Addressing Inequities in Eye Care: Examining Social Vulnerability through Patient-Centered Solutions

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Introduction

Ensuring access to quality eye care services is pivotal for maintaining a key determinant of health—adequate vision. However, disparities in access persist, influenced by factors such as social vulnerability, geographic distribution of services, and health conditions.[1] The exclusive concentration of glaucoma treatment services in urban areas contributes to inequities, causing delayed diagnoses in underserved communities.[2] Recent telemedicine advancements, accelerated by the COVID-19 pandemic, present potential solutions for non-urban areas, where access to ophthalmological care is limited.

Social vulnerability is the intersectional sphere of oppression that defines barriers for underserved communities to access resources, and is certainly applicable to eye care services. A 2023 neighborhood-level cohort study showed that the higher a patient's level of social vulnerability, represented numerically by the Social Vulnerability Index (SVI), the more significant the association with non-adherence to ophthalmology appointments. SVI "is a rank score of 15 social factors into four themes, including socioeconomic status, household composition/disability, minority status/language, and housing type/transportation."[1] Their work further considers individual characteristics, demonstrating more nuanced factors influence appointment adherence and the importance of targeted interventions to mitigate these discrepancies. Similarly, across Canadian provinces, the skewed optometrist distribution reveals another metric behind SVI in addition to access: utilization. Of the 109 health regions, (HRs), "35 HRs were classified as low utilization, 39 HRs were classified as moderate, and 32 HRs as high utilization"[3] for vision care services. The study proposes better-informed workforce planning to advocate for equitable access to vital eye care services, especially across vulnerable populations under-utilizing existing sparse services. With the multi-level intervention strategies suggested, addressing patients belonging to vulnerable populations' access to eye care services requires appropriate policy interventions.

In the wake of the COVID-19 pandemic, the telecommunications landscape in specialized eye care has evolved in order to fill the need for a more convenient method for analyzing patient information. A 2022 study demonstrated high satisfaction among participants, despite appointments being longer and increased technical challenges relative to traditional in-person appointments. Particularly among pediatric patients, "99% of parents were comfortable with exam quality, and 97% indicated they would have another telemedicine examination."[4] Due to the concentration of specialized eye care in urban areas, the results suggest that telecommunications could improve access to specialized eye care and further the more collaborative nature of care between eye care providers and their patients. A similar review on the cost effectiveness of telemedicine in glaucoma screenings found that teleglaucoma "has been shown to reduce the screening time and costs per patient," and that "100% of the patients were either satisfied or very satisfied with the eye screening."[5] While eye care experts initially offered telecommunications as an adaptation to COVID-19 restrictions, its use in glaucoma screenings indicates a more efficient and economical approach that could mitigate healthcare inequities. Focusing on a patient-centered approach to care helps to improve healthcare efficacy in facilitating a closer bond between eye care providers and their patients, which would otherwise be inaccessible due to sociodemographic barriers.

The barriers to specialized ophthalmologic services and impacts on overall health are not limited to only the North American continent. A cross-sectional Ethiopian glaucoma population study revealed "the prevalence of poor quality of sleep was 82.5% among the glaucoma population,"[6] realizing a significant association between glaucoma and poor sleep quality. The study highlighted that advanced stages of glaucoma are associated with older age, depression, and visual impairment. The impacts of compromised sleep quality extend beyond health and productivity concerns, influencing intersecting societal oppressions and contributing to increased social vulnerability. The researchers ultimately recommended integrating psychiatric counseling into glaucoma follow-up protocols to address poor sleep impacts on patients psychologically. This approach advocates for a more holistic approach to glaucoma management and patient care, resulting in a more sustainable and accessible environment for eye care.

Given persistent challenges in equitable access to ophthalmologic services, targeted interventions addressing social vulnerability and promoting telemedicine emerge as crucial strategies. While acknowledging telemedicine's potential, long-term sustainability in mitigating sociodemographic inequities remains uncertain. My research aims to explore associations between glaucoma, psychological health, and sociodemographic factors to propose tailored interventions, contributing to sustainable and inclusive eye care practices. Such research endeavors may contribute to advancing inclusive and sustainable eye care practices that prioritize and address the needs of vulnerable populations. Specifically, in this study, I will examine existing associations between social vulnerability and eye care outcomes in the United States. Additionally, I will evaluate the efficacy and sustainability of telemedicine in enhancing access to ophthalmology services, particularly in non-urban and underprivileged communities.

