

The sight of disparity: how social determinants shape visual impairment and blindness across the U.S.

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SUMMARY

Visual impairment and blindness are a growing public health challenge in the United States, creating burdens on individuals and on society as a whole. Social and geographic factors are known to have substantial impacts on eye health. Our study examined this issue by analyzing differences between social determinants of health (SDH) in the southern and northern United States and correlating these differences with vision loss. We hypothesized that SDH, including race and ethnicity, age, socioeconomic status, access to healthcare, and geographic location, correlate with visual impairment and blindness rates. To test this, we used publicly available data from 18 states (9 northern, 9 southern) to examine associations among these SDH and vision loss. A Bayesian correlation analysis revealed very strong association of vision loss with poverty ($r = 0.918$) and education ($r = -0.735$) and moderate association with optometrist density ($r = -0.610$) and a higher Black population ($r = 0.566$). Southern states showed higher rates of vision loss than northern states and had lower optometrist densities, higher poverty, lower education, and a larger Black population. These findings reveal that SDH significantly influence vision health, reflecting broader disparities in healthcare access and socioeconomic status. Policymakers and community leaders must address these systemic issues to reduce inequity in vision health. Targeted public health interventions are needed in underserved populations, particularly those in the southern United States. By identifying the SDH that correlate with visual impairment and blindness, our study provides a framework for addressing disparities in eye health across the U.S.

INTRODUCTION

Vision disability ranks among the 10 most common disabilities in United States (U.S.) adults aged 18 and older and is also one of the most widespread disabling conditions affecting children (1). Based on its severity, vision loss can be categorized as blindness or visual impairment. Blindness is defined by the Centers for Disease Control and Prevention (CDC) as vision in the better eye, even with correction, that is 20/200 or worse (2). This means that even with the best possible corrective lenses, the individual cannot see objects at a distance farther than 20 feet that an individual with normal

vision could see from 200 feet away. The CDC defines visual impairment as corrected vision that falls between 20/32 and 20/200 (2).

The U.S. Census Bureau estimated that 8.3 million Americans had a visual disability in 2023, which is about 2.5% of the population (3). The prevalence of vision loss increases as a function of age—from 0.9% of individuals under 18 years old, to 2.1% of individuals between the ages of 18 and 64, and 5.9% of individuals 65 years or older (3). This occurs because risk factors of vision loss tend to become more prevalent in older age. Globally, cataracts are the leading cause of blindness in older individuals, with glaucoma, uncorrected vision problems, age-related macular degeneration, and diabetic retinopathy being the next major contributors (4).

Due to changing demographics and a growing elderly population, the prevalence of vision disability is increasing worldwide. A U.S. population-based cross-sectional study comparing data from 2015 to projections in 2050 estimated that among people aged 40 and older, there will be an approximate 25% increase in visual impairment and 21% increase in blindness per decade (5). Because of the aging population of the U.S., a higher proportion of the population lives with risk factors associated with blindness, causing this trend (4).

Vision impairment and blindness are a significant risk for children as well. Studies project that there will be a 26% rise in number of visually impaired preschool-aged children in the U.S. by the year 2060 (6). A majority of these cases result from uncorrected refractive errors, a type of preventable and reversible vision loss that can be restored with glasses, contact lenses, or surgery (6). This trend is predominantly because of a growing younger Hispanic population, as Hispanic children have higher rates of vision impairment (6). Furthermore, due to increased screen time, decreased outside time, and more close-work activities, refractive errors have grown significantly in the last decade (7). This trend became especially evident during the COVID-19 pandemic. A meta-analysis studying the refractive change in children found significant increase in both spherical equivalent refractive measurements (overall focusing power of the eye) and axial length measurements (front-to-back distance of the eye), indicating a rapid progression of myopia, also known as nearsightedness, during pandemic home confinement compared to the pre-COVID period (8).

Visual impairment and blindness pose significant challenges for both individuals and society. Vision loss in young children leads to major impacts on their ability to learn, work, and live independently (9). Vision loss also presents a considerable economic challenge; in 2017, vision loss was estimated to cost the U.S. approximately 134.2 billion United

States dollars (USD) in economic burden (10). This includes indirect costs such as reduced labor force participation in those younger than 64 years of age and direct costs such as nursing home costs in those older than 65 years of age. This burden is expected to rise to 373 billion USD by 2050 (1).

