UNIVERSITY OF CALIFORNIA,
IRVINE

# Racial and Ethnic Disparities in Prevalence of Self-Reported Visual Impairment and Eye Care Utilization among U.S. Adults

THESIS

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MASTER OF SCIENCE

in Biomedical and Translational Science

by

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# ABSTRACT OF THE THESIS

Racial and Ethnic Disparities in Prevalence of Self-Reported Visual Impairment and Eye Care Utilization among U.S. Adults

By

Kaili Ding

Master of Science in Biomedical and Translational Science

University of California, Irvine, 2016

Professor John Billimek, Chair

**Purpose**: The purpose of this study is to examine the disparities in visual impairment, annual eye care visits, and eyeglass affordability by race/ethnicity and associated covariates among the United States (U.S.) adult population.

**Method**: The combined sample size of six years' NHIS data was 199,622, which represented 241,555,788 U.S. adults population each year. The prevalence of were standardized to the 2014 U.S. Census population. Multivariable logistic regression models were built to calculate adjusted odds ratios to find the potential explanations for the disparities. Weighted least squares linear regression was used to estimate the linear trends of the prevalence.

**Results**: For adults age ≥18, there were significant disparities in the prevalence of self-reported visual impairment (VI) and eye care utilization between different racial and ethnic groups. Associated covariates each carried an independent association with the disparities, and provided some understanding in racial and ethnic disparities. There was no trend of visual impairment, but an increasing trend of annual eye doctor visits and a decreasing trend of being unable to afford eyeglasses during the past six years.

**Conclusions**: There were disparities in visual impairment and eye care utilization among U.S. adults by race and ethnicity. The associated covariates contributed to racial and ethnic disparities. There was an increasing trend of annual eye doctor visits and a decreasing trend of being unable to afford eyeglasses among the U.S. adults. More research is imperative to understand the underlying reasons and mechanisms. Innovative interventions are needed to reduce unnecessary vision loss among high-risk groups.

# CHAPTER 1: INTRODUCTION

## 1. Visual Impairment

Visual impairment is a severe reduction in vision that cannot be corrected with standard glasses or contact lenses and reduces a person's ability to accomplish certain tasks. Visual impairment is associated with poor self-reported health status and low quality of life. [1] It increases the risk of falling [2-4] and social isolation, [5] and also increased the risk of death. [6] Visual impairment ranks among the top 10 disabilities among U.S. residents aged 18 years or older. According to national data from Centers for Disease Control and Prevention, more than 14 million Americans aged 12 years or older reported to have visual impairment or blindness (vision acuity <20/50). [7-8] However, approximately 80% of blindness or visual impairment could be prevented by early detection and timely intervention. [9] According to a report in 2007, visual impairment costs $51.4 billion annual burden to the U.S. economy, [10] including the burden of direct medical costs at $16 billion, [11] and the financial burden to individual caregivers and other healthcare payers at $35.4 billion. [12] Visual impairment is disproportionately represented among different groups. One of the overarching goals of Healthy People 2010/2020 is to eliminate these disparities, but knowledge gaps exist in both our understanding of vision health disparities and our ability to detect and monitor trends.

## 2. Visual Impairment Disparities

Disparities in visual impairment have been observed based on race, age, sex, and sociodemographic, access to care, and geographic factors. The following paragraphs present the existing knowledge on visual impairment disparities and try to identify a knowledge gap to improve the vision health of the U.S. population.

### 2.1 Racial and Ethnic Disparities

Racial and ethnic disparities in visual impairment have been widely documented. The National Center for Health Statistics (NHCS) reported that blacks and Mexican Americans are more likely to be visually impaired than whites. [13] According to Eye Diseases Prevalence Research Group (EDPRG), the prevalence of age-specific blindness was highest among blacks compared with whites or Hispanics, whereas the prevalence of low vision was the highest among Hispanics. [14] There were also significant racial and ethnic disparities in the prevalence of self-reported visual impairment. One study found that among adults (18 years of age and older), the age-adjusted prevalence of visual impairment or blindness was higher among blacks than whites, but that Hispanics and whites had similar prevalence rates. [15]

There is mounting evidence that indicate the racial and ethnic difference in the prevalence of visual impairment, but there is some uncertainty. Moreover, current information about the inherent characteristics of racial and ethnic minorities in the U.S. does not fully explain the health disparities experienced by these groups. Other associated covariates apparently contribute to racial and ethnic disparities in visual impairment.

## 2.2 Associated Covariates

Sociodemographic factors such as age, gender, education, income, and regions play a role in the racial and ethnic disparities of visual impairment. A paper concluded that visual impairment increased with age. A review published three years ago studied the social inequalities in visual impairment and blindness. The article reported that women have a higher rate of visual impairment and blindness than men. There is an indisputable relationship between lower socioeconomic status and the higher rate of blindness. Similarly, the developing countries have a higher prevalence of blindness compared to the developed countries. In comparison, those with a higher education level, and the non-manual occupational social class had a lower prevalence of visual impairment and blindness. Geographical inequality and visual impairment were associated with income (regional, national or continental), living in rural areas, and suggested the socioeconomic and political context of the association. [16-17] Giving the fact, that different racial and ethnic groups do not share the same sociodemographic characteristics. Various data indicated that the contribution of these associated covariates to the racial and ethnic visual impairment differences.

Sociodemographic factors were strongly related to race and ethnicity in the United States, but the role of socioeconomic factors play on racial and ethnic health differences is complex. Many studies have documented that the low socioeconomic status is an important partial explanation why blacks have poorer health outcomes when compared to whites. Studies have also pointed out that socioeconomic differences often do not fully explain all health differences between African Americans and non-Hispanic whites. Blacks/whites differences in health

outcomes still exist after adjustment of socioeconomic conditions. [18] Asian Americans' comparatively high socioeconomic status has been suggested as a contributor of this group's better health. The similar inconclusive results could also be found in the relationship between visual impairment disparities and associated variables. [19]

Some confusion regarding the role of associated variables on the racial and ethnic visual impairment disparities also exists. Limited studies are available. Also, many studies reported the consistent disparities, but some studies showed there were no significant difference in the prevalence between ethnic or racial minorities and Caucasian populations. Besides, not all the studies adjusted for socioeconomic position variables when they made the comparisons.

More research is needed to draw more accurate conclusions to fully understand the racial and ethnic visual impairment disparities, as well as the potential power of the associated covariates in contributing the current difference.

## 3. Eye Care Utilization Disparities

Disparities in eye care utilization by race and ethnicity, age, gender, education, and income as well as insurance coverage have been documented in the U.S. [20-23]
The following paragraphs present the current understanding of the eye care utilization disparities.

### 3.1 Racial and Ethnic Disparities

Race is a significant variable in eye care utilization. African Americans and Hispanics are significantly less likely to participate in vision screenings or use eye care services. [24-29] Studies such as the Salisbury Eye Evaluation Study [30] tried to identify the underlying causes of visual impairment and blindness in older Americans and found more than 50% of the conditions were either surgically treatable or potentially preventable. Other than race, other factors also play a large role in these racial and ethnic disparities.

### 3.2 Associated Covariates and Eye Care Utilization

The following associated factors are heavily correlated with race, making the racial and ethnic differences seen in health care partly sustained by socioeconomic factors. Eye care access and utilization in the United States vary according to factors such as race, age, sex, education, income, insurance, and awareness of preexisting vision or eye problems. [24-29] Low-socioeconomic status appears to be independently associated with increased visual impairment,

placing disadvantaged ethnic minorities at highest risk. [34-35] A considerable proportion of people suffered from vision loss have difficulty attaining the eye care services they need. About 8.2% of Americans with self-reported visual problems have no health insurance. These uninsured Americans have the lowest rate of eye care services utilization (42%) compared with Americans with private health insurance (67%) or public health insurance (55%). (Health insurance coverage and use of eye care services.) [36]

Health disparities in the use of vision and eye care may lead to the potential negative impact on public health. Increased health care costs linked to consecutive invalid providance for health care services and inadequate management of eye disease put a huge challenge to vision health in the future. Those from disadvantaged, underserved population or those not covered by the health insurance will continue contributing to the current racial and ethnic vision health disparities, increasingly burdening public health.

### 4. Gaps in Knowledge

Although many studies have shown that the prevalence of visual impairment and eye care utilization differ between racial or ethnic groups, not all of them take those associated covariates into consideration. It is unclear what demographic, socioeconomic and access to care variables explain these disparities. Further comprehensive study is required to draw an accurate conclusion.

## 5. Vision Objectives

Healthy People 2010/2020 launched a goal for national prevention of visual diseases with an objective to identify opportunities in order to improve the health of all Americans. [37-39] Those efforts included the elimination of disparities in health status against those of specific race/ethnicity, gender, sexual identity, age, disability, socioeconomic status, and geographic location. Closing and narrowing visual health disparities gap will improve the nation's vision and eye health tremendously. [40-41]

## 6. Study Objectives

Although some studies show that different racial and ethnic groups have different prevalence of visual impairment and eye care services utilization, some confusion remains regarding race and ethnicity, and the other associated covariates. Not all the study adjusted for socioeconomic position variables. It is still difficult to determine whether the prevalence of visual impairment or blindness disparities that are truly inherent in a racial or ethnic population or the difference is due to low socioeconomic position and marginalization which a specific racial group was exposed to. In the lack of monitoring, limited data or trends present enormous obstacles to vision health disparities tracking. More comprehensive studies would need to draw accurate conclusions and reveal some underlying reasons.

The purpose of this study is to describe not only the prevalence and the trends of visual impairment and eye care utilization among U.S. adult population, but also try to identify potential opportunities for improvement in vision health. The study also intends to unearth the underlying issues that deal with the racial and ethnic disparities in vision health. The models we built adjusted for the associated variables such as demographic factors, socioeconomic status, and eye care access step by step. This method is used to decide how much of the association is due to the inherent racial or ethnic and what percentages are caused by socioeconomic status or lack of eye care services for various reasons. The final objective is to promote policy development and implementation, programmatic decision-making, proper interventions, as well as stimulate research in visual impairment to ensure the best possible vision for all people, thereby improving their quality of life.

# CHAPTER 2: BACKGROUND

This chapter provides an overview of the literature related to this study. There is a great wealth of scientific evidence demonstrating the racial and ethnic disparities in visual impairment and eye care utilization. Research has also highlighted the associated factors that might contribute to the phenomenon.

## 1. Prevalence of Visual Impairment

Visual impairment is a severe reduction in vision function that cannot be corrected with any standard glasses or contact lenses. Thus, it reduces the person's ability to function in certain or all tasks. According to the 2012 World Health Organization (WHO) report, around 285 million people worldwide have visual impairment, including 39 million blind people, and 246 million people with poor vision. However, 80％ of visual impairment can be prevented or cured if diagnosed and intervened at an early time point. [42] In the United States, around 4 million people over 40 years old are visually impaired. Among those people age 40 or older, more than 2.9 million people only have vision acuity less or equal to 20/40 in their better eye with the best correction. Other than those people, around 1.3 million people over 40 years old are legally blind; their vision acuity is less than 20/200, or visual field is less than 20 degrees in diameter even with eyeglasses in the better eye. [43-44]

Regarding specific eye diseases, the leading causes of avoidable visual impairment are cataracts and uncorrected refractive errors, which consist of 33% and 42% of the causes respectively. About 24.4 million people in the U.S. age 40 years or older suffer from cataracts. It is estimated that direct medical costs for cataracts and related intervention are $6.8 billion every year. Myopia is another leading cause of vision problems. It affects more than 34 million people in the U.S. over 40 years old. In addition, it is estimated more than 14 million American people over 40 years old have hyperopia. Approximate 2.7 million Americans over 40 years old suffer from glaucoma. More than 2 million people in the U.S. are diagnosed with advanced AMD when they turn age 50 and older. 7.7 million American people age 40 or older get diabetic retinopathy, and the number of people who get dry eye syndrome is estimated to reach 4.88 million among those over age 50. [45-46] Due to the rapidly aging population with increasing prevalence of other chronic diseases, visual impairment will continue to challenge and devastate the United States health care system.

### 2. Social Burden of Visual Impairment

Visual impairment is not only an individual problem, but also causes a huge social burden to society. One study estimated that the U.S. shoulders social and economic burden caused by patients over age 40 with significant visual impairment totaling approximately $35.4 billion in 2004, including direct medical costs of $16.2 billion, $11.1 billion of other direct costs, and $8 billion cost of productivity loss. Each year, the federal government and state medical institutions pay at least $13.7 billion of these costs. [47]

Another study also suggested that overall vision problems lead to a $139 billion economic burden including direct medical costs of $65 billion, productivity loss of $48 billion, $2 billion informal care costs, and an additional $20 billion in long-term care costs each year. Other costs, including special education, screening, government aid programs, and low vision aid and equipment costs add up to $1.7 billion. Transfer payments and tax breaks cost the government $2.5 billion leading to a total deadweight loss of about $1 billion, a substantial increase of total economic burden on the budget over previous years. [48]

In addition, a study using the Medical Expenses Panel Survey (MEPS) datasets, the Income and Program Participation (SIPP), and the National Health and Nutrition Examination Survey (NHANES) survey data, determined that the total economic burden of vision problems amounted to $450 per person. The annual costs for the visually impaired and blind patients were $15,900 and $26,900 in the U.S. respectively. [49-50] These huge economic burdens caused by vision problems require more surveillance, prophylaxis, diagnosis, intervention, and treatment to prevent future eye diseases and vision loss. Visual impairment can interfere with school [51-53] Early detection can give better management before the diseases progress. However, more efforts are needed to perform the strategies required to prevent or delay the onset of the disease and to preserve a patient's eyesight. Visual impairment imposes a tremendous cost on the U.S. economy. More research is needed to identify the knowledge gaps to address this issue and improve vision health in the United States.

## 3. Evidence for Disparities in the Prevalence of Visual Impairment

Although the burdens of visual impairment are large for the entire United Status population, they are disproportionately distributed among different subsets of the population, including traditionally underserved minority racial and ethnic groups. The causes and consequences of these disproportionate burdens are examined in the study of health disparities, defined by the U.S. Centers for Disease Control and Prevention. Health disparities are defined as "Preventable differences in the presence of disease, injury, violence, health outcomes or access to health care and the opportunities to achieve their optimum health among populations." Health disparities are directly related to the uneven historical and current distribution of social, political, economic and environmental resources. Given the rapid growth of racial and ethnic diversity in the U.S., we already see visual health disparities across different racial and ethnic groups, ages, demographics, sexes, education and income levels, and geographical locations.

### 3.1 Racial and Ethnic Disparities

Studies in visual impairment disparities have been observed to be related to race and ethnicity. A study demonstrated the highest rate of visual impairment in indigenous Americans, followed by Chinese Americans, Puerto Ricans, Dominicans, Central and South Americas in the elderly (aged 65 years and older). [54] However, the Eye Diseases Prevalence Research Group (EDPRG) reported that blacks had the highest age-specific prevalence of blindness (best corrected visual acuity according to the U.S. definition of <20/200 or World Health Organization definition of <20/400 in the better eye) when compared to whites or Hispanics. According to the

U.S. Baltimore Eye Survey, the prevalence of blindness (defined best corrected visual acuity <6/60 in the better eye) among blacks 40 years old or over was 1.75%, which was much higher than whites (0.76%). Another study reported a higher prevalence of blindness among Asian-Indians and African groups when compared to whites. [13] Ryskulova and his colleagues also found that the age-adjusted prevalence of blindness or visual impairment was higher in blacks than whites in U.S. adults (18 years' age and older). The NHCS report had similar finding that blacks (21.1%) and Mexican Americans (24.0%) had higher rates of visual impairment than whites (13.8%). [14-15]

In 2010, a longitudinal study also showed that a higher prevalence of visual impairment in Hispanics than non-Hispanic whites. Another study also reported that low vision prevalence rate (best corrected visual acuity <20/40 in the better eye) was higher in Hispanics. [55] Based on global data on visual impairments 2010 by WHO, the prevalence estimation was 4.82% for Southeast Asian Region (Indian excluded), 3.32% for Western Pacific Region (China excluded), 5.31% for India, and 5.61% for China. [56] Although there are numerous racial and ethnic disparities in visual impairment and outcomes, there are a variaty of demographic, socioeconomic, and access to eye care factors that may explain some of the groups' differences reported in the literature.

## 3.2 Associated Covariates

### 3.2.1 Demographic Factors

Different racial and ethnic groups do not necessarily share a uniform distribution of demographic characteristics. These demographic factors not only differ among racial and ethnic groups but are also associated with different risks for visual impairment. Examining age and gender disparities in the prevalence and management of visual impairment may therefore help explain racial and ethnic disparities in these areas.

#### 3.2.1.1 Age

Numerous studies have shown the association between visual impairment and blindness and age. For example, various epidemiological studies have indicated age-related macular degeneration diagnosis (AMD) is restricted to people over the age of 50 or over, and there is a substantial increase in the risk and prevalence of AMD as people age. [57-58] Also, other diseases such as diabetic retinopathy (DR), glaucoma, cataracts are also age-related eye diseases. Old people have a higher risk of glaucoma; more than 50% of Americans over 80 years old have cataracts. [59-61]

#### 3.2.1.2 Gender

Important inequalities in the prevalence of blindness among sexes have been widely reported. A recent population-based survey published a meta-analysis to assess the relationship between prevalence of blindness and gender. This meta-analysis reported that the rate of age-adjusted blindness was higher in females compared to males worldwide. Taking all the data from all the countries worldwide together, the analysis found that 64.50% of the world's blind population are women. [61] Another systemic review also reported that in the same age group, women's prevalence of blindness was greater than men's in all world regions. According to another meta-analysis, age-adjusted blindness was more common in females than males. [62] Based on population-based data from 1980-2012, the systematic review also reported that blindness prevalence is greater in women than men worldwide even when adjusting for age and the other associated variables. For blindness, the relative difference is higher in high-income regions, and the age-standardized incidence rate of blindness is 1.5 times higher in females than males. [63] The same pattern is also present throughout the United States, two-thirds of the blind and visual impaired population are elderly women. There are 700,000 blind and 2.3 million of visually impaired women populations in the United States. [64] Demographic inequalities were found to exist in the prevalence of visual impairment, and an association with socioeconomic status was also suggested.

### 3.2.2 Socioeconomic Status

Different racial and ethnic groups share different socioeconomic stratification. The differences in socioeconomic status are assumed to provide some explanation of the visual impairment disparities among different racial and ethnic subgroups.

#### 3.2.2.1 Education Levels

A low level of education was found to be associated with higher incidence of visual impairment. A study conducted in Australia, Taiwan, the United States, India, and China reported the same finding. [65] In 1991, studies also observed a reverse association between years of education and the prevalence of visual impairment and blindness, and the prevalence increased with the increased rate of illiteracy in India, Pakistan, Nigeria, and the United States. [66-71]

#### 3.2.2.2 Income

Numerous studies have documented the relationship between visual impairment and income. The Andhra Pradesh Eye Disease Study from India reported that blindness (defined as corrected vision acuity <6/60 or central field of vision <20 degrees in the better eye) reduced the monthly per capita income. Those who classified as extremely low (monthly income per capita <U.S. $4.5) and lower income (monthly income per capita <U.S. $11.3) socioeconomic status have 10 times and 5 times higher risk of blindness, respectively when compared to those belonging to the upper socioeconomic status groups (monthly income per capita > U.S. $45.5).

[72] Similar results were revealed from a study of blindness in elderly people from three communities in the United States. Those from the high-income category were 30% less likely to have functional blindness (best-corrected vision acuity <6/60 in the better eye) compared to those belonging to the low-income category. Similarly, the Beaver Dam study results showed that those with higher incomes were 30% less likely to be blind (best corrected visual acuity <6/60 in the better eye), although this result was not statistically significant. [73] In France and the United States, studies show that people with low vision have less income. In less developed countries, such as Kenya, the Philippines, and Bangladesh, the multivariate analysis reported that, even after adjusting for the other social demographic indicators, and using three different measures of poverty level, there was still a strong association between higher rates of visual impairment and blindness with low-income level. [74]

#### 3.2.2.3 Marital Status

Marital status association with vision impariment has also been documented. Unmarried status is associated with visual impairment, especially among the elderly Malays and Indians. [20] Single people and those who have to live alone compared to those who are in a relationship had a higher prevalence of visual impairment. The Centers for Disease Control (CDC) research center concluded that married people show better physical health compared to those who have never been married. In another study, those who are in relationships or living with other people might benefit from the same health effects of the CDC reporting mechanisms. The results showed that higher marital satisfaction is a protective factor against poorer self-reported functional

limitations and depressive symptoms. These results suggest that a more satisfying marriage may be the key resource for elderly people to buffer the visual dysfunctions. Many studies have emphasised the importance of socioeconomic status in partial explanation for visual impairment. Access to care is also a big contributor to the difference.

