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Prevalence of Nonrefractive Visual Impairment in US Adults and Associated Risk Factors, 1999-2002 and 2005-2008

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Abstract

Context—Over the past decade, chronic illnesses with ophthalmic sequelae such as diabetes and diabetic retinopathy have increased.

Objectives—To estimate prevalence of nonrefractive visual impairment and to describe its relationship with demographic and systemic risk factors including diagnosed diabetes.

Design, Setting, and Participants—The National Health and Nutrition Examination Survey (NHANES) examined a representative sample of the US noninstitutionalized population. In 1999-2002 and 2005-2008, 9471 and 10 480 participants aged 20 years or older received questionnaires, laboratory tests, and physical examinations. Visual acuity of less than 20/40 aided by autorefractor was classified as nonrefractive visual impairment.

Main Outcome Measure—Nonrefractive visual impairment.

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Results—Weighted prevalence of nonrefractive visual impairment increased 21% among US adults aged 20 years and older from 1.4% in 1999-2002 to 1.7% in 2005-2008 (P=.03); and increased 40% among non-Hispanic whites aged 20-39 years from 0.5% to 0.7% (P=.008). In multivariable analyses, statistically significant risk factors for nonrefractive visual impairment in 1999-2002 included age (per year odds ratio [OR], 1.07; 95% CI, 1.05-1.09), poverty (OR, 2.18; 95% CI, 1.31-3.64), lack of insurance (OR, 1.85; 95% CI, 1.16-2.95), and diabetes with 10 or more years since diagnosis (OR, 1.93; 95% CI, 1.15-3.25). In 2005-2008, risk factors included age (OR, 1.05; 95% CI, 1.04-1.07), poverty (OR, 2.23; 95% CI, 1.55-3.22), education less than high school (OR, 2.11; 95% CI, 1.54-2.90), and diabetes with 10 or more years since diagnosis (OR, 2.67; 95% CI, 1.64-4.37). Prevalence of diabetes with 10 or more years since diagnosis increased 22% overall from 2.8% to 3.6% (P=.02); and 133% among non-Hispanic whites aged 20-39 years from 0.3% to 0.7% (P<.001).

Conclusion—Prevalence of nonrefractive visual impairment was significantly higher in 2005-2008 than in 1999-2002 and may be attributable, in part, to higher prevalence of diabetes, an associated risk factor that increased in prevalence during this time period.

IT IS ESTIMATED THAT MORE THAN 14 million individuals in the United States aged 12 years and older are visually impaired (<20/40). Of these cases, 11 million are attributable to refractive error.[1] In the United States, the most common causes of nonrefractive visual impairment are age-related macular degeneration, cataract, diabetic retinopathy, glaucoma, and other retinal disorders.[2,3] Previous studies have shown that visual impairment is common in diabetic persons; 11% of adults with diabetes have a visual acuity of less than 20/40, and 3.8% (one-third of the 11%) of these cases cannot be corrected with refraction.[4] Among individuals with diabetes aged 40 years and older, 28% to 40% have diabetic retinopathy and 4.1% to 8.2% have vision-threatening diabetic retinopathy (retinopathy severity level ≥50, macular edema, or both).[5,6] Diabetic retinopathy is the leading cause of new cases of legal blindness among adults aged 20 to 74 years and has been reported as the leading cause of blindness among US adults aged 40 years and older.[7-9]

The prevalence of diagnosed diabetes has increased among adults in recent years,[10] rising from 4.9% in 1990 to 6.5% in 1998, 7.9% in 2001, 10.7% in 2007, and 11.3% in 2010.[9-13] Among US individuals aged 20 to 39 years, there is evidence that diabetes prevalence may be increasing as well, from 2.1% in 1990 to 3.7% in 1998.[11] A study of diabetes prevalence in Native American populations reported a 46% increase among individuals aged 20 to 34 years from 1990 to 1998.[14] Recent studies have shown that higher rates of renal disease are associated with increasing rates of diabetes.[15] Because diabetes is also strongly associated with visual impairment, we hypothesized that nonrefractive visual impairment prevalence would also be higher in more recent time periods, and that this might be evident among younger adults.

This study analyzed data from the National Health and Nutrition Examination Survey (NHANES), which has continually assessed visual acuity among US residents since 1999 to compare the prevalence of nonrefractive visual impairment among US adults in 2 time periods, 1999 to 2002 and 2005 to 2008 to describe factors associated with risk of nonrefractive visual impairment with particular attention to diabetes and to document changes in the prevalence of risk factors for nonrefractive visual impairment over time.

