Spring 5-4-2021

# Determining Disparities by Income Level as Risk Factor for Low Visual Acuity Among U.S. Adults Using the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2008

Mariana Umbria

## ABSTRACT

DETERMINING DISPARITIES BY INCOME LEVEL AS RISK FACTOR FOR LOW VISUAL ACUITY AMONG U.S. ADULTS USING THE NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY (NHANES) FROM 1999 TO 2008.

By

MARIANA VIRGINIA UMBRIA CASTRO

DATE: April 21st, 2021

**INTRODUCTION:** Visual loss is a serious health, social and economic problem worldwide in the United States (U.S.), being a cause of morbidity and disability in society. Subsequently, low vision is high in developing countries, where social determinants of health (SDH) play a significant role in individuals' health status. Studies confirm the impact of SDH on low vision and access to visual healthcare in the U.S. Yet there is no recent research that addresses the relationship between income level, as a SDH and low vision in the U.S. at the national level.

**AIM:** This study aims to analyze income disparities in visual acuity using data from the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2008 to verify the association between income level and low vision.

**METHODS:** This study is a population-based and nationally-representative, observational, secondary data analysis using information from NHANES (1999 – 2008) with a sample=27,200 adult participants. The study measured descriptive statistics, bivariate statistics (chi-squared), and

logistic regression to compute the strength of association between the household income and visual acuity.

**RESULTS:** Lower-income subjects had significantly lower odds of normal vision (OR=0.822, $p<0.05$) and higher odds of low visual acuity (OR=1.214, $p<0.05$) and severe visual impairment (OR=1.44, $p<0.05$), compared to high-income level groups.

**DISCUSSION:** Low income is associated with lower likelihood of normal vision and higher risk of visual impairment. To improve disparities in visual health, economic inequality and its effects (for example, unequal access to health insurance and preventative visual healthcare) must be improved.

# DETERMINING DISPARITIES BY INCOME LEVEL AS RISK FACTOR FOR LOW VISUAL ACUITY AMONG U.S. ADULTS USING THE NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY (NHANES) FROM 1999 TO 2008.

By

MARIANA VIRGINIA UMBRIA CASTRO

M.D. - OPHTHALMOLOGIST, UNIVERSIDAD DE LOS ANDES, VENEZUELA.

A Thesis Submitted to the Graduate Faculty

of Georgia State University in Partial Fulfillment

of the Requirements for the Degree

MASTER OF PUBLIC HEALTH

ATLANTA, GEORGIA.

30303

APPROVAL PAGE

DETERMINING DISPARITIES BY INCOME LEVEL AS RISK FACTOR FOR LOW VISUAL ACUITY AMONG U.S. ADULTS USING THE NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY (NHANES) FROM 1999 TO 2008.

By

MARIANA VIRGINIA UMBRIA CASTRO

Approved:

Dr. Kathleen M. Baggett

**Committee Chair**

Dr. Elizabeth Ann Mosley

**Committee Member**

April 21st, 2021

**Date**

Author's Statement Page

In presenting this thesis as a partial fulfillment of the requirements for an advanced degree from Georgia State University, I agree that the Library of the University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote from, to copy from, or to publish this thesis may be granted by the author or, in his/her absence, by the professor under whose direction it was written, or in his/her absence, by the Associate Dean, School of Public Health. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this dissertation which involves potential financial gain will not be allowed without written permission of the author.

Mariana Umbria.

Signature of Author

**Table of Contents**

## Chapter I: Introduction

Visual loss is a serious health, economic, and social problem globally and in the United States (U.S.). The costs of education, rehabilitation, and loss of productivity due to blindness significantly impact individuals, families, communities, and nations (Köberlein et al., 2013; West & Sommer, 2001; World Health Organization, 2019). As life expectancy increases, older people need a more comprehensive range of health services, disease prevention, rehabilitation, acute and chronic care, and palliative care (Chou et al., 2013). Given the projected demographic changes and population growth, the incidence of chronic non-communicable diseases affecting vision is expected to increase (Bastawrous & Suni, 2020; Rein et al., 2009; Wong et al., 2014). Lack of good vision is a significant cause of morbidity and impairment globally, as it affects people's routine tasks and access to social resources (Pascolini & Mariotti, 2012; World Health Organization, 2019). Low vision and visual impairment also contribute to a decrease in an adult person's productivity (Wittenborn et al., 2013; World Health Organization, 2019). Eckert et al. (2015) states that the cost of mild to severe visual impairment was $16.5 billion in the U.S. solely (Eckert et al., 2015, p. 2).

Furthermore, low vision is more prevalent in developing countries, globally, where social determinants of health (SDH) can play a substantial negative role in a person's health status (World Health Organization, 2020). The SDH are defined as the circumstances in which people are born, grow up, live, work, and age, including the health system (Office of Disease Prevention and Health Promotion, 2020). SDH are a set of complex factors that, acting in combination, determine the health of individuals and their communities (Office of Disease Prevention and Health Promotion, 2020). These include environmental and social factors such as level of income that influence the health status of communities and populations through numerous, diverse mechanisms (Office of Disease Prevention and Health Promotion, 2020).

To date, the evidence available demonstrates there are disparities and inequities, in the access to visual healthcare that contribute to visual health disparities in the U.S. In their article, Zambelli-Weiner et al. (2012), report disparities in vision health care and outcomes are related to race, ethnicity, education and income level (Zambelli-Weiner et al., 2012). Yet there is no recent research that addresses the relationship between income level and low vision or visual impairment in the U.S. at the national level (Zambelli-Weiner et al., 2012). For that reason, this study aims to analyze income disparities in visual acuity using data from the National Health and Nutrition Examination Survey (NHANES) (from 1999 to 2008).

**Research Question and Hypothesis**

The central research question for this study is: Is there a relationship between reported annual household income and low visual acuity in the U.S. population? Secondary data collection from NHANES 1999 – 2000, 2001 – 2002, 2003 – 2004, 2005 – 2006 and 2007 – 2008 will be analyzed. The null hypothesis is that there is no association between annual household income and low visual acuity in the population of the U.S. The alternate hypothesis is that lower annual household income is associated with higher risk factor of low visual acuity in the U.S. adult population.