### 3.2.3 Access to Eye Care

#### 3.2.3.1 Insurance Coverage and Eye Care Utilization

Vision insurance was found to be independently associated with the prevalence of visual impairment. Approximately 8.2% of Americans with self-reported vision problems did not have health insurance. Only 4% of Americans without health insurance reported having optional vision insurance, compared with 58% of Americans with private health insurance, 44% of Americans with public health insurance, and 54% of Canadians. (National Data from Center for Disease Control and Prevention) Lack of vision insurance impeded eye care utilization, which, in turn, may irrevocably affect vision. All the data suggested insurance status is a critical variable in vision health.

In sum, each associated covariate is reported to be independently associated with visual impairment. The role of socioeconomic factors play in racial and ethnic health differences is inconclusive. We are still unsure about the extent to which associated variables account for these differences in visual impairment. Ambiguity also surrounds the mechanisms through which associated factors promote racial and ethnic differences in visual impairment.

## 4. Evidence for Disparities in the Eye Care Utilization

There are several factors such as race and ethnicity and associated covariates which could influence the utilization of available, accessible, and affordable eye care services. This section will discuss racial and ethnic disparities in eye care utilization and associated contributors such as demographic factors, socioeconomic status, and access to care factors.

### 4.1 Racial and Ethnic Disparities

Race is a significant variable in eye care utilization rates across all groups. Various studies documented that African Americans and Hispanics were less likely to visit eye doctors or have dilated eye examinations than whites, despite the fact that they are more likely to suffer visual impairment and blindness. [24-29] One study examined the affordability of eyeglass, yet it observed only limited racial and ethnic differences in the inability to afford eyeglasses in several years for particular groups. Other factors also play an important role in these racial and ethnic disparities.

### 4.2 Associated Covariates

Where there are accessible and affordable eye care services, there are several factors that may contribute to the racial and ethnic disparities in eye care utilization. Different racial and ethnic groups do not necessarily share the same demography, socioeconomic status, and insurance coverage. These factors are discussed below.

#### 4.2.1 Demographic Factors

##### 4.2.1.1 Age

The risk of visual impairment or blindness increases with age. One study found that the use of eye care increased significantly with age and this was attributed to the fact that most eye diseases manifest themselves during old age. Also, a study reported that the likelihood of using eye care services increased with advancing age due to the higher prevalence of disease such as diabetes, hypertension, cataract, and related maculopathy. [75]

##### 4.2.1.2 Gender

Gender has also been found to influence the use of eye care services. One study reported that women in Iran were more likely to utilize eye care services than men. [76] Also, another study reported that women in Timor-Leste with either low vision or blindness more frequently utilize eye care services than men. Four other studies also reported that women tended to have eye examinations more frequently than men. [77-80]

These reports suggest that demographic factors have an influence on eye care utilization. Although, some racial and ethnic groups may have similar demographic characteristics, the differences in socioeconomic status have been found to influence the use of eye care services.

#### 4.2.2 Socioeconomic Status

Socioeconomic status such as education level and income have been identified to influence the use of eye care services.

##### 4.2.2.1 Education Level

There is a strong association between education and eye care utilization. A study reporetd the higher the level of education, the more likely and timely eye exams are performed, it is less likely that blindness will occur. [81] One two year study found a significant association between educational level and having an eye examination among American women. [82] Among persons with glaucoma in rural South India, a study found that the use of eye care was increased with increasing education. This relationship was attributed to the lack knowledge of how to take care of themselves, as most of the people did not have a higher education or were illiterate. [83] Also individuals with higher education possess greater knowledge and therefore, adopt more reasonable behavior. It was also presumed to be due to the fact that educated people are members of higher socioeconomic classes, thus they may have greater access to eye care services and find them more affordable.

##### 4.2.2.2 Income

Higher utilization of eye care services was documented in people with higher income. One study found that people who were higher earners could better afford health care services. [84] Another study found that individuals with higher income levels were more likely to use eye

care services. [85] Also another study reported that the odds of using eye care increased significantly with higher income. In addition, those with higher household incomes were particularly likely to have frequent eye examinations. [83] One study found an association between eye care utilization with high occupational status and a home ownership. However, another study did not find such an association. [86]

Based on these findings, people with low socioeconomic status, regardless of race or ethnicity, receive less eye care services. More than that, a lack of sufficient insurance was considered the biggest barrier.

### 4.2.3 Insurance Coverage

Insurance status is another related critical variable in eye care utilization. One study found that the uninsured were less likely (42%) to have received a dilated eye exam in the past year compared with those with private insurance (69%). [87] In another study, persons with no health care coverage were twice likely not to have an eye exam in the previous year. [88] In a comparison of lower-income and higher-income uninsured adults, lack of insurance was associated with significantly less use of health care services, including eye exams, when compared to insured adults. Another study showed that individuals of lower socioeconomic status and uninsured individuals were at a higher risk for not having eye examinations. [88]

In sum, significant evidence reveals racial and ethnic disparities in visual impairment and eye care utilization. Researchers should also pay close attention to the contribution of associated demographic factors, socioeconomic status, and access to care factors.

## 5. Model for Analysis of Population Health and Health Disparities

Giving the complexity of the factors contributing to health disparities, we need an appropriate model to study this problem. We propose a conceptual model adapted from a general model proposed by Warnecke et al., which approaches the health disparities question from a multilevel perspective.

In this general model, three primary types of determinants are posited (Figure 1). Distal determinants include the population social environment and policies that affect the social context, as well as the policymaking bodies that influence or determine them. The covariates in this study such as health insurance coverage and actual access to care were used to represent the determinants. Intermediate determinants, the second level of the model, include the immediate social and physical condition as well as social relationships in which the distal effects are experienced, such as the community or neighborhood, this includes marital status. Proximal determinants refer to individual determinants including socioeconomic status (SES), and level of acculturation. Behavioral factors such as diet, exercise, alcohol and tobacco use are also individual-level determinants, as well as cultural beliefs, which mediate behavior and the capacity to respond to health needs. Finally, proximal determinants also include biological and genetic factors such as race/ethnicity, age, and gender. In addition, markers include elevated cholesterol or other indicators of prolonged or intense stress, such as body mass index, high blood pressure, abnormal cells in the cervix, or a lump in the breast. [91]

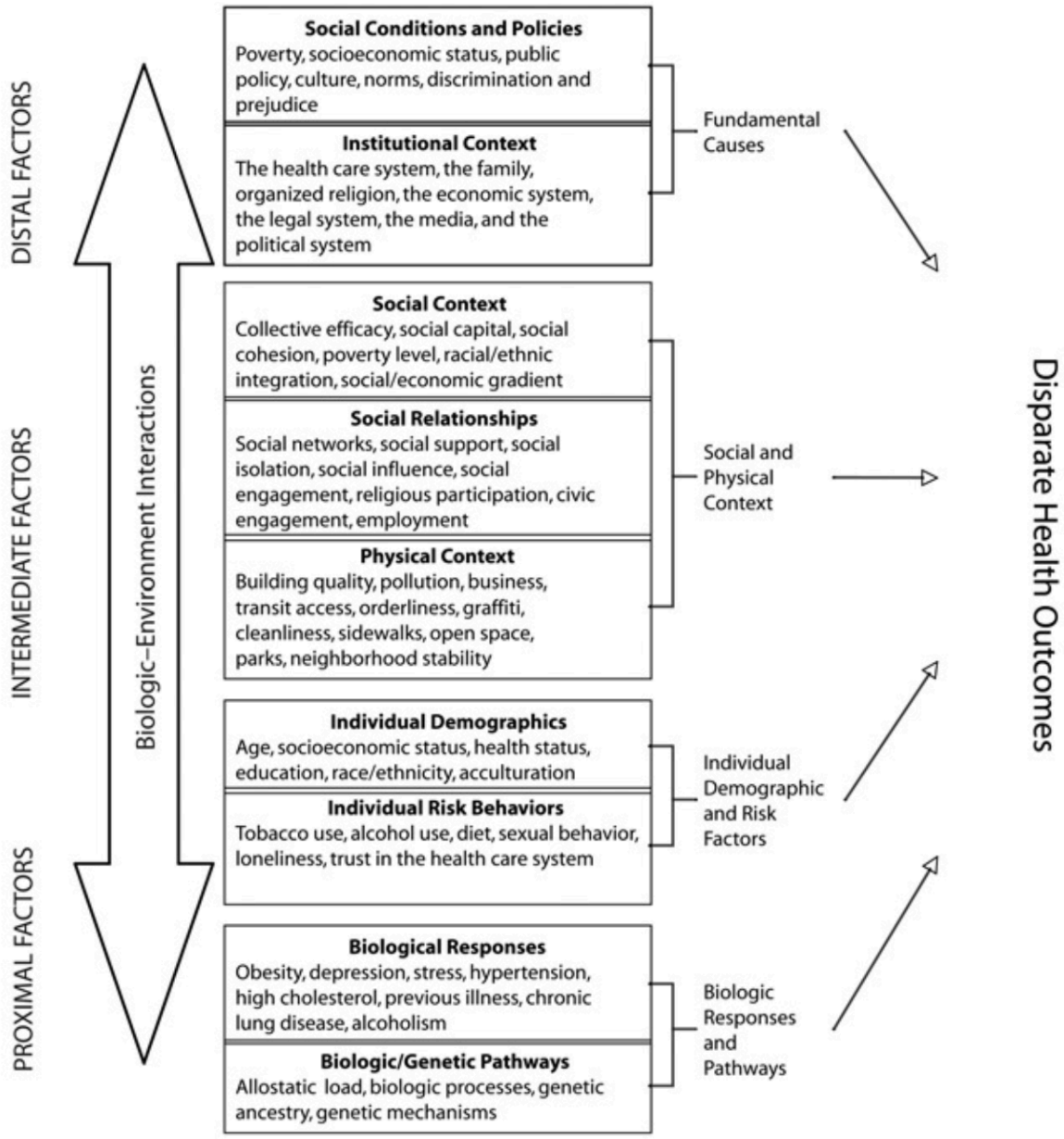



Figure 1. Model for Analysis of Population Health and Health Disparities.

Warnecke et al. AJPH 2008. Approaching Health Disparities from a Population Perspective: The National Institutes of Health Centers for Population Health and Health Disparities. [91]

Adopting this framework of proximal, intermediate and distal factors that drive health disparities, we propose a specific conceptual model to examine disparities in visual impairment. This VI-specific model includes factors that have been implicated as possible contributors to racial/ethnic disparities in VI in prior studies, summarized in this background chapter.

Demographic factors, such as age and gender in a given population, were identified as proximal factors, which represent characteristics that cannot be changed, that may differ between racial and ethnic groups, and may have independent effects on the disparities problem.

Socioeconomic status, such as income and education level in a spesific group, was indentified as an intermediate determinant, which is a sociological construct affecting individuals' capacity to respond to environmental challenges, that may also differ between racial and ethnic groups, and may contribute to the disparity problems. Marital status has also been selected as an intermidated determinants, that could also differ among different racial and ethnic groups, and may also plays a role in the disparity problem.

Health care contextual factors, such as health insurance coverage and actual access to care, were examined in this study as distal determinants in our model, which presents how health care is organized, covered, and accessed, that may also differ between racial and ethnic groups, and also shape disparities as do proximal and intermediate factors.

We try to focus the visual impairment and eye care utilization differences from individual characteristics to social relationship contexts, from internal factors to more changeable and social and environmental level elements.

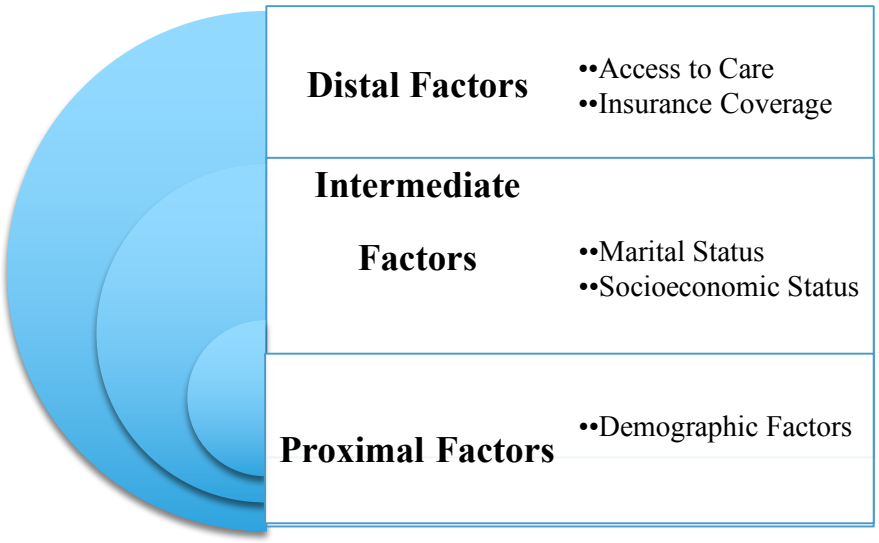



Figure 2. Condition-specific Model for Analysis of Racial/Ethnic Disparities in Visual impairment and Eye Care Utilization

## 6. Changes in Visual Impairment and Eye Care Utilization over time

Racial and ethnic disparities of visual impairment and eye care utilization have been widely studied. Equal attention has also been put on trends of visual impairment and eye care utilization over time. A lot of studies are carried out, these population-based data are available on visual impairment in the last decade, which allows for making more accurate estimates.

Some studies estimated there is an incresing trend of visual impairment. The U.S. population is becoming more racially and ethnically diverse. Projections indicate that by 2050, 54% of U.S. residents will be members of racial and ethnic minority groups [89] (i.e., groups other than non-Hispanic whites), up from 34% in 2008. [90] In addition, the minorities have a higher prevalence rate of visual impairment and eye disease than non-minorities. [91-92] Given these demographic changes, the number of Americans with visual impairment and major eye diseases are likely to increase. Besides, one study estimated that, the United States will experience considerable growth in its older population between 2012 and 2050. So the prevalence of visual impairment may have increased.

Another population-based systematic review on visual impairment from 1980-2012 reported the global age-adjusted prevalence of blindness (vision acuity <6/60) for older adults decreased from 3.0% (95% CI, 2.7%-3.4%) worldwide in 1990 to 1.9% (95% CI, 1.7%-2.2%) in 2010. The global age-adjusted prevalence of moderate and severe visual impairment (vision acuity <6/18 but > 3/60) from 14.3% (95% CI, 12.1%-16.2%) worldwide in 1990 to 10.4% (95% CI, 9.5%-12.3%) in 2010. However, because of population growth and aging, the blind

population could be stable, but the moderate and severe visual impairment population may have increased. [93-94] One study used the National Health Interview Survey from 1999-2008; they reported stable trend in eye care visits, but they showed an increasing trend of the prevalence of being unable to afford eyeglasses among non-Hispanic white and Hispanic groups. [37]

Some interventions have also been carried out to address observed visual health disparities. It is reported that since the launch of the Healthe People 2010/2020 there have been some notable achievements in the prevention and management of avoidable visual impairment and blindness. These achievements included: Increased public awareness and eye care utilization; increased availability and affordability of eye health care services; increased professional, organizational, and political commitment to prevention of visual impairment; more effective primary eye care activities to fight against vision loss caused by trachoma, onchocerciasis, vitamin A deficiency and even from cataract through better eye care services and community education. The present study will provide updated population-based data for more accurate estimates.

## 7. Study Aims

Our study aims to determine and report the most recent racial and ethnic disparities in visual impairment and eye care utilization among U.S adults as well as to identify the underlying reasons. Specifically, the Aims for this study are as follows:

1. Specific Aim #1: To determine the prevalence of self-reported visual impairment in adults among U.S. racial and ethnic subgroups.

   Hypothesis #1: There are disparities in the prevalence of self-reported visual impairment among U.S. racial and ethnic subgroups. Socioeconomically disadvantaged racial and ethnic groups (American Indians, black/African Americans, and Hispanic whites) have a higher prevalence of VI when compared to less disadvantaged groups (non-Hispanic whites and Asians).

2. Specific Aim #2: To determine the relationship between associated variables and the prevalence of self-reported visual impairment in U.S. adults.

   Hypothesis #2: Demographic, socioeconomic status and access to care each carry an independent association with prevalence of self-reported visual impairment in U.S. adults.

3. Specific Aim #3: To determine whether the disparities in prevalence of self-reported visual impairment in adults among U.S. racial and ethnic subgroups still exist after adjusting for related covariates.

Hypothesis #3: Racial and ethnic differences in the prevalence of self-reported visual impairment in U.S adults can be explained, in parts, by demographic, socioeconomic and access to care variables.

4. Specific Aim #4: To determine the prevalence of self-reported annual eye care visits and being unable to afford eyeglasses in adults among U.S. racial and ethnic subgroups.

   Hypothesis #4: There are disparities in prevalence of self-reported annual eye care visits and being unable to afford eyeglasses among U.S. racial and ethnic subgroups. Soioeconomically disadvantaged racial and ethnic groups (American Indians, black/African Americans, and Hispanic whites) have a lower self-reported prevalence of annual eye care visits and higher prevalence of being unable to afford eyeglasses when compared to less disadvantaged groups (non-Hispanic whites and Asians).

5. Specific Aim #5: To determine the relationship between associated variables and the prevalence of self-reported annual eye care visits and being unable to afford eyeglasses in U.S. adults.

   Hypothesis #5: Demographic factors, socioeconomic status and insurance coverage each carry an independent association with the prevalence of self-reported annual eye care visits and being unable to afford eyeglasses in U.S. adults.

6. Specific Aim #6: To determine whether the disparities in prevalence of self-reported annual eye care visits and being unable to afford eyeglasses in adults among U.S. racial and ethnic subgroups still exist after adjusting for related socioeconomic covariates.

Hypothesis #6: Racial and ethnic differences in the prevalence of self-reported eye care visits and eyeglasses affordability in U.S adults can be explained, in parts, by demographic, socioeconomic and access to care variables.

7. Specific Aim #7: To determine the prevalence trends of self-reported visual impairment, eye care utilization, and eyeglass affordability among U.S. adults.

   Hypothesis #7: During a ten-year period when Health People 2010/2020 goals have been pursued, there are increasing trends for self-reported visual impairment, annual eye care visits, and eyeglass affordability among U.S. adults.

# CHAPTER 3: METHOD

This chapter describes the methodology used for the study. It is divided into the following sections: data sources, sample design and data collection, measures, and statistical analyses.

## 1. Data Sources

This study investigated the prevalence of self-reported visual impairment and eye care utilization among U.S. adults (age ≥18 years) by different racial and ethnic subgroups and different socio-demographic groups using data from the National Health Interview Survey (NHIS 2010-2015). The pooled sample size was 199,622, which represented the U.S adult population of approximate 241,555,788 inhabitants each year.

The National Health Interview Survey (NHIS) is a large, annual national survey conducted by National Center for Health Statistics (NCHS) within the Centers for Disease Control (CDC), NHIS is designed to provide an annual, nationally representative, and cross-sectional estimation of a wide range of health status and the health care utilization among the non-military, non-institutionalized population of the United States. NHIS data is widely used throughout the Department of Health and Human Services (DHHS) in monitoring diseases and disabilities trends, and to track progress in achieving national health goals. These data are also used by the public health community to issue timely epidemiologic and public policy recommendations such as those related to the characterization of a variety of health problems, and identify barriers to access and use of appropriate health care.

## 2. Sample Design and Data Collection

NHIS using multi-stage sample design strategy for data collection, which involves stratification, clustering and oversampling of a particular population subgroup. Multistage sampling techniques are used to select households in the NHIS sample. These multistage techniques divide the target population into several nested layers and clusters. The first step of the current sample design consisted of a sample of 428 primary sampling units (PSUs) drawn from approximately 1,900 geographically defined PSUs, with some PSUs in each of the 50 states and the District of Columbia. Within the PSU, two types of second-level units are used: the area segments and the permit segments. The area segments are geographically defined. The permit covers, in part, the housing units built after the 2000 census. To improve the estimation accuracy of black, Hispanic and Asian populations, current NHIS sample designs are over-sampling blacks, Hispanics, and Asians.

The probability of each person to be selected is reflected in the sample weight provided in the accompanying data file. Sampling hierarchies allow the creation of basic weights at the household and individual levels. Each basic weight is the product of the reciprocal of the selection probabilities for each sampling stage. The final personal level weights were also adjusted on a quarterly basis according to the age, sex, race, and ethnicity category estimated by the U.S. Census Bureau.

Face-to-face interviews were conducted at the respondents' homes, but follow-up interviews could be completed by telephone. A telephone interview can also be conducted when the interviewer requests a telephone interview or when it is difficult to arrange an individual visit before the required completion date when the traffic or travel distance makes it difficult.

We use the Stata package to analyze complex samples to obtain the final national estimate. For more details, see the Data Preparation section.

### 3. Measures

To test the study hypotheses, measures of key study variables for visual impairment related outcomes, demographic factors, socioeconomic status and access to eye care were identified in the NHIS data. These measures were chosen to evaluate visual impairment as well as eye care utilization and its associations with many socio-demographic characteristics such as race and ethnicity, age, sex, education level, income, marital status and insurance coverage. Table 1 summarizes the dataset files in use. Table 2 summarizes the key variables for the analysis, including the variables' names in the NHIS dataset that represent each measure.