METHODS

NHANES is a cross-sectional sample of the noninstitutionalized US population, with ongoing surveys of health status performed in 2-year cycles by the National Center for Health Statistics, Centers for Disease Control and Prevention.[16] In each 2-year cycle, approximately 10 000 individuals are recruited and are administered an in-home questionnaire. Participants are then invited to a mobile examination center for an extensive examination that includes physical examinations, assessments, and laboratory tests. The NHANES 1999-2008 protocol was reviewed and approved by the National Center for Health Statistics research ethics review board. Written informed consent was obtained from all participants.

NHANES data were analyzed to obtain the estimated prevalence of nonrefractive visual impairment, its risk factors, and the changes in prevalence of nonrefractive visual impairment and associated risk factors over a 10-year period. Participants aged 20 years and older who participated in the household interview were included; younger participants were excluded to avoid the problem of defining appropriate educational attainment for age. Those without complete visual acuity data were excluded. In 1999-2000 and 2005-2008 (2008 was the last year in which visual acuity measurements were obtained by NHANES), 9471 and 10 480 adults aged 20 years or older were invited to participate at the mobile examination center, respectively; 8790 (92.8%) and 9762 (93.1%) completed the visual acuity examination. Missing data were handled by using multiple imputation.[17,18]

Demographic data were collected at the household interview, including age, sex, race/ethnicity, years of schooling, and income. Questions relating to diabetes, access to health care, health insurance coverage, and smoking history were also asked during the household interview. Age cutoffs were chosen to avoid the problem of defining appropriate educational attainment for those younger than aged 20 years, to maintain consistency with literature that examines individuals aged 40 years and older, and to have 20-year intervals.[5-9] Adults aged 20 years and older were defined as having educational attainment less than high school if they reported having less than 12 years of schooling or equivalent. Poverty was defined as having a poverty income ratio of 1.0 or less, further explained as a ratio of family income to poverty threshold.

Participants were asked whether they had received a diagnosis of diabetes from a clinician, age at diagnosis, and whether insulin was used to treat their diabetes. Undiagnosed diabetes was not ascertained in this study; participants were classified as either having or not having diagnosed diabetes. The term *diabetes* refers to diagnosed diabetes and *diabetes at least 10 years* refers to diabetes diagnosed at least 10 years ago, based on the reported age of diabetes diagnosis on the questionnaire. Undiagnosed diabetes with fasting blood glucose of 125 or greater was measured in a subset of participants and was considered in preliminary analysis, but was not included in multivariable regression modeling due to small numbers and no significant effect on results (data available upon request).

Access to health care and health insurance coverage at the time of survey were assessed via the questions: “Is there a place you usually go when you are sick or need advice about your health?” and “Are you covered by health insurance or some other kind of health care plan?” Health insurance was defined to include private health insurance obtained through employment or health insurance purchased directly, as well as government programs such as Medicare and Medicaid that provide medical care or help pay medical bills. Current smoking was assessed via the question, “Do you now smoke cigarettes?” Former smoking was defined as answering “no” to the aforementioned question but “yes” to the question, “Have you smoked at least 100 cigarettes in your entire life?”[16]

Methods for the vision examination that was conducted at the mobile examination center have been described in detail previously.[1,19] In brief, presenting visual acuity was measured for each eye with the participant’s usual distance vision correction using an autorefractor (ARK-760, Nidek Co Ltd) containing built-in visual acuity charts with 20/20, 20/25, 20/30, 20/40, 20/50, 20/60, 20/80, and 20/200 lines. The 20/50 line was presented first and at least

4 of the 5 characters (numbers, letters, or both) had to be read correctly to advance to the next line (with smaller characters). If the participant was unable to read the 20/50 line, the 20/200 line was presented. Corrective lenses were then removed and an automated refraction was performed for each eye. For eyes with visual acuity of less than 20/25, visual acuity was remeasured, aided by the autorefractor measurements. We defined nonrefractive error–related visual impairment (nonrefractive visual impairment) as presenting visual acuity of less than 20/40 that remained less than 20/40 when aided by the automated refraction results in the better-seeing eye. Autorefractor calibration was performed weekly. Consultants from the review center regularly observed examiners to determine whether appropriate techniques were followed; as well, the entire examination at the mobile examination center was repeated among a subset of participants and compared with original results for quality control.[1,19]