## Chapter II: Literature Review

### Visual Health Globally and in the U.S.

Visual impairment is defined based on visual acuity and sight range (Chan et al., 2018). When speaking about visual impairment, there is a significant decrease in visual acuity, even with correction of the main cause or a significant decrease in the sight range (Congdon et al., 2004). The World Health Organization defines visual impairment as reduction of far or near sight/vision equal or lower than 20/70, with no possible correction (World Health Organization, 2010b). There are approximately 300 million visually impaired people globally, of which 39 million are blind, and 246 million have low vision (World Health Organization, 2010b). Approximately 90% of the global burden of visual impairment is concentrated in low-income countries and 82% of people who are blind are aged 50 or over (World Health Organization, 2010b). In global terms, uncorrected refractive errors, like myopia, hypermetropy and astigmatism, are the most important cause of visual impairment, albeit in low- and middle-income countries, cataracts remain the leading cause of blindness (World Health Organization, 2010b). Eighty percent of all cases of visual impairment worldwide can be prevented or cured, either through medical or surgical treatment (World Health Organization, 2010b).

In the U.S., age-related macular degeneration is the leading cause of visual impairment among the white population, and among African-American individuals, cataracts and glaucoma are the leading cause (Chan et al., 2018; Congdon et al., 2004). Additionally, in 2006, the CDC published a report titled "Visual Impairment and Eye Care Among Older Adults --- Five States" which was based on data from American citizens 50 years and older (Bailey et al., 2006). Approximately 15% and 20% of each state's participants in this research reported having severe low vision at the interview time (Bailey et al., 2006). Almost half of the subjects that response to the survey in Ohio, and more than half in the other states, reported eye disorders and low vision,

as a result of limited access for lack of insurance(Bailey et al., 2006). Finally, another notable finding was that almost 25% of the sample (in each state) mentioned cost and not having vision insurance as reasons for not seeking visual healthcare (Bailey et al., 2006).

### *Disparities in U.S. Visual Health*

Currently, most of the population mistakenly believes the only leading causes of health disparities are genetics or lifestyle behaviors. While genetics and lifestyle factors are significant, they do not completely explain disparities in population health status nor, more specifically, the underlying causes of eye health inequalities in a given society. In 2012, Zambelli-Weiner et al. published a review of research conducted in the U.S. related to inequalities involving eye health in adults, with the purpose of grouping and examining information to collaborate in the creation of an eye health surveillance system appropriate to the needs of the population (Zambelli-Weiner et al., 2012). The review included 129 studies from 1980 to 2010 that included participants 40 years of age and older (Zambelli-Weiner et al., 2012). They found that there are disparities in visual health with higher risk for female gender, older age, and being Black or Hispanic (Zambelli-Weiner et al., 2012).

This research's limitations include insufficient available data related to income and education level from the reviewed studies (Zambelli-Weiner et al., 2012). Importantly, Zambelli-Weiner found that visual impairment is more prevalent in individuals living below the poverty level, as well as in Non-Hispanics Blacks (21%) and Hispanics (24%) than in Non-Hispanics Whites (13.8%) (Zambelli-Weiner et al., 2012). Finally, reviewing studies focused on specific race/ethnic groups (e.g., Proyecto VER only for Hispanics in the state of Arizona) could have affected the results, being this another limitation (Zambelli-Weiner et al., 2012).

***Economic Disparities in Visual Health Globally***

As previously explained, there are few studies on the association between income and blindness, visual impairment, or low vision in the U.S., however, the existence of such relationship has been documented internationally. In 2010, Perruccio et al. developed a cross-sectional, observational, population-based study with 113,212 participants, where secondary data collection from "Canada's Statistics from 2000-2001 Canadian Community Health Survey Cycle 1.1" was used and where income level, measured as annual household income, and the presence of visual impairment was self-reported (Perruccio et al., 2010, p.2). The purpose of this study was to determine, among Canadian adults (20 years and older), which sociodemographic factors were related to vision problems and associated with pre-existing conditions such as glaucoma, cataracts, and diabetes (Perruccio et al., 2010). The authors of this research found that more than half of the sample reported some visual problems with medium, medium-low and low income level at higher risk of visual problems compared to the other income levels (Perruccio et al., 2010). Study limitations included lack of control for confounding factors.

Despite the fact that several other countries have studied and documented an association between income level and low vision, such studies have important limitations, which jeopardize generalizability and validity, such as insufficient sample size and lack of control for confounding factors and response bias. In 2017, Katibeh et al. published an observational study with a cluster sample of 3,000 Iranian adults, over 50 years old, randomly sampled (Katibeh et al., 2017). The main objective of this research was to examine what kind of association exists between socioeconomic level and visual impairment in the district of Varamin in Iran (Katibeh et al., 2017). They found that the presence of visual impairment was two times higher in the participants who reported low income compared to those with high income. However, this study might have been

impacted by response bias, especially socially desirable responses and non-response due to the participants' cultural factors. Another limitation of this study is that they focused solely on subjects older than 50 years old. Also, more diverse samples are needed to make the study generalizable and secure that confounding is addressed in the study's data analysis to have statistically significant results.

Other studies that have shown an association between socioeconomic status (SES) and low vision only focus on one main cause of visual problems, such as glaucoma, rather than on the entire eye disease spectrum. In South Korea, Sung et al. (2017) conducted a cohort study in order to verify the correlation between SES and low vision and blindness caused by glaucoma using secondary data collection from the Korean National Health Insurance (KNHI), where they selected 1,728 participants with only one inclusion factor: patients diagnosed with primary glaucoma (idiopathic onset) from 2002 to 2013 (Sung et al., 2017). The categorization of SES was based on income level and visual acuity, primary glaucoma diagnosis and blindness was determined by clinicians. The researchers presented evidence that SES represents a statistically significant risk factor for patients to have blindness or low vision, when they have been previously diagnosed with primary glaucoma (Sung et al., 2017). Finally, another limitation is that the authors focus solely on glaucoma, which limits the evidence on visual health more broadly. Additionally, a low percentage of patients with glaucoma are asymptomatic (Weinreb et al., 2014). For that reason, they might be undiagnosed or underdiagnosed, along with the fact of not considering any other ocular diseases (Sung et al., 2017). Moreover, the relatively small sample size might also be an issue. Future researcher should include larger sample sizes given the low prevalence of some visual health disorders such as glaucoma and consider more ocular diseases.