Approaches and Methods

Broader Context

My research will answer how evidence-based interventions designed to address sociodemographic disparities in ophthalmology care contribute to advancing sustainable eye care practices in the United States. Which interventions show the most promise in effectively addressing sociodemographic disparities in access to ophthalmology care access, and in what ways can the implementation of these interventions be optimized? Professionals in the field of ophthalmology, healthcare policymakers, public health officials, and researchers specializing in healthcare disparities would be interested in sustainable practices in eye care. Additionally, professionals from academic institutions, including UCLA JSEI, government health agencies, and healthcare providers, would benefit from the data-driven decision-making that addresses sociodemographic disparities in ophthalmology care.

Overall Approach

To gauge the effectiveness of healthcare and policy interventions in ophthalmology, I will assess reduced wait times, neighborhood eye care utilization, and patient-reported outcomes in the United States. Therefore, community-level health data, such as that provided in the United States 2020 Census, are the optimal data sources to incorporate a broader understanding of social vulnerability and ophthalmology-related metrics. Following the guidance provided by Dr. Pei Fu of JSEI, I will consider the National Health and Nutrition Examination Survey (NHANES by NCHS), the American Community Survey (ACS by the U.S. Census Bureau), and the Behavioral Risk Factor Surveillance System (BRFSS by Centers for Disease Control and Prevention (CDC)). These datasets offer valuable insights into nutrition, vision impairment, and visual acuity, serving as indicators of social vulnerability factors and ophthalmology services utilization. Through extracting and analyzing these specified data sources, I can discern proxy indicators of social vulnerability and their impacts on glaucoma and patient care management.

In evaluating intervention effectiveness, my approach involves developing and deploying a machine learning algorithm to predict outcomes and discern influential factors contributing to patient eye care disparities. Working under Dr. Sajad Besharati and Dr. Vahid Mohammadzadeh at JSEI, I will collect demographic data from NHANES, ACS, and BRFSS, focusing on eye health and social vulnerability variables. After merging these factors into a single dataset and performing data analysis, my next step is to enhance the precision of the analysis[7]; I plan to employ a clustering technique based on socioeconomic status and match patients based on criteria such as appointment follow-up time and whether the patient has glaucoma. From this information, I hope to find out which interventions are most effective in helping people get the eye care they need based on their background. The core of the analysis will be calculating qualified success rates, and utilizing Kaplan-Meier survival curves to demonstrate significant differences between groups. I will leverage Cox proportional hazard models to estimate how interventions impact follow-up time.[8] My experimental design aims to provide a comprehensive understanding of clinical findings and intervention strategies, offering valuable insights for addressing disparities in patient eye care.

Week	Expected Work
Winter Quarter 2024 Weeks 1-6	Complete: Integrate data derived from diverse surveys, censuses, and patient reports into a unified dataset, categorized according to patient demographics and socioeconomic indicators.
Winter Quarter 2024 Weeks 7-10	Complete: Determine the significance of multicollinear factors and the binary criteria associated with each patient observation.
Spring Quarter 2024 Weeks 1-4	In progress: Investigate existing intervention strategies and their implementation targeted at pertinent demographic segments within the dataset. Document and note findings pertaining to follow-up time.
Spring Quarter 2024 Weeks 5-10	In progress: Compose a comprehensive research report, adhering to professional standards, for presentation to JSEI Dr. Kouros Nouri-Mahdavi. Conclude the SLAGC course with a summary of the study's outcomes and implications.

Data Cleaning Details

I completed several data processing procedures within the R programming language to ensure the integrity of the dataset for further analysis. I cleaned four datasets: the NHANES, ACS, BRFSS, and NCBI NLM glaucoma clinical notes. First, I changed column names to include precise and informative descriptors, enhancing the data's interpretability. Careful cleaning of numerical values was performed to facilitate conversion into a standard numeric format by removing unnecessary characters like commas and percentage marks. I refined the dataset by handling margin of error indicators, extracting numerical values, and eliminating symbols such as "±". Additionally, I generated confidence interval bounds for population estimations. The percentages of people with and without disabilities were preprocessed similarly, involving cleaning, managing the margin of error, and subsequent calculation of confidence intervals. To focus on the important variables of interest, I selected relevant columns of the percentages of people with and without disabilities along with their corresponding boundaries for further research. These rigorous preprocessing steps, executed within the R programming language, form the groundwork for robust statistical analysis of the various datasets.