Body measurements, including body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) and waist circumference, were collected at the mobile examination center.[20] Obesity was defined as BMI of at least 30 and central obesity was defined as waist measurement greater than 102 cm in men and greater than 88 cm in women.[21,22] Other risk factors considered were high blood pressure (hereafter referred to as hypertension) of 140 mm Hg or greater for systolic and 90 mm Hg or greater for diastolic, triglycerides level of 200 mg/dL or greater, high-density lipoprotein (HDL) less than 40 mg/dL in men or less than 50 mg/dL in women, low-density lipoprotein (LDL) of 160 mg/dL or greater, and total cholesterol of 240 mg/dL or greater.[20]

Because of the multistage probability sampling design of the NHANES, weights (computed by National Center for Health Statistics and provided with the NHANES datasets) were used to obtain valid estimates.[23] Because subgroups in the NHANES were oversampled then weighted to the US census population, we recommend interpreting unweighted numbers with caution. The weights are based on the probability of an individual being selected and adjusted for likelihood of nonresponse; weights are poststratified to make the sample match the 2000 US Census population totals.[23] Certain laboratory values (triglycerides and LDL) obtained via morning fasting were collected on a randomly selected subsample (1/2) of all mobile examination center participants. Weights were adjusted depending on whether an analysis was based on a subgroup vs the entire group.[23] We present analyses on 4-year cycles as recommended by NHANES for greater statistical reliability for demographic subdomains.[23]

SAS statistical software version 9.2 (SAS Institute) and SAS-callable SUDAAN version 11.0.0 (Research Triangle Institute) were used to compute prevalence, standard error, and 95% CI estimates. All analyses used appropriate sampling weights and estimation procedures that account for the complex sampling design.[23] To identify variables related to nonrefractive visual impairment and estimate odds ratios, we fit logistic regression models separately for the 2 time periods 1999-2002 and 2005-2008. Risk factors found to be statistically significant (P value <.05) in single-variable analysis, as well as basic demographic variables such as sex, were included in multivariable-regression modeling. To compare estimated prevalence between the 2 time periods, we used 2-sided t tests in the manner recommended by NHANES guidelines.[24] To confirm significance testing of difference in prevalence between time periods, χ^2 analyses were performed and are consistent with reported P values. Results were considered significant if the P value was less than .05. Missing data were handled by using multiple imputation using MCMC method, with use of weights to combine multiple imputated datasets.[17,18]

RESULTS

Demographic characteristics of participants, aged 20 years or older, are described in Table 1. Demographics and potential risk factors for nonrefractive visual impairment among individuals with visual acuity data were compared between 1999-2002 and 2005-2008. The mean age (SD) of participants in the former time period were slightly younger than in the latter (45.1 [16.8] years vs 46.7 [16.9] years; *P*=.005). In 1999-2002, there was a greater percentage of participants aged 20 to 39 years, compared with 2005-2008 (42.5% [95% CI, 40.6%-44.4%] vs 37.8% [95% CI, 35.8%-39.7%]; *P*<.001). There was a lower percentage of 40- to 59-year-olds in the former than in the latter time period (36.5% [95% CI, 35.0%-38.0%] vs 38.9% [95% CI, 37.2%-45.6%]; *P* = .03). The prevalence of poverty (15.9% [95% CI, 14.4%-17.4%] vs 13.5% [95% CI, 12.1%-14.9%]; *P*=.02) decreased between the 2 time periods, but the mean poverty income ratio did not change significantly. The overall prevalence of diagnosed diabetes increased from 6.5% (95% CI, 5.8%-7.1%) in 1999-2002 to 8.2% (95% CI, 7.3%-9.1%) in 2005-2008 (*P*=.001), and prevalence of diabetes diagnosed at least 10 years ago increased from 2.8% (95% CI, 2.4%-3.2%) in 1999-2002 to 3.6% (95% CI, 3.0%-4.2%) in 2005-2008 (*P*=.02). Race/ethnicity, sex, educational attainment, and insurance status remained similar between the 2 time periods.

The prevalence of nonrefractive visual impairment among US adults was 1.4% (95% CI, 1.2%-1.6%) in 1999-2002 and 1.7% (95% CI, 1.5%-2.0%) in 2005-2008 (*P*=.03 for difference in prevalence; Table 2). The number of participants (unweighted) with nonrefractive visual impairment was 1177 in 1999-2002 and 1416 in 2005-2008. Comparing within race/ethnicity subgroups, the prevalence of nonrefractive visual impairment was higher in 2005-2008 than in 1999-2002 for all participants and was statistically significant among Mexican Americans, increasing from 1.1% (95% CI, 0.6%-1.7%) to 2.2% (95% CI, 1.4%-3.0%; *P*=.02). When age and ethnicity were considered together, most groups had increased prevalence of nonrefractive visual impairment and it was statistically significant among white non-Hispanic individuals aged 20 to 39 years (0.5% [95% CI, 0%-0.9%] in 1999-2002 vs 0.7% [95% CI, 0.3%-1.2%] in 2005-2008; *P*=.008) and Mexican Americans aged 60 years or older (4.6% [95% CI, 2.7%-6.6%] in 1999-2002 vs 8.9% [95% CI, 4.5%-13.3%] in 2005-2008; *P*<.001; Table 2).