Finally, other studies on socioeconomic disparities in visual health tend to focus on particular populations and, therefore, are not generalizable. Yan et al. (2019) designed a cross-sectional investigation with the purpose of determining the association between SES and low vision, acknowledging participants' lifestyle as a modifying agent between the two variables (Yan et al., 2019). The researchers selected 12,233 participants from different rural regions of China, during a period of 17 months (November 2015 to March 2017) (Yan et al., 2019). Sociodemographic characteristics were measured through a survey created and tested by the researchers and, to determine the presence of blindness and low vision, visual acuity was measured by clinicians (Yan et al., 2019). After obtaining the results, the researchers concluded that patients with low income and low educational attainment had a higher risk of visual problems that would generate low vision and blindness than those participants with high income (Yan et al., 2019). Lastly, this study has some limitations. Data collection was cross sectional during the specific period of 17 months. Future studies will want to look at longitudinal data or at least review cross-sectional data from a wider period of time. Moreover, considering the study was based on the rural population, the selection of the sample may not represent all the entire population, or may not be generalizable (Yan et al., 2019). Lengthening the period for data collection and including a more diverse sample are recommended for future trials.

**Conceptual Framework: Social Determinants of Health**

In 2005, the WHO organized a commission called: “Commission on Social Determinants of Health” (CSDH) to apply scientific knowledge regarding the ultimate or structural causes of health problems (World Health Organization, 2020). Research on SDH was strongly revived in this millennium to draw governments', researchers’, and practitioners’ attention to the root causes of health inequalities. The SDH point to the specific features of the social context that affect

health—for example, income inequality—and the mechanisms by which social conditions translate into an impact on health status—for example, through income-based access to preventative vision health services. Given that the purpose of the current study is to determine if annual household income is related to low visual acuity in the adult U.S. population, the SDH framework will be used as the conceptual framework for this study.

## Chapter III: Methods and Procedures

### Study Design and Data Sources

This research study is an observational secondary data analysis using data collected by NHANES (1999 – 2008). According to the NHANES dataset, well-trained clinicians including optometrist and ophthalmologists, performed the screening of visual acuity from 1999 to 2008. For that reason, those years were selected for the research with the intention of increase the study's validity, taking away the subjectivity of a variable with self-reported visual acuity and turning it in an objective variable.

### Population and Sample

The study is population-based and nationally-representative, and its target population consisted of U.S. adults 18 years and older. To assess the influence of annual household income as a risk factor, all subjects (age groups, all sex and gender, with all eye problems) will be considered to secure the generalizability of this research. Since during pregnancy, women suffer from refractive changes that can temporarily affect their sight, resulting in low vision, pregnant women will be excluded from this study. The software utilized in this study's statistical analysis was SAS 9.4. After cleaning and filtering NHANES datasets, the total sample obtained was 27,200 adult participants.

### Measurements

**Visual Acuity.** Low vision (20/60 or lower) was measured by specialized and trained technicians in the Mobile Examination Center (MEC), with distant vision tests labeled as "Right visual acuity, presenting" and "Left visual acuity, presenting", both defined as "The presenting visual acuity of the right and left eye with usual correction" (CDC, 2005). In this study, participants who took the questionnaire and at the same time examined on the MEC were selected to develop

and categorized the dependent variables as follows: a) Normal Visual Acuity: 20/20 to 20/50, b) Low Visual Acuity: 20/60 to 20/200, and c) Severe Visual Impairment: lower than 20/200. These variables were converted from numerical (visual acuity measured by Snellen chart from 20/20 to 20/200 and lower) to categorical/dichotomous variables (if the visual acuity was within the class range, it falls into the "Yes" category, otherwise "No").

**Annual Household Income.** Likewise, the data for annual household income was taken from the demographic archives from the years mentioned previously, obtained through the interview questions. This variable is defined as "Total household income (reported as a range value in dollars)". Hence, annual household income categorization is classified as follows: lower income ($0 to $54,999) and higher income level (over $55,000) (CDC, 2002).

**Covariates.** Data for the co-varying demographic variables, from the same years (1999-2008), were utilized to measure age (first defined as "Best age in years of the sample person at time of House Hold screening survey" then classified as " 18-39 years old", "40-59 years old" and "60 years or older"), gender (defined as "gender of the sample person, both male and female"), race/ethnicity (categorized as "Mexican American , Other Hispanic, Non-Hispanic White, Non-Hispanic Black and Other Race - Including Multi-Racial"), and level of education at exam (classified as "Less Than 9th Grade", "9-11th Grade", "High School Grad/GED or Equivalent", "Some College or AA – Associate of Arts – degree" and "College Graduate or above") (CDC, 2002).

**Statistical Analysis**

First, the study measured descriptive statistics of the dependent variables (proportions) and independent variables (proportions). Bivariate statistics were then calculated between the dependent and independent variables as chi-squared statistics. The primary purpose of this study

is to know the strength of the association between the visual acuity variables and the independent variables "Level of Education at Exam" and "Income Level" (Annual Household Income). Logistic regression and odds ratios (OR) were used to isolate the effects of education and income independent of the other predictors. To determine the statistical significance of the measure of association, confidence intervals were computed with a-priori significance thresholds set at $p < 0.05$.

## Chapter IV: Results

### Sample Distribution

A total sample of 27,200 was analyzed for this study, represented by 52% female participants (14,121) and 48% male participants (13,079) (see Table 1). Concerning age, the sample was primarily represented by young adult participants aged 18-39 years with 41% of the sample (11,258), 40-59 years with 27% of the sample (7,428), and by older adult participants aged 60 years and older with 31% (8,517). The sample's predominant race/ethnicity was Non-Hispanic White, with 57%, followed by Mexican-American and Non-Hispanic Black, 22.01% and 21.26% respectively. Regarding the level of education, 26% of participants had Some College or AA Degree (6,359) and 24% had high school or equivalent (5,924). Regarding income level, 68.35% of the subjects were in the lower income level group (17,172) and 31.65% were in the higher income level group (7,953). Finally, 91% (22,472) of the sample had normal visual acuity, 7.69% (1,927) had low visual acuity, and 2.58% (645) had severe visual impairment (see Table 1).