Visual impairment and blindness are affected by several factors such as age, race, income, and access to health services (11,12). The term social determinants of health (SDH) refers to the environmental factors that shape how individuals live, ultimately influencing health outcomes (11). Given the large individual and economic impacts of vision loss, it is necessary to address the SDH associated with this disability. We hypothesized that various SDH, including race and ethnicity, age, socioeconomic status, access to healthcare, and geographic location, correlate with visual impairment and blindness rates. Our study revealed that states located in the southern U.S. had higher rates of vision loss that correlated with low optometrist density, high poverty, low education level, and a larger Black population, while the opposite trend was true in the northern U.S. Further studies are warranted to explore if improving community-based programs and acknowledging the effects of SDH can serve as ways to improve equity in targeted areas.

RESULTS

Although visual impairment and blindness are known to be shaped by SDH, the specific state-level patterns linking SDH to vision loss across the northern and southern United States remain unclear. We hypothesized that vision loss would correlate with multiple SDH factors, including age, poverty, education, race, and provider availability, and that these relationships would differ by region. To test this hypothesis, we analyzed publicly available state-level data from 18 U.S. states and examined how vision loss varied across demographic, socioeconomic, and geographic variables.

To test our hypothesis that SDH variables may correlate with visual impairment and blindness, we analyzed vision loss rates in the U.S. and compared them to different SDH variables including age, race, poverty level, and geographic distribution. We used the CDC Vision and Eye Health Surveillance System (VEHSS), which gathers data from the American Community Survey (ACS). We used the Area Health Resources File (AHRF) from the U.S. Department of Health and Human Services (HHS) to gather data on the geographic distribution of optometrists. We then used the U.S. Census data from the ACS 2022 1-year survey to determine geographic patterns in poverty.

We first determined the trends in vision loss over time for different age groups between 2014 and 2022. Our data revealed opposing trends between younger and older cohorts. Among individuals above 85 years old, vision loss trended down from 17.20% (95% CI: 16.80-17.60) of the population in 2014 to 14.63% (95% CI: 14.31-14.96) in 2022. However, the opposite shift was found in people under 18; between 2014 and 2022, vision loss trended up from 0.70% (95% CI: 0.70-0.80) to 0.84% (95% CI: 0.81-0.87). The middle of these two extremes was the cohort between 40 and 64 years old, where vision loss remained stable over time: 2.80% (95% CI: 2.70-2.80) in 2014 and 2.79% (95% CI: 2.74-2.84) in 2022 (**Figure 1**).

We next explored the trends in vision loss over time for Black, Hispanic, and White populations in the U.S. between

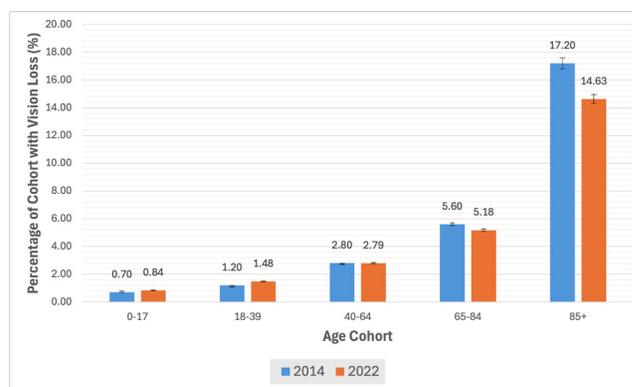


Figure 1: Relationship between age cohort and vision loss in the U.S. between 2014 and 2022. Bar graph of 5 age cohorts (0–17, 18–39, 40–64, 65–84, 85+) showing trends in the percentage of the cohort with vision loss in 2014 (blue) and in 2022 (orange). Error bars indicate 95% confidence intervals. Data were obtained from the VEHSS. The percentage of the cohort with vision loss is significantly higher in 2022 than in 2014 for age cohorts 0–17 and 18–39. The percentage of the cohort with vision loss is significantly lower in 2022 than in 2014 for age cohorts 65–85 and 85+. The percentage of the age cohort 40–64 with vision loss has no significant change in 2014 to 2022.

the years 2014 and 2022. In 2022, the rate of vision loss was highest in the Black population, next highest in the Hispanic population, and lowest among the White population. In the White population, the rate of vision loss remained relatively constant, hovering around 2.5%, while the rate of vision loss trended upward in the Black and Hispanic communities from 3.10%–3.37% and 2.20%–2.61% respectively.