Increased prevalence of nonrefractive visual impairment was significantly associated in single-variable regression analyses with older age (1999-2002 OR, 1.07 [95% CI, 1.05-1.09] and 2005-2008 OR, 1.06 [95% CI, 1.05-1.07]), race/ethnicity other than non-Hispanic white (1999-2002 OR, 2.13 [95% CI, 1.50-3.01] and 2005-2008 OR, 2.03 [95% CI, 1.51-2.72]), poverty (1999-2002 OR, 2.89 [95% CI, 1.85-4.50] and 2005-2008 OR, 3.30 [95% CI, 2.38-4.57]), less education (1999-2002 OR, 1.92 [95% CI, 1.37-2.71] and 2005-2008 OR, 2.90 [95% CI, 2.22-3.78]), lack of health insurance at the time of the survey (1999-2002 OR, 2.50 [95% CI, 1.62-3.87] and 2005-2008 OR, 1.69 [95% CI, 1.02-2.81]), diabetes (1999-2002 OR, 1.65 [95% CI, 1.16-2.34] and 2005-2008 OR, 2.26 [95% CI, 1.54-3.34]), diabetes diagnosed at least 10 years ago (1999-2002 OR, 2.24 [95% CI, 1.36-3.67] and 2005-2008 OR, 3.20 [95% CI, 1.94-5.26]), and current insulin use (1999-2002 OR, 2.49 [95% CI, 1.17-5.29] and 2005-2008 OR, 2.25 [95% CI, 1.22-4.17]). Associations of nonrefractive visual impairment with sex, access to health care, current or former smoking, obesity, central obesity, systolic hypertension, diastolic hypertension, high triglycerides, low HDL, high LDL, and high total cholesterol were not statistically significant (eTable available at http://www.jama.com).

Multivariable logistic regression modeling was performed with risk factors found to be statistically significant in univariable analysis (Table 3). Time of 10 or more years since diagnosis of diabetes was associated with an increased risk of nonrefractive visual impairment in both time periods (1999-2002 OR, 1.93 [95% CI, 1.15-3.25] and 2005-2008 OR, 2.67 [95% CI, 1.64-4.37]). Older individuals were more likely to have nonrefractive visual impairment than younger individuals in both time periods (1999-2002 OR, 1.07 [95% CI, 1.05-1.09] and 2005-2008 OR, 1.05 [95% CI, 1.04-1.07]) and poverty was also associated with nonrefractive visual impairment in both time periods (1999-2002 OR, 2.18 [95% CI, 1.31-3.64] and 2005-2008 OR, 2.23 [95% CI, 1.55-3.22]).

In 1999-2002 there was increased risk of nonrefractive visual impairment associated with lack of health insurance (OR, 1.85; 95% CI, 1.16-2.95) as well as non-Hispanic black ethnicity (OR, 1.56; 95% CI, 1.01-2.41) but these were not significant in 2005-2008. In 2005-2008 there was increased risk of nonrefractive visual impairment associated with an education of less than high school (OR, 2.11; 95% CI, 1.54-2.90) but this was not significant in 1999-2002. Sex was not significant in the multivariable logistic regression models for either time period.

