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Review

Spatial Vision Inequalities: A Literature Review of the Impact of Place on Vision and Eye Health Outcomes

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"Neighborhood and built environment" is one of the five domains of social determinants of health that has been outlined by Healthy People 2030, and this domain impacts an individual's well-being, health, and quality of life. Social risk factors (SRFs) in the neighborhood and built environment domain include unstable or unsafe housing, poor access to transportation, lack of green spaces, pollution, safety concerns, and neighborhood measures of inequity. In this narrative literature review, we assess the relationship between neighborhood and built environment SRFs and eye health and vision outcomes. We explain how mapping neighborhood-level SRFs may be used to advance health equity in the field of eye health and vision care.

Introduction

Healthy People 2030 outlined five domains of social determinants of health (SDoH): (1) economic stability, (2) social and community context, (3) education access and quality, (4) health care and quality, and (5) neighborhood and built environment.[1] SDoH are the conditions in which people are born, play, work, learn, live, worship, and age that impact their health outcomes, including eye health outcomes.[2] SDoH account for 80% to 90% of modifiable health risk factors at a population level.[3,4] Thus, it is very important to understand how these differing domains impact eye care utilization, eye health, and vision outcomes. Although SDoH can have either a negative or a positive valence (e.g., income can be high or low), social risk factors (SRFs) are those SDoH that have a negative valence. There are many examples of SRFs, including access to respectful and culturally appropriate care, exposure to violence and trauma, access to early childhood education, and access to employment opportunities. Identifying which SRFs impact eye health outcomes can inform assessments in healthcare settings on an individual level and can inform interventions and policy at the population level.[5]

In 2021, the National Eye Institute emphasized in their strategic plan the importance of health disparities research to both improve quality of life and eliminate vision loss. Since this call of action, researchers have