3.1 Visual impairment related outcomes.

Three outcomes related to visual impairment were assessed:

3.1.1 Visual impairment was assessed from a single questionnaire item. "Do you have any trouble seeing, even when wearing glasses or contact lenses?" Respondents were classified as having visual impairment if they answered yes to the question. Data for this measure is found in the variable "AVISION" in the dataset, which has been recorded to variable "VI" for the final analysis.

3.1.2 Annual eye care visits were assessed from a single questionnaire item. "During the past 12 months, have you seen or talked to any of the following health care providers about your own health? ..... An optometrist, ophthalmologist, or eye doctor (someone who prescribes eyeglasses)." Respondents were classified as utilizing the eye care services if they answered yes to the question. Data for this measure is found in the variable "AHCSYR2" in the dataset, which has been recorded to variable "eyevisit" for the final analysis.

3.1.3 Being unable to afford eyeglasses were assessed from a single questionnaire item. "During the past 12 months, was there any time when you needed any of the following, but did not get it because you could not afford it? ..... Eyeglasses." Respondents were considered as unable to afford eyeglasses if they answered yes to the question. This demonstrates the financial barriers and their effect of reducing visual acuity caused by the uncorrected refractive error on vision-related quality of life. Data for this measure is found in the variable "AHCAFYR4" in the dataset, which has been recorded to variable "eyeglasses" for the final analysis.

## 3.2 Independent variables and associated covariates

The primary independent variables involved in the project are race and ethnicity; the associated covariates include demographic factors, socioeconomic status and access to eye care. The values and description of each variable are as follows:

### 3.2.1 Primary independent variable:

Race: Variable "MRACRPI2" recorded race, this variable identified the primary or main race reported by the respondent which included seven categories whites, black/Africans, Indian (American)/Alaska Natives, Asian Indians, Chinese, Filipinos, other Asians, multiple races, no primary races selected. Other Asians include Korean, Vietnamese, Japanese, and other Asian subgroups.

Ethnicity: Variable "HISPAN_I" gave detailed information regarding the respondent's Hispanic origin or ancestry.

Race Final: Variable "racenew" was used for the final analysis, it was generated according to the classification of variable "race" and "HISPAN_I", and it included five categories: non-Hispanic white, Hispanic whites, black/African Americans, American Indians, Alaska Natives, and Asians.

3.2.2 Associated study covariates were classified into three categories:

3.2.2.1 Demographic factors:

Age: Variable “age” was a continuous variable ranging from 18 to 85, which has been recorded into five categories. (18-24; 25-45; 45-65; 65+)

Gender: Variable “sex” records the gender of the respondent. (Female and male)

3.2.2.2 Socioeconomic Status:

Education: Variable “EDUC1” documents the highest level of education obtained by the respondents. We classified it into four categories, less than high school, high school diploma, some college, college and graduate school.

Income: Variable “POVRATI3” is the ratio of family income to poverty threshold which varies by family size and composition. It was calculated by dollar value and information from the Census Bureau and adjusted for inflation every year. Poverty-to-income ratio (PIR; ratio of total annual family income to the federal poverty threshold according to the U.S. Census; poor, PIR < 1.00; low income, PIR = 1.00-2.99; middle income, PIR = 3.00-3.99; high income). Marital status referred to married or not married.

3.2.2.3 Access to eye care:

Insurance coverage: Variable “NOTCOV” documents the insurance status at the time of interview (uninsured and insured).

Annual eye care visits and being unable to afford eye glasses when needed. (Please see visual impairment related outcomes section)

## 3.3 Other variables

3.3.1 Family Number (FMX), Household Number (HHX), Personal Number (FPX) and Survey Year (SRVY_YR) were combined to identify individual family. These variables were used to merge data within each year to incorporate variables from different data files.

3.3.2 Pseudo-stratum (STRAT_P) was the stratum for variance estimation variable; Pseudo-PSU (PSU_P) was the PSU for variance estimation variable, they were pseudo-levels or simplified versions of the true NHIS sample design variables. Weight-Final Annual (WTFA) was the weight variable.

3.3.3 Standardized age and sex weight variable (agesex) were used for standardization using the corresponding weight variable (std_wgt) calculated from the 2014 U.S. Census data.

**Table 1. Dataset file Information**

| Dataset File | Information |
|---|---|
| Sample adult file | Visual impairment/ Eye care visit/ Eyeglasses/ Race / Ethnic/ Gender/Marital Status |
| Personal file | Education level/ Insurance coverage state |
| Income file | Income level |

| Table 2. 2010-2015 NHIS Public Use Variable Summary | | | | |
|---|---|---|---|---|
| Variables | Name on Dataset | Recorded Name | Characters | Descriptive |
| Merge dataset Variable | HHX | - | Categorical | Household Number |
| Merge dataset Variable | FMX | - | Categorical | Family Number |
| Merge dataset Variable | FPX | - | Categorical | Person Number (Within family) |
| Survey year | SRVY_YR | - | Categorical | Year of National Health Interview Survey |
| Variance Estimation | WTFA | - | Categorical | Weight - Final Annual |
| Variance Estimation | STRAT_P | - | Categorical | Pseudo-stratum for public-use file variance estimation |
| Variance Estimation | PSU_P | - | Categorical | Pseudo-PSU for public-use file variance estimation |
| Age and sex Standardization | agesex | - | Categorical | Variable for standardization-use |
| Age and sex Standardization | std_wgt | - | Categorical | Standardized weight |
| Visual impairment | AVISION | VI | Dichotomous | Have trouble seeing when wearing glasses/lenses |
| Eye care Visit | AHCSYR2 | eyevisit | Dichotomous | Seen/talked to eye doctor, past 12 months |
| Eyeglasses | AHCAFYR4 | eyeglasses | Dichotomous | Could not afford eyeglasses, past 12 months |
| Age | AGE_P | age | Continues | Age |
| Sex | SEX | - | Dichotomous | Sex |
| Race | MRACRPI2 | race | Categorical | Race coded to single/multiple race group |
| Hispanic Origin | HISPAN_I | - | Categorical | Hispanic subgroup detail |
| Final Race Variables | racenew | - | Categorical | Final five category race groups for analysis |
| Education Level | EDUC1 | education | Categorical | Highest level of school completed |
| Income Level | POVRATI3 | PIR | Categorical | Ratio of family income to poverty threshold |
| Marriage | R_MARITL | Marital | Dichotomous | Marital Status |
| Insurance Coverage status | NOTCOV | - | Dichotomous | Coverage status as used in Health United States |

## 4. Statistical Analysis

Stata 14 software (StataCorp LP, College Station, TX) was used for all statistical analyses. We used the data from the 2010-2015 National Health Interview Surveys. The combined sample size across six years was 199,622, which represented a population of 235,223,828 (2010), 237,801,767 (2011), 240,392,551 (2012), 242,834,652 (2013), 245,308,220 (2014), and 247,773,709 (2015) adults for each year.

All the results including means and proportions, 95% confidence intervals (CIs), and adjusted odds ratios were adjusted for the complex multistage sampling design and by the post-stratification weights and age to reflect population-level estimates using the Variance Estimation Method.

### 4.1 Data preparation

The associated variables were identified, followed by editing, cleaning, recording for the final analysis.

#### 4.1.1 Merge dataset within each year

We used Family Number (FMX), Household Number (HHX), Personal Number (PFX) and Survey Year (SRVY_YR) to identify individual families. These variables were combined to

merge sample adult file, personal file, and income file within each year to incorporate all the needed variables.

Box 1. Sample syntax to merge the NHIS 2014 Files

```
/* Sample syntax to merge the 2014 Income File and the 2014 Personal File. */
/* Use 2014 Income File */
use "/Users/Kailiding/Desktop/ Thesis final/2014/2014 dataset/incmimp52014.dta"
/* Merge with 2014 Personal File */
merge 1:1 hhx fmx fpx using "/Users/Kailiding/Desktop/Thesis final/2014
dataset/personsx2014.dta"
```

4.1.2 Combine dataset across six years

To account for the aggregation of data over multiple survey years, these sample weights were modified by dividing the annual weight by six, the number of years combined as specified by the NHIS method. The purpose was to increase the number of respondents while retaining variables common to both files. This will provide a more precision of estimation.

Box 2. Sample syntax to combine the 2010-2011 data and adjust final weight

```
/* Sample syntax to combine the 2010-2011 data and adjust final weight*/
/* Use 2010 data */
use "/Users/Kailiding/Desktop/Thesis final/Combine/2010 adultmerged final.dta"
/* Combine 2010-2011 data */
append using "/Users/Kailiding /Desktop/Thesis final/Combine/2011 adultmerge
final.dta"
/* Adjust final weight*/
replace WTFA=WTFA/2
```

4.2 Variance Estimation

Pseudo-stratum (STRAT_P) was the stratum for variance estimation variable; Pseudo-PSU (PSU_P) was the PSU for variance estimation variable, and Weight-Final Annual (WTFA) was the weight variable. These three were designed variables necessary for variance estimation.

Box 3. Sample syntax for Variance Estimation Method

```
/* Sample syntax for Variance Estimation Method */
svyset [pweight=wtfa], strata(strat_p) psu(psu_p)
svy: regress eyeglass srvy_yr
```

4.3 Age and sex-adjusted prevalence calculation

Age and sex-adjusted prevalence of visual impairment, annual eye care visits, and eyeglass affordability were calculated based on the direct method specified by Klein and Schoenborn. [95] All prevalence estimates were age- and sex-standardized to the 2014 U.S. Census population. [96-98] Table 13 summarize the direct method used in this paper to generate a new variable.

Box 4. Sample syntax for calculating age and sex adjusted prevalence

```
/* Sample syntax for calculating age and sex adjusted prevalence of visual
impairment for different education level groups*/
svyset [pweight=wtfa], strata(strat_p) psu(psu_p)
svy: proportion VI, stdize(agesex) stdweight(std_wgt) over(education)
```

**Table 3. Age Adjustment Using the 2014 Projected U.S. Population**

| Sex | Age | Groups population | Total population | New Variable (agesex) | Weight (std_wgt) |
|---|---|---|---|---|---|
| Male | 18-24 | 16137577 | 245308220 | 1 | 0.065784901 |
| | 25-44 | 42150469 | 245308220 | 2 | 0.171826566 |
| | 45-64 | 40743938 | 245308220 | 3 | 0.166092836 |
| | 65+ | 20331348 | 245308220 | 4 | 0.082880826 |
| Female | 18-24 | 15346380 | 245308220 | 5 | 0.062559583 |
| | 25-44 | 41931114 | 245308220 | 6 | 0.170932364 |
| | 45-64 | 42797012 | 245308220 | 7 | 0.174462201 |
| | 65+ | 25870382 | 245308220 | 8 | 0.105460722 |

Chi-squared tests were used for the comparisons among different categorical variables to compare prevalence among different groups. Multivariable logistic regressions were calculated to evaluate the relationship between prevalence with demographic characteristics. Adjusted odds ratios were used to find the potential explanations for the difference in the prevalence results. Weighted least squares linear regression was used to estimate the linear trends in the prevalence. Generally, P value $< 0.05$ were considered statistically significant, Bonferroni correction was used to calculate the P value level for multiple comparisons. [99-101]

# CHAPTER 4: RESULTS

This chapter describes the results of the study on racial and ethnic disparities in visual impairement and eye care utilization. It is divided into the following sections: Demographic composition of the sample and projected estimation of the population; characteristics of associated covariates among different studied racial and ethnic groups; racial and ethnic disparities in the prevalence of visual impairment and eye care utilization; the relationships between each associated covariates with the prevalences, and the multi-regression model results.

## 1. Demographic Characteristics

This section presents the demographic composition of the sample, projected estimation of visual impairment among different groups from the 2010-2015 combined dataset. (Table 4)

The study sample size was 199,622, which was projected to represent the U.S. adult population of 241,555,788. Among the projected population, 69.48% were non-Hispanic whites, 11.48% were Hispanic whites, 12.95% were black/African Americans, 4.70% were Asians and 0.97% were American Indians, Alaska Native. Around 54.00% of the population was female, 43% were reported to be married, and 85.40% were covered by insurance. Approximately 43.83% were estimated to have seen or talked to optometrist, ophthalmologist, or eye doctor during the past 12 months. It was estimated that 14.25% of the population would have difficulty obtaining needed eyeglasses during the past 12 months. Around 49.40% of the population's PIR

were above 3.16. 21% of the population did not have high school degree, 22.49% had high school diploma, 31.01% of the population had some college degree and 29.86% of the population graduated from college and graduate schools.

In addition, 23.7 million American adults 18 and older reported experiencing visual impairment. Among the visually impaired American adults, approximately 16.6 million were non-Hispanic white, 2.5 million were Hispanic white, 3.5 million were black and African American, 338,936 were Alaska Native, and 656,541 were Asian. Around 10.0 million American adults between the ages of 45 and 64 and 7.7 million American adults 65 years and older reported experiencing visual impairment. Of the Americans who have visual impairment, 9.0 million were men and 14.7 million were women. 5.8 million had less than a high school diploma, 5.5 million had a high school diploma, 7.3 million had some college degrees, and 4.9 million have a bachelor's degree or higher. Approximately 6.1 million people with visual impairment in the U.S. had a PIR less than 1, 4.4 million people had a PIR between 1 and 2, 2.9 million people had a PIR between 2 and 3, and 10.4 million people had a PIR more than 3. Approximately 36.53% Americans who had visual impairment were married (8.7 million) and 85.67% were covered by insurance (20.0 million). Around 51.03% of Americans with visual impairment reported having annual eye care visits (12.0 million) and 23.54% of visually impaired Americans reported having difficulty obtaining needed eyeglasses (5.0 million).

Overall, the majority of the study samples were non-Hispanic whites (69.48%). There were also more females in the study sample and projected population than males. Approximately 50% of the people had a PIR under 3; 30% of the population had college and graduate degree; 14% of the population were uninsured; 56% of the population reported having no annual eye care visits; 14% of the population could not afford eyeglasses when needed. It is estimated that 23 million U.S. adults had visual impairment leading to a prevalence of 9.82%.

**Table 4. Demographic Composition of the Sample and Projected Population. National Health Interview Survey 2010-2015**

| | Estimate U.S. population | % | Estimate VI | % | Sample No. | % |
|---|---|---|---|---|---|---|
| All Participants | 241,555,788 | | 23,701,827 | 9.82 | 199,622 | |
| Race | | | | | | |
| Non-Hispanic White | 201,399,554 | 69.48 | 16,614,981 | 70.10 | 121,082 | 60.66 |
| Hispanic White | 33,276,725 | 11.48 | 2,476,841 | 10.45 | 31,346 | 15.70 |
| Black/African American | 37,537,769 | 12.95 | 3,510,241 | 14.81 | 30,955 | 15.51 |
| American Indian | 2,811,709 | 0.97 | 338,936 | 1.43 | 2,449 | 1.23 |
| Asian | 13,623,746 | 4.70 | 656,541 | 2.77 | 12,562 | 6.29 |
| Age | | | | | | |
| 18 to 24 years | 29,740,349 | 10.26 | 1,315,451 | 5.55 | 19,041 | 9.54 |
| 25 to 44 years | 97,047,453 | 33.48 | 4,723,774 | 19.93 | 68,817 | 34.47 |
| 45 to 64 years | 98,004,014 | 33.81 | 9,973,729 | 42.08 | 67,276 | 33.70 |
| 65 years and over | 65,046,143 | 22.44 | 7,686,502 | 32.43 | 44,488 | 22.29 |
| Sex | | | | | | |
| Male | 132,353,247 | 45.66 | 9,023,286 | 38.07 | 88,979 | 44.57 |
| Female | 157,513,698 | 54.34 | 14,678,541 | 61.93 | 110,643 | 55.43 |
| Education | | | | | | |
| Less than high school | 46,987,432 | 16.21 | 5,842,500 | 24.65 | 37,164 | 18.62 |
| High school diploma | 65,191,076 | 22.49 | 5,532,006 | 23.34 | 45,262 | 22.67 |
| Some college | 89,887,740 | 31.01 | 7,266,980 | 30.66 | 60,785 | 30.45 |
| College and graduate | 86,554,270 | 29.86 | 4,925,240 | 20.78 | 55,480 | 27.79 |
| Income | | | | | | |
| PIR<1 | 52,002,130 | 17.94 | 6,051,076 | 25.53 | 40,782 | 20.43 |
| 1<PIR<2 | 50,958,609 | 17.58 | 4,408,540 | 18.60 | 37,115 | 18.59 |
| 2<=PIR<3 | 43,711,935 | 15.08 | 2,867,921 | 12.10 | 30,153 | 15.11 |
| 3<=PIR | 143,194,271 | 49.40 | 10,374,290 | 43.77 | 91,572 | 45.87 |
| Marital Status | | | | | | |
| Other | 162,818,263 | 56.17 | 15,043,550 | 63.47 | 112,547 | 56.38 |
| Married | 127,048,682 | 43.83 | 8,658,277 | 36.53 | 87,075 | 43.62 |
| Insurance | | | | | | |
| Not covered | 41,306,040 | 14.25 | 3,322,996 | 14.02 | 31,629 | 15.84 |
| Covered | 247,546,371 | 85.40 | 20,305,355 | 85.67 | 167,282 | 83.80 |
| Eye Care Visit | | | | | | |
| No | 162,818,263 | 56.17 | 11,606,785 | 48.97 | 112,547 | 56.38 |
| Yes | 127,048,682 | 43.83 | 12,095,042 | 51.03 | 87,075 | 43.62 |
| Eyeglass | | | | | | |
| No | 247,546,371 | 85.40 | 18,122,417 | 76.46 | 31,629 | 15.84 |
| Yes | 41,306,040 | 14.25 | 5,579,410 | 23.54 | 167,282 | 83.80 |

Note: CI = confidence interval; PIR = poverty to income ratio; Eye Care Visits = have annual eye care visits; Eyeglasses = could not afford eyeglasses

**2. Characteristics of Associated Covariates in Racial Subgroups.**

This section summarizes the characteristics of study covariates in each racial subgroup. (Table 5)

People in the non-Hispanic whites group were older than the other groups. There were more females in the black/African Americans groups compared with the other groups. Asians had the highest proportion of people who held college and graduate degrees (52.94%), followed by non-Hispanic whites and black/African Americans (30.36%). Around 14% of Hispanic whites and American Indians (Alaska Native) graduated from college and graduate schools. As for the income level, non-Hispanic whites and Asians had an advantage over the other three groups. Asians had the highest proportion of married people, followed by non-Hispanic whites and Hispanic whites. Black/African Americans had the lowest marriage rate, with 74.14% unmarried people. Asians (86.88%) and non-Hispanic whites (86.14%) had better insurance coverage compared to Hispanic whites (66.77%) and American Indians (71.68%). Non-Hispanic whites were reported to have the highest rate of eye care visits during the last 12 months; the rate was estimated to be more than 40%. Only 4.46% of Asians had trouble getting needed eyeglasses, which was much lower than the other groups, especially compared to American Indians, for which the rate was 12.47%.

Overall, the data shows non-Hispanic whites and Asians had socioeconomic advantages over the other three groups, which could be found across education levels, income levels, marital status, insurance coverage status and eye care utilization.

**Table 5 Individual Characteristics of Associated Covariates in Racial Subgroups.**

| | Non-Hispanic White | Hispanic White | Black/African American | American Indian | Asian |
|---|---|---|---|---|---|
| Age | | | | | |
| 18 to 24 years | 9.78 | 13.44 | 12.29 | 12.80 | 11.63 |
| 25 to 44 years | 32.10 | 46.44 | 37.15 | 37.92 | 44.91 |
| 45 to 64 years | 34.22 | 26.83 | 33.73 | 34.03 | 27.78 |
| 65 years and | 23.90 | 13.29 | 18.83 | 15.24 | 15.69 |
| Gender | | | | | |
| Male | 46.32 | 47.18 | 41.19 | 46.44 | 46.57 |
| Female | 53.68 | 52.82 | 58.81 | 53.56 | 53.43 |
| Education | | | | | |
| Less than high | 15.62 | 37.94 | 21.08 | 30.34 | 10.25 |
| High school | 22.55 | 21.84 | 25.09 | 21.34 | 14.29 |
| Some college | 31.08 | 25.14 | 33.52 | 33.61 | 21.81 |
| College and | 30.36 | 14.25 | 19.67 | 14.1 | 52.94 |
| Income | | | | | |
| PIR<1 | 16.04 | 29.87 | 28.63 | 31.76 | 17.79 |
| 1<PIR<2 | 17.54 | 20.54 | 18.49 | 17.63 | 15.67 |
| 2<=PIR<3 | 15.64 | 11.47 | 11.81 | 9.92 | 15.64 |
| 3<=PIR | 50.78 | 38.11 | 41.06 | 40.69 | 50.9 |
| Marital Status | | | | | |
| Other | 53.78 | 53.64 | 74.14 | 65.14 | 45.08 |
| Married | 46.21 | 46.36 | 25.86 | 34.86 | 54.92 |
| Insurance | | | | | |
| Not covered | 13.57 | 32.87 | 17.93 | 27.77 | 12.62 |
| Covered | 86.14 | 66.77 | 81.43 | 71.68 | 86.88 |
| Eye Care Visits | | | | | |
| No | 58.86 | 71.66 | 66.37 | 66.68 | 64.00 |
| Yes | 41.14 | 28.34 | 33.63 | 33.32 | 36.00 |
| Eyeglass | | | | | |
| No | 92.48 | 90.20 | 90.22 | 87.53 | 95.54 |
| Yes | 7.52 | 9.80 | 9.770 | 12.47 | 4.46 |

Note: CI = confidence interval; PIR = poverty to income ratio; Eye Care Visits = have annual eye care visits; Eyeglasses = could not afford eyeglasses

### 3. Racial and Ethnic Disparities in the Prevalence of Visual Impairment

The results in this section reveal the age and sex adjusted prevalence of visual impairment among the five racial groups, which is the specific Aim 1.