Most deleterious factors found to be significant in multivariable modeling, including lack of health insurance, lower level of education, and poverty, remained stable or decreased in prevalence between the 2 time periods considered (Table 1); thus, nonrefractive visual impairment prevalence was stratified by diabetes, which was the remaining risk factor (Table 4). Among individuals without diabetes, the prevalence of nonrefractive visual impairment was 1.2% (95% CI, 1.0%-1.4%) in 1999-2002 and 1.4% (95% CI, 1.2%-1.6%) in 2005-2008. The estimated prevalence of nonrefractive visual impairment among individuals with any diabetes diagnosis was greater than among individuals without diabetes at 3.7% (95% CI, 2.4%-5.1%; $P < .001$ in 1999-2002) and 5.3% (95% CI, 3.6%-7.0%; $P < .001$ in 2005-2008). Individuals with a diabetes diagnosis for less than 10 years had intermediate prevalence of nonrefractive visual impairment. The highest estimated prevalence of nonrefractive visual impairment was among individuals with a diabetes diagnosis for 10 years or greater at 6.1% (95% CI, 3.3%-8.9% in 1999-2002; $P = .001$) and 8.1% (95% CI, 4.5%-11.7% in 2005-2008; $P < .001$) when compared to those without diabetes in each time period. Rao-scott χ^2 testing showed significance when comparing diabetes status within each time period ($\chi^2 = 488.7$ and $P < .001$ in 1999-2002; $\chi^2 = 962.5$ and $P < .001$ in 2005-2008). Notably, there was no difference in prevalence of nonrefractive visual impairment from 1999-2002 to 2005-2008 after controlling for diabetes status (Table 4). Rao-scott χ^2 analysis showed no significance when comparing across time periods after controlling for diabetes status.

Subgroup analysis by age and race/ethnicity showed that prevalence of diabetes diagnosed 10 or more years ago increased significantly from 2.8% (95% CI, 2.4%-3.2%) in 1999-2002 to 3.6% (95% CI, 3.0%-4.2%) in 2005-2008 ($P = .02$) (Table 5). This increase between time periods was among all ethnicities and significant among non-Hispanic black individuals (4.3% [95% CI, 3.4%-5.2%] vs 6.0% [95% CI, 4.9%-7.1%]; $P = .02$) and Mexican Americans (2.3% [95% CI, 1.8%-2.8%] vs 3.1% [95% CI, 2.5%-3.8%]; $P = .04$). Increased prevalence persisted after stratification by age, and was statistically significant among those aged 20 to 39 years (0.3% [95% CI, 0.1%-0.5%] vs 0.7% [95% CI, 0.4%-1.0%]; $P = .03$) and non-Hispanic white individuals aged 20 to 39 years (0.3% [95% CI, 0%-0.5%] vs 0.7% [95% CI, 0.3%-1.1%]; $P < .001$) in comparisons between 1999-2002 and 2005-2008, respectively.

COMMENT

Using NHANES data from 1999-2002 and 2005-2008, we found that the prevalence of nonrefractive visual impairment has increased 21% from 1.4% to 1.7% ($P = .03$); to our knowledge, we are the first to report this finding. In multivariable analysis among all participants, factors associated with nonrefractive visual impairment included older age, poverty, lower education level, and diabetes diagnosed 10 or more years ago. Among these risk factors, only the latter has increased in prevalence between the 2 time periods considered. Others have shown rising prevalence of type 2 diabetes in the pediatric age group, associated with the increase in childhood obesity.[25-28] Our observation of increasing rates of nonrefractive visual impairment among non-Hispanic white individuals aged 20 to 39 years (0.5%-0.7%; $P = .008$), coupled with the rising prevalence of diabetes diagnosed 10 or more years ago years among non-Hispanic white individuals aged 20 to 39 years (0.3% to 0.7%; $P < .001$), is consistent with the hypothesis that increasing prevalence of diabetes among younger US residents, with subsequent increasing duration of diabetes, may be related to worsening vision.

Our results show that individuals with diabetes, particularly those for whom more time has passed since its diagnosis, have higher rates of nonrefractive visual impairment than individuals without diabetes (Table 4). Furthermore, after stratification by diabetes status, there was no longer a significant increase in prevalence of nonrefractive visual impairment across survey years (Table 4). This may be because diabetes accounts for the change in prevalence in nonrefractive visual impairment in the time period considered; it is also possible that another factor is present but with an effect too small to detect with the current sample. Other studies have shown that prevalence of diabetes has increased in the last decade.[11,14] We found increased prevalence of longer-duration diabetes, from 2.8% to 3.6% ($P = .02$), representing a 29% change. This mirrors the increasing prevalence of nonrefractive visual impairment.

Other factors strongly associated with nonrefractive visual impairment included poverty, lower education, and lack of health insurance at the time of survey. Fewer individuals were below the poverty threshold in the latter time period; education less than high school and lack of health insurance did not change significantly between the 2 time periods considered (Table 1). Furthermore, since participants were instructed to include both private and government-provided health insurance such as Medicare and Medicaid, nearly all participants aged 65 years and older would have been insured based on this definition. Other than diabetes, we were unable to identify any other reason for increasing prevalence of nonrefractive visual impairment.