To investigate the impact of socioeconomic status on visual disability, we compared the percentage of the population that experienced blindness and visual impairment among individuals with household incomes above or below the poverty level in the year 2022. 2.19% of the population living above the poverty line experienced vision loss, while 4.64% of the population living below or at the poverty level experienced vision loss.

We then analyzed patterns in the geographic distribution of vision loss in the U.S. In a study of 18 U.S. states, we found that, on average, states in the southern U.S. had a higher percentage of the population experiencing vision loss than states in the northern U.S. For example, Alabama reported 3.51% of the population experiencing vision loss in 2022 and 3.37% in 2019. Conversely, Minnesota reported 1.71% of the population experiencing vision loss in 2022 and 1.65% in 2019 (**Table 1**).

To investigate the relationship between visual disability to eye care access, we compared the geographic distribution of vision loss to the geographic distribution of optometrists. Our findings revealed that, on average, states in the southern U.S. had a lower number of optometrists per capita than states in the northern part of the country. For instance, Alabama reported 9.15 optometrists per 100,000 population in 2022 and 10.81 optometrists per 100,000 population in 2019. In contrast, Minnesota reported 15.96 optometrists per 100,000 population in 2022 and 17.45 optometrists per 100,000 population in 2019. Upon plotting vision loss by optometrist density for each state, we observed that vision loss was generally higher in states that had lower optometrist density,

State	Region	% Vision Loss (95% CI)	Optometrists per 100,000 Population	% Below Poverty Line (90% CI)	% HS grads (25+) (90% CI)	% Black (90% CI)
Virginia	South	2.32 (2.19-2.46)	15.90	10.6 (10.3-10.9)	91.1 (91.0-91.2)	18.6 (18.5-18.7)
Kentucky	South	3.76 (3.52-4.02)	6.53	16.5 (16.0-17.0)	88.2 (88.0-88.4)	7.9 (7.8-8.0)
Oklahoma	South	3.90 (3.65-4.17)	14.73	15.7 (15.3-16.1)	88.9 (88.8-89.0)	7.0 (6.9-7.1)
Arkansas	South	3.73 (3.49-3.99)	12.49	16.8 (16.1-17.5)	88.2 (88.0-88.4)	15.1 (15.0-15.2)
Alabama	South	3.51 (3.30-3.73)	9.15	16.2 (16.1-16.3)	87.7 (87.5-87.9)	26.2 (26.1-26.3)
Florida	South	2.58 (2.49-2.67)	12.52	12.7 (12.5-12.9)	89.3 (89.2-89.4)	14.9 (14.8-15.0)
Mississippi	South	4.81 (4.48-5.16)	10.51	19.1 (18.5-19.7)	86.2 (85.9-86.5)	37.1 (37.0-37.2)
South Carolina	South	2.77 (2.61-2.93)	8.46	14.0 (13.6-14.4)	89.3 (89.1-89.5)	25.6 (25.5-25.7)
Texas	South	2.88 (2.79-2.96)	14.84	14.0 (13.8-14.2)	85.2 (85.1-85.3)	11.8 (11.7-11.9)
Colorado	North	2.11 (1.96-2.28)	19.75	9.4 (9.1-9.7)	92.5 (92.4-92.6)	3.8 (3.7-3.90)
Illinois	North	2.35 (2.24-2.46)	17.35	11.9 (11.6-12.2)	90.1 (90.0-90.2)	13.7 (13.6-13.8)
Michigan	North	2.26 (2.15-2.37)	16.83	13.4 (13.1-13.7)	91.8 (91.7-91.9)	13.4 (13.3-13.5)
Kansas	North	2.61 (2.35-2.90)	19.48	12.0 (11.5-12.5)	91.8 (91.6-92.0)	5.4 (5.3-5.5)
Minnesota	North	1.71 (1.57-1.86)	15.96	9.6 (9.2-10.0)	93.7 (93.6-93.8)	6.6 (6.5-6.7)
New York	North	2.36 (2.26-2.47)	13.41	14.3 (14.0-14.6)	87.6 (87.5-87.7)	13.8 (13.7-13.9)
Pennsylvania	North	2.52 (2.38-2.66)	17.86	11.8 (11.5-12.1)	91.7 (91.6-91.8)	10.4 (10.3-10.5)
Washington	North	2.35 (2.20-2.50)	17.55	10.0 (9.7-10.3)	92.1 (92.0-92.2)	3.8 (3.7-3.9)
Wisconsin	North	1.89 (1.73-2.06)	14.96	10.7 (10.4-11.0)	93.1 (93.0-93.2)	6.1 (6.0-6.2)