For adults age ≥18, there were significant self-reported visual impairment (VI) disparities between different racial/ethnic groups. American Indians (Alaska Native) had the highest age and sex adjusted prevalence 14.92% (13.24%-16.77%), followed by African Americans with 11.27％ (10.83%-11.73%), Hispanic whites had 10.02% (9.56%-10.50%), non-Hispanic whites had 9.21% (8.97%-9.46%) and Asians had 6.32% (5.79%-6.89%). (Table 6)

Table 7 demonstrates the age and sex adjusted prevalence of visual impairment among the five racial groups of each year. For adults age ≥18, there were significant self-reported visual impairment (VI) disparities between different racial and ethnic group, and the disparities were also consistent across different years. American Indians (Alaska Native) had the highest age and sex adjusted prevalence 15.81% (2010), 15.25% (2011), 17.71% (2012), 15.99% (2013), 17.23% (2014), and 15.81% (2015). African Americans had high prevalence 12.58% (2010), 11.68% (2011), 10.05% (2012), 10.88(% (2013), 11.29% (2014), and 12.58% (2015). Hispanic whites had 9.75% (2010), 10.15% (2011), 10.10% (2012), 10.20% (2013), 9.34% (2014), and 9.75% (2015). Non-Hispanic whites had relatively low prevalence, which were 9.57% (2010), 9.21% (2011), 8.91% (2012), 9.29% (2013), 8.85% (2014), and 9.57% (2015). Asians had the lowest prevalence, 6.31% (2010), 6.63% (2011), 6.58% (2012), 5.73% (2013), 6.17% (2014), and 6.31% (2015).

Table 7 also shows there were no trends in the prevalence within each racial and ethnic group across six years. In conclusion, our data supported the hypothesis #1: There were disparities in the prevalence of self-reported visual impairment among the five racial and ethnic groups. Social disadvantaged racial and ethnic groups (American Indians, black/Americans, and Hispanic whites) had a higher prevalence of visual impairment when compared to less disadvantaged groups (non-Hispanic whites and Asians).

**Table 6 Age, Sex-Standardized Prevalence[a] of Self-Reported Visual Impairment (VI) for U.S. Adults by Race and Ethnicity National Health Interview Survey 2010-2015**

| Race | VI<br>%, 95%CI |
|---|---|
| Non-Hispanic White | 9.21(8.97-9.46) |
| Hispanic White | 10.02(9.56-10.50) |
| Black/African American | 11.27(10.83-11.73) |
| American Indian | 14.92(13.24-16.77) |
| Asian | 6.32(5.79-6.89) |

Note: CI = confidence interval; VI = visual impairment;
[a]Standardized by the direct method to the 2014 U.S. Census population

**Table 7. Age, Sex-Standardized Prevalence[a] of Self-Reported Visual Impairment for U.S. Adults by Race and Ethnicity. National Health Interview Survey 2010-2015**

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | P Value |
|---|---|---|---|---|---|---|---|
| | %, 95%CI | %, 95%CI | %, 95%CI | %, 95%CI | %, 95%CI | %, 95%CI | |
| Non-Hispanic White | 9.6(9.1-10.1) | 9.2(8.7-9.7) | 8.91(8.5-9.4) | 9.3(8.8-9.8) | 8.9(8.4-9.4) | 9.6(9.1-10.1) | 0.72 |
| Hispanic White | 9.8(8.8-10.8) | 10.1(9.1-11.3) | 10.1(9.2-11.1) | 10.2(9.3-11.2) | 9.3(8.5-10.3) | 9.8(8.8-10.8) | 0.46 |
| Black/African American | 12.6(11.6-13.7) | 11.7(10.7-12.7) | 10.1(9.2-11.0) | 10.9(9.8-12.0) | 11.3(10.3-12.4) | 12.6(11.6-13.7) | 0.97 |
| American Indian | 15.8(11.6-21.2) | 15.3(11.8-19.5) | 17.7(13.5-22.8) | 16.0(12.3-20.5) | 17.2(13.4-21.9) | 15.8(11.6-21.2) | 0.65 |
| Asian | 6.3(5.09-7.8) | 6.6(5.4-8.1) | 6.6(5.4-8.0) | 5.73(4.78-6.86) | 6.2(5.0-7.5) | 6.3(5.1-7.8) | 0.47 |

Note: CI = confidence interval.
[a]Standardized by the direct method to the 2014 U.S. Census population

## 4. The Relationship between Associated Covariates with Visual Impairment

This section focuses on the association between the covariates with the prevalence of visual impairment, which is the specific Aim #2. We calculated the unadjusted odds ratios of each variable. The purpose is to reveal the independent association between related covariates such as age, gender, socioeconomic status, and access to care with visual impairment.

Table 8 and Figure 2 display the odds ratios (ORs) quantifying the association between each covariate in the conceptual model and self-reported VI. As people age, the odds of getting visual impairment increased. The odds of reporting VI was significantly greater for females (OR = 1.41; 95% CI = 1.37-1.47) than males. Higher education level, higher income level, being married and insured were found to have protective effects against VI. For example, individuals with a PIR above 3.00 were less likely to have visual impairment than those with a PIR less than 1.00 (OR = 0.59; 95% CI = 0.56-0.62). Those who graduated from college and graduate school were less likely to have visual impairment when compared to people who did not graduate from high school (OR = 0.42; 95% CI = 0.39-0.44). Married people were found to be significantly less likely to have a visual impairment (OR = 0.71; 95% CI = 0.69-0.74). However, being insured did not have any statistically strong association with visual impairment (OR = 1.02; 95% CI = 0.99-1.07). Being unable to afford eyeglasses was heavily correlated with VI (OR = 4.82; 95% CI = 4.60-5.05). These indicators of socioeconomic status were contributing to racial/ethnic differences seen in visual impairment partly produced and sustained by socioeconomic factors.

In conclusion, the data supports hypothesis # 2: Demographic, socioeconomic status and access to care each carry an independent association with the prevalence of self-reported visual impairment in the U.S adults.

**Table 8. Age, Sex-Standardized Prevalence[a] of Self-Reported Visual Impairment (VI) for U.S. Adults by Associated Covariates National Health Interview 2010-2015**

| All Participants | 2010-2015 VI%, 95%CI | 2010-2015 OR (95%CI) |
|---|---|---|
| Age | | |
| 18 to 24 years | 5.23(4.87-5.61) | 1 |
| 25 to 44 years | 5.78(5.56-6.00) | 1.10(1.02-1.20)*** |
| 45 to 64 years | 12.17(11.81-12.53) | 2.48(2.29-2.69)*** |
| 65 years and over | 14.08(13.64-14.54) | 2.95(2.71-3.20)*** |
| Sex | | |
| Male | 7.92(7.69-8.16) | 1 |
| Female | 10.89(10.61-11.18) | 1.41(1.37-1.47)*** |
| Education | | |
| Less than high school | 13.98(13.49-14.48) | 1 |
| High school diploma | 9.46(9.12-9.82) | 0.64(0.61-0.70)*** |
| Some college | 9.68(9.40-10.00) | 0.61(0.58-0.64)*** |
| College and graduate | 6.76(6.50-7.03) | 0.42(0.39-0.44)*** |
| Income | | |
| PIR<1 | 14.51(14.01-15.04) | 1 |
| 1<PIR<2 | 9.97(9.59-10.36) | 0.72(0.68-0.76)*** |
| 2<=PIR<3 | 7.58(7.23-7.94) | 0.53(0.49-0.56)*** |
| 3<=PIR | 8.34(8.09-8.60) | 0.59(0.56-0.62)*** |
| Marital Status | | |
| Other | 10.99(10.72-11.27) | 1 |
| Married | 7.78(7.50-8.07) | 0.71(0.69-0.74)*** |
| Insurance | | |
| Not covered | 11.11(10.31-11.96) | 1 |
| Covered | 9.13(8.93-9.34) | 1.024(0.978-1.072) |
| Eye Care Visits | | |
| No | 8.30(8.06-8.55) | 1 |
| Yes | 11.22(10.93-11.52) | 1.66(1.60-1.73)*** |
| Eyeglass | | |
| No | 7.78(7.60-7.96) | 1 |
| Yes | 29.21(28.18-30.26) | 4.82(4.60-5.05)*** |

Note: CI = confidence interval; OR = odds ratio; PIR = poverty to income ratio; VI = Visual impairment; Eye Care Visits = have annual eye care visits; Eyeglasses = could not afford eyeglasses.

[a]Standardized by the direct method to the 2014 U.S. Census population.

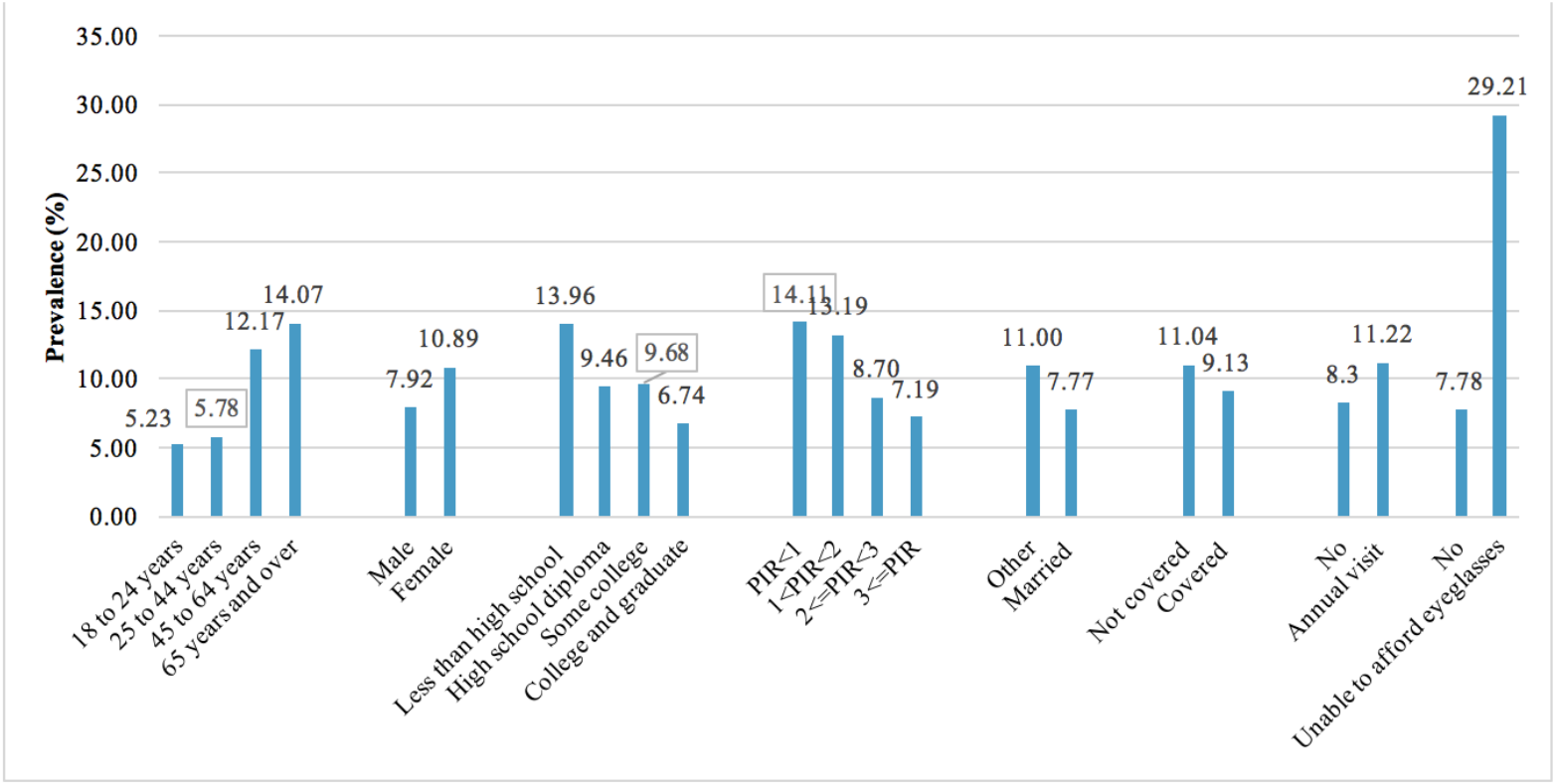



Figure 3. Age, Sex-Standardized Prevalence of Self-Reported Visual Impairment (VI) for U.S. Adults by Associated Covariates

## 5. Multivariable Logistic Regression Models of Visual Impairment

Multivariable logistic regression models were built to examine how and to what extent the associated covariates would influence the racial and ethnic visual impairment disparities (Specific Aim #3). Six models were used for step by step adjustment of different factors. Table 9 represents the results and the changes of the prevalence after controlling for different covariates.

Model 1 showed the crude comparison of the five groups. Model 2 was adjusted for age and sex. Racial groups that were more likely to have visual impairment compared to non-Hispanic whites included Hispanic whites (OR = 1.09; 95% CI = 1.03-1.15), black/African Americans (OR = 1.26; 95% CI = 1.20-1.33), American Indians (OR = 1.75; 95% CI = 1.52-0,20). Asians were less likely to have visual impairment compared to non-Hispanic whites (OR = 0.65; 95% CI = 0.59-0.72). Model 3 was adjusted for the covariates in Model 2 plus education attainment and PIR. After adjustment, overall the differences between different groups were getting smaller, although those three groups were still more likely to get visual impairment. Additionally, Hispanic whites were significantly less likely to develop visual impairment (OR = 0.84; 95% CI = 0.79-0.89). Model 3 showed socioeconomic status could partially explain the disparities especially for Hispanic whites. Model 4 was adjusted for all the covariates in Model 3 plus marital status. After adjustment, the differences between different groups were getting even smaller. Besides, black/African Americans were no more likely to have visual impairment than non-Hispanic whites (OR = 1.03; 95% CI = 0.98-1.08). Additionally, Hispanic whites were significantly less likely to develop visual impairment (OR = 0.85; 95% CI = 0.81-0.90). Model 4

showed demographic factors and socioeconomic status could offer some explanation as to why those two groups have a higher prevalence of visual impairment. Model 5 was adjusted for the covariates in Model 4 plus insurance coverage. After fully adjusted for all the covariates, the ORs value of each racial and ethnic group was almost the same as the model 4. Model 6 was adjusted for the covariates in Model 5 plus annual eye care visits and eyeglass affordability. After complete adjustment for all the covariates, Hispanic whites were still significantly less likely to develop visual impairment (OR = 0.87; 95% CI = 0.82-0.92). Black/African Americans were no more likely to develop visual impairment; the OR did not reach a statistical significant level (OR = 1.04; 95% CI = 0.99-1.10). This suggested that a component of the racial and ethnic disparities observed could be attributed to other demographic, socioeconomic or access to care related factors.

For American Indian adults, although the disparity in the prevalence narrowed after controlling for all the associated covariates, this group still had a significantly higher prevalence. This suggested that other factors besides the examined covariates could be the reason for such high prevalence. On the contrary, the odds of Asian groups were always smaller compared to the other groups, although there was a small increase after adjustment. This suggested high socioeconomic status contributed to this group's low prevalence of visual impairment.

In conclusion, the data supported hypothesis #3: The differences in the prevalence of self-reported visual impairment still exist within certain groups, such as American Indians and Asians when compared with non-Hispanic whites. This would suggest the differences cannot be fully explained by associated covariates. However, for the social disadvantaged groups such as black/Americans, and Hispanic whites, associated covariates could explain why they have poor outcomes when compared to non-Hispanic whites.

**Table 9. Multivariable Logistic Regression Models of Self-Reported Prevalence of Visual Impairment (VI) among U.S. Adults. National Health Interview Survey 2010-2015**

| All Participants | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| | OR (95%CI) | OR (95%CI) | OR (95%CI) | OR (95%CI) | OR (95%CI) | OR (95%CI) |
| Race | | | | | | |
| Non-Hispanic White | 1 | 1 | 1 | 1 | 1 | 1 |
| Hispanic White | 0.90(0.85-0.94)*** | 1.09(1.03-1.15)** | 0.84(0.79-0.89)*** | 0.85(0.81-0.90)*** | 0.85(0.80-0.90)*** | 0.87(0.82-0.92)*** |
| Black/African American | 1.15(1.10-1.21)*** | 1.26(1.20-1.33)*** | 1.07(1.02-1.12)** | 1.03(0.98-1.08) | 1.03(0.98-1.08) | 1.04(0.99-1.10) |
| American Indian | 1.54(1.34-1.78)*** | 1.75(1.52-2.02)*** | 1.40(1.21-1.61)*** | 1.38(1.20-1.59)*** | 1.37(1.19-1.58)*** | 1.35(1.17-1.56)*** |
| Asian | 0.56(0.51-0.62)*** | 0.65(0.59-0.72)*** | 0.66(0.60-0.73)*** | 0.68(0.62-0.75)*** | 0.68(0.62-0.75)*** | 0.72(0.65-0.79)*** |
| Age | | | | | | |
| 18 to 24 years | - | 1 | 1 | 1 | 1 | 1 |
| 25 to 44 years | - | 1.11(1.02-1.21)* | 1.28(1.18-1.39)*** | 1.39(1.27-1.51)*** | 1.38(1.27-1.50)*** | 1.30(1.19-1.41)*** |
| 45 to 64 years | - | 2.51(2.31-2.71)*** | 2.86(2.64-3.11)*** | 3.13(2.88-3.39)*** | 3.12(2.88-3.39)*** | 2.56(2.36-2.78)*** |
| 65 years and over | - | 2.95(2.72-3.20)*** | 3.11(2.86-3.37)*** | 3.31(3.05-3.59)*** | 3.34(3.07-3.63)*** | 2.93(2.70-3.18)*** |
| Sex | | | | | | |
| Male | - | 1 | 1 | 1 | 1 | 1 |
| Female | - | 1.37(1.32-1.42)*** | 1.34(1.29-1.39)*** | 1.31(1.27-1.36)*** | 1.31(1.27-1.36)*** | 1.18(1.13-1.22)*** |
| Education | | | | | | |
| Less than high school | - | - | 1 | 1 | 1 | 1 |
| High school diploma | - | - | 0.67(0.64-0.71)*** | 0.68(0.65-0.72)*** | 0.68(0.65-0.72)*** | 0.70(0.66-0.73)*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Some college | - | - | 0.71(0.68-0.75)*** | 0.71(0.68-0.75)*** | 0.72(0.68-0.75)*** | 0.69(0.65-0.72)*** |
| College and graduate | - | - | 0.51(0.48-0.54)*** | 0.52(0.49-0.55)*** | 0.52(0.49-0.56)*** | 0.53(0.50-0.56)*** |
| Income | | | | | | |
| PIR<1 | - | - | 1 | 1 | 1 | 1 |
| 1<PIR<2 | - | - | 0.72(0.68-0.76)*** | 0.74(0.70-0.79)*** | 0.74(0.70-0.79)*** | 0.79(0.74-0.84)*** |
| 2<=PIR<3 | - | - | 0.57(0.54-0.61)*** | 0.61(0.57-0.65)*** | 0.61(0.57-0.65)*** | 0.68(0.64-0.73)*** |
| 3<=PIR | - | - | 0.63(0.60-0.67)*** | 0.67(0.64-0.71)*** | 0.67(0.64-0.71)*** | 0.72(0.68-0.76)*** |
| Marital Status | | | | | | |
| Other | - | - | - | 1 | 1 | 1 |
| Married | - | - | - | 0.76(0.73-0.79)*** | 0.76(0.73-0.79)*** | 0.79(0.76-0.83)*** |
| Insurance | | | | | | |
| Not covered | - | - | - | - | 1 | 1 |
| Covered | - | - | - | - | 0.94(0.89-0.99)* | 1.13(1.07-1.19)*** |
| Eye Care Visits | | | | | - | |
| No | - | - | - | - | - | 1 |
| Yes | - | - | - | - | - | 1.69(1.62-1.76)*** |
| Eyeglasses | | | | | | |
| No | - | - | - | - | - | 1 |
| Yes | - | - | - | - | - | 4.66(4.43-4.90)*** |

Note: CI = confidence interval; OR = odds ratio; PIR = poverty to income ratio; VI = Visual impairment; Eye Care Visits = have annual eye care visits; Eyeglasses = could not afford eyeglasses.
Model 1: Simple regression model between VI and race/ethnicity
Model 2: Adjusted for age and gender.
Model 3: Adjusted for age, gender, education, and PIR.
Model 4: Adjusted for age, gender, education, PIR, and marital status.
Model 5: Adjusted for age, gender, education, PIR, marital status and insurance coverage.
Model 6: Adjusted for age, gender, education, PIR, marital status, insurance coverage, annual eye care visits and eyeglasses affordability.
*p<0.05; **p<0.01; ***p<0.001

### 6. Racial and Ethnic Disparities in the Prevalence of Eye Care Utilization

The results in this section reveal the age and sex adjusted prevalence of eye care utilization among the five racial groups, which is the specific Aim 4.