Analysis for Datasets Used for Evaluating Social Vulnerability

I conducted a comprehensive examination of various datasets, including ACS, BRFSS by CDC, and NHANES, to explain the social vulnerability determinants underlying health disparities, particularly in access to ophthalmological treatment. ACS collects data from 2022, BRFSS data is from 2016, and NHANES data is a long-term study that began in 1999, with survey years conducted every year since then until 2018. The limitations the Health Insurance Portability and Accountability Act (HIPAA) impose makes individual patient-specific information unattainable. As a result, I could not obtain statistics about the distribution and use of individual patients, especially demographic information. However, I used the NCBI NLM dataset of notes from patients examined for glaucoma by comprehensive or glaucoma ophthalmologists, collected from 480 patients seen between January 1, 2019, to August 31, 2020. This dataset included a variety of identifiers, including billing codes, provider names, medical record numbers (MRNs), and visit identification numbers. To analyze the text comprehensively, I constructed a text corpus, a container of documents, to generate a term-document matrix. This matrix helped identify recurring terms across the documents. Additionally, I conducted sentiment analysis to assess the emotional connotation associated with common words within the dataset. Each word's sentiment was mapped on a scale from -1 (negative) to 1 (positive), with 0 indicating neutrality. The following are my findings regarding the social vulnerability determinants underlying health disparities in access to ophthalmological treatment, based on a comprehensive examination of these various datasets.

Results and Discussion

I will explore a number of issues pertaining to differences in the use of eye care services and access to ophthalmological services. My investigation starts by looking at the interaction between employment and disability status, highlighting potential socioeconomic vulnerabilities that could affect people's capacity to receive eye care services. Next, I examine differences in gender, age, and vision impairment. Then, I look into how race, age, and glaucoma detection interact, along with trends in illness prevalence and sentiment taken from glaucoma clinical notes. I arranged these sections to provide a thorough explanation of the various factors that contribute to variations in the use of eye care. The discussion that follows focuses on intervention strategies that aim to address these variations and promote a more inclusive healthcare system.

Disability Status and Employment

Based on the ACS 1-year estimates for 2022, although the majority of working people aged 16 and older were found to be disability-free, (Figure 1), the greatest discrepancy in employment between disabled and non-disabled employed individuals over the age of 16 was unpaid family workers who are more likely than not to have a disability (Figure 2). This discrepancy reflects a type of social vulnerability, disability status, and unpaid labor, that may affect their use of social services like glaucoma treatment.[9]

As people with higher incomes and educational levels had lower rates of disability (Figure 3), the correlation between socioeconomic status and disability emphasizes how critical it is to mitigate accessibility obstacles to available resources.[9] People *without* a disability are marginally more likely to work from home and drive alone, so differences in work schedules and transportation options by disability status highlight the need for tailored treatments to guarantee fair access to eye care.[10] As such, my analysis emphasizes the significance of considering socio-economic factors and employment dynamics in understanding and addressing disparities in glaucoma service prevalence and utilization within the broader context of disability prevalence among the working-age population.

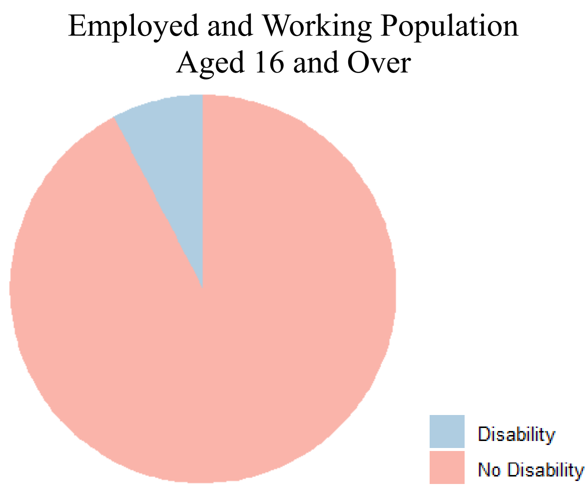

Figure 1: Employment Status of Individuals Aged 16 and Over, Stratified by Disability Status, Derived from ACS 2022 Data.

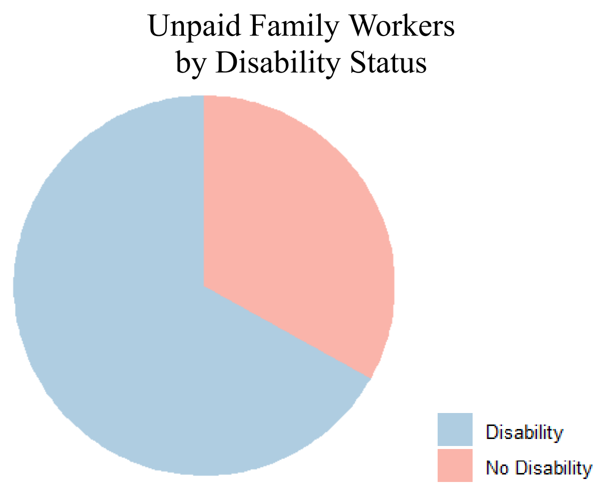

Figure 2: Proportion of Unpaid Family Workers among Individuals Aged 16 and Over, Stratified by Disability Status, Derived from ACS 2022 Data.