### Bivariate Results

During the bivariate analysis, low visual acuity and severe visual impairment were more common in older adults, in participants with low level of education, and in those with lower income (see Table 2). When comparing lower income against the higher income group it was identified that participants in low income households had higher likelihood of low visual acuity compare to the higher income level group (8.70% vs. 5.12%, $\chi^2$= 93.6395, p<.001) and severe visual impairment (3.18% vs 1.20%, $\chi^2$=80.6165, p<.001) but lower likelihood of normal vision (90.74% vs 94.84%, $\chi^2$=115.3418, p<.001). A chi-square test was also carried out for the overall race/ethnicity statistic with the dependent variables. Upon deeper examination with dichotomous group comparisons, it became clear that for normal vision Whites had greater likelihood than other groups (92.36% vs 91.55%, $\chi^2$=5.50, p=0.02) and Hispanics had lower likelihood than other groups

(90.94% vs. 92.32%, $\chi^2$=12.41, p<.001). Regarding low visual acuity, Whites had lower likelihood than other groups (6.65% vs 8.66%, $\chi^2$=35.47, p<.001), and Hispanics had greater likelihood compared to all other groups (9.33% vs 7.08%, $\chi^2$=35.3942, p<0.05). There were no significant racial/ethnic differences for severe vision loss.

It was also evident that the prevalence of normal visual acuity was higher in female participants, with 92.08% than 91.80% in the male group ($\chi^2$=0.6805, p=0.4094). The same was true for the age group 18 to 39 years (95.06%, $\chi^2$=599.3753, p<.001) and for participants with higher education level (some university degree or AA - 93.25%, $\chi^2$=241.0773, p<.001).

**Logistic Regression Results**

There was evidence of a strong inverse association between low visual acuity and severe visual impairment and education level and income (see Table 3). An inverse relationship was seen between the probability of presenting low visual acuity and income level. The lower the income level had higher the plausibility or higher the risk of presenting visual loss, demonstrated by an OR of 1.214 for low visual acuity with lower income level, with 95% confidence intervals between 1.091 and 1.35 (p<0.05), and an OR of 1.442 for severe visual impairment with lower income level, with 95% confidence intervals between 1.186 and 1.752 (p<0.05). A similar phenomenon was seen when assessing the dependent variables' relationship with the participants' education level in this study. An inverse relationship between these variables was also confirmed. It was possible to observe low visual acuity odds of 1.715 for the lowest educational level (less than 9th grade), with a 95% confidence interval between 1.45 and 2.027 (p<.0001). Regarding, severe visual impairment and low education level, the OR was 2.337, with a 95% confidence interval between 1.729 and 3.159 (p<.0001). Additionally, there was a lower likelihood of presenting normal visual

acuity in low educational level participants, with an OR of 0.523 for this relationship, with 95% confidence intervals between 0.441 and 0.621 ($p<.0001$).

The logistic regressions also showed that an increase in age raises the probability of presenting low visual acuity and severe visual impairment. The association between age and severe visual impairment is strong, with an OR of 4.774 and 95% confidence intervals between 3.799 and 6.001 for participants 60 years and older ($p<.0001$). Regarding the demographic variables of gender and race/ethnicity, there is no evidence of association between these variables and the dependent variables.

## Chapter V: Discussion

This research found that the prevalence of severe visual impairment in the sample was 2.58%. This data is taken from a national database (NHANES), and they resemble other estimates of severe visual impairment from former studies. For example, one recent study by Wittenborn and Rein found 2.4% of the U.S. population has severe visual impairment (Wittenborn & Rein, 2014). This is a decrease in visual acuity not meeting the criteria for legal blindness but causing disability, but which negatively impacts both the health and economic system, as well as the quality of life of the people who suffer from it and their families (Jones et al., 2010; Wittenborn et al., 2013).

It is also important to highlight that this study demonstrates that low income levels is a risk factor for developing visual loss, as a result of finding the highest number of people affected by this disorder in the low income groups. Therefore, this study's statistical analysis findings are similar to prior research results (Katibeh et al., 2017; Perruccio et al., 2010; Sung et al., 2017; Yan et al., 2019). The alternate hypothesis was verified based on statistically significant results that the low-income level acts as a risk factor for presenting low vision probability. Therefore, the probability of low vision increases with low-income level. Moreover, this study findings determined that high-income level acts as a protective factor against the probability of presenting low vision, which can be interpreted as: if an individual has high the income level, the probabilities of presenting normal visual acuity are higher than for a person with low-income level.

Another significant finding from the current study, which coincides with Yan et al. in 2019 and other global studies of visual health disparities, is the strong association between low education level and visual acuity. It was found that participants with a lower level of education have a higher

risk of presenting low visual acuity and severe visual impairment. In addition, it was determined that participants with a high level of education were more likely to have normal vision.

The findings obtained in the logistic regression analysis between education and income level may be related because educational attainment and income level are inter-related social determinants of health. Recall that SDH represents barriers to society that impact and affect access to health care and health status (Mogford et al., 2011; National Library of Medicine et al., 2015; Office of Disease Prevention and Health Promotion, 2019). Therefore, it can be said that health literacy is an SDH, in addition to being directly related to educational level affecting people's lives through: a) limiting access to health services, b) impacting health/illness management and decision making, c) influencing nutritional and physical activity choices and practices, d) restricting access to accurate and truthful health care information in written sources, which could be related to low vision (Braveman et al., 2011; Office of Disease Prevention and Health Promotion, 2019; World Health Organization, 2020). Individuals with low income are not equally likely to have access to educational opportunities or quality educational opportunities. Educational attainment has an impact on access to health care, health status, and health outcomes by influencing a chain of factors, such as type of work or working conditions, that affect work resources, benefits, and income level, which impacts health care benefits, such as health insurance, sick or maternity leave, etc. (Braveman et al., 2011; Office of Disease Prevention and Health Promotion, 2019). Socioeconomic status is a multidimensional variable that can be measured in terms of monthly economic income, educational level, and residence place (Office of Disease Prevention and Health Promotion, 2020).