For adults age ≥18, there were significant self-reported annual eye care visits disparities between different racial and ethnic groups. Non-Hispanic whites had the highest age and sex adjusted prevalence 41.01% (40.62%-41.41%), followed by Asians with 37.25% (36.20%-38.31%), Indian Americas had 33.95% (31.61%-36.37%), black/African Americans had 33.62% (32.90%-34.34%), and Hispanic whites had 31.03% (30.32%-31.76%). (Table 6)

For adults age ≥18, there were disparities in self-reported inability to afford eyeglasses between different racial and ethnic groups. American Indians had the highest age and sex adjusted prevalence 12.32% (10.85%-13.95%), followed by Hispanic whites with 10.12% (9.66%-10.59%), black/African Americans had 9.48% (9.03%-9.94%), non-Hispanic whites had 7.22% (7.01%-7.46%). Asians had the lowest prevalence 4.70% (4.29%-5.15%). (Table 10)

In sum, our data supported hypothesis #4: There were disparities in the prevalence of self-reported eye care utilization among the five racial and ethnic groups. Social disadvantaged racial and ethnic groups (American Indians, black/Americans, and Hispanic whites) had a lower prevalence of eye care utilization when compared to less disadvantaged groups (non-Hispanic whites and Asians).

**Table 10. Age, Sex-Standardized Prevalence[a] of Self-Reported Annual Eye Care Visits and Being Unable to Afford Eyeglasses When Needed for U.S. Adults by Race and Ethnicity. National Health Interview Survey 2010-2015**

| Race | Eye Care Visits %, 95%CI | Eyeglasses %, 95%CI |
|---|---|---|
| Non-Hispanic White | 41.01(40.62-41.41) | 7.22(7.01-7.46) |
| Hispanic White | 31.03(30.32-31.76) | 10.12(9.66-10.59) |
| Black/African American | 33.62(32.90-34.34) | 9.48(9.03-9.94) |
| American Indian | 33.95(31.61-36.37) | 12.32(10.85-13.95) |
| Asian | 37.25(36.20-38.31) | 4.70(4.29-5.15) |

Note: CI = confidence interval; Eye care visits = annual eye care visits; Eyeglasses = couldn't afford eyeglasses

[a]Standardized by the direct method to the 2014 U.S. Census population

### 7. The Relationship between Associated Covariates with Annual Eye Care Visits

This section focuses on the association between the covariates with the prevalence of annual eye care visits, which is the specific Aim #5. We calculated the unadjusted odds ratios of each variable. The purpose is to reveal the independent association between related covariates such as age, gender, socioeconomic status, and insurance coverage with annual eye care visits. (Table 10)

The odds of reporting annual eye care visits increased with age. The odds of reporting annual eye care visits were significantly greater for females (OR =1.49; 95% CI = 1.46-1.52) than males. Higher education level, higher income level, being married and insured were found to have positive effects on annual eye care visits. For example, individuals with a PIR of more than 3.00 were more likely to have annual eye care visits than those with a PIR less than 1.00 (OR = 1.70; 95% CI = 1.64-1.76). Those graduated from college and graduate school were more likely to have annual eye care visits when compared to people who did not graduate from high school (OR = 2.13; 95% CI = 2.04-2.20). Married people were found to be significantly more likely to have annual eye care visits (OR = 1.25; 95% CI = 1.22-1.28). Insurance coverage was heavily correlated with annual eye care visits (OR = 4.11; 95% CI = 3.95-4.27).

In conclusion, the data supports our hypothesis # 5: Demographic, socioeconomic status and access to care each carry an independent association with the prevalence of annual eye care visits in U.S. adults.

**Table 11. Age, Sex-Standardized Prevalence[a] of Self-Reported Annual Eye Care Visits for U.S. Adults by Associated Covariates National Health Interview 2010-2015**

| All Participants | 2010-2015 Eye Care Visits %, 95%CI | 2010-2015 OR (95%CI) |
|---|---|---|
| Age | | |
| 18 to 24 years | 28.90(27.97-29.85) | 1 |
| 25 to 44 years | 28.37(27.92-28.82) | 0.97(0.93-1.02) |
| 45 to 64 years | 41.58(41.10-42.06) | 1.74(1.66-1.83)*** |
| 65 years and over | 58.23(57.57-58.89) | 3.42(3.25-3.60)*** |
| Sex | | |
| Male | 33.80(33.40-34.19) | 1 |
| Female | 43.07(42.64-43.51) | 1.49(1.46-1.52)*** |
| Education | | |
| Less than high school | 26.36(25.80-26.93) | 1 |
| High school diploma | 33.29(32.77-33.82) | 1.37(1.32-1.42)*** |
| Some college | 39.98(39.49-40.48) | 1.59(1.52-1.65)*** |
| College and graduate | 47.04(46.50-47.58) | 2.12(2.04-2.20)*** |
| Income | | |
| PIR<1 | 29.47(28.84-30.12) | 1 |
| 1<PIR<2 | 35.05(34.43-35.67) | 1.38(1.32-1.44)*** |
| 2<=PIR<3 | 41.79(41.06-42.52) | 1.72 (1.64-1.80)*** |
| 3<=PIR | 41.59(41.17-42.01) | 1.70(1.64-1.76)*** |
| Marital Status | | |
| Other | 36.09(35.66-36.52) | 1 |
| Married | 40.45(39.97-40.95) | 1.25(1.22-1.28)*** |
| Insurance | | |
| Not covered | 18.59(17.42-19.82) | 1 |
| Covered | 41.69(41.34-42.04) | 4.11(3.95-4.27)*** |

Note: CI = confidence interval; OR = odds ratio; PIR = poverty to income ratio; Eye Care Visits = have annual eye care visits.
aStandardized by the direct method to the 2014 U.S. Census population.

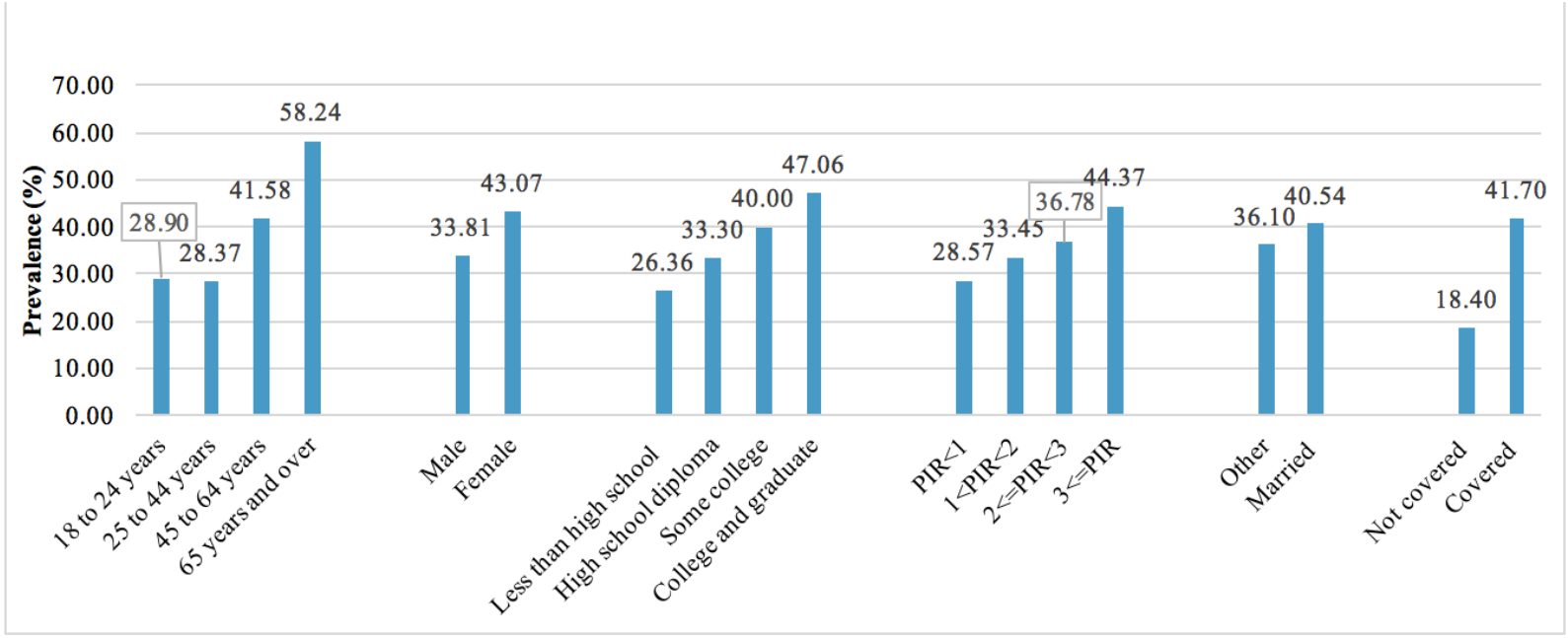



Figure 4. Age, Sex-Standardized Prevalence of Self-Reported Annual Eye Care Visits for U.S. Adults by Associated Covariates

### 8. Multivariable Logistic Regression Models of Annual Eye Care Visits

Multivariable logistic regression models were built to examine how and to what extent the associated covariates of would influence the racial and ethnic annual eye care visits disparities (Specific Aim #6). Five models were used for step by step adjustment of associated covariates. Table 11 represents the results and the changes of the prevalence after controlling for different covariates.

Model 1 shows the rough comparison of the five groups. Model 2 was adjusted for age and sex. All the racial groups were less likely to have eye care visits compared to non-Hispanic whites: Hispanic whites (OR = 0.76; 95% CI = 0.73-0.79), black/African Americans (OR = 0.83; 95% CI = 0.80-0.86), American Indians (OR = 0.88; 95% CI = 0.79-0.99), Asians (OR = 0.78; 95% CI = 0.75-0.82). Model 3 was adjusted for the covariates in Model 2 plus education attainment and PIR. Overall, the ORs were getting smaller after adjustment. This suggested socioeconomic status could partially explain the disparities. Also, after adjustment, American Indians was no less likely to have eye care visits; the OR did not reach a statistically significant level (OR = 0.90; 95% CI = 0.81-1.01). This indicates low socioeconomic status could explain this group's low rate of annual eye care visits. Model 4 was adjusted for the covariates in Model 3 plus marital status. The odds ratios of each groups were almost the same as model 3. Model 5 was adjusted for the covariates in Model 4 plus insurance coverage. Overall, the ORs were getting even closer to 1 after adjustment: Hispanic whites (OR = 0.88; 95% CI = 0.83-0.90); black/African Americans (OR = 0.86; 95% CI = 0.83-0.89); American Indians (OR = 0.99; 95%

CI = 0.88-1.11); Asians (OR = 0.81; 95% CI = 0.77-0.85). This suggested the differences between different groups were getting smaller. Also, after full adjustment, American Indians were no less likely to have eye care visits; the OR did not reach a statistically significant level. This suggested that a component of the racial and ethnic disparities observed in annual eye care visits can be attributed to other demographic, socioeconomic or insurance coverage status.

In conclusion, the data supported hypothesis #6: The differences in the prevalence of self-reported annual eye care visits still exist within certain groups, such as Hispanic whites, black/African Americans, and Asians when compared with non-Hispanic whites. This would suggest the differences cannot be fully explained by associated covariates. However, for American Indians, associated covariates could explain why they have less annual eye visits when compared to non-Hispanic whites.

**Table 12. Multivariable Logistic Regression Models of Self-Reported Prevalence of Annual Eye Care Visits for U.S. Adults. National Health Interview Survey 2010-2015**

| All Participants | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| | OR (95%CI) | OR (95%CI) | OR (95%CI) | OR (95%CI) | OR (95%CI) |
| Race | | | | | |
| Non-Hispanic White | 1 | 1 | 1 | 1 | 1 |
| Hispanic White | 0.52(0.50-0.54)*** | 0.61(0.59-0.64)*** | 0.79(0.75-0.82)*** | 0.78(0.75-0.81)*** | 0.88(0.83-0.90)*** |
| Black/African American | 0.66(0.64-0.69)*** | 0.72(0.69-0.74)*** | 0.83(0.80-0.86)*** | 0.85(0.82-0.88)*** | 0.86(0.83-0.89)*** |
| American Indian | 0.66(0.58-0.74)*** | 0.73(0.66-0.82)*** | 0.90(0.81-1.01) | 0.91(0.81-1.02) | 0.99(0.88-1.11) |
| Asian | 0.74(0.70-0.77)*** | 0.86(0.82-0.90)*** | 0.81(0.77-0.85)*** | 0.80(0.76-0.84)*** | 0.81(0.77-0.85)*** |
| Age | | | | | |
| 18 to 24 years | - | 1 | 1 | 1 | 1 |
| 25 to 44 years | - | 0.97(0.93-1.02) | 0.85(0.81-0.89)*** | 0.81(0.77-0.84)*** | 0.83(0.79-0.87)*** |
| 45 to 64 years | - | 1.68(1.60-1.76)*** | 1.53(1.46-1.61)*** | 1.45(1.38-1.52)*** | 1.45(1.38-1.52)*** |
| 65 years and over | - | 3.17(3.01-3.33)*** | 3.27(3.12-3.43)*** | 3.14(2.99-3.30)*** | 2.77(2.64-2.90)*** |
| Sex | | | | | |
| Male | - | 1 | 1 | 1 | 1 |
| Female | - | 1.45(1.42-1.49)*** | 1.47(1.44-1.51)*** | 1.49(1.45-1.52)*** | 1.45(1.42-1.49)*** |
| Education | | | | | |
| Less than high school | - | - | 1 | 1 | 1 |
| High school diploma | - | - | 1.30(1.25-1.35)*** | 1.29(1.25-1.34)*** | 1.25(1.21-1.30)*** |
| Some college | - | - | 1.72(1.65-1.79)*** | 1.71(1.65-1.78)*** | 1.62(1.56-1.69)*** |

| | | | | | |
|---|---|---|---|---|---|
| College and graduate | - | - | 2.24(2.15-2.33)*** | 2.22(2.13-2.32)*** | 2.00(1.92-2.08)*** |
| Income | | | | | |
| PIR<1 | - | - | 1 | 1 | 1 |
| 1<PIR<2 | - | - | 1.16(1.11-1.21)*** | 1.14(1.09-1.19)*** | 1.11(1.07-1.16)*** |
| 2<=PIR<3 | - | - | 1.38(1.31-1.44)*** | 1.33(1.27-1.40)*** | 1.23(1.18-1.29)*** |
| 3<=PIR | - | - | 1.37(1.32-1.43)*** | 1.33(1.28-1.38)*** | 1.27(1.22-1.32)*** |
| Marital Status | | | | | |
| Other | - | - | - | 1 | 1 |
| Married | - | - | - | 1.15(1.13-1.18)*** | 1.11(1.08-1.14)*** |
| Insurance | | | | | |
| Not covered | - | - | - | - | 1 |
| Covered | - | - | - | - | 2.53(2.43-2.64)*** |

Note: CI = confidence interval; OR = odds ratio; PIR = poverty to income ratio; Eye Care Visits = have annual eye care visits.
Eyeglasses = could not afford eyeglasses when needed.
Model 1: Simple regression model between annual eye care visits and race/ethnicity
Model 2: Adjusted for age and gender.
Model 3: Adjusted for age, gender, education, and PIR.
Model 4: Adjusted for age, gender, education, PIR, and marital status.
Model 5: Adjusted for age, gender, education, PIR, marital status and insurance coverage.
*p<0.05
**p<0.01
***p<0.001

### 9. The Relationship between Associated Covariates with Eyeglass Affordability

This section focuses on the association between covariates with the prevalence of eyeglass affordability, which is the specific Aim #5. We calculated the unadjusted odds ratios of each variable. The purpose is to reveal the independent association between related covariates such as age, gender, socioeconomic status, and insurance coverage with eyeglass affordability. (Table 12)

The odds of being unable to afford eyeglasses were significantly greater for females (OR =1.66; 95% CI = 1.59-1.73) than males. Higher education level, higher income level, being married and insured were found to have protective effects against the inability to afford eyeglasses. For example, individuals with a PIR more than 3.00 were less likely to have difficulty in obtaining needed eyeglasses than those with a PIR less than 1.00 (OR = 0.42; 95% CI = 0.40-0.43). Those who graduated from college and graduate school were less likely to have a barrier in obtaining needed eyeglasses when compared to people who did not graduate from high school (OR = 0.30; 95% CI = 0.28-0.32). Married people were found to be significantly less likely to have difficulty in obtaining needed eyeglasses (OR = 0.57; 95% CI = 0.54-0.59). Being insured was heavily correlated with eyeglass affordability (OR = 0.25; 95% CI = 0.25-0.27).

In conclusion, the data supported hypothesis # 5: Demographic, socioeconomic status and access to care each carry an independent association with the prevalence of eye care utilization in U.S. adults.

**Table 13. Age, Sex-Standardized Prevalence[a] of Self-Reported Being Unable to Afford Eyeglasses When Needed for U.S. Adults by Associated Covariates National Health Interview Survey 2010-2015**

| All Participants | 2010-2015 Eyeglasses%, 95%CI | 2010-2015 OR (95%CI) |
|---|---|---|
| Age | | |
| 18 to 24 years | 5.94(5.54-6.37) | 1 |
| 25 to 44 years | 7.26(7.03-7.51) | 1.24(1.14-1.35) |
| 45 to 64 years | 10.79(10.46-11.12) | 1.90(1.75-2.06)*** |
| 65 years and over | 4.21(3.99-4.44) | 0.64(0.63-0.76)*** |
| Sex | | |
| Male | 5.85(5.64-6.05) | 1 |
| Female | 9.49(9.23-9.76) | 1.66(1.59-1.73)*** |
| Education | | |
| Less than high school | 12.89(12.44-13.35) | 1 |
| High school diploma | 8.18(7.84-8.55) | 0.60(0.57-0.64)*** |
| Some college | 8.74(8.47-9.02) | 0.70(0.67-0.74)*** |
| College and graduate | 3.97(3.77-4.18) | 0.30(0.28-0.32)*** |
| Income | | |
| PIR<1 | 14.60(14.11-15.10) | 1 |
| 1<PIR<2 | 9.12(8.75-9.51) | 0.58(0.55-0.61)*** |
| 2<=PIR<3 | 4.34(4.05-4.65) | 0.29(0.26-0.30)*** |
| 3<=PIR | 6.22(6.02-6.43) | 0.42(0.40-0.43)*** |
| Marital Status | | |
| Other | 9.82(9.60-10.08) | 1 |
| Married | 5.58(5.35-5.82) | 0.57(0.54- |
| Insurance | | |
| Not covered | 19.68(18.70-20.70) | 1 |
| Covered | 5.72(5.55-5.90) | 0.25(0.25-0.27)*** |

Note: CI = confidence interval; OR = odds ratio; PIR = poverty to income ratio;
Eyeglasses = could not afford eyeglasses
[a]Standardized by the direct method to the 2014 U.S. Census population.
*p<0.05
**p<0.01
***p<0.001