Table 1: Descriptive statistics for social determinants of health and vision loss in 2022. Table summarizing vision loss, optometrist availability per 100,000 people, poverty rates, high school graduation rates for those aged 25 years or older, and Black population percentages for 18 U.S. states (9 southern, 9 northern). All data was compiled from the VEHSS, AHRF, and the ACS 1-Year Estimates for 2022.

depicting the impact of geography on eye care access and vision loss (Figure 2, Table 1).

Furthermore, the geographic distribution of vision loss correlated with overall socioeconomic status and education level of people living in that region. For the year 2022, U.S. Census Bureau data showed that states in the southern U.S. had a higher percentage of people in poverty than states in the northern part of the country. For example, in 2022, Alabama reported 16.2% of the population experiencing poverty, while Minnesota reported 9.6% of the population experiencing poverty. We then plotted vision loss by poverty for each state, which revealed that vision loss was generally higher in states that had a higher percentage of the population living in poverty (Figure 3, Table 1).

By analyzing the data on the percentage of individuals aged 25 and above who had earned a high school diploma in the year 2022, we observed that the southern U.S. generally had a lower graduation rate compared to the northern part of the country. For instance, in 2022, Alabama reported a graduation rate of 87.7% among the population aged 25 and above, while Minnesota had a graduation rate of 93.7% in the same age group (Figure 4, Table 1). Moreover, racial demographics correlated with similar geographic observations. Our findings revealed that, on average, Black people constituted a larger demographic in southern states compared to northern states. For instance, in 2022, Alabama had a population of 26.2% that was Black, while Minnesota had a population of 6.6% that was Black (Figure 5, Table 1).

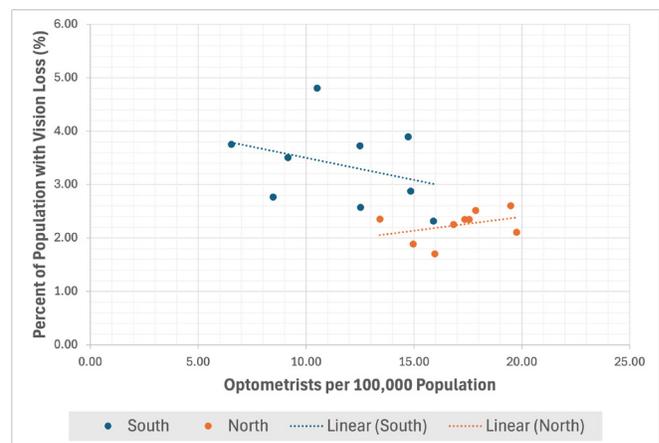


Figure 2: Relationship between optometrist density and vision loss in northern and southern U.S. states in 2022. Scatter plot of 9 northern states (orange) and 9 southern states (blue) showing a negative correlation between the number of optometrists per 100,000 population with the percentage of the population with vision loss. Trendlines show the overall trend for each region. Vision loss data were obtained from the VEHSS, and optometrist density data were obtained from the AHRF. Northern states tend to have higher optometrist densities and a lower proportion of the population with vision loss, while the opposite trend is true among southern states.