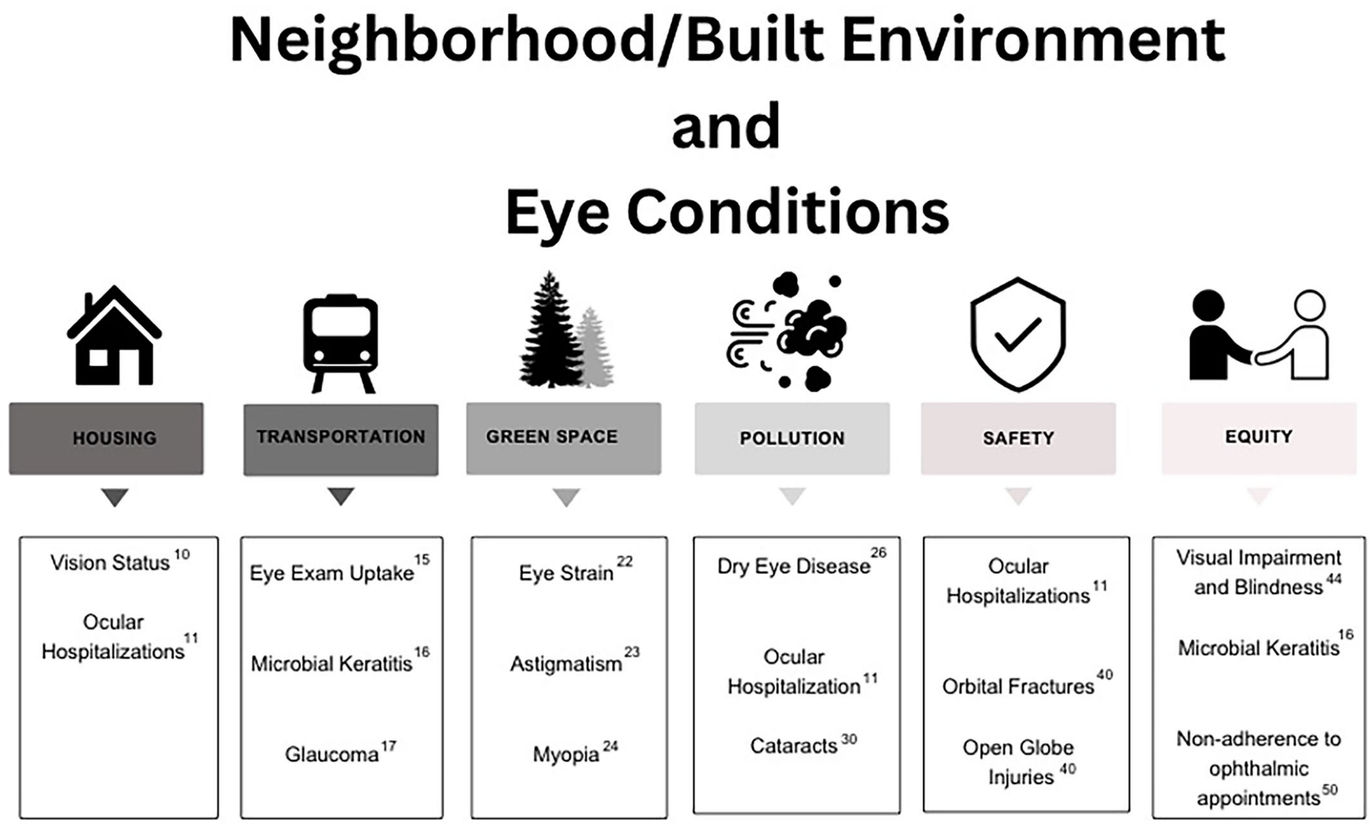

Figure. Neighborhood and built environment and eye conditions.

sought to understand how the neighborhood and built environment impacts eye health and vision outcomes. The neighborhood and built environment includes an assessment of housing, access to transportation, access to green spaces, pollution, and neighborhood levels of poverty and inequity (Fig.).[6] In this review, we collate the research on the impact of neighborhood and built environment on eye health and vision outcomes and identify gaps in knowledge that are important for future research and intervention. We also discuss how mapping neighborhood SRFs may inform policy to advance health equity.

Neighborhood and Built Environment SRFs

Housing

A lack of stable, affordable, quality housing is associated with both higher healthcare costs and decreased healthcare utilization.[7] Housing can impact health outcomes through stability (the ability to remain in a residence for as long as is preferred), affordability (whether residents can pay the cost of the housing without burden), quality and safety (the adequacy of both the environmental conditions and the physical hardware of the residence), and neighborhood (the presence of negative or positive health-relevant resources in the surrounding neighborhood).[8] Individuals who experience chronic homelessness have higher morbidity and mortality.[9] Housing factors have been associated with eye health and vision outcomes. Shiue[10] utilized data from the U.S. National Health and Nutrition Examination Survey (NHANES) to examine the relationship between housing quality and vision. The study found that participants who reported that their residence had a mildew or musty odor had increased odds for self-reporting fair vision (odds ratio [OR] =1.67; 95% confidence interval [CI], 1.20–2.32; P = 0.005) or poor vision (OR = 2.10; 95% CI, 1.27–3.46; P = 0.006) as compared to individuals who did not report that their residence had an odor of mildew or must. This was after adjusting for age, sex, body mass index, family poverty income ratio, and serum cotinine. French et al.[11] utilized the 2015 National Medicare 100% Inpatient Limited Dataset to assess the association between hospitalizations for ocular diagnoses and individual-level and neighborhood-level measures

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of SRFs in the neighborhood and built environment. Severe housing problems were defined as the percentage of households with at least one of the following problems: high housing costs, lack of kitchen facilities, overcrowding, or lack of plumbing facilities.[12] The study reported an association between ocular hospitalizations (primary or admitting diagnosis of an ophthalmic condition) and severe housing problems. In communities where severe housing problems exceeded the median of 14.38%, there was a 13% increased odds of having an ocular hospitalization (primary or admitting diagnosis