Diabetes diagnosed less than 10 years ago was not significantly associated with nonrefractive visual impairment. In a preliminary analysis of a subset of participants who received fasting glucose measurements (data available upon request), results remained consistent with the current analysis. Although it is possible for diabetic retinopathy to be observed even before diabetes is diagnosed,[29] our results suggest that those with a longer duration of diabetes are at greater risk for nonrefractive visual impairment than are those with shorter duration.

We would expect visual complications associated with diabetes to decrease with improved systemic and ocular management of disease. However, this was not observed in our study, suggesting that there is either insufficient population-wide diabetes management or that any advancement made in disease management is overshadowed by the effect of increasing prevalence of diabetes. A survey of individuals with diabetes showed self-reported visual impairment has declined from 1997 to 2010.[30] However, the study did not distinguish between refractive visual impairment, which can be corrected with spectacles, and nonrefractive visual impairment, which cannot. Among individuals with type 1 diabetes, there may be decreasing incidence of diabetic retinopathy, which is related to improved management of systemic risk factors such as glycemia, blood pressure, smoking, and lipid levels.[31-33] However, among those with type 2 diabetes, there is evidence that the opposite is true, and incidence of diabetic retinopathy is increasing.[5,34,35] Regardless of changing rates of visual impairment among people with diabetes, dramatically increasing prevalence of diabetic disease could still result in an increased prevalence of visual impairment overall.

This study compares nonrefractive visual impairment from 2 discrete time intervals within a 10-year continuous study conducted by NHANES. The study is limited in that it examines serial cross-sectional population samples and causality cannot be determined since causes of vision loss were not documented in NHANES. Only visual acuity, a single measure of visual function, and refraction were measured in 1999-2004 NHANES. Fundus photos were added to the NHANES vision examination in 2005-2008; however, this information may not be directly pertinent since presence of funduscopic findings do not necessarily correlate with visual impairment. Of the 4 leading causes of nonrefractive visual impairment in the United States—age-related macular degeneraton, glaucoma, cataract, and diabetic retinopathy[2,3]—the first 2 are largely age related and would not be expected to cause increasing prevalence of nonrefractive visual impairment in those aged 20 to 39 years. Cataract can be secondary to a variety of etiologies including diabetes. Our estimates of factors such as income, education, and smoking may be affected by social desirability bias. This study's strengths include its large, representative, national sample and its use of standardized methods over the period of the study.

We report a previously unrecognized increase of visual impairment among US adults that cannot be attributed to refractive error. This finding suggests an increasing problem. Blindness and visual impairment are associated with increased medical care expenditure, decreased work productivity, and decreased quality-adjusted life years.[36,37] Concurrently, prevalence of diabetes has been increasing, specifically diabetes of longer duration (Table 5). This may account for part of the increased prevalence of nonrefractive visual impairment. If the current finding becomes a persisting trend, it could result in increasing rates of disability in the US population, including greater numbers of patients with end-organ diabetic damage who would require ophthalmic care. These results have important implications for resource allocation in the debate of distribution of limited medical services and funding. Continued monitoring of visual disability and diabetes, as well as additional research addressing causes, prevention, and treatment, is warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographics and Potential Risk Factors for Nonrefractive Visual Impairment in US Adults Aged 20 Years and Older

	1999-2002		2005-2008		
Characteristic	**Participants, No. n = 9471**	**% (95% CI)[a]**	**Participants, No. n = 10 480**	**% (95% CI)[a]**	**P Value[b]**
Age, mean (SD), y	45.1 (16.8)		46.7 (16.9)		.005
20-39	3412	42.5 (40.6-44.4)	3683	37.8 (35.8-39.7)	<.001
40-59	2825	36.5 (35.0-38.0)	3264	38.9 (37.2-45.6)	.03
≥60	3234	21.1 (19.7-22.4)	3533	23.3 (21.2-25.4)	.07
Race/ethnicity White non-Hispanic	4591	70.9 (67.1-74.6)	5054	70.6 (65.9-75.3)	.93
Black non-Hispanic	1813	10.9 (8.4-13.3)	2274	11.4 (8.6-14.1)	.78
Mexican American	2256	6.8 (5.2-8.4)	1941	8.2 (6.3-10.0)	.25
Other	811	11.5 (7.6-15.4)	1211	9.8 (7.7-12.0)	.45
Female sex	5011	52.2 (51.3-53.2)	5399	51.9 (51.1-52.7)	.54
Education <high school	3261	21.8 (20.1-23.6)	3103	19.2 (17.1-21.3)	.06
Poverty income ratio ≤1[c]	1908	15.9 (14.4-17.4)	2099	13.5 (12.1-14.9)	.02
Poverty income ratio, mean (SD)[c]	2.96 (1.64)		3.1 (1.62)		.24
Lack of health insurance	1872	17.9 (16.1-19.8)	2409	19.2 (17.0-21.3)	.37
Diabetes All diabetes	911	6.5 (5.8-7.1)	1214	8.2 (7.3-9.1)	.001
At least 10-year duration	436	2.8 (2.4-3.2)	570	3.6 (3.0-4.2)	.02

[a] Percentage values are weighted according to the US 2000 Census, whereas numbers of participants are unweighted.