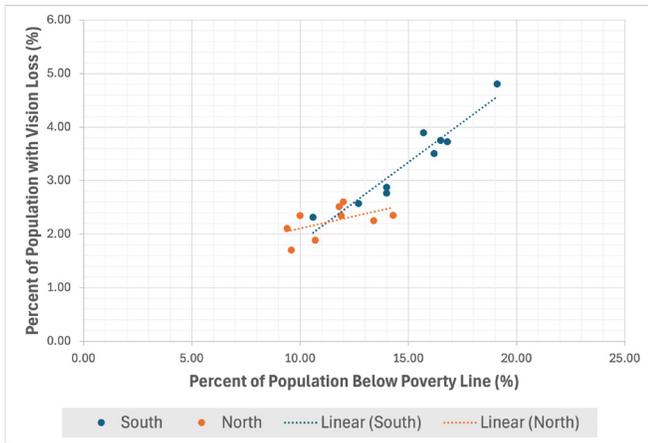


Figure 3: Association between poverty and vision loss in northern and southern U.S. states in 2022. Scatter plot of 9 northern states (orange) and 9 southern states (blue) showing a positive correlation between the percentage of the population below the poverty line and the percentage of the population with vision loss. Trendlines show the overall trend for each region. Vision loss data were obtained from the VEHSS, and poverty data were obtained from the U.S. Census ACS 2022 1-year survey. Northern states tend to have a lower proportion of the population below the poverty line and a lower proportion of the population with vision loss, while the opposite trend is true among southern states.

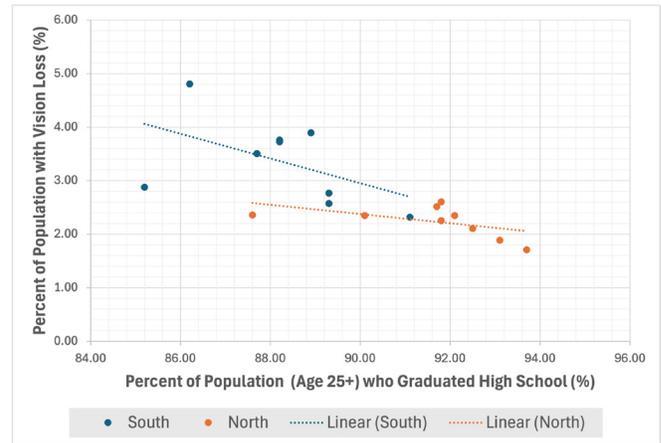


Figure 4: Association between high school graduation and vision loss in northern and southern U.S. states in 2022. Scatter plot of 9 northern states (orange) and 9 southern states (blue) showing a negative correlation between the percentage of the population (age 25+) achieving high school graduation and the percentage of the population with vision loss. Trendlines show the overall trend for each region. Vision loss data were obtained from the VEHSS, and high school graduation data were obtained from the U.S. Census ACS 2022 1-year survey. Northern states tend to have a higher proportion of the adult population achieving high school graduation and a lower proportion of the population with vision loss, while the opposite trend is true among southern states.

To further study the effect of each SDH variable on vision loss, we conducted Bayesian correlation analysis. Vision loss was the dependent variable, while the SDH factors of optometrist density, poverty, education, and Black population were the four independent variables. The correlation analysis revealed strong associations between several SDH and vision loss at the state level. Poverty showed the strongest correlation ($r = 0.918$, $BF_{10} = 148,933.349$), meaning that states with higher poverty had a very strong correlation with vision loss. Education had the next strongest correlation ($r = -0.735$, $BF_{10} = 76.151$), indicating that states with lower education had a very strong correlation with vision loss. There was moderate evidence for correlation between optometrist density ($r = -0.61$, $BF_{10} = 8.244$) or Black population ($r = 0.566$, $BF_{10} = 4.722$) with vision loss, providing evidence to support our hypothesis that SDH factors influence vision loss.

DISCUSSION

Our study aimed to understand how social determinants of health shape disparities in vision loss across the United States, focusing on differences between northern and southern states. Guided by the hypothesis that factors such as poverty, education, eye-care access, and racial demographics influence visual impairment rates, we analyzed publicly available datasets to compare vision loss trends across age groups, racial groups, and regions, and to examine how these patterns related to optometrist density, poverty levels, racial demographics, and educational attainment. This multi-step analysis revealed clear and consistent patterns: states in the southern U.S. showed higher vision loss alongside higher poverty, lower educational attainment, lower optometrist density, and larger Black populations, while northern

states demonstrated the opposite trends. These findings highlight how structural and socioeconomic conditions intersect to produce predictable geographic patterns in eye-health outcomes, reflecting broader inequalities in access, resources, and preventive care.