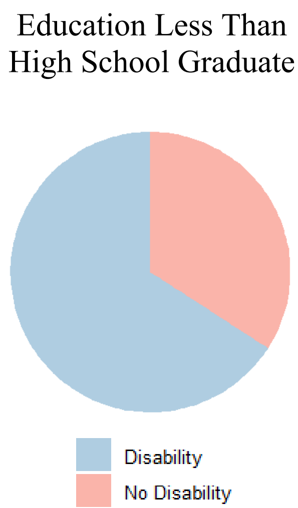

Figure 3a: Education Status of Individuals Less than High School Graduate Equivalency. Derived from ACS 2022 Data.

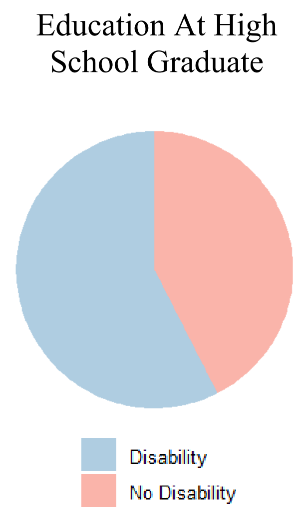

Figure 3b: Education Status of Individuals At High School Graduate Equivalency. Derived from ACS 2022 Data.

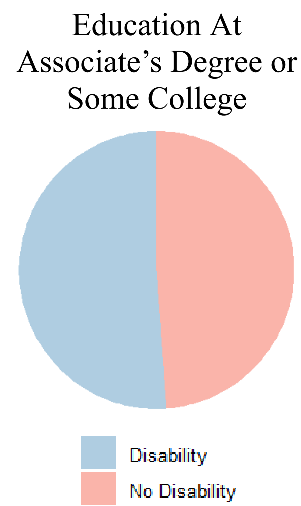

Figure 3c: Education Status of Individuals At Some College/Associate's Degree. Derived from ACS 2022 Data.

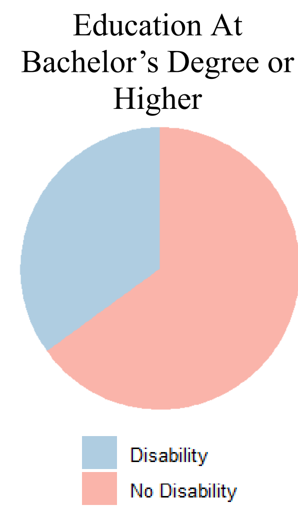

Figure 3d: Education Status of Individuals At Bachelor's Degree or Higher. Derived from ACS 2022 Data.

Gender, Age, and Vision Impairment

Further exploring the intersections of social vulnerabilities, ACS data from 2022 highlights gender differences in visual impairment prevalence among older populations. Data on visual impairment in people 75 years and older reveals a relationship between gender differences in visual health. Compared to males, females in this age bracket are proportionally more prone to visual impairment (Figure 4a). This disparity raises concerns regarding possible gender-specific health or lifestyle factors that could lead to older age-related visual impairment[11]. Females may be diagnosed with visual impairment at a higher prevalence or more frequently, which emphasizes the necessity for gender-sensitive practices in the provision of visual health care[12] (Figure 4b). Yet, there is a counterintuitive pattern; in every age group, females are more likely than males to lack visual impairment (Figure 4c). This paradox presents fascinating possibilities about how lifestyle choices, biological conditions, or healthcare access could influence visual health outcomes. There is a gender-neutral distribution of the *absence* of visual impairment in all age groups (Figure 4d). While there may be gender differences in the reasons causing vision impairment, other universal variables may affect its absence. This comprehensive analysis of gender, aging, and visual health reveals the imperative for additional research endeavors to further explore the social determinants of visual health disparities.

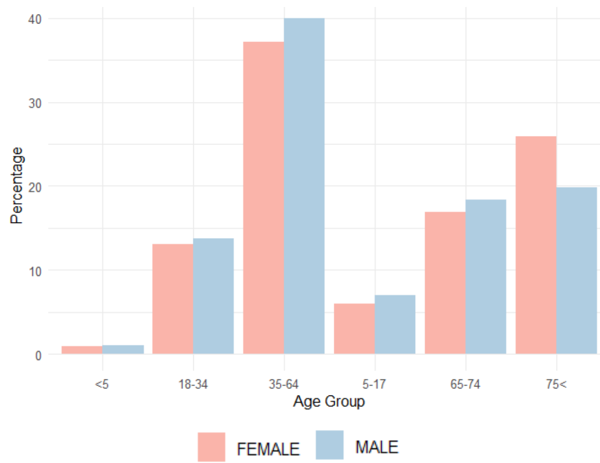

Figure 4a: Percentage of Individuals with Visual Difficulty, Stratified by Gender and Age Group, Derived from ACS 2022 Data.