[b] *P* value tests the likelihood that the difference detected between the 2 time periods is due to chance.

[c] Poverty income ratio is the ratio of family income to poverty threshold. A poverty income ratio of less than 1 indicates that the family income is below the poverty threshold.

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Table 2

Prevalence of Nonrefractive Visual Impairment (Corrected Visual Acuity <20/40) Among US Adults Aged 20 Years and Older by Age and Race/Ethnicity[a]

	1999-2002		2005-2008		
	Participants, No.	**Prevalence, % (95% CI)[b]**	**Participants, No.**	**Prevalence, % (95% CI)[b]**	***P* Value**
Overall	1177	1.4 (1.2-1.6)	1416	1.7 (1.5-2.0)	.03
White non-Hispanic	593	1.2 (1.0-1.5)	668	1.6 (1.3-1.9)	.08
Black non-Hispanic	240	1.9 (1.1-2.7)	312	2.3 (1.6-3.0)	.38
Mexican American	229	1.1 (0.6-1.7)	288	2.2 (1.4-3.0)	.02
Age 20-39 y	115	0.6 (0.3-1.0)	243	1.0 (0.7-1.4)	.09
White non-Hispanic	30	0.5 (0-0.9)	65	0.7 (0.3-1.2)	.008
Black non-Hispanic	35	1.1 (0-2.2)	56	1.4 (0.2-2.5)	.73
Mexican American	35	0.8 (0.3-1.3)	71	1.6 (0.7-2.5)	.11
Age 40-59 y	90	0.4 (0.1-0.8)	162	0.6 (0.3-1.0)	.35
White non-Hispanic	20	0.3 (0-0.7)	30	0.3 (0-0.7)	.91
Black non-Hispanic	35	1.1 (0.2-2.0)	75	1.9 (1.0-2.8)	.21
Mexican American	25	0.7 (0-1.5)	30	1.0 (0.1-1.8)	.36
Age ≥60 y	972	4.5 (3.8-5.1)	1011	4.7 (4.0-5.4)	.67
White non-Hispanic	543	3.9 (3.3-4.6)	573	4.5 (3.6-5.3)	.34
Black non-Hispanic	170	5.8 (3.8-7.8)	181	5.5 (3.4-7.5)	.68
Mexican American	169	4.6 (2.7-6.6)	187	8.9 (4.5-13.3)	<.001

[a]"Other" race/ethnicity is not reported because of small numbers.

[b]Percentage values are weighted according to the US 2000 Census, whereas numbers of participants are unweighted.

Table 3

Multivariable Logistic Regression Analyses Predicting Nonrefractive Visual Impairment

	1999-2002		2005-2008	
	Prevalence, % (95% CI)[a]	**Odds Ratio (95% CI)**	**Prevalence, % (95% CI)[a]**	**Odds Ratio (95% CI)**
Age per year		1.07 (1.05-1.09)		1.05 (1.04-1.07)
Ethnicity White non-Hispanic	1.4 (1.0-1.5)	1 [Reference]	1.6 (1.3-1.9)	1 [Reference]
Black non-Hispanic	1.9 (1.1-2.7)	1.56 (1.01-2.41)	2.3 (1.6-3.0)	1.28 (0.90-1.83)
Mexican American	1.1 (0.6-1.7)	1.19 (0.72-1.97)	2.2 (1.4-3.0)	1.30 (0.79-2.13)
Other	1.8 (1.0-2.6)	1.45 (0.91-2.29)	1.8 (0.8-2.8)	1.24 (0.71-2.17)
Sex Men	1.2 (1.0-1.4)	1 [Reference]	1.5 (1.1-1.9)	1 [Reference]
Women	1.5 (1.3-1.7)	1.08 (0.75-1.55)	1.9 (1.5-2.3)	1.11 (0.86-1.43)
Poverty income ratio[b] >1	1.1 (0.9-1.3)	1 [Reference]	1.4 (1.2-1.6)	1 [Reference]
≤1	2.7 (1.7-3.7)	2.18 (1.31-3.64)	3.6 (2.6-4.6)	2.23 (1.55-3.22)
Education ≥ High school	1.0 (0.8-1.2)	1 [Reference]	1.2 (1.0-1.4)	1 [Reference]
<High school	2.7 (1.9-3.5)	1.27 (0.87-1.84)	4.1 (3.3-4.9)	2.11 (1.54-2.90)
Health insurance Yes	1.4 (1.2-1.6)	1 [Reference]	1.8 (1.4-2.2)	1 [Reference]
No	1.2 (0.8-1.6)	1.85 (1.16-2.95)	1.3 (0.7-1.9)	1.10 (0.63-1.92)
Diabetes None	1.2 (1.0-1.4)	1 [Reference]	1.4 (1.2-1.6)	1 [Reference]
Diagnosis <10 y ago	1.9 (0.7-3.2)	0.89 (0.49-1.62)	3.1 (1.8-4.4)	1.23 (0.77-1.95)
Diagnosis ≥10 y ago	6.1 (3.3-8.9)	1.93 (1.15-3.25)	8.1 (4.5-11.7)	2.67 (1.64-4.37)