Data that identify geographic variations in the prevalence of vision loss can guide interventions to enhance eye care services. A prior study examining 2009-2013 data showed results similar to ours. Over three-quarters (77.3%) of counties in the top quartile for severe vision loss were situated in the southern U.S. (13). Previous studies have also suggested that vision loss correlates with varying SDH between the southern and northern U.S. In a striking study by Gibson, it was found that 24% of U.S. counties in 2011 had no ophthalmologists or optometrists (14). With respect to U.S. geography, the study indicated that the southern U.S. had less eye care providers per capita than other regions of the country. Specifically, 71.4% of southern counties were in the lower half of eye provider availability (14). In our analysis of 18 U.S. states, southern states generally had lower optometrist density and higher vision loss rates, while northern states had higher optometrist density and lower vision loss.

In addition, our study echoed reports associating poverty with vision loss, in which southern states tended to have higher poverty rates and higher vision loss, while northern states had the opposite. A previous study analyzing data between 2009-2013 found a significant correlation between vision loss and poverty. Notably, 83.1% of the 437 counties ranked in the top quartile for both poverty and severe visual impairment were located in the southern U.S. (13). This was also shown by a county-level study using 2019 data which found a positive correlation between vision loss and poverty

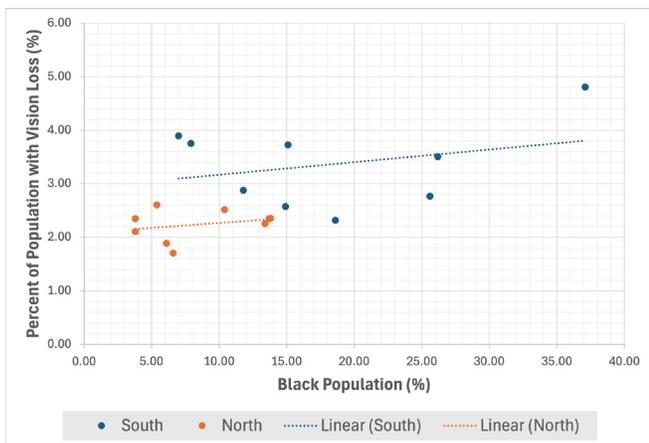


Figure 5: Correlation between Black population and vision loss in northern and southern U.S. states in 2022. Scatter plot of 9 northern states (orange) and 9 southern states (blue) showing a positive correlation between Black population and vision loss. Trendlines show the overall trend for each region. Northern states tend to have a lower proportion of the population being Black and a lower proportion of the population with vision loss, while the opposite trend is true among southern states.

(15). Another study reported a correlation between vision loss and education similar to ours; in 2002, 14.4% of people who did not graduate high school experienced vision loss, while only 7.4% of individuals who completed a bachelor’s degree or higher experienced vision loss (16).

A key position statement by the American Academy of Ophthalmology Taskforce discusses the current state of disparities in vision health and access to eye care (17). Early detection of eye problems and their prompt treatment are extremely important to improve the state of vision health. Timely intervention can prevent about 90% of diabetes-related blindness in U.S. adults (10). Improving access to eye care in medically underserved regions and improving eye care education for patients would help address health disparities (18). Any solution for this issue must be multifaceted, involving expansion of Medicare and Medicaid coverage to include eye care, state-sponsored insurance programs in children, mandatory eye screenings in schools, and community-based eye care programs (19).

Our study found interesting trends regarding vision loss among different age groups over time. Specifically, from 2014 to 2022, vision loss trended down in individuals above 85 years old, while it trended up in children under 18 years of age. Globally, there are decreasing trends in age-adjusted prevalence of blindness over the past three decades. In a large systemic review and meta-analysis of population-based surveys, age-standardized prevalence of avoidable blindness decreased by 15.4% between 2010 and 2019 globally (4). However, the global crude prevalence of avoidable blindness in adults aged 50 years and older did not change during the same time (4). These numbers reflect progress in the right direction, but improvements are not keeping pace with the tremendous global needs, as the total number of people affected by vision loss has markedly increased worldwide. A trend analysis in children and adolescents from 1990 to 2019 also reported a decrease in vision loss primarily due to improvement in refractive disorders but

also reported substantial increases in the burden of near-vision loss among adolescents (20). Interestingly, the higher rates of vision loss in children are noted in countries with higher sociodemographic indexes (20). Various factors may contribute to this trend, such as excessive use of electronic devices and a reduction in outdoor activities in high-income countries. This observation warrants further exploration, as childhood vision loss accounts for about a third of the global economic burden of this disability.