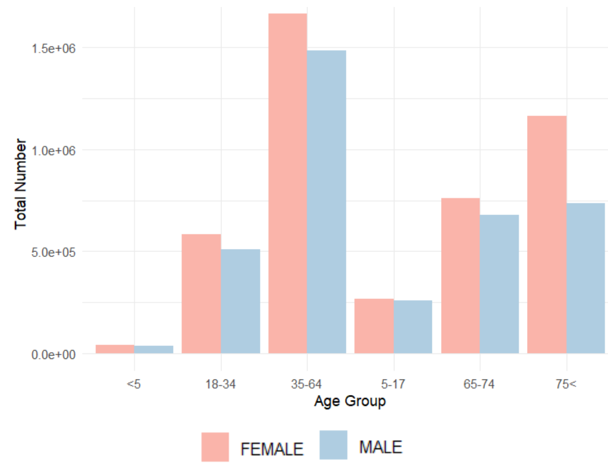

Figure 4b: Total Number of Individuals with Visual Difficulty, Stratified by Gender and Age Group, Derived from ACS 2022 Data.

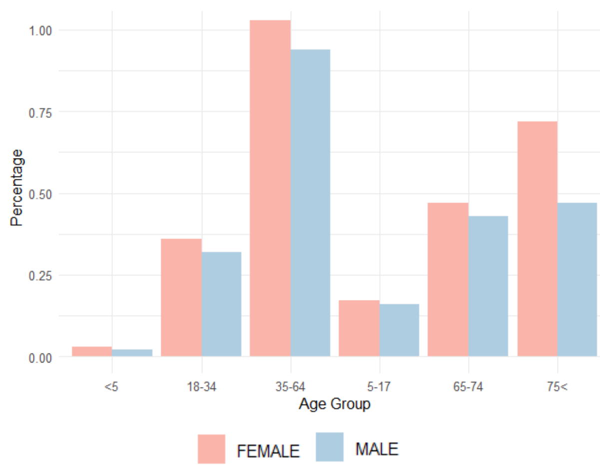

Figure 4c: Percentage of Individuals without Visual Difficulty, Stratified by Gender and Age Group, Derived from ACS 2022 Data.

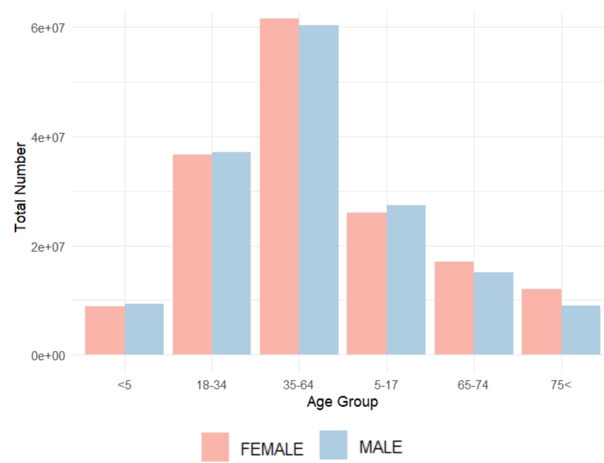

Figure 4d: Total Number of Individuals without Visual Difficulty, Stratified by Gender and Age Group, Derived from ACS 2022 Data.

Race, Age, and Glaucoma Detection

Moreover, analyzing specific glaucoma types data from the 2016 BRFSS by the CDC provides insight into the distribution of glaucoma across different demographic parameters. Although glaucoma may affect anyone of any age, ophthalmologists frequently detect it in those between 40 and 64, emphasizing the importance of detection efforts throughout one's lifetime (Figure 8). Furthermore, the limited variation in frequency between racial groups indicates that the impact of glaucoma is universal. However, there are gaps in data collecting for several racial categories such as “Other” and “North American Native” (Figure 9), which warrants improved reporting procedures or data collection[14]. A higher frequency of response rate regarding glaucoma from California and New York and lowest response rates from Utah, Alabama, and Alaska, demonstrates differences in data collection or reporting efforts and informs targeted strategies to improve eye care services in underrepresented regions (Figure 10). There may also be an unrepresented trend in differences in population size, healthcare utilization patterns, and insurance coverage rates.[13] Ultimately, the higher annual presence of certain conditions among glaucoma patients highlights the need for tailored interventions to address the unique challenges posed by these diseases in affected individuals.