Additionally, this research shows that both female and male participants presented a homogeneous distribution in the presentation of normal visual acuity. However, when comparing

both groups with the dependent variables of interest, more frequently observed women are presenting low visual acuity than men. In contrast, more males are observed with severe visual impairment compared to female participants. These findings contradict the literature reviewed, especially to Zambelli-Wiener (2012), who reviewed numerous studies with an age-adjusted analysis of gender (Zambelli-Weiner et al., 2012).

Furthermore, the negative relationship between age and visual loss found in this study are consistent with the results obtained by Katibeh et al. in 2017 (Katibeh et al., 2017). Regarding the demographic variable of race/ethnicity, it is showed that Hispanic participants have higher probabilities to be more affected by vision loss and visual impairment than other ethnic groups, while White participants were more likely to have normal vision and less likely to have low visual acuity. The rationale that the Hispanic population faces more disparities related to visual loss than Non-Hispanic Whites may be based on language barriers, immigration status, obstacles to accessing eye-health services, and health care costs (Becerra et al., 2017; Schenker et al., 2015; U.S. Centers for Medicare & Medicaid Services, 2020). In the U.S., health programs and policies such as Medicaid, Medicare, and CHIP exist to provide opportunities for low-income individuals who do not have the opportunity to enroll in private insurance (Schenker et al., 2015; U.S. Centers for Medicare & Medicaid Services, 2020). However, Hispanic individuals who are undocumented do not have access to these programs. Consequently, due to their immigration status, many Hispanic migrants are self-employed, being victims of employers who take advantage of their situation to obtain low-cost labor, preventing access to high-cost services (Schenker et al., 2015). Finally, the lack of knowledge about available health services due to the language barrier is another obstacle to consider (Becerra et al., 2017). The deficiency of awareness in culturally, linguistically,

and literacy appropriate health care services embodies a portion of the factors that may be impacting the Hispanic population (Becerra et al., 2017).

Moreover, this study's limitations were mainly due to the secondary use of measurement instruments and data from a previous data collection study. In the future, it is recommended to conduct primary data collection research that will allow researchers to develop their own measurement tool. However, this study is of great value because it examined socioeconomic disparities in visual health using a nationally-representative study in the U.S., which had not been done before. Finally, this study took the data based on annual household income instead of measuring individual annual income. Thus, it is recommended to create an instrument that measures the participants' individual income and, at the same time, their visual acuity to obtain a more accurate statistical analysis and results. Relatedly, it is impossible to establish causality and temporality of the relationship between socioeconomic status and visual acuity as visual disability can impair economic opportunities (Pascolini & Mariotti, 2012; World Health Organization, 2019). Future studies might measure income dynamically as it changes over the course of time and how that predicts changes in visual acuity. Finally, the contradiction of this study's results with other studies related to gender is another limitation. Therefore, it is recommended to investigate this deeply in the future by implementing age-adjusted analysis of this demographic variable, like it is mentioned in Zambelli-Wiener's review (Zambelli-Weiner et al., 2012).

To expand the knowledge available in this field, we also need to add to future questionnaires the use of visual health services and analyze its relationship to educational level, income level, and demographic variables manifested as risk factors. Hence, the relationship between income level, education, and access to eye care services, whether through a third-party (health insurance) or not (self-pay), could be examined and verified. It is possible that access to

eye care services mediate the relationships we see in the current study between socioeconomic status and visual health.

**Conclusions**

Visual health promotion, health education, and prevention aimed at early diagnosis and timely correction of refractive disorders in society is essential and can help maintain good visual health, reduce visual impairment, prevent blindness, and directly impact life quality. Therefore, it can be concluded that visual disorders are influenced by structural and standard social determinants of health, modifiable with actions related to education level/attainment and socioeconomic status (represented in this study by income level). Therefore, public health policies about socioeconomic status should be included to improve communities' quality of life and reduce preventable low vision and visual impairment. For example, one contributing factor that could not measure in this study was insurance status. Providing universal insurance to increase access and universal coverage in healthcare, including eye care, could mitigate the economic disparities we see in visual health. Accordingly, it is essential that visual health teams realize that they constitute fundamental and irreplaceable rights of their patients, and that they develop programs, campaigns, and workshops for education and promotion of visual health. Communities need to be made aware of the significance of periodic ophthalmologic exams, and the public health and healthcare systems must provide all the means and human resources necessary for treating eye diseases and the preventing the disabling complications that interfere with a harmonious life in society.

The deficiencies experienced by specific socially vulnerable populations and individuals place them in circumstances in which they have greater social and health needs. Not being able to access quality visual health services, treatments, and technologies harm these social groups' eye health outcomes and quality of life. Hence, these socially vulnerable groups have more significant

visual health needs due to the enormous deficits to which they are subjected. They should have more access to health services, treatments, and technologies. However, what happens in practice is not exactly what should be, including the noticeable imbalance of socioeconomic status groups and their access to visual health care. Thus, in order to resolve the inequities in visual health and access to visual healthcare, it is necessary to address inequities and create inter-sectoral instances that go beyond the field of health. All sectors must combine their resources to shape public policies that promote and guarantee the full enjoyment of social rights, especially health, by all people in our society and the community of this planet. This is a considerable challenge for all of us in the next decades.