[a]Percentage values are weighted according to the US 2000 Census.

[b]Poverty income ratio is a ratio of family income to poverty threshold. A poverty income ratio less than 1 indicates that the family income is below the poverty threshold.

Table 4

Prevalence of Nonrefractive Visual Impairment by Diabetes Status

	1999-2002		2005-2008		
	Prevalence, % (95% CI)	***P* Value[a]**	**Prevalence, % (95% CI)**	***P* Value[a]**	***P* Value[b]**
No diabetes	1.2 (1.0-1.4)	[Reference]	1.4 (1.2-1.6)	1 [Reference]	.13
All diabetes	3.7 (2.4-5.1)	<.001	5.3 (3.6-7.0)	<.001	.15
Diabetes less than 10 years ago	1.9 (0.7-3.2)	.24	3.1 (1.8-4.4)	.02	.19
Diabetes at least 10 years ago	6.1 (3.3-8.9)	.001	8.1 (4.5-11.7)	<.001	.36

[a] *P* value by diabetes status.

[b] *P* value across time periods.

Table 5

Prevalence of Diabetes Diagnosed 10 or More Years Ago Among US Adults Aged 20 Years and Older by Age and Race/Ethnicity[a]

	1999-2002		2005-2008		
	Participants, No.	Prevalence, % (95% CI)[b]	Participants, No.	Prevalence, % (95% CI)[b]	*P* Value
Overall	2422	2.8 (2.4-3.2)	3031	3.6 (3.0-4.2)	.02
White non-hispanic	922	2.5 (2.1-3.0)	1187	3.4 (2.6-4.2)	.07
Black non-Hispanic	652	4.3 (3.4-5.2)	981	6.0 (4.9-7.1)	.02
Mexican American	631	2.3 (1.8-2.8)	520	3.1 (2.5-3.8)	.04
Aged 20 to 39 years	64	0.3 (0.1-0.5)	135	0.7 (0.4-1.0)	.03
White non-Hispanic	29	0.3 (0-0.5)	60	0.7 (0.3-1.1)	<.001
Black non-Hispanic	25	0.8 (0-1.7)	40	1.0 (0.4-1.7)	.65
Mexican American	5	0 (0-0.3)	25	0.5 (0-1.0)	.16
Aged 40 to 59 years	436	2.4 (1.9-2.9)	736	3.2 (2.5-3.9)	.06
White non-Hispanic	120	1.8 (1.1-2.4)	262	2.7 (1.7-3.6)	.10
Black non-Hispanic	115	3.7 (2.2-5.3)	240	5.7 (4.0-7.3)	.08
Mexican American	121	3.5 (2.3-4.6)	134	4.2 (2.8-5.6)	.07
Aged 60 years and older	1922	8.6 (7.5-9.8)	2124	9.0 (7.2-10.7)	.72
White non-Hispanic	773	7.3 (6.2-8.5)	865	7.6 (5.6-9.6)	.80
Black non-Hispanic	512	16.3 (13.0-19.7)	701	18.6 (15.3-22.0)	.12
Mexican American	505	13.9 (11.1-16.7)	361	14.4 (10.1-18.8)	.38

[a]"Other" race/ethnicity is not reported because of small numbers.

[b]Percentage values are weighted according to the US 2000 Census, whereas numbers of participants are unweighted.