This study is limited by its use of state-level data, which may not show variations within individual counties or cities. Only 18 representative states were examined in this study, as data was not available for all 50 states, which may mask other factors. The study also only considers trends between the northern and southern United States and does not factor in patterns of smaller regions such as the Midwest or New England. The study also only focusses on Non-Hispanic White, Non-Hispanic Black, and Hispanic racial groups for the vision loss over time by race analysis due to the lack of data for other racial groups. Additionally, we relied on publicly available data from different sources, and not all datasets covered the same years. Large data sets may overlook individuals from racially, ethnically diverse, or low-income communities (21). Future studies could explore more detailed, county-level data or conduct surveys that include access to eye exams, transportation, and health literacy. Lastly, the criterion for blindness is variable among different organizations. We considered the CDC definitions and did not include visual field as a criterion. This might underestimate the prevalence of visual impairment as certain diseases such as glaucoma and retinal degeneration cause peripheral visual field loss.

Our findings highlight the importance of viewing visual impairment through both a social and a geographic lens. It is not surprising that SDH are key factors that correlate with vision health, and it is imperative that eye care providers and health policymakers consider SDH as we seek to eliminate disparities in eye care. Addressing vision loss in the U.S. will require targeted public health interventions in areas where poverty, race-based disparities, and provider shortages are acknowledged. By identifying these high-risk regions, this research can help guide policy efforts and resource distribution aimed at reducing preventable vision loss nationwide. Specifically, our study suggests targeting efforts to areas in the southern U.S., notably Black communities, people in poverty, and those without high education. Black communities experience additional barriers to access to eye care and health care in general. People in poverty often lack the resources or education to have a good eye health. A future approach addressing these issues might help reduce the prevalence and burden of vision disability in the U.S.

MATERIALS AND METHODS

We accessed data for visual impairment through the CDC VEHSS (22). The VEHSS uses publicly available data from the ACS, last updated on June 2, 2022. We utilized the VEHSS to discover trends in visual impairment among different social determinants. We analyzed shifts in visual impairment in the following age groups between 2014 and 2022: 0-17, 18-39, 40-64, 65-85, and 85+. We examined shifts in the following races between 2014 and 2022: non-Hispanic Black, non-Hispanic White, and Hispanic. Only these races were

selected due to the availability of publicly accessible data in the datasets. Other determinants we analyzed using the VEHS were poverty level and geographic distribution for the years 2022 and 2019. We then used the VEHS to identify patterns in visual impairment in the 18 states of interest for the year 2022. Of note, there was extremely limited data for the year 2020 due to a lack of data collection during the COVID-19 pandemic.

We used the AHRF, created by the Health Resources and Services Administration in the HHS, to gather state-level data on the geographic distribution of optometrists (23). The AHRF used data that was last updated November 11, 2024. We used the AHRF to determine trends in the number of optometrists per 100,000 people for the 18 states of interest.

We used the U.S. Census state-level data from the ACS 2022 1-year survey to determine patterns in various SDH for each of the 18 states of interest (24, 25). We analyzed data on the percentage of 25-year-olds who had graduated high school as a measure of education in the state. We also evaluated the ethnicity demographics of each state's population, specifically the percentage that is non-Hispanic Black.

For each dataset, we found data from 18 U.S. states, 9 from the northern part of the country (CO, IL, KS, MI, MN, NY, PA, WA, WI) and 9 from the southern part of the country (AL, AR, FL, KY, MS, OK, SC, TX, VA). These states were chosen because they had data for all SDH factors and vision loss and were representative of their respective regions. As all data in the VEHS, AHRF, and U.S. Census was anonymous and publicly available, no approval was required for use of this data.

We then compared patterns in the distribution of visual impairment, optometrist density, poverty level, education, and racial groups to identify correlations between the northern and southern U.S. using bivariate analysis. We plotted vision loss against optometrist density and poverty on separate graphs for each state.

In our statistical analysis, we performed a Bayesian Pearson's correlation test, in which vision loss was the dependent variable and optometrist density, poverty rate, education, and Black population were the independent variables. We used the JASP Statistics system to perform this analysis. Note that the Bayes factor was used to confirm the correlations, with a factor of 1-3 indicating limited evidence, 3-10 indicating moderate evidence, 10-30 indicating strong evidence, and >30 indicating very strong evidence.

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