–2002 with visual acuity data available

Variable	Vision Impairment OR (95% CI)	Unilaterial OR (95% CI)	Bilateral OR (95% CI)
Race			
White	Referent (*n*=287)	Referent (*n*=199)	Referent (*n*=88)
Hispanic	1.00 (.78–1.30) (*n*=123)	1.11 (.83–1.48) (*n*=92)	.80 (.51–1.27) (*n*=31)
African American	.92 (.70–1.19) (*n*=91)	.93 (.69–1.27) (*n*=63)	.905 (.58–1.43) (*n*=28)
Age, years			
18–39	Referent (*n*=91)	Referent (*n*=69)	Referent (*n*=22)
40–62	1.20 (.87–1.64) (*n*=77)	1.24 (.87–1.77) (*n*=60)	1.05 (.55–2.01) (*n*=17)
63–85	6.28 (4.80–8.22)* (*n*=321)	5.40 (3.96–7.36)* (*n*=216)	6.74 (4.03–11.27)* (*n*=105)
Education			
Less than high school	Referent (*n*=224)	Referent (*n*=151)	Referent (*n*=73)
High school	.91 (.71–1.16) (*n*=132)	.95 (.71–1.27) (*n*=92)	.85 (.56–1.29) (*n*=40)
More than high school	.64 (.50–.81) (*n*=144)	.73 (.55–.97) (*n*=110)	.51 (.32–.80) (*n*=34)
Annual Income			
<$25,000	Referent (*n*=173)	Referent (*n*=109)	Referent (*n*=64)
$25,000–$45,000	.93 (.74–1.16) (*n*=160)	1.01 (.78–1.31) (*n*=115)	.81 (.55–1.18) (*n*=45)
$45,000–$75,000	.75 (.56–1.01) (*n*=72)	.89 (.64–1.25) (*n*=57)	.52 (.29–.93) (*n*=15)
>$75,000	.51 (.36–.73) (*n*=43)	.58 (.39–.88) (*n*=33)	.42 (.21–.84) (*n*=10)
Insurance Status			
Insured	Referent (*n*=64)	Referent (*n*=48)	Referent (*n*=16)
Uninsured	1.04 (.76–1.42) (*n*=428)	1.06 (.75–1.52) (*n*=299)	1.00 (.56–1.82) (*n*=129)

NHANES = National Health and Nutrition Examination Survey, OR = odds ratio, CI = confidence interval.
* $P<.001$.

previous prevalence studies on vision impairment that did not correct for refractive error.

The Hispanic Health and Nutrition Examination Survey (HHANES) of 1982–1984 was the first population-based study of vision impairment in the Hispanic population.[3] Data from this survey was comparatively analyzed with that of the NHANES I Augmentation Survey of 1974–1975.[4] Significantly higher prevalence rates of vision impairment were found in non-Hispanic Whites when compared with African-Americans, Cuban Americans, Mexican Americans, and Puerto Ricans.[5] That study compared two surveys that were conducted more than seven years apart.

By contrast, in the Barbados Eye Study, which examined participants from the same geographical region, a higher prevalence of visual impairment was observed for African Americans than Whites.[6] Lam et al reported higher rates of vision impairment in African Americans vs non-Hispanic Whites when usual-corrected visual acuities were used. Usual-corrected visual acuities were obtained by having participants read the eye chart using whatever corrective lenses (eyeglasses, or contact lenses) they presently owned.[7] No refraction was conducted on the participants of these studies to obtain their best-corrected visual acuities.

Because refractive status and refractive corrections were not undertaken in the HHANES or NHANES before 1999, it previously was not possible to ascertain whether or not racial differences in visual acuity were due to disparities in the prevalence of various disabling eye diseases. In NHANES 2001–2002, objective refractions were conducted by using an automated refractor on all patients with uncorrected visions of 20/30 or worse. Inclusion of this technological advancement into the NHANES vision examination protocol allowed for an unbiased refraction, thus eliminating any residual refractive error not corrected for by the participants' current corrective lenses. We used these data to investigate prevalence rates of vision impairment not due to refractive error.

Vitale et al recently conducted a vision impairment study of NHANES from 1999 through 2002. The autorefractor was used during these four years. They found a 6.4% prevalence rate in vision impairment before correcting for refractive error. Eighty-three percent of these participants were no longer visually impaired after refraction was completed. The resulting prevalence rate was 1.1%.[8] This finding differs from the overall prevalence rate of 8.7% in our study. The difference in these prevalence rates may be due to the inclusion of adolescents in the previous study. As we included only adults in our study, all participants aged 12–17 years were excluded. As our study confirms, age is significantly associated with vision impairment. In addition, the merging of two consecutive NHANES datasets in the previous study resulted in a much larger sample size of 13,265, as compared with 5719 in our study.

Our study was limited to adults because the leading causes of blindness in the United States (age-related macular degeneration, cataracts, diabetic retinopathy, and glaucoma) disproportionately afflict those >40 years of age. To increase the power of the analysis, future studies on vision impairment should combine multiple successive NHANES datasets. With a larger sample size, lack of racial disparities in best-corrected visual acuity impairment may be confirmed, and other populations at risk for vision impairment (eg, diabetics) may be studied as well.