Age Breakdown of
Patient Glaucoma Detection

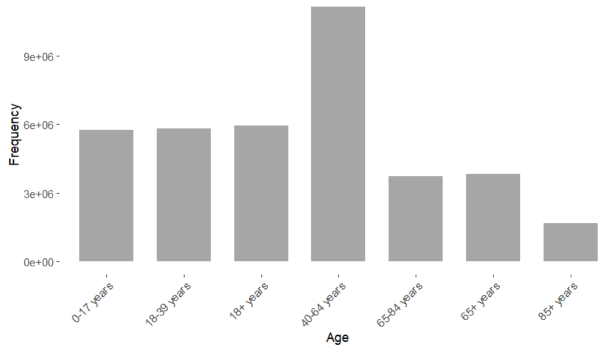

Figure 8: Glaucoma Detection by Type of Detection and Age Group, Derived from BRFSS by CDC 2016 Data.

Racial Breakdown of
Patient Glaucoma Detection

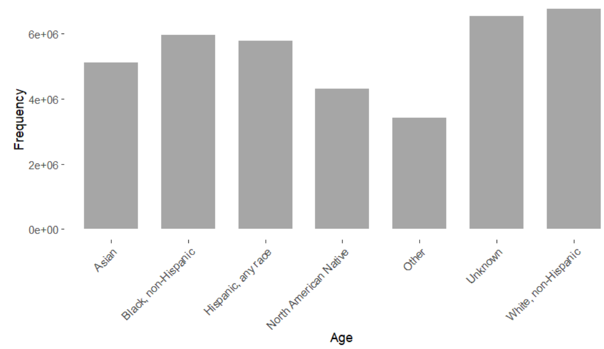

Figure 9: Glaucoma Detection by Type of Detection and Race, Derived from BRFSS by CDC 2016 Data.

U.S. Map of Insurance Claims Responses for Glaucoma by State

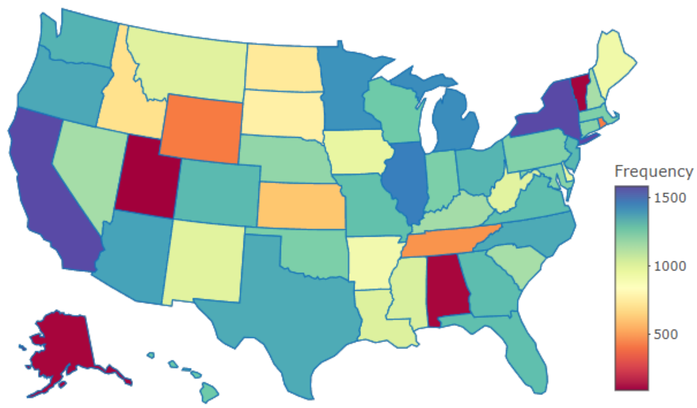

Figure 10: U.S. Map depicting Frequency of Glaucoma Insurance Responses, Derived from BRFSS by CDC 2016 Data.

Disease Prevalence

The NHANES data offers significant insights into the prevalence and interrelationships of various health conditions within the surveyed population from various 1-year long surveys from 1999 to 2018. There was a range in confidence levels for oral, chronic, and acute diseases, illustrating variability and uncertainty in prevalence estimates (Figure 11), underscoring the necessity for a comprehensive analysis of the presented data.[14] With acute diseases accounting for 35 percent of participants and confidence levels as high as 80 percent, the population's acute health disorders represent a significant burden that informs healthcare planning and resource allocation tactics. The observed difference in median prevalence between chronic and acute diseases for survey year 1-year period from 2017 to 2018 (Figures 12-13) demonstrates the dynamic shift in disease patterns that observations reveal over time, highlighting the need for ongoing monitoring and strategy adaptation in the healthcare industry. These findings offer valuable insights into the prevalence and interrelationships of health conditions within the surveyed population, facilitating targeted healthcare interventions and resource allocation efforts.

Collectively, these datasets provide a thorough understanding of health disparities and their complex causes based on social vulnerability.

Percentage of Individuals with Oral Diseases

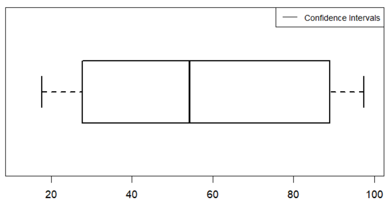

Figure 11a: Percentage of Individuals with Oral Diseases and Confidence Intervals, Derived from NHANES.

Percentage of Individuals with Chronic Diseases

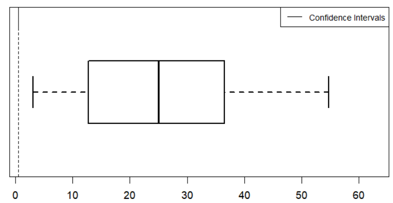

Figure 11b: Percentage of Individuals with Chronic Diseases and Confidence Intervals, Derived from NHANES.