## List of Tables

**Table 1: Sample Distribution Table from NHANES 1999-2008**

| Demographic Variables and Predictors | | |
|---|---|---|
| | **Frequency** | **Percent** |
| **Age Groups** | | |
| 18 to 39 years old | 11,258 | 41.39% |
| 40 to 59 years old | 7,425 | 27.30% |
| 60 years and older | 8,517 | 31.31% |
| ***Total*** | 27,200 | 100.00% |
| **Gender** | | |
| Male | 13,079 | 48.08% |
| Female | 14,121 | 51.92% |
| ***Total*** | 27,200 | 100.00% |
| **Race/Ethnicity** | | |
| Mexican American | 5,986 | 22.01% |
| Other Hispanic | 1,552 | 5.71% |
| Non-Hispanic White | 12,825 | 47.15% |
| Non-Hispanic Black | 5,782 | 21.26% |
| Other Race - Including Multi-Racial | 1,055 | 3.80% |
| ***Total*** | 27,200 | 100.00% |
| **Level of Education at Exam** | | |
| Less Than 9th Grade | 3,604 | 14.62% |
| 9-11th Grade | 4,143 | 16.81% |
| High School Grad/GED or Equivalent | 5,924 | 24.03% |
| Some College or AA degree | 6,395 | 25.95% |
| College Graduate or above | 4,582 | 18.59% |
| ***Total*** | 24,648 | 100.00% |
| **Income Level** | | |
| Lower Income Level | 17,172 | 68.35% |
| Higher Income Level | 7,953 | 31.65% |
| ***Total*** | 25,125 | 100.00% |
| **Dependent Variables** | | |
| | **Frequency** | **Percent** |
| **Normal Visual Acuity** | | |
| No | 1,969 | 8.06% |
| Yes | 22,472 | 91.94% |
| ***Total*** | 24,441 | 100.00% |
| **Low Visual Acuity** | | |
| No | 23,117 | 92.31% |
| Yes | 1,927 | 7.69% |
| ***Total*** | 25,044 | 100.00% |
| **Severe Visual Impairment** | | |
| No | 24,399 | 97.42% |
| Yes | 645 | 2.58% |
| ***Total*** | 25,044 | 100.00% |

**Table 2: Bivariate Analyses of Visual Acuity from NHANES data 1999-2008 in the U.S. adult population**

| Dependent Variables by Predictors Table | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Visual Acuity** | **Normal Visual Acuity** | | | | **Low Visual Acuity** | | | | **Severe Visual Impairment** | | | |
| | **Yes** | | **Chi-Sq** | **P-Value** | **Yes** | | **Chi-Sq** | **P-Value** | **Yes** | | **Chi-Sq** | **P-Value** |
| **Predictor** | **Fq** | **%** | | | **Fq** | **%** | | | **Fq** | **%** | | |
| ***Level of Education at Exam*** | | | 241.0773 | <.0001 | | | 208.6762 | <.0001 | | | 170.8467 | <.0001 |
| Less Than 9th Grade | 2,466 | 84.92% | | | 414 | 13.54% | | | 178 | 5.82% | | |
| 9-11th Grade | 3,299 | 90.56% | | | 319 | 8.49% | | | 138 | 3.67% | | |
| High School Grad/GED or Equivalent | 4,939 | 91.73% | | | 416 | 7.57% | | | 138 | 2.51% | | |
| Some College or AA degree | 5,526 | 93.25% | | | 381 | 6.33% | | | 109 | 1.81% | | |
| College Graduate or above | 4,050 | 94.49% | | | 218 | 5.04% | | | 60 | 1.39% | | |
| ***Income Level*** | | | 115.3418 | <.0001 | | | 93.6395 | <.0001 | | | 80.6165 | <.0001 |
| Lower Income Level | 13,811 | 90.74% | | | 1,364 | 8.70% | | | 499 | 3.18% | | |
| Higher Income Level | 7,075 | 94.84% | | | 387 | 5.12% | | | 91 | 1.20% | | |
| **Demographic Variable by Dependent Variable Table** | | | | | | | | | | | | |
| **Visual Acuity** | **Normal VABE** | | | | **Not Severe VABE** | | | | **Severe VABE** | | | |
| | **Yes** | | **Chi-Sq** | **P-Value** | **Yes** | | **Chi-Sq** | **P-Value** | **Yes** | | **Chi-Sq** | **P-Value** |
| **Variable** | **Fq** | **%** | | | **Fq** | **%** | | | **Fq** | **%** | | |
| ***Age Groups*** | | | 599.3753 | <.0001 | | | 238.9898 | <.0001 | | | 411.2519 | <.0001 |
| 18 to 39 years old | 9,696 | 95.06% | | | 669 | 6.39% | | | 105 | 1.00% | | |
| 40 to 59 years old | 6,453 | 94.27% | | | 374 | 5.39% | | | 111 | 1.60% | | |
| 60 years and older | 6,323 | 85.49% | | | 884 | 11.59% | | | 429 | 5.62% | | |
| ***Gender*** | | | 0.6805 | 0.4094 | | | 0.4529 | 0.5010 | | | 2.894 | 0.0889 |
| Male | 10,887 | 91.80% | | | 920 | 7.58% | | | 334 | 2.75% | | |
| Female | 11,585 | 92.08% | | | 1,007 | 7.80% | | | 311 | 2.41% | | |
| ***Race/Ethnicity*** | | | 14.0376 | 0.0072 | | | 54.4829 | <.0001 | | | 4.5944 | 0.3315 |
| Mexican American | 4,794 | 91.14% | | | 482 | 8.87% | | | 155 | 2.85% | | |
| Other Hispanic | 1,227 | 90.15% | | | 157 | 11.06% | | | 36 | 2.54% | | |
| Non-Hispanic White | 10,936 | 92.36% | | | 800 | 6.65% | | | 292 | 2.43% | | |
| Non-Hispanic Black | 4,669 | 92.27% | | | 401 | 7.69% | | | 143 | 2.74% | | |
| Other Race - Including Multi-Racial | 846 | 91.96% | | | 87 | 9.14% | | | 19 | 2.00% | | |