Several studies have been conducted in the past to examine ethnic disparities in ocular health. The leading cause of blindness (54% of cases) in the United States among Whites is age-related macular degeneration.[9] Among African Americans, cataracts and glaucoma account for >60% of cases of blindness.[10] Ethnic groups also differ considerably in the frequency of diabetes in their populations. For example, rates of type 2 diabetes are particularly high among American Indians, African Americans, Hispanic Americans, and Asian and Pacific Islanders. African Americans have >40% higher rates of diabetic retinopathy than do Caucasian Americans. This disparity is attributable to the higher levels of risk factors for retinopathy in African Americans.[11] The excess risk of diabetic retinopathy in Mexican Americans appears to be related to the strong American Indian heritage in this population.

The odds of having cortical opacities are four times greater among African Americans than among Whites, who were significantly more likely to have nuclear opacities. The odds of cataract surgery are 2.8 times higher among Whites.[12]

Primary open-angle glaucoma POAG is the leading cause of blindness in the African American community. Age-adjusted rates for POAG are four to five times higher in African Americans than in Whites.[13] POAG is more likely to result in irreversible blindness, appears ≈10 years earlier, and progresses more rapidly in African Americans than in Whites. African Americans have larger optic discs than do Whites. Intraocular pressure may be underestimated in African Americans, perhaps because they have thinner corneas. African Americans may also be less responsive to both drug and surgical treatment for POAG. African Americans often have reduced accessibility to treatment and are less aware of the risks of having POAG.[14]

Vision impairment due to glaucoma manifests with progressive defects in the peripheral visual field. The central vision, required in visual acuity testing, is spared until the end stage of this disease. The initial sign of vision impairment due to cataracts is an abnormality in contrast sensitivity. As this defect progresses, it eventually has an effect on visual acuity. Because these early manifestations of vision impairment were not included in the assessment of visual function by NHANES

2001–2002, a comprehensive evaluation of vision impairment was not possible. As age-related macular degeneration is a disease that impairs central vision, visual acuity is markedly affected at the initial stage. Therefore measuring visual acuity without regard to visual field or contrast sensitivity may skew the data to appear to have a higher prevalence of vision impairment in Whites. Future national surveys should consider the addition of visual field and contrast sensitivity testing to more accurately address racial and ethnic differences in vision impairment.

ACKNOWLEDGMENTS

The study was supported by Clinical Research Education and Career Development Minority Institutions (CRECD) grant numberRR17694, Clinical Research Center (CRC) grant number 5P20RR11104, National Center for Research Resources.

REFERENCES

1. Miller D. Section 3: optics, refraction, and contact lenses. In: *Basic and Clinical Science Course*. San Francisco: American Academy of Ophthalmology; 2004. P. 221
2. Klein BE, Moss SE, Klein R, Lee KE, Cruickshanks KJ. Associations of visual function with physical outcomes and limitations 5 years later in an older population: the Beaver Eye Dam Study. *Ophthalmology*. 2003;110: 644–650.
3. Delgado JL, Johnson CL, Roy I, Trevino FM. Hispanic Health and Nutrition Examination Survey: methodological considerations. *Am J Public Health*. 1990;80(Suppl):6–10.
4. Ensel A, Murphy RS, Maurer K, Collins E. Plan and operation of the NHANES I augmentation survey of adults 25–74 years United States, 1974–1975. *Vital Health Stat*. 1978;14:1–110.
5. Lee DJ, Gomez-Marin O, Lam BL. Prevalence of uncorrected binocular distance visual acuity in Hispanic and non-Hispanic adults. Results from the HHANES and the NHANES I. *Ophthalmology*. 1998;105:552–560.
6. Hyman L, Wu SY, Connell AM, Schachat A, Nemesure B, Hennis A, Leske MC. Prevalence and causes of visual impairment in the Barbados Eye Study. *Ophthalmology*. 2001;108(10):1751–1756.
7. Lam BL, Lee DJ, Gomez-Marin O. Prevalence of usual-corrected binocular distance visual acuity impairment in Hispanic and non-Hispanic adults. *Ophthalmic Epidemiol*. 2000;7(1):73–83.
8. Vitale S, Cotch MF, Sperduto RD. Prevalence of visual impairment in the United States. *JAMA*. 2006;295:2158–2163.
9. Klein R, Klein BE, Jensen SC, Mares-Perlman JA, Cruickshanks KJ. Age-related maculopathy in a multiracial United States population: the National Health and Nutrition Examination Survey III. *Ophthalmology*. 1999;106(6): 1056–1065.
10. Congdon N, O'Colmain B, Klaver CC, et al. Causes and prevalence of visual impairment among adults in the United States. *Arch Ophthalmol*. 2004;122(4):477–485.
11. Harris MI, Klein R, Cowie CC, Rowland M, Byrd-Holt DD. Is the risk of diabetic retinopathy greater in non-Hispanic Blacks and Mexican Americans than in non-Hispanic Whites with type 2 diabetes? A US population study. *Diabetes Care*. 1998;21(8):1230–1235.
12. Sommer A, Tielsch JM, Katz J, Quigley HA, et al. Racial differences in the cause-specific prevalence of blindness in east Baltimore. *N Engl J Med*. 1991 Nov 14;325(20):1412–7.
13. Tielsch JM, Sommer A, Katz J, Royall RM, Quigley HA, Javitt J. Racial variations in the prevalence of primary open-angle glaucoma. The Baltimore Eye Survey. *JAMA*. 1991;266: 369–374.
14. Racette L, Wilson MR, Zangwill LM, Weinreb RN, Sample PA. Primary open-angle glaucoma in Blacks: a review. *Surv Ophthalmol*. 2003;48:295–313.