Percentage of Individuals with Acute Diseases

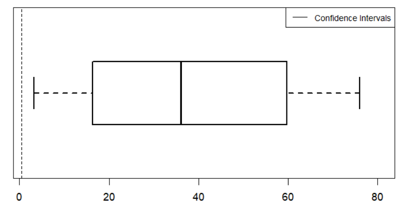

Figure 11c: Percentage of Individuals with Acute Diseases and Confidence Intervals, Derived from NHANES.

Median Percentage of Individuals with Diseases

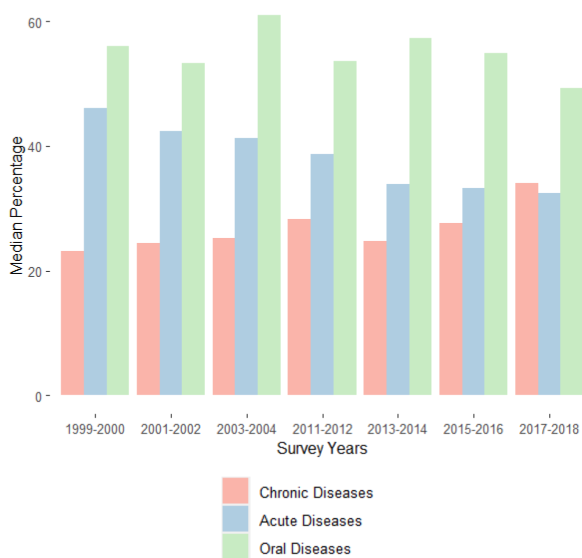

Figure 12: Median Percentage of Individuals with Diseases, Derived from NHANES.

Mean Percentage of Individuals with Diseases

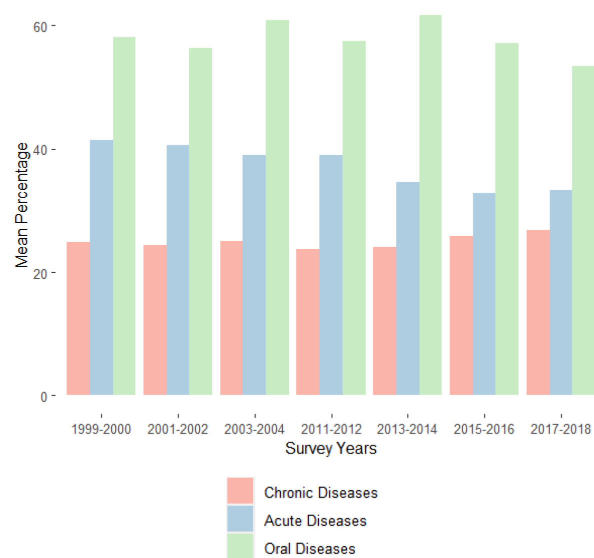

Figure 13: Mean Percentage of Individuals with Diseases, Derived from NHANES.

Glaucoma Clinical Notes

Out of the 2,245 matched words from the 2022 NCBI NLM dataset of 480 clinical notes, the majority were categorized as neutral[15]. Specifically, less than 20% displayed either a negative or positive sentiment, with a higher proportion falling into the negative category (Figure 14). To identify the most common words excluding stop words (common prepositions and filler words), I parsed each clinical note into strings and tallied the frequency of each word, and this approach yielded 2,352 unique words. Notably, the abbreviation "OU," meaning "oculus uterque" or "each eye," emerged as the most frequently occurring term (782 counts). This was followed by "eye" (422 counts) and "HPI" (History of Presenting Illness) (384 counts). The most common non-neutral words were "vision" (358 counts), "patient" (201 counts), and "female" (178 counts), all positively scored terms of 0.5, 0.5, and 0.4, respectively. Upon subjecting these 2,352 words to sentiment analysis, the distribution of neutral, negative, and positive sentiments remained consistent with previous findings, reaffirming the robustness of the results (Figure 15).

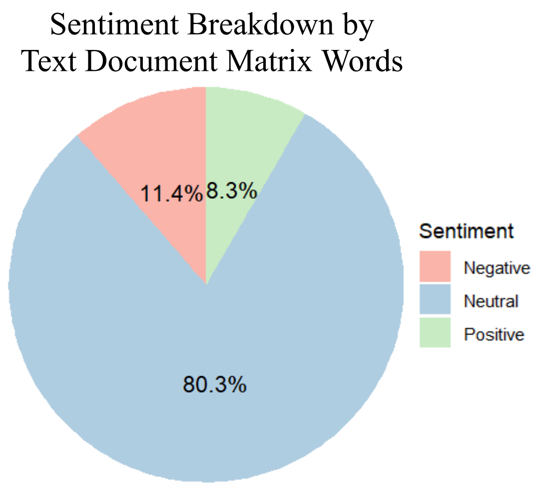

Figure 14: Sentiment breakdown by individual words in the text document matrix, Derived from NCBI NLM 2019-2020.