**Table 3: Logistic Regression Models of Visual Acuity from NHANES Data 1999-2008 in the U.S. Adult Population**

| Variable | Normal Visual Acuity | | | | Low Visual Acuity | | | | Severe Visual Impairment | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | | P Value | OR | 95% CI | | P Value | OR | 95% CI | | P Value |
| ***Age Groups*** | | | | | | | | | | | | |
| 40 to 59 years old | 0.889 | 0.774 | 1.021 | 0.0970 | 0.823 | 0.72 | 0.941 | 0.0043 | 1.527 | 1.162 | 2.006 | 0.0024 |
| 60 years and older | ***0.349*** | ***0.31*** | ***0.393*** | <.0001 | ***1.749*** | ***1.559*** | ***1.961*** | <.0001 | ***4.774*** | ***3.799*** | ***6.001*** | <.0001 |
| ***Gender*** | | | | | | | | | | | | |
| Female | 1.027 | 0.935 | 1.129 | 0.5728 | 1.035 | 0.942 | 1.137 | 0.4735 | 0.889 | 0.758 | 1.042 | 0.1473 |
| ***Race/Ethnicity*** | | | | | | | | | | | | |
| Mexican American | 1.167 | 0.896 | 1.52 | 0.2535 | 0.783 | 0.613 | 1.002 | 0.0516 | 0.98 | 0.598 | 1.605 | 0.9347 |
| Other Hispanic | 0.982 | 0.725 | 1.331 | 0.9089 | 1.067 | 0.807 | 1.412 | 0.6483 | 0.937 | 0.53 | 1.658 | 0.8232 |
| Non-Hispanic White | 1.323 | 1.028 | 1.703 | 0.0296 | 0.632 | 0.499 | 0.799 | 0.0001 | 0.886 | 0.551 | 1.427 | 0.6193 |
| Non-Hispanic Black | 1.212 | 0.931 | 1.579 | 0.1534 | 0.763 | 0.596 | 0.975 | 0.0308 | 1.087 | 0.665 | 1.777 | 0.7381 |
| ***Level of Education at Exam*** | | | | | | | | | | | | |
| Less Than 9th Grade | ***0.523*** | ***0.441*** | ***0.621*** | <.0001 | ***1.715*** | ***1.45*** | ***2.027*** | <.0001 | ***2.337*** | ***1.729*** | ***3.159*** | <.0001 |
| 9-11th Grade | ***0.685*** | ***0.581*** | ***0.808*** | <.0001 | ***1.228*** | ***1.045*** | ***1.442*** | 0.0124 | ***1.985*** | ***1.482*** | ***2.657*** | <.0001 |
| High School Grad/GED or Equivalent | ***0.754*** | ***0.647*** | ***0.877*** | 0.0003 | ***1.178*** | ***1.017*** | ***1.366*** | 0.0292 | ***1.428*** | ***1.073*** | ***1.899*** | 0.0144 |
| Some College or AA degree | ***0.843*** | ***0.724*** | ***0.982*** | 0.0284 | 1.04 | 0.897 | 1.206 | 0.6026 | 1.2 | 0.894 | 1.611 | 0.2257 |
| ***Income Level*** | | | | | | | | | | | | |
| Lower Income Level | ***0.822*** | ***0.739*** | ***0.915*** | 0.0003 | ***1.214*** | ***1.091*** | ***1.35*** | 0.0004 | ***1.442*** | ***1.186*** | ***1.752*** | 0.0002 |

**References**


Bailey, R. N., Indian, R. W., Zhang, X., Geiss, L. S., Duenas, M. R., Saaddine, J. B., & Centers for Disease Control and Prevention. (2006). Visual impairment and eye care among older adults—Five States, 2005. *MMWR. Morbidity and Mortality Weekly Report*, *55*(49), 1321–1325.

Bastawrous, A., & Suni, A.-V. (2020). Thirty Year Projected Magnitude (to 2050) of Near and Distance Vision Impairment and the Economic Impact if Existing Solutions are Implemented Globally. *Ophthalmic Epidemiology*, *27*(2), 115–120. https://doi.org/10.1080/09286586.2019.1700532

Becerra, B. J., Arias, D., & Becerra, M. B. (2017). Low Health Literacy among Immigrant Hispanics. *Journal of Racial and Ethnic Health Disparities*, *4*(3), 480–483. https://doi.org/10.1007/s40615-016-0249-5

Braveman, P., Egerter, S., & Williams, D. R. (2011). The social determinants of health: Coming of age. *Annual Review of Public Health*, *32*, 381–398. https://doi.org/10.1146/annurev-publhealth-031210-101218

Centers for Disease Control and Prevention - CDC. (2002). *NHANES 1999-2000 Demographics Data*. https://wwwn.cdc.gov/Nchs/Nhanes/Search/DataPage.aspx?Component=Demographics&CycleBeginYear=1999

Centers for Disease Control and Prevention - CDC. (2005). *NHANES 1999-2000: Vision Data Documentation, Codebook, and Frequencies*. https://wwwn.cdc.gov/Nchs/Nhanes/1999-2000/VIQ.htm

Chan, T., Friedman, D. S., Bradley, C., & Massof, R. (2018). Estimates of Incidence and Prevalence of Visual Impairment, Low Vision, and Blindness in the United States. *JAMA Ophthalmology*, *136*(1). https://doi.org/10.1001/jamaophthalmol.2017.4655

Chou, C.-F., Cotch, M. F., Vitale, S., Zhang, X., Klein, R., Friedman, D. S., Klein, B. E. K., & Saaddine, J. B. (2013). Age-Related Eye Diseases and Visual Impairment Among U.S. Adults. *American Journal of Preventive Medicine*, *45*(1), 29–35. https://doi.org/10.1016/j.amepre.2013.02.018

Congdon, N., O'Colmain, B., Klaver, C. C. W., Klein, R., Muñoz, B., Friedman, D. S., Kempen, J., Taylor, H. R., Mitchell, P., & Eye Diseases Prevalence Research Group. (2004). Causes and prevalence of visual impairment among adults in the United States. *Archives of Ophthalmology (Chicago, Ill.: 1960)*, *122*(4), 477–485. https://doi.org/10.1001/archopht.122.4.477

Eckert, K. A., Carter, M. J., Lansingh, V. C., Wilson, D. A., Furtado, J. M., Frick, K. D., & Resnikoff, S. (2015). A Simple Method for Estimating the Economic Cost of Productivity Loss Due to Blindness and Moderate to Severe Visual Impairment. *Ophthalmic Epidemiology*, *22*(5), 349–355. https://doi.org/10.3109/09286586.2015.1066394

Jones, G. C., Crews, J. E., & Danielson, M. L. (2010). Health risk profile for older adults with blindness: An application of the International Classification of Functioning, Disability, and Health framework. *Ophthalmic Epidemiology*, *17*(6), 400–410. https://doi.org/10.3109/09286586.2010.528137