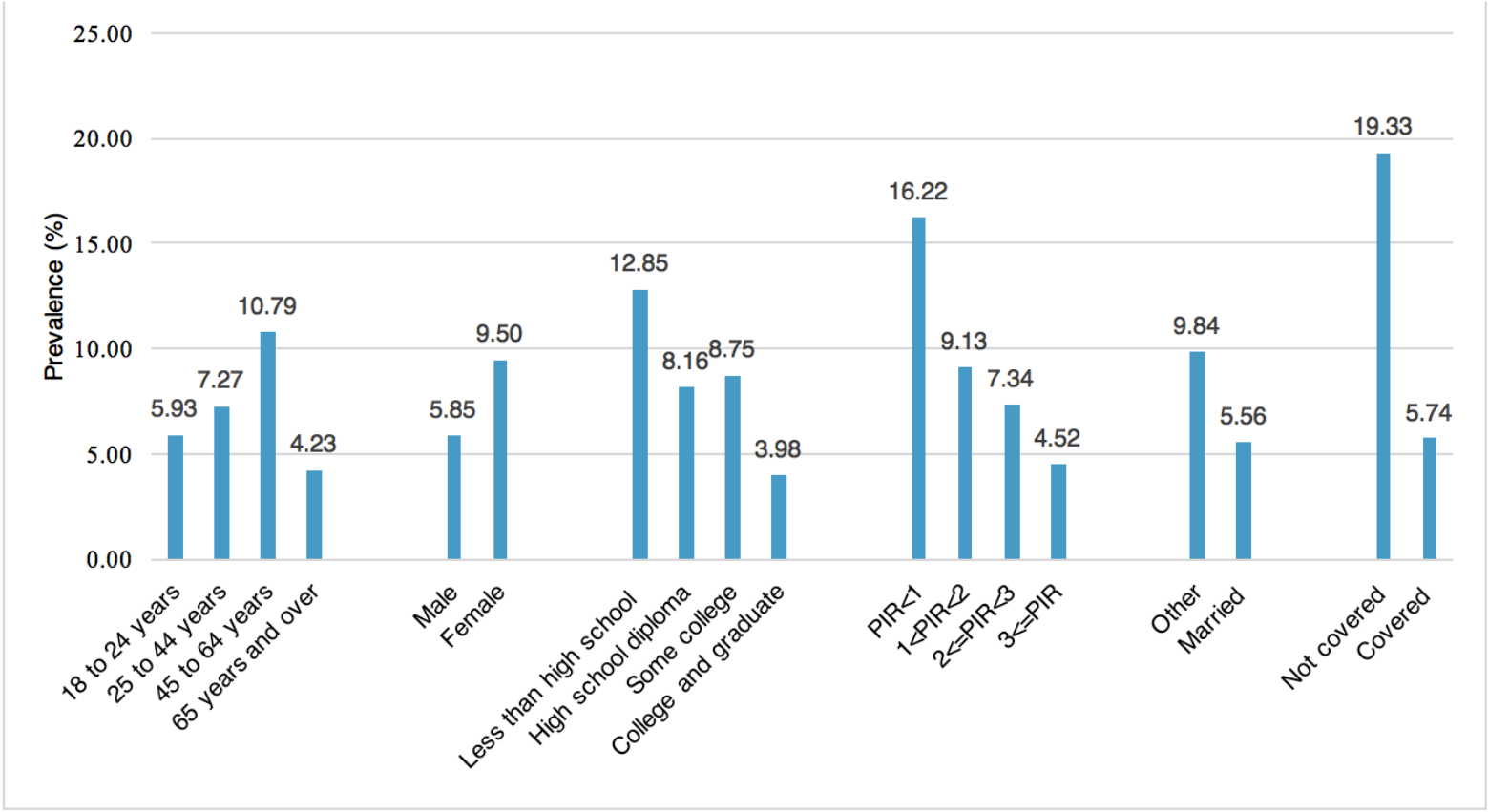



Figure 5. Age, Sex-Standardized Prevalence of Self-Reported Being Unable to Afford Eyeglasses for U.S. Adults by Associated Covariates

### 10. Multivariable Logistic Regression Models of Eyeglasses Affordability

Multivariable logistic regression models were built to examine how and to what extent the associated covariates would influence the racial and ethnic eyeglasses affordability disparities (Specific Aim #6). Five models were used for step by step adjustment of associated covariates. Table 11 represents the results and the changes of the prevalence after controlling for different covariates. (Table 13)

Model 1 shows the crude comparison of the five groups. Model 2 was adjusted for age and sex. All the racial groups were more likely to report having difficulty affording eyeglasses when needed compared to non-Hispanic whites except for Asians (OR = 0.68; 95% CI = 0.62-0.75): Hispanic whites (OR = 1.08; 95% CI = 1.01-1.15), black/African American (OR = 1.16; 95% CI = 1.09-1.23), American Indian (OR = 1.43; 95% CI = 1.23-1.67). Model 3 was adjusted for the covariates in Model 2 plus education attainment and PIR. After adjustment, Hispanic whites (OR = 0.84; 95% CI = 0.79-0.90) and black/African Americans (OR = 0.95; 95% CI = 0.89-1.01) were no more likely to be unable to afford needed eyeglasses; the OR of those two groups did not reach a statistically significant level. American Indians were still more likely to have difficulty obtaining needed eyeglasses, but the OR value was much smaller (OR = 1.28; 95% CI = 1.10-1.50). Model 4 was adjusted for the covariates in Model 3 plus marital status. After adjustment, Hispanic whites (OR = 1.03; 95% CI = 0.96-1.09) and black/African Americans (OR = 0.96; 95% CI = 0.91-1.02) were no more likely to be unable to afford needed eyeglasses; the OR of those two groups did not reach a statistically significant level. American

Indians were still more likely to have difficulty obtaining needed eyeglasses, but the OR value was even much smaller (OR = 1.25; 95% CI = 1.07-1.47). Model 5 was adjusted for the covariates in Model 4 plus insurance coverage. After adjustment, Hispanic whites (OR = 0.84; 95% CI = 0.79-0.90) were less likely to be unable to afford needed eyeglasses; black/African Americans (OR = 0.95; 95% CI = 0.89-1.01) and American Indians (OR = 1.11; 95% CI = 0.94-1.31) were no more likely to be unable to afford need eyeglasses; the ORs of these two groups did not reach a statistically significant level. After adjusting for all the covariates, Hispanic whites, black/African Americans, and American Indians were no more likely to have trouble obtaining eyeglasses. This indicated that financial barriers could be the main reason for racial disparities.

As for Asians, we could not draw any conclusion because the ORs in different models were very close: Model 1 (OR = 0.61; 95% CI = 0.55-0.67) (OR = 0.60; 95% CI = 0.55-0.67) (OR = 0.65; 95% CI = 0.59-0.72) (OR = 0.69; 95% CI = 0.62-0.76) (OR = 0.66; 95% CI = 0.60-0.73).

In conclusion, the data supported hypothesis #6: The differences in the prevalence of self-reported inability to afford eyeglasses still exist within certain groups, such as Asians when compared with non-Hispanic whites. This would suggest the differences cannot be fully explained by associated covariates. However, for Hispanic whites, black/African Americans Asians, and American Indians, those associated covariates could explain why they have a high prevalence of being unable to afford eyeglasses when compared to non-Hispanic whites.

**Table 14. Multivariable Logistic Regression Models of Self-Reported Prevalence of Being Unable to Afford Eyeglasses When Needed for U.S. Adults. National Health Interview Survey 2010-2015**

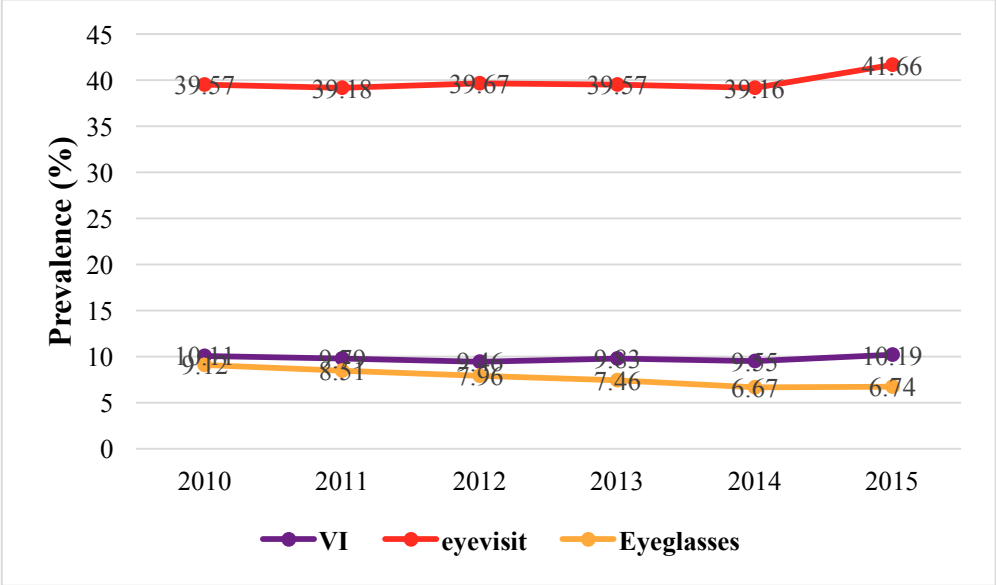
| All Participants | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| | OR (95%CI) | OR (95%CI) | OR (95%CI) | OR (95%CI) | OR (95%CI) |
| Race | | | | | |
| Non-Hispanic White | 1 | 1 | 1 | 1 | 1 |
| Hispanic White | 1.41(1.33-1.49)*** | 1.42(1.34-1.51)*** | 0.99(0.93-1.05) | 1.03(0.96-1.09) | 0.84(0.79-0.90)*** |
| Black/African American | 1.41(1.33-1.49)*** | 1.35(1.27-1.43)*** | 1.04(0.98-1.11) | 0.96(0.91-1.02) | 0.95(0.89-1.01) |
| American Indian | 1.85(1.59-2.15)*** | 1.81(1.55-2.10)*** | 1.28(1.10-1.50)*** | 1.25(1.07-1.47)** | 1.11(0.94-1.31) |
| Asian | 0.61(0.55-0.67)*** | 0.60(0.55-0.67)*** | 0.65(0.59-0.72)*** | 0.69(0.62-0.76)*** | 0.66(0.60-0.73)*** |
| Age | | | | | |
| 18 to 24 years | - | 1 | 1 | 1 | 1 |
| 25 to 44 years | - | 1.25(1.15-1.35)*** | 1.60(1.46-1.75)*** | 1.83(1.67-2.00)*** | 1.67(1.54-1.82)*** |
| 45 to 64 years | - | 1.96(1.81-2.12)*** | 2.50(2.29-2.72)*** | 0.89(2.65-3.15)*** | 2.98(2.74-3.23)*** |
| 65 years and over | - | 0.70(0.64-0.77)*** | 0.77(0.70-0.85)*** | 0.84(0.76-0.93)*** | 1.14(1.03-1.25)*** |
| Sex | | | | | |
| Male | - | 1 | 1 | 1 | 1 |
| Female | - | 1.71(1.64-1.78)*** | 1.67(1.60-1.74)*** | 1.65(1.58-1.72)*** | 1.78(1.70-1.86)*** |
| Education | | | | | |
| Less than high school | - | - | 1 | 1 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| High school diploma | - | - | 0.67(0.63-0.71)*** | 0.68(0.64-0.72)*** | 0.71(0.67-0.75)*** |
| Some college | - | - | 0.77(0.73-0.81)*** | 0.76(0.72-0.81)*** | 0.85(0.80-0.90)*** |
| College and graduate | - | - | 0.36(0.34-0.39)*** | 0.37(0.35-0.40)*** | 0.46(0.42-0.49)*** |
| Income | | | 0.52(0.38-0.71)*** | 0.51(0.37-0.70)*** | |
| PIR<1 | - | - | 1 | 1 | 1 |
| 1<PIR<2 | - | - | 0.65(0.62-0.69)*** | 0.69(0.65-0.73)*** | 0.71(0.67-0.75)*** |
| 2<=PIR<3 | - | - | 0.33(0.30-0.36)*** | 0.36(0.34-0.40)*** | 0.42(0.39-0.46)*** |
| 3<=PIR | - | - | 0.49(0.46-0.52)*** | 0.54(0.51-0.57)*** | 0.58(0.55-0.62)*** |
| Marital Status | | | | | |
| Other | - | - | - | 1 | 1 |
| Married | - | - | - | 0.61(0.59-0.64)*** | 0.65(0.62-0.68)*** |
| Insurance | | | | | |
| Not covered | - | - | - | - | 1 |
| Covered | - | - | - | - | 0.32(0.31-0.34)*** |

Note: CI = confidence interval; OR = odds ratio; PIR = poverty to income ratio.
Model 1: Simple regression model between being unable to afford eyeglasses and race/ethnicity
Model 2: Adjusted for age and gender.
Model 3: Adjusted for age, gender, education, and PIR.
Model 4: Adjusted for age, gender, education, PIR, and marital status.
Model 5: Adjusted for age, gender, education, PIR, marital status and insurance coverage.
*p<0.05
**p<0.01
***p<0.001

## 11. Trends of Visual Impairment and Eye Care Utilization

There was no trend of prevalence of visual impairment within the six years but evidence of an increasing prevalence from 2014-2015. There was an increasing trend of annual eye care visits and a decreasing trend of inability of obtaining needed eyeglasses found in U.S. adults within this six years' period (Specific Aim #7). (Figure 5)




| P VALUES | 2010-2015 | 2010-2014 | 2014-2015 |
|---|---|---|---|
| VISUAL | 0.936 | 0.109 | 0.025* |
| EYE CARE VISITS | 0.001** | | |
| EYEGLASSES | 0.000*** | | |

Figure 6. Trends of Self-Reported Prevalence of Visual impairment, Annual Eye Care Visits and Being Unable to Afford Eyeglasses When Needed among U.S. Adults. National Health Interview Survey 2010-2015

# CHAPTER 5: DISCUSSION

As described in Chapter 1 and 2, a large body of research reported that racial and ethnic minorities experience higher prevalence of visual impairment and lack of eye care utilization. Additionally, racial and ethnic disparities are associated with worse visual outcomes. The efforts to eliminate health disparities, monitoring and identifying potential opportunities for improvement are critically important. This study provides the most recent data on visual impairment and eye care utilization, which could be used to address this issues.

## 1. The Current Status of Visual Impairment and Eye Care Utilization

This section covers the conclusions and discussion based on the study results and other research to provide the most updated data for monitoring the status of national visual impairment and eye care utilization.

We estimated that 9.82% of the U.S. adult population had visual impairment. Around 23.7 million adult Americans 18 and older reported experiencing visual impairment. Our survey-based evidence is consistent with the 2010 global data, which reported that 10.99% of people worldwide were visually impaired. [56] Previous findings from 2007-2010 National Health Interview Surveys reported a similar prevalence rate (9.2%). [102] Another study which used the National Health and Nutrition Examination Survey also estimated a prevalence of visual impairment in the U.S. population of 8.4% for blacks, 10.7% for Hispanics and 5.0% for whites. [103] Our findings were not strictly comparable with some of the studies, because of differences either in the study population or the definition of visual impairment. In an analysis

of earlier NHIS data of all adults age 18 years or older, the author reported lower estimates for the crude prevalence of visual impairment (6%). [104] The National Eye Institute reported that the overall national visual impairment rate was 2% for the U.S. population age 40 and older, indicating that 2.9 million older Americans have visual impairment (defined as having 20/40 or worse vision in the better eye even with eyeglasses), the National Eye Institute also excluded blindness in their analysis. [64]

Estimates of the prevalence of visual impairment vary, depending upon the criteria used and the population they studied. They also vary depending on whether the visual impairment is self-reported or verified by screening or examination, whether they use the same definition and whether the study includes uncorrected refractive error. There are several different definitions of visual impairment, for example, two standards are the United States definition of < 20/200 and the World Health Organization standard of < 20/400 for best-corrected visual acuity in the better-seeing eye. More recently, researchers have defined visual impairment for those with best-corrected visual acuity less than 20/40 because this level of vision is associated with substantial impairment of daily activities. Variations in definitions of vision health outcomes in part explain some of the variability of prevalence estimates and comparisons across groups. Despite all this, our study results are consistent with most studies, blacks and Hispanics had higher levels of vision loss and do not access eye care as frequently as whites, and some studies reported there is no association between high prevalence of visual impairment with race and ethnicity. The development of universal standards and guidelines for assessing vision outcomes, particularly visual impairment, are imperative to the development of appropriate and reliable surveillance systems.

The two indicators used in this study to reflect eye care utilization were annual eye care visits and eyeglass affordability. Our data also showed that the age and sex standardized self-reported prevalence of annual eye care visits was 38.56%. The result is not strictly comparable with previous studies, because of the study population. One study used the data from 2006-2009 Behavioral Risk Factor Surveillance System; the author reported that the age-adjusted state-level prevalence of yearly eye doctor visits ranged from 48% to 69% among visually impaired U.S. residents age 40 or older. Another study used previous NHIS data from 1999-2008, the estimation varied between 36.9% to 54.5% for different races and ethnicities within different years among visually impaired U.S. adults. [37]

Our data shows that the age and sex standardized prevalence of self-reported inability to afford eyeglasses was 7.72%. Another study used the previous NHIS data from 1999-2008, the estimation varied between 11.2% to 26.7% for different races and ethnicities within different years among visually impaired U.S. adults. [37]

### 2. Relationship of Associated Covariates with Visual Impairment and Underutilization of Eye Care Services.

Our study identified several associated covariates with strong contributions on racial and ethnic disparities in visual impairment and eye care utilization, such as increasing age, female, low education level, low income level, unmarried, uninsured, and underutilization of eye care services. We found that females were more likely to suffer from visual impairment, have more annual eye care visits and be unable to afford eyeglasses, which is consistent with other studies. We also found individuals with lower levels of education and income were less likely to have annual eye care visits and more likely to have difficulty in obtaining needed eyeglasses despite the fact that they are more likely to have vision impairement. This is in agreement with reports from most studies. Our data shows insurance status is another related critical variable in eye care utilization. Modifications to the existing health care system are needed to ensure that lack of health insurance and affordability are no longer contributing factors in vision loss.

Researchers, health care managers, professional must be aware of these contributors. Subsequently, some factors should be addressed properly. In addition, there are other associated factors mentioned in other studies such as diabetes, hypertension, and degree of myopia which were not examined in this study. However, as this investigation was a cross-sectional study, we could not draw any causal relationship between socioeconomic factors and visual impairment because we are not clear whether the socioeconomic disparities are the cause or the consequence of visual impairment.

### 3. Disparities in the Prevalence of Visual Impairment and Eye Care Utilization

We found that American Indians had the highest age and sex standardized prevalence of visual impairment (14.92%) when compared to the other groups. Our data also showed that black/African Americans had a higher age and sex standardized prevalence of visual impairment (11.27%) when compared to non-Hispanic whites (9.21%) and Hispanic whites (10.02%). These findings have been documented in other studies. We estimated that Asians had the lowest age and sex standardized prevalence of visual impairment (6.32%). This finding has not been documented in other studies. Most of the studies classified U.S. adults into whites and blacks or Hispanics and non-Hispanics, while almost all the studies combined Asians into others. Therefore, the estimation of the prevalence of visual impairement and eye care utilization in this racial group could not be provided by these studies. In addition, we found that individuals who belonged to low socioeconomic status groups were more likely to have visual impairment within the past years. This finding was consistent with the results from previous studies.

Furthermore, we not only calculated the prevalence of visual impairment, but we also built multivariable logistic regression models to control for covariates and calculated the adjusted odds ratios. Overall, the difference narrowed after adjustment. Low socioeconomic status and underutilization of eye care services could explain part of the disparities among black/African Americans and Hispanic whites when compared with non-Hispanic whites. But for American Indians, probably the disparity is due to inherent racial or ethnic difference and the other factors not included in the models. As for Asians, the high socioeconomic status appears to contribute to this group's low prevalence of visual impairment.

Our study suggested that there were disparities in eye care utilization among different racial and ethnic groups. Hispanic whites, black/African Americans, American Indians, and Asians were less likely to have annual eye care visits when compared to non-Hispanic whites. Except for Asians, the other racial groups were more likely to have difficulty obtaining needed eye glasses.

As for eyeglass affordability, associated covariates could explain why Hispanic whites, black/African Americans and American Indians were less likely to have eye care visits. The findings that socioeconomic status, health insurance coverage, and access to care were associated with eye care visits suggested that financial barriers could be an important contributor. These results have not been previously examined in other studies. But there are still some disparities unexplained by these associated covarites.

In our study, we found African Americans had the highest prevalence of visual impairment. The possible explanation for this problem could be some inherent characteristics. African Americans are 1.5 times more likely to develop cataract compared to the general population and are five times more likely to develop related blindness. In addition, African Americans are at five times higher risk than whites to develop glaucoma and four times more likely to suffer from related blindness. African-American adults are twice likely to develop diabetic retinopathy. Also, African Americans are significantly more likely to have high blood pressure and Human Immunodeficiency Virus (HIV) infection. The high proportion of females in this subgroup could explain the higher prevalence of visual impairment, since females tend to

have a higher prevalence of visual impairment. More than that, African Americans may not be able to get the eye care that they need. In fact, we found that just 34% of African Americans had an annual eye exam within the past year. Low socioeconomic status could be the reasons for not scheduling annual eye care visits. One study reported the reasons for African Americans not scheduling eye exam included cost (44%), not acknowledging the value of an eye exam because they were not experiencing problems with their vision (28%), and being too busy (24%). [105-109]

Although we found Asian Americans had the lowest prevalence of visual impairment, this subgroup is at a higher risk for various vision problems such as myopia and diabetic retinopathy. We could not conclude whether they are underdiagnosed or underreported due to cultural conception and language barrier. In our study, we also found Asian Americans had a low rate of annual eye care visits, possibly due to obstacles in receiving adequate eye care such as cultural and language barriers. [110-111]

Hispanics have among the highest risk for developing centain eye health issues, but many are not taking the right steps to protect their vision. Genetic factors could explain the higher prevalence since cataract and glaucoma are the leading cause of blindness among Hispanics. Prevalence of pterygia, diabetic retinopathy, and hypertension are also significantly higher among Hispanic Americans. Also, just 31% of Hispanics visited their eye doctor within the past year, the lowest of all demographic groups. Socioeconomic factors and access to eye care are the main reasons for not scheduling an appointment because most of Hispanic whites reported that barriers included cost, being too busy and not experiencing any vision problems.

Clearly, social disadvantaged racial groups have higher levels of visual impairment and do not access eye care services as frequently as non-Hispanic whites. Our study reveals several reasons and barriers. Also, other potential sources of disparities should be identified. More research is needed to understand the mechanisms of the relevance of racial and other socioeconomic factors to visual impairment and eye care utilization. In addition, it is important to understand why some ethnic subgroups do not make the best use of eye care services, and what changes to the system need to be made to provide better care. Developing effective interventions and monitoring the changes in disparities will be essential in improving the overall vision health of U.S populations.

### 4. Prevalence Trends of Visual Impairment and Eye Care Utilization

In our study, we found no trend ofprevalence of visual impairment within the six years but an increasing prevalence from 2014 to 2015. There was an increasing trend of annual eye care visits and a decreasing trend in the difficulty of getting needed eyeglasses found in U.S. adults within this six years' period. Population-based research reported that the prevalence of visual impairment is increasing. According to a study using previous 2007 NHIS data, they estimate 9.5% or 21.2 million of the U.S. adults reported have visual impairment. The estimation increased from a previous level of 8.8% or 19.1 million in 2004. [112]

Our results were not exactly the same as previous findings. The reason why we did not find any trend in visual impairment could be because we only included six years of data, which could not be long enough to detect any trend. In addition, the demographic trends, the

investment of governments, the national development in improving eye health services and socioeconomic developments could also influence the trends of visual impairment and eye care utilization. No significant trend found could also be due to some achievements made in the prevention and management of visual imparment such as increased utilization of eye health care services found in this study.

### 5. Limitations of the Study

Four major types of potential errors encountered during NHIS data collection include: non-coverage by the sample frame, sampling biases, measurement errors, and nonresponse. The restriction of the observed population to the subpopulation with telephone access which can provide biased results.

The biases arise because the telephone access in associated with some background variables. The results of the Consumer Survey confirmed the association of telephone access with age, marital status, activity status, occupation, education and income of the head of household, size of the households and province. Some groups may have low telephone access (e.g., aged under 30, single or divorced persons, unemployed persons, manual employee, those

with education below the postsecondary level, those who have low income, living in rented accommodation, and those living in remote areas) and other groups have high access (e.g., professional, managerial, or white collar worker with high income, living in own home.) In addition, language or vision problems could potentially contribute to the omission of disadvantaged groups from the research. Also, the non-coverage rates varied considerably by racial and ethnic origins. It was 6% for white persons, 16% for black persons and 19% for Hispanic persons. Additionally, the NHIS household response rate fell from 90% in 1998 to 82% in 2001 (National Center for Health Statistics, Division of Health Interview Statistics 2000, 2012)

The self-reported data used in this study has other biases, including recall bias, social desirability bias, and access to health care biases. Therefore, some conditions are subject to be under- or over-reported and diagnosed. In addition, these biases are difficult to detect and evaluate, so this self-reported data can only provide a rough estimation of visual impairment among U.S. populations. Not all the U.S. residents were included in this dataset, for example, the armed forces, prisoners and the U.S. residents living abroad. Some populations may have a higher prevalence of certain eye diseases.

Culture is a major factor in visual impairment and eye care utilization disparities. It shapes the vision health of different racial and ethnic groups and alters the types of eye care services they use. The meaning of visual impairment varies among different racial and ethnic groups. It can account for some racial and ethnic disparities in how people report their vision

symptoms during the survey. There are some differences in vision symptom presentation across culture. For example, an ethnic group could be more likely to report their vision problems, while some groups are less likely to acknowledge they have problems. Also, cultures can influence whether people even seek health care, and what types of care they are looking for. Cultural factors contribute to the disparities in eye care utilization and the contribution varies by race and ethnicity.

An essential feature of surveys, whether self-administered by mail or interviewer-administered in person or by phone, is the respondent's language. However, limited translations of the NHIS survey are available; there are only English and Spanish versions. The study language that the respondents see has a significant effect on the results even in the racial and ethnic groups with a multi-language background. Many types of research found higher response rates will be achieved when the survey is delivered in the native language. So, this may introduce some bias into our results.

This study did not classify different eye disease subgroups, like glaucoma, cataracts, uncorrected visual impairment, diabetic retinopathy due to the limitation of the survey questions. It did not have a more comprehensive examination or questionnaire data of different eye diseases and eye care services utilized due to the high cost of these surveys. Additionally, assessing the incidence of the disease is critical to understand the impact of the disease on the population and the effectiveness of prevention efforts. However, national surveys rarely provide information on incidence.

Moreover, because they are cross-sectional, it is not possible to derive or infer causal inferences from national surveys. Finally, due to logistical constraints, national surveys tend to have only a small sample size for certain ethnic groups (e.g., Some Asians groups, Pacific Islanders, and Native Americans). A comprehensive description of visual health, with the passage of time and the trend of various ethnic groups in the United States, is currently not feasible. More research on the reliability and validity of self-reported measures and ways to improve their collection is needed.

## 6. Public Implications

Our results suggest the need for an effective surveillance system in monitoring the current visual impairment and eye care utilization status and effectiveness of the interventions. Further targeted epidemiological research and educational and innovative interventions are needed for the high-risk populations. More research is needed to understand the differences in visual impairment and the underlying causes of the improvement in visual health in the American population.

Monitoring data can assist in the development of health policy recommendations and the evaluation of the effectiveness of intervention programs on preventing and controlling vision problems and different eye diseases. Although there is a lot of prevalence data from a variety of population-based research, we need to ensure that the available data is continually updated. In addition, we should emphasize the need for standardized metrics in different datasets and efforts.

Potential activities include setting standard case definitions, test parameters, and standards. In addition, the self-reported method and other measurement methods for visual impairment were validated. This will allow people working in the relevant visual field to develop plans to understand the national vision health care needs, especially for minorities and high-risk populations, to expand access to the system and to change patients' behavior patterns.

Our study also identified several high-risk groups for visual impairment and underutilization of eye care. Strategies to reduce and eliminate disparities in visual impairment and eye care utilization should focus on those who are at high risk. Addressing visual impairment and eye care use disparities will help improve national eye health and strengthen support program for continuous improvement of vision health. Affordability, continuity and regular source of care, as well as physician advice, are still the core factors that are significantly associated with receiving the needed eye care. It is important to understand the use of services among those high-risk and vulnerable populations to ensure that resource allocation is maximized. Some strategies including developing and expanding an understanding of the use of care sources, particularly in ethnic and minority groups is critical to identify potential alternatives and barriers to vision care.

There is a wide range of variables that may affect access to care services. Some effective strategies, methods, or approaches to address these barriers include working with partners within the community by providing data to help formulate policies and inform policy decisions,

educating the public about early detection, disseminating appropriate health information, and providing access to care at low to no cost.

## 7. Future Research

Model for analysis of population health and health disparities is showed in Figure 7. Our future work will identify associated risk factors of visual impairment and eye care utilization in the database. The next step is to incorporate these elements into our multi-regression models, such as profession, family history, other health conditions, behavioral factors, and geological locations.

# CHAPTER 6: CONCLUSION

For adults age ≥18, there were significant self-reported visual impairment (VI) and eye care utilization disparities between different racial and ethnic groups. The odds of reporting VI, eye care visits and inability to afford eyeglasses were significantly greater in females than males. Those who had socioeconomic disadvantages were more likely to have visual impairment, less likely to have annual eye care visits and had more difficulty in obtaining needed eyeglasses.

Overall, the disparities in the self-reported prevalence of visual impairment and eye care utilization were reduced after adjusting for socioeconomic factors. Our regression models showed associated covariates could explain why Hispanic whites and black/African Americans had a higher prevalence of self-reported visual impairment than non-Hispanic whites. As for American Indians, these socioeconomic covariates could only partially explain the prevalence disparity. For Asians, high socioeconomic status may help explain this group's low prevalence of visual impairment.

Our study suggested that there were disparities in eye care utilization among different racial and ethnic groups. Hispanic whites, black/African Americans, American Indians, and Asians were less likely to have annual eye care visits when compared to non-Hispanic whites.

Overall, the disparities of annual eye care visit narrowed after adjusting for the associated covariates, especially for American Indians.

As for eyeglass affordability, except for Asians, the other racial groups were more likely to have difficulty obtaining needed eyeglasses. Associated covariates could explain why Hispanic whites, black/African Americans and American Indians were more likely to have trouble getting eyeglasses. This indicated that financial barriers could be the main reason for eyeglass affordability disparities in these groups. For Asians, there were other potential explanations for the disparity.

There was no trend of the prevalence of visual impairment, but an increasing trend of annual eye doctor visits and a decreasing trend of inability to afford eyeglasses.

These findings suggested the need for further targeted epidemiologic studies and educational and innovative interventions. More research is imperative to understand the visual impairment and eye care utilization disparities and their underlying reasons in order to improve vision health among U.S. populations.

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**APPENDIX A. Demographic Composition of the Sample and Projected Population. National Health Interview Survey 2010**

| | Sample | | | | Any VI | | | |
|---|---|---|---|---|---|---|---|---|
| | Estimate population | % | No. | % | Estimate population | % | No. | % |
| All Participants | 235,223,828 | | 27,157 | | 23,761,249 | | 2768 | |
| Race | | | | | | | | |
| White | 191,589,808 | 81.45 | 20,285 | 74.70 | 19,030,384 | 80.09 | 2005 | 72.43 |
| African American | 30,884,890 | 13.13 | 4,688 | 17.26 | 3,778,037 | 15.90 | 605 | 21.86 |
| American Indian | 2,164,060 | 0.92 | 262 | 0.96 | 311,273 | 1.31 | 42 | 1.52 |
| Asian Indian | 1,811,224 | 0.77 | 311 | 1.15 | 71,283 | 0.30 | 13 | 0.47 |
| Chinese | 1,881,790 | 0.80 | 366 | 1.35 | 90,293 | 0.38 | 20 | 0.72 |
| Filipino | 2,375,761 | 1.01 | 435 | 1.60 | 33,265 | 0.14 | 29 | 1.05 |
| Other Asian | 3,645,969 | 1.55 | 683 | 2.52 | 211,476 | 0.89 | 41 | 1.48 |
| Multiple Race | 470,448 | 0.20 | 75 | 0.28 | 64,155 | 0.27 | 8 | 0.29 |
| Hispanic Origin | | | | | | | | |
| Multiple Hispanic | 541,014 | 0.23 | 104 | 0.38 | 45,146 | 0.19 | 9 | 0.33 |
| Puerto Rican | 3,128,478 | 1.33 | 531 | 1.96 | 387,310 | 1.63 | 65 | 2.35 |
| Mexican | 10,373,372 | 4.41 | 2,006 | 7.39 | 762,735 | 3.21 | 153 | 5.53 |
| Mexican American | 5,810,029 | 2.47 | 1,050 | 3.87 | 544,132 | 2.29 | 105 | 3.79 |
| Cuban/Cuban | 1,293,731 | 0.55 | 273 | 1.01 | 142,567 | 0.60 | 30 | 1.08 |
| Dominican | 1,011,461 | 0.43 | 197 | 0.73 | 90,293 | 0.38 | 18 | 0.65 |
| Central or South | 4,775,044 | 2.03 | 881 | 3.24 | 377,805 | 1.59 | 70 | 2.53 |
| Other Spanish | 705,671 | 0.30 | 107 | 0.39 | 80,788 | 0.34 | 15 | 0.54 |
| Not Hispanic | 207,514,462 | 88.22 | 21,999 | 81.01 | 21,328,097 | 89.76 | 2303 | 83.20 |
| Age | | | | | | | | |
| 18 to 24 years | 25,004,293 | 10.63 | 2,801 | 10.31 | 1,477,950 | 6.22 | 176 | 6.36 |
| 25 to 44 years | 80,752,340 | 34.33 | 9,779 | 36.01 | 5,094,412 | 21.44 | 599 | 21.64 |
| 45 to 64 years | 80,281,893 | 34.13 | 9,127 | 33.61 | 10,029,624 | 42.21 | 1175 | 42.45 |
| 65 years and over | 49,185,302 | 20.91 | 5,450 | 20.07 | 7,159,266 | 30.13 | 818 | 29.55 |
| Sex | | | | | | | | |
| Male | 106,274,126 | 45.18 | 11,986 | 44.14 | 8,908,093 | 37.49 | 1025 | 37.03 |
| Female | 128,949,702 | 54.82 | 15,171 | 55.86 | 14,853,156 | 62.51 | 1743 | 62.97 |
| Education | | | | | | | | |
| Less than high | 40,035,095 | 17.02 | 5,457 | 20.09 | 6,387,023 | 26.88 | 828 | 29.91 |
| High school diploma | 55,442,255 | 23.57 | 6,367 | 23.45 | 5,926,056 | 24.94 | 684 | 24.71 |
| Some college | 72,025,535 | 30.62 | 8,041 | 29.61 | 7,021,450 | 29.55 | 788 | 28.47 |
| College and graduate | 66,756,523 | 28.38 | 7,167 | 26.39 | 42,770 | 0.18 | 448 | 16.18 |
| Income | | | | | | | | |
| PIR<1 | 2,399,284 | 1.02 | 276 | 1.02 | 178,208 | 0.75 | 24 | 0.87 |
| 1<PIR<2 | - | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 2<=PIR<3 | 23,523 | 0.01 | 5 | 0.02 | 0 | 0.00 | 1 | 0.04 |
| 3<=PIR | 232,777,501 | 98.96 | 26,876 | 98.97 | 23,568,783 | 99.19 | 2743 | 99.10 |
| Marital Status | | | | | | | | |
| Other | 131,113,761 | 55.74 | 15,126 | 55.70 | 15,385,409 | 64.75 | 1767 | 65.05 |
| Married | 104,110,067 | 44.26 | 12,031 | 44.30 | 8,375,840 | 35.25 | 995 | 34.95 |
| Insurance | | | | | | | | |
| Not covered | 39,235,334 | 16.68 | 5,095 | 18.76 | 4,037,036 | 16.99 | 505 | 18.24 |
| Covered | 195,306,345 | 83.03 | 21,982 | 80.94 | 19,681,443 | 82.83 | 2258 | 81.58 |

VI= visual impairment

## APPENDIX B. Demographic Composition of the Sample and Projected Population. National Health Interview Survey 2011

| | Sample | | | | Any VI | | | |
|---|---|---|---|---|---|---|---|---|
| | Estimate population | % | No. | % | Estimate population | % | No. | % |
| All Participants | 237,801,767 | | 33,014 | | 23,261,551 | | 3,294 | |
| Race | | | | | | | | |
| White | 193,903,560 | 81.54 | 25,074 | 75.95 | 18,744,158 | 80.58 | 2,453 | 74.47 |
| African American | 29,963,022 | 12.60 | 5,193 | 15.73 | 3,431,079 | 14.75 | 641 | 19.46 |
| American Indian | 2,401,797 | 1.01 | 397 | 1.20 | 355,901 | 1.53 | 57 | 1.73 |
| Asian Indian | 2,068,876 | 0.87 | 403 | 1.22 | 81,414 | 0.35 | 14 | 0.43 |
| Chinese | 2,330,458 | 0.98 | 477 | 1.44 | 148,873 | 0.64 | 30 | 0.91 |
| Filipino | 2,259,116 | 0.95 | 468 | 1.42 | 167,482 | 0.72 | 34 | 1.03 |
| Other Asian | 3,828,608 | 1.61 | 818 | 2.48 | 220,986 | 0.95 | 46 | 1.40 |
| Multiple Race | 642,066 | 0.27 | 106 | 0.32 | 65,133 | 0.28 | 11 | 0.33 |
| Hispanic Origin | | | | | | | | |
| Multiple Hispanic | 642,066 | 0.27 | 122 | 0.37 | 44,197 | 0.19 | 10 | 0.30 |
| Puerto Rican | 3,115,203 | 1.31 | 567 | 1.72 | 309,379 | 1.33 | 62 | 1.88 |
| Mexican | 9,940,113 | 4.18 | 2,181 | 6.61 | 851,373 | 3.66 | 189 | 5.74 |
| Mexican American | 6,539,548 | 2.75 | 1,348 | 4.08 | 746,697 | 3.21 | 164 | 4.98 |
| Cuban/Cuban | 1,355,471 | 0.57 | 295 | 0.89 | 120,960 | 0.52 | 27 | 0.82 |
| Dominican | 1,046,329 | 0.44 | 225 | 0.68 | 127,939 | 0.55 | 28 | 0.85 |
| Central or South | 4,684,694 | 1.97 | 955 | 2.89 | 297,749 | 1.28 | 60 | 1.82 |
| Other Spanish | 832,306 | 0.35 | 161 | 0.49 | 86,068 | 0.37 | 16 | 0.49 |
| Not Hispanic | 209,574,698 | 88.13 | 27,147 | 82.23 | 20,667,888 | 88.85 | 2,737 | 83.09 |
| Age | | | | | | | | |
| 18 to 24 years | 25,064,307 | 10.54 | 3,291 | 9.97 | 1,370,106 | 5.89 | 180 | 5.46 |
| 25 to 44 years | 81,161,743 | 34.13 | 11,743 | 35.57 | 4,582,527 | 19.70 | 669 | 20.31 |
| 45 to 64 years | 81,161,743 | 34.13 | 11,078 | 33.56 | 10,297,888 | 44.27 | 1,441 | 43.75 |
| 65 years and over | 50,413,974 | 21.20 | 6,902 | 20.91 | 7,011,031 | 30.14 | 1,004 | 30.48 |
| Sex | | | | | | | | |
| Male | 109,793,076 | 46.17 | 14,811 | 44.86 | 9,030,133 | 38.82 | 1,249 | 37.92 |
| Female | 128,008,691 | 53.83 | 18,203 | 55.14 | 14,231,418 | 61.18 | 2,045 | 62.08 |
| Education | | | | | | | | |
| Less than high | 40,426,300 | 17.00 | 6,438 | 19.50 | 6,120,114 | 26.31 | 960 | 29.14 |
| High school diploma | 53,862,100 | 22.65 | 7,485 | 22.67 | 5,643,253 | 24.26 | 788 | 23.92 |
| Some college | 73,956,348 | 31.10 | 10,058 | 30.47 | 6,997,076 | 30.08 | 960 | 29.14 |
| College and graduate | 68,463,129 | 28.79 | 8,854 | 26.82 | 4,405,738 | 18.94 | 565 | 17.15 |
| Income | | | | | | | | |
| PIR<1 | 2,092,655 | 0.88 | 292 | 0.88 | 241,920 | 1.04 | 34 | 1.03 |
| 1<PIR<2 | 23,781 | 0.01 | 5 | 0.02 | 6,979 | 0.03 | 1 | 0.03 |
| 2<=PIR<3 | 47,561 | 0.02 | 7 | 0.02 | 4,653 | 0.02 | 1 | 0.03 |
| 3<=PIR | 235,613,990 | 99.08 | 32,710 | 99.08 | 23,008,001 | 98.91 | 3,258 | 98.91 |
| Marital Status | | | | | | | | |
| Other | 133,073,869 | 55.96 | 22,540 | 56.16 | 14,761,780 | 63.46 | 2,118 | 64.30 |
| Married | 104,727,898 | 44.04 | 14,474 | 43.84 | 8,499,771 | 36.54 | 1,176 | 35.70 |
| Insurance | | | | | | | | |
| Not covered | 38,190,964 | 16.06 | 5,947 | 18.01 | 3,994,008 | 17.17 | 590 | 17.91 |
| Covered | 198,873,617 | 83.63 | 26,958 | 81.66 | 19,179,150 | 82.45 | 2,692 | 81.72 |

VI= visual impairment

**APPENDIX C. Demographic Composition of the Sample and Projected Population. National Health Interview Survey 2012**

| | Sample | | | | Any VI | | | |
|---|---|---|---|---|---|---|---|---|
| | Estimate population | % | No. | % | Estimate population | % | No. | % |
| All Participants | 240,392,551 | | 34,525 | | 22,725,722 | | 3387 | |
| Race | | | | | | | | |
| White | 195,006,438 | 81.12 | 26,214 | 75.93 | 18,487,376 | 81.35 | 2,565 | 75.73 |
| African American | 30,890,442 | 12.85 | 5,452 | 15.79 | 3,131,605 | 13.78 | 604 | 17.83 |
| American Indian | 2,235,651 | 0.93 | 413 | 1.20 | 356,794 | 1.57 | 65 | 1.92 |
| Asian Indian | 2,259,689 | 0.94 | 408 | 1.18 | 88,631 | 0.39 | 16 | 0.47 |
| Chinese | 2,259,689 | 0.94 | 449 | 1.30 | 129,535 | 0.57 | 26 | 0.77 |
| Filipino | 2,524,121 | 1.05 | 518 | 1.50 | 152,263 | 0.67 | 33 | 0.97 |
| Other Asian | 4,158,790 | 1.73 | 849 | 2.46 | 293,162 | 1.29 | 59 | 1.74 |
| Multiple Race | 673,099 | 0.28 | 120 | 0.35 | 40,907 | 0.18 | 10 | 0.30 |
| Hispanic Origin | | | | | | | | |
| Multiple Hispanic | 600,982 | 0.25 | 110 | 0.32 | 40,907 | 0.18 | 8 | 0.24 |
| Puerto Rican | 3,461,653 | 1.44 | 578 | 1.67 | 409,063 | 1.80 | 72 | 2.13 |
| Mexican | 11,154,213 | 4.64 | 2,226 | 6.45 | 968,116 | 4.26 | 195 | 5.76 |
| Mexican American | 7,139,660 | 2.97 | 1,358 | 3.63 | 579,505 | 2.55 | 115 | 3.40 |
| Cuban/Cuban | 1,466,394 | 0.61 | 291 | 0.84 | 170,442 | 0.75 | 32 | 4.34 |
| Dominican | 961,570 | 0.40 | 189 | 0.55 | 34,088 | 0.15 | 9 | 0.27 |
| Central or South | 5,120,362 | 2.13 | 945 | 2.74 | 420,426 | 1.85 | 78 | 2.30 |
| Other Spanish | 721,178 | 0.30 | 152 | 0.44 | 120,446 | 0.53 | 23 | 0.68 |
| Not Hispanic | 209,742,501 | 87.25 | 28,666 | 83.03 | 19,980,455 | 87.92 | 2,854 | 84.26 |
| Age | | | | | | | | |
| 18 to 24 years | 25,121,021 | 10.45 | 3,417 | 9.90 | 1,290,822 | 5.68 | 187 | 5.52 |
| 25 to 44 years | 80,026,681 | 33.29 | 11,873 | 34.39 | 4,465,605 | 19.65 | 697 | 20.58 |
| 45 to 64 years | 82,142,136 | 34.17 | 11,853 | 34.33 | 9,835,692 | 43.28 | 1,459 | 43.08 |
| 65 years and over | 53,102,714 | 22.09 | 7,382 | 21.38 | 7,135,877 | 31.40 | 1,044 | 30.82 |
| Sex | | | | | | | | |
| Male | 108,969,943 | 45.33 | 15,273 | 44.24 | 8,540,327 | 37.58 | 1,256 | 37.08 |
| Female | 131,422,608 | 54.67 | 19,252 | 55.76 | 14,185,395 | 62.42 | 2,131 | 62.92 |
| Education | | | | | | | | |
| Less than high | 39,736,888 | 16.53 | 6,569 | 19.03 | 5,667,795 | 24.94 | 935 | 27.61 |
| High school diploma | 54,208,520 | 22.55 | 7,856 | 22.75 | 5,217,826 | 22.96 | 770 | 22.73 |
| Some college | 75,339,026 | 31.34 | 10,579 | 30.64 | 7,192,692 | 31.65 | 1,042 | 30.76 |
| College and graduate | 70,122,508 | 29.17 | 9,368 | 27.13 | 4,556,507 | 20.05 | 625 | 18.45 |
| Income | | | | | | | | |
| PIR<1 | 65,074,262 | 27.07 | 10,460 | 30.30 | 8,749,402 | 38.50 | 1,435 | 42.37 |
| 1<PIR<2 | 62,646,299 | 26.06 | 9,104 | 26.37 | 6,199,576 | 27.28 | 909 | 26.84 |
| 2<=PIR<3 | 53,415,225 | 22.22 | 7,328 | 21.23 | 4,217,894 | 18.56 | 573 | 16.92 |
| 3<=PIR | 59,256,763 | 24.65 | 7,633 | 22.11 | 3,558,847 | 15.66 | 470 | 13.88 |
| Marital Status | | | | | | | | |
| Other | 135,557,360 | 56.39 | 19,595 | 56.76 | 14,460,378 | 63.63 | 2,208 | 65.19 |
| Married | 104,835,191 | 43.61 | 14,930 | 43.24 | 8,265,344 | 36.37 | 1,179 | 34.81 |
| Insurance | | | | | | | | |
| Not covered | 38,006,063 | 15.81 | 6,156 | 17.83 | 3,445,219 | 15.16 | 576 | 17.01 |
| Covered | 201,713,388 | 83.91 | 28,257 | 81.85 | 19,210,053 | 84.53 | 2,799 | 82.64 |

VI= visual impairment

**APPENDIX D. Demographic Composition of the Sample and Projected Population. National Health Interview Survey 2013**

| | | Sample | | | | Any VI | | |
|---|---|---|---|---|---|---|---|---|
| | Estimate population | % | No. | % | Estimate population | % | No. | % |
| | 242,834,652 | | 34,557 | | 23,854,518 | | 3512 | |
| Race | | | | | | | | |
| White | 195,627,595 | 80.56 | 26,215 | 75.86 | 19,310,232 | 80.95 | 2,650 | 75.46 |
| African American | 31,787,055 | 13.09 | 5,508 | 15.94 | 3,442,206 | 14.43 | 639 | 18.19 |
| American Indian | 2,258,362 | 0.93 | 437 | 1.26 | 360,202 | 1.51 | 76 | 2.16 |
| Asian Indian | 2,525,481 | 1.04 | 417 | 1.21 | 135,970 | 0.57 | 23 | 0.65 |
| Chinese | 2,622,615 | 1.08 | 462 | 1.34 | 121,659 | 0.51 | 23 | 0.65 |
| Filipino | 2,768,315 | 1.14 | 518 | 1.50 | 155,055 | 0.65 | 36 | 1.03 |
| Other Asian | 4,201,039 | 1.73 | 787 | 2.28 | 240,932 | 1.01 | 46 | 1.31 |
| Multiple Race | 509,952 | 0.21 | 99 | 0.29 | 42,937 | 0.18 | 10 | 0.28 |
| Hispanic Origin | | | | | | | | |
| Multiple Hispanic | 485,670 | 0.20 | 91 | 0.26 | 26,240 | 0.11 | 7 | 0.20 |
| Puerto Rican | 3,448,253 | 1.42 | 597 | 1.73 | 441,310 | 1.85 | 80 | 2.28 |
| Mexican | 11,631,780 | 4.79 | 2,240 | 6.48 | 1,059,141 | 4.44 | 218 | 6.21 |
| Mexican | 7,066,488 | 2.91 | 1,332 | 3.85 | 696,553 | 2.92 | 133 | 3.79 |
| Cuban/Cuban | 1,651,276 | 0.68 | 307 | 0.89 | 145,513 | 0.61 | 26 | 0.74 |
| Dominican | 1,189,891 | 0.49 | 220 | 0.64 | 100,188 | 0.42 | 22 | 0.63 |
| Central or South | 5,026,677 | 2.07 | 964 | 2.79 | 233,775 | 0.98 | 49 | 1.40 |
| Other Spanish | 801,355 | 0.33 | 172 | 0.50 | 93,033 | 0.39 | 21 | 0.60 |
| Not Hispanic | 211,436,132 | 87.07 | 28,614 | 82.80 | 21,042,072 | 88.21 | 2,952 | 84.05 |
| Age | | | | | | | | |
| 18 to 24 years | 25,570,490 | 10.53 | 3,289 | 9.52 | 1,369,249 | 5.74 | 182 | 5.18 |
| 25 to 44 years | 80,329,704 | 33.08 | 11,977 | 34.66 | 4,654,017 | 19.51 | 719 | 20.47 |
| 45 to 64 years | 82,175,246 | 33.84 | 11,559 | 33.45 | 9,944,948 | 41.69 | 1,441 | 41.03 |
| 65 years and over | 54,759,214 | 22.55 | 7,732 | 22.37 | 7,888,690 | 33.07 | 1,170 | 33.31 |
| Sex | | | | | | | | |
| Male | 111,121,137 | 45.76 | 15,440 | 44.68 | 9,167,292 | 38.43 | 1,301 | 37.04 |
| Female | 131,713,515 | 54.24 | 19,117 | 55.32 | 14,687,226 | 61.57 | 2,211 | 62.96 |
| Education | | | | | | | | |
| Less than high | 39,120,662 | 16.11 | 6,415 | 18.56 | 5,923,076 | 24.83 | 969 | 27.59 |
| High school | 54,856,349 | 22.59 | 7,829 | 22.66 | 5,810,960 | 24.36 | 827 | 23.55 |
| Some college | 75,618,710 | 31.14 | 10,470 | 30.30 | 6,917,811 | 29.00 | 1,020 | 29.04 |
| College and | 72,219,024 | 29.74 | 9,680 | 28.01 | 5,097,710 | 21.37 | 678 | 19.31 |
| Income | | | | | | | | |
| PIR<1 | 64,351,183 | 26.50 | 10,141 | 29.35 | 9,412,993 | 39.46 | 1,498 | 42.65 |
| 1<PIR<2 | 63,889,796 | 26.31 | 9,235 | 26.72 | 6,471,730 | 27.13 | 964 | 27.45 |
| 2<=PIR<3 | 54,953,481 | 22.63 | 7,523 | 21.77 | 4,150,687 | 17.40 | 575 | 16.37 |
| 3<=PIR | 59,640,190 | 24.56 | 7,658 | 22.16 | 3,819,108 | 16.01 | 475 | 13.53 |
| Marital Status | | | | | | | | |
| Other | 138,027,217 | 56.84 | 19,756 | 57.16 | 12,991,171 | 54.46 | 2,291 | 65.24 |
| Married | 104,807,435 | 43.16 | 14,799 | 42.84 | 8,477,896 | 35.54 | 1,221 | 34.76 |
| Insurance | | | | | | | | |
| Not covered | 37,420,821 | 15.41 | 5,917 | 17.12 | 3,647,355 | 15.29 | 592 | 16.86 |
| Covered | 204,588,195 | 84.25 | 28,521 | 82.53 | 20,137,984 | 84.42 | 2,910 | 82.86 |

VI= visual impairment

## APPENDIX E. Demographic Composition of the Sample and Projected Population. National Health Interview Survey 2014

| | Sample | | | | Any VI | | | |
|---|---|---|---|---|---|---|---|---|
| | Estimate population | % | No. | % | Estimate populatio | % | No. | % |
| All Participants | 245,308,220 | | 36,697 | | 23,399,52 | | 3707 | |
| Race | | | | | | | | |
| White | 197,841,078 | 80.65 | 28,526 | 77.7 | 18,562,84 | 79.3 | 2,851 | 76.91 |
| African American | 32,282,562 | 13.16 | 5,310 | 14.4 | 3,652,665 | 15.6 | 618 | 16.67 |
| American Indian | 2,305,896 | 0.94 | 468 | 1.28 | 397,792 | 1.70 | 75 | 2.02 |
| Asian Indian | 2,649,328 | 1.08 | 411 | 1.12 | 128,697 | 0.55 | 21 | 0.57 |
| Chinese | 2,747,452 | 1.12 | 467 | 1.27 | 147,417 | 0.63 | 22 | 0.59 |
| Filipino | 2,477,613 | 1.01 | 518 | 1.41 | 121,677 | 0.52 | 34 | 0.92 |
| Other Asian | 4,096,647 | 1.67 | 772 | 2.10 | 301,854 | 1.29 | 58 | 1.56 |
| Multiple Race | 515,147 | 0.21 | 101 | 0.28 | 30,421 | 0.13 | 9 | 0.24 |
| Hispanic Origin | | | | | | | | |
| Multiple Hispanic | 564,208 | 0.23 | 96 | 0.26 | 63,178 | 0.27 | 9 | 0.24 |
| Puerto Rican | 3,434,314 | 1.40 | 573 | 1.56 | 376,733 | 1.61 | 67 | 1.81 |
| Mexican | 11,823,857 | 4.82 | 2,357 | 10.9 | 1,001,500 | 4.28 | 197 | 5.31 |
| Mexican American | 6,893,162 | 2.81 | 1,294 | 3.53 | 568,607 | 2.43 | 116 | 3.13 |
| Cuban/Cuban | 1,692,626 | 0.69 | 318 | 0.87 | 98,279 | 0.42 | 21 | 0.57 |
| Dominican Republic | 1,152,949 | 0.47 | 209 | 0.57 | 105,296 | 0.45 | 18 | 0.49 |
| Central or South | 5,372,251 | 2.19 | 978 | 2.67 | 400,131 | 1.71 | 75 | 2.02 |
| Other Spanish | 981,232 | 0.40 | 211 | 0.57 | 86,579 | 0.37 | 22 | 0.59 |
| Not Hispanic | 213,320,027 | 86.96 | 30,644 | 83.5 | 206,828,4 | 88.3 | 3,179 | 85.76 |
| Age | | | | | | | | |
| 18 to 24 years | 24,383,637 | 9.94 | 3,353 | 9.14 | 1,233,155 | 5.27 | 172 | 4.64 |
| 25 to 44 years | 81,614,044 | 33.27 | 12,378 | 33.7 | 4,703,304 | 20.1 | 761 | 20.53 |
| 45 to 64 years | 81,712,168 | 33.31 | 12,322 | 33.5 | 9,558,708 | 40.8 | 1,549 | 41.79 |
| 65 years and over | 57,622,900 | 23.49 | 8,644 | 23.5 | 7,904,361 | 33.7 | 1,225 | 33.05 |
| Sex | | | | | | | | |
| Male | 112,105,855 | 45.70 | 16,398 | 44.6 | 9,221,753 | 39.4 | 1,422 | 38.36 |
| Female | 133,202,365 | 54.30 | 20,299 | 55.3 | 14,177,77 | 60.5 | 2,285 | 61.64 |
| Education | | | | | | | | |
| Less than high school | 39,126,661 | 15.95 | 6,622 | 1036 | 5,484,850 | 23.4 | 945 | 25.49 |
| High school diploma | 54,777,325 | 22.33 | 8,348 | 22.7 | 5,239,154 | 22.3 | 828 | 22.34 |
| Some college | 75,334,153 | 30.71 | 11,201 | 30.5 | 7,349,791 | 31.4 | 1,137 | 30.67 |
| College and graduate | 74,941,660 | 30.55 | 10,363 | 28.2 | 5,178,316 | 22.1 | 774 | 20.88 |
| Income | | | | | | | | |
| PIR<1 | 64,368,878 | 26.24 | 10,491 | 28.5 | 8,653,145 | 36.9 | 1,472 | 39.71 |
| 1<PIR<2 | 63,976,383 | 26.08 | 9,801 | 26.7 | 6,570,588 | 28.0 | 1,012 | 27.30 |
| 2<=PIR<3 | 550,716,953 | 22.45 | 8,003 | 21.8 | 4,134,697 | 17.6 | 644 | 17.37 |
| 3<=PIR | 61,891,265 | 25.23 | 8,402 | 22.9 | 4,041,098 | 17.2 | 579 | 15.62 |
| Marital Status | | | | | | | | |
| Other | 137,666,973 | 56.12 | 20,659 | 56.2 | 14,652,78 | 62.6 | 2,334 | 62.98 |
| Married | 107,641,247 | 43.88 | 16,038 | 43.7 | 8,746,744 | 37.3 | 1,373 | 37.02 |
| Insurance | | | | | | | | |
| Not covered | 30,148,379 | 12.29 | 4,947 | 13.4 | 262,075 | 1.12 | 449 | 12.11 |
| Covered | 214,178,607 | 87.31 | 31,609 | 86.1 | 20,734,32 | 88.6 | 3,251 | 87.70 |

VI= visual impairment

**APPENDIX F. Demographic Composition of the Sample and Projected Population. National Health Interview Survey 2015**

| | Sample | | | | Any VI | | | |
|---|---|---|---|---|---|---|---|---|
| | Estimate population | % | No. | % | Estimate population | % | No. | % |
| All Participants | 247,773,709 | | | | 25,234,580 | | | |
| Race | | | | | | | | |
| White | 199,333,949 | 80.45 | 26,114 | 77.55 | 20,399,635 | 80.84 | 2,698 | 77.20 |
| African American | 31,913,253 | 12.88 | 4,804 | 14.27 | 3,676,678 | 14.57 | 581 | 16.62 |
| Chinese | 2,651,178 | 1.07 | 472 | 1.40 | 244,776 | 0.97 | 59 | 1.69 |
| Filipino | 2,998,063 | 1.21 | 423 | 1.26 | 75,704 | 0.30 | 8 | 0.23 |
| Asian Indian | 2,849,399 | 1.15 | 431 | 1.28 | 176,642 | 0.70 | 26 | 0.74 |
| American Indian | 2,651,178 | 1.07 | 470 | 1.40 | 194,306 | 0.77 | 38 | 1.09 |
| Other Asian | 4,088,267 | 1.65 | 701 | 2.08 | 328,049 | 1.30 | 56 | 1.60 |
| Multiple Race | 743,320 | 0.30 | 129 | 0.38 | 75,704 | 0.30 | 15 | 0.43 |
| Hispanic Origin | | | | | | | | |
| Multiple Hispanic | 520,325 | 0.21 | 83 | 0.25 | 32,806 | 0.13 | 4 | 0.11 |
| Puerto Rican | 3,815,716 | 1.54 | 584 | 1.73 | 590,489 | 2.34 | 97 | 2.78 |
| Mexican | 11,694,920 | 4.72 | 2,113 | 6.28 | 953,867 | 3.78 | 164 | 4.69 |
| Mexican | 7,061,550 | 2.85 | 1,205 | 3.58 | 721,708 | 2.86 | 123 | 3.52 |
| Cuban/Cuban | 1,560,974 | 0.63 | 285 | 0.85 | 100,938 | 0.40 | 19 | 0.54 |
| Dominican | 1,090,205 | 0.44 | 182 | 0.54 | 158,977 | 0.63 | 24 | 0.69 |
| Central or South | 5,574,908 | 2.25 | 947 | 2.81 | 454,223 | 1.80 | 81 | 2.32 |
| Other Spanish | 792,876 | 0.32 | 173 | 0.51 | 98,415 | 0.39 | 21 | 0.60 |
| Not Spanish | 215,612,682 | 87.02 | 28,081 | 83.40 | 22,110,538 | 87.62 | 2,959 | 84.66 |
| Age | | | | | | | | |
| 18 to 24 years | 23,588,057 | 9.52 | 2,890 | 8.58 | 1,160,790 | 4.60 | 147 | 4.21 |
| 25 to 44 years | 81,443,218 | 32.87 | 11,067 | 32.87 | 4,829,898 | 19.14 | 668 | 19.11 |
| 45 to 64 years | 82,533,423 | 33.31 | 11,337 | 33.67 | 10,209,912 | 40.46 | 1,438 | 41.14 |
| 65 years and over | 60,233,788 | 24.31 | 8,378 | 24.88 | 9,033,980 | 35.80 | 1,242 | 35.54 |
| Sex | | | | | | | | |
| Male | 113,430,805 | 45.78 | 15,071 | 44.76 | 9,235,856 | 36.60 | 1,290 | 36.91 |
| Female | 134,342,904 | 54.22 | 18,601 | 55.24 | 15,998,724 | 63.40 | 2,205 | 63.09 |
| Education | | | | | | | | |
| Less than high | 36,472,289 | 14.72 | 5,663 | 16.82 | 5,516,280 | 21.86 | 823 | 23.55 |
| High school | 52,775,799 | 21.30 | 7,377 | 21.91 | 5,321,972 | 21.09 | 756 | 21.63 |
| Some college | 77,131,956 | 31.13 | 10,436 | 30.99 | 8,201,237 | 32.50 | 1,134 | 32.45 |
| College and | 80,278,683 | 32.40 | 1,004 | 29.84 | 5,983,118 | 23.71 | 751 | 21.49 |
| Income | | | | | | | | |
| PIR<1 | 61,497,436 | 24.82 | 9,122 | 27.09 | 9,006,222 | 35.69 | 1,313 | 37.57 |
| 1<PIR<2 | 63,950,394 | 25.81 | 8,970 | 26.64 | 7,234,753 | 28.67 | 1,027 | 29.38 |
| 2<=PIR<3 | 54,906,654 | 22.16 | 7,287 | 21.64 | 4,670,920 | 18.51 | 608 | 17.40 |
| 3<=PIR | 67,419,225 | 27.21 | 8,293 | 24.63 | 4,320,160 | 17.12 | 547 | 15.65 |
| Marital Status | | | | | | | | |
| Other | 138,604,613 | 55.94 | 18,885 | 56.09 | 16,266,211 | 64.46 | 2,184 | 62.49 |
| Married | 109,169,096 | 44.06 | 14,787 | 43.91 | 8,968,368 | 35.54 | 1,311 | 37.51 |
| Insurance | | | | | | | | |
| Not covered | 23,389,837 | 9.44 | 3,567 | 10.59 | 2,147,463 | 8.51 | 309 | 8.84 |
| Covered | 223,268,888 | 90.11 | 29,955 | 88.96 | 23,013,938 | 91.20 | 3,177 | 90.90 |

VI= visual impairment