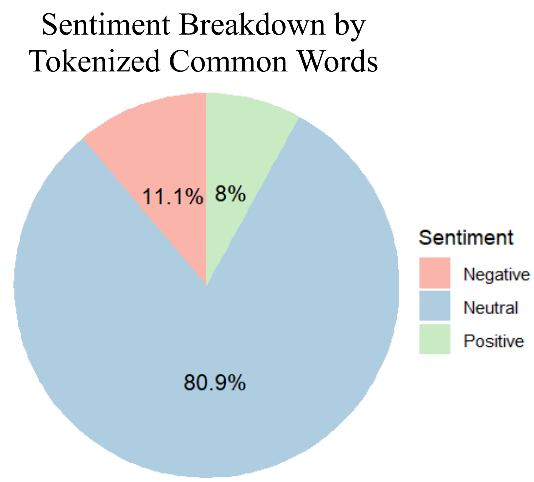

Figure 15: Sentiment breakdown by individual tokenized words, Derived from NCBI NLM 2019-2020.

Intervention categories include medications, family history-based interventions, progress checks, and further assessments and plans (Figure 16). The data indicates a predominant reliance on medication-based interventions in glaucoma management. Using sentiment analysis alongside intervention data sheds light on the effectiveness and medical neutrality of various treatment approaches conducted by glaucoma specialists.[16] By examining the distribution and contextual subtleties of these interventions, it is possible to identify regions in glaucoma interventions that can benefit from optimization, which would improve the general standard of patient ophthalmological treatment.

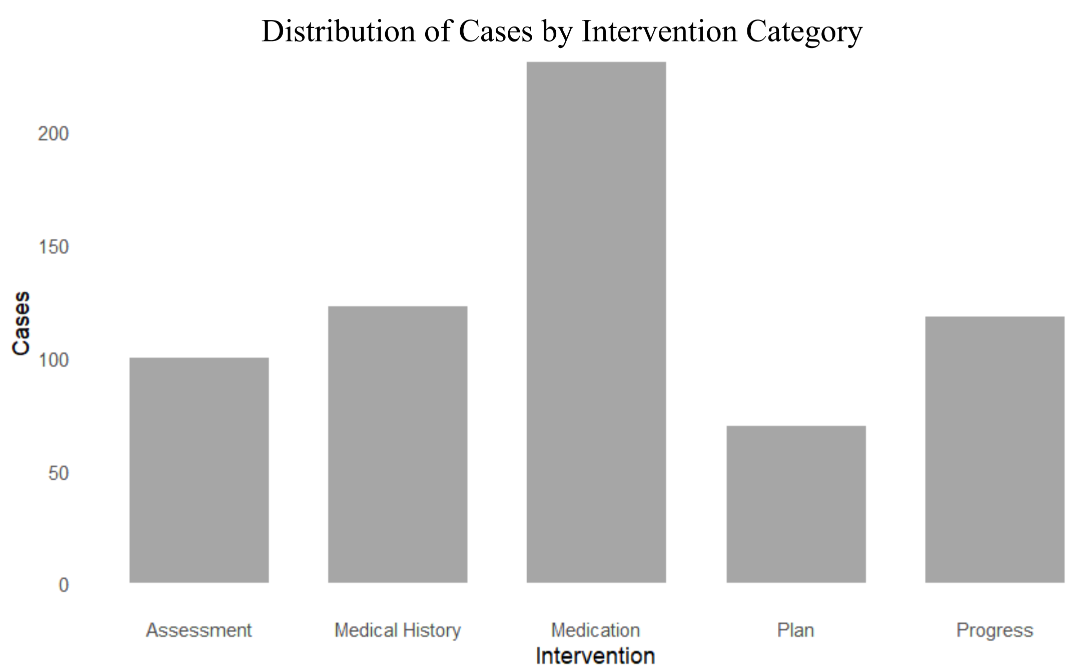

Figure 16: Distribution of Cases by Intervention Category. Derived from NCBI NLM 2019-2020.

In addition to exploring contributing factors to differences in glaucoma detection, my research aims to utilize criteria matching and machine learning techniques. These approaches will help determine the most effective intervention strategies for facilitating access to necessary eye care among individuals from diverse socioeconomic backgrounds. To supplement this analysis, I plan to calculate qualifying success rates and apply Kaplan-Meier survival curves to showcase statistically significant differences between groups based on social vulnerabilities such as age, gender, and ethnic background. I will also use Cox proportional hazard models to calculate the effect of interventions on follow-up duration. By incorporating these methodologies, my experimental design seeks to provide a comprehensive understanding of clinical findings and glaucoma intervention strategies to address disparities in patient eye care and contribute to a more inclusive healthcare system.

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