Katibeh, M., Rajavi, Z., Yaseri, M., Hosseini, S., Hosseini, S., Akbarian, S., & Sehat, M. (2017). Association of Socio-Economic Status and Visual Impairment: A Population-Based

Study in Iran. *Archives of Iranian Medicine*, *20*(1), 43–48. https://doi.org/0172001/AIM.0010

Köberlein, J., Beifus, K., Schaffert, C., & Finger, R. P. (2013). The economic burden of visual impairment and blindness: A systematic review. *BMJ Open*, *3*(11). https://doi.org/10.1136/bmjopen-2013-003471

Mogford, E., Gould, L., & DeVoght, A. (2011). Teaching critical health literacy in the US as a means to action on the social determinants of health. *Health Promotion International*, *26*(1), 4–13. https://doi.org/10.1093/heapro/daq049

National Library of Medicine, Logan, R. A., Wong, W. F., Kaiser Permanente, Villaire, M., Institute for Healthcare Advancement, Daus, G., Health Resources and Services Administration, Parnell, T. A., Health Literacy Partners, Willis, E., Medical College of Wisconsin, Paasche-Orlow, M. K., & Boston University School of Medicine. (2015). Health Literacy: A Necessary Element for Achieving Health Equity. *NAM Perspectives*, *5*(7). https://doi.org/10.31478/201507a

Office of Disease Prevention and Health Promotion. (2019, April 1). *Healthy People 2020*. https://www.cdc.gov/nchs/healthy_people/hp2020.htm

Office of Disease Prevention and Health Promotion. (2020). *Healthy People 2020* |. https://www.healthypeople.gov/

Pascolini, D., & Mariotti, S. P. (2012). Global estimates of visual impairment: 2010. *The British Journal of Ophthalmology*, *96*(5), 614–618. https://doi.org/10.1136/bjophthalmol-2011-300539

Perruccio, A. V., Badley, E. M., & Trope, G. E. (2010). A Canadian population-based study of vision problems: Assessing the significance of socioeconomic status. *Canadian Journal*

*of Ophthalmology. Journal Canadien D'ophtalmologie*, *45*(5), 477–483. https://doi.org/10.3129/i10-061

Rein, D. B., Wittenborn, J. S., Zhang, X., Honeycutt, A. A., Lesesne, S. B., Saaddine, J., & Vision Health Cost-Effectiveness Study Group. (2009). Forecasting age-related macular degeneration through the year 2050: The potential impact of new treatments. *Archives of Ophthalmology (Chicago, Ill.: 1960)*, *127*(4), 533–540. https://doi.org/10.1001/archophthalmol.2009.58

Schenker, M., Castaneda, X., & Wallace, S. (2015). *Migration and Health: Profile of Latin Americans in the United States*. UCLA Center for Health Policy Research. https://healthpolicy.ucla.edu/publications/Documents/PDF/2015/migration-report-oct2015.pdf

Sung, H., Shin, H. H., Baek, Y., Kim, G. A., Koh, J. S., Park, E.-C., & Shin, J. (2017). The association between socioeconomic status and visual impairments among primary glaucoma: The results from Nationwide Korean National Health Insurance Cohort from 2004 to 2013. *BMC Ophthalmology*, *17*. https://doi.org/10.1186/s12886-017-0551-y

U.S. Centers for Medicare & Medicaid Services. (2020). *Coverage for lawfully present immigrants*. HealthCare.Gov. https://www.healthcare.gov/immigrants/lawfully-present-immigrants/

Weinreb, R. N., Aung, T., & Medeiros, F. A. (2014). The Pathophysiology and Treatment of Glaucoma. *JAMA*, *311*(18), 1901–1911. https://doi.org/10.1001/jama.2014.3192

West, S., & Sommer, A. (2001). Prevention of blindness and priorities for the future. *Bulletin of the World Health Organization*, *79*(3), 244–248.

Wittenborn, J. S., Zhang, X., Feagan, C. W., Crouse, W. L., Shrestha, S., Kemper, A. R., Hoerger, T. J., & Saaddine, J. B. (2013). The Economic Burden of Vision Loss and Eye Disorders among the United States Population Younger than 40 Years. *Ophthalmology*, *120*(9), 1728–1735. https://doi.org/10.1016/j.ophtha.2013.01.068

Wittenborn, & Rein, D. (2014). *The Future of Vision: Forecasting the Prevalence and Costs of Vision Problems—Vision Impact Institute*. https://visionimpactinstitute.org/wp-content/uploads/2019/02/The-Future-of-Vision_Forecasting-the-Prevalence-and-Costs-of-Vision-Problems.pdf

Wong, W. L., Su, X., Li, X., Cheung, C. M. G., Klein, R., Cheng, C.-Y., & Wong, T. Y. (2014). Global prevalence of age-related macular degeneration and disease burden projection for 2020 and 2040: A systematic review and meta-analysis. *The Lancet. Global Health*, *2*(2), e106-116. https://doi.org/10.1016/S2214-109X(13)70145-1

World Health Organization. (2010a). *A conceptual framework for action on the social determinants of health: Debates, policy & practice, case studies.* http://apps.who.int/iris/bitstream/10665/44489/1/9789241500852_eng.pdf

World Health Organization. (2010b). *Global data on visual impairment*. http://www.who.int/blindness/publications/globaldata/en/

World Health Organization. (2019, October 8). *World Report on Vision*. https://www.who.int/publications-detail/world-report-on-vision

World Health Organization. (2020). *Constitution*. https://www.who.int/about/who-we-are/constitution

Yan, X., Chen, L., & Yan, H. (2019). Socio-economic status, visual impairment and the mediating role of lifestyles in developed rural areas of China. *PLoS ONE*, *14*(4). https://doi.org/10.1371/journal.pone.0215329

Zambelli-Weiner, A., Crews, J. E., & Friedman, D. S. (2012). Disparities in Adult Vision Health in the United States. *American Journal of Ophthalmology*, *154*(6, Supplement), S23-S30.e1. https://doi.org/10.1016/j.ajo.2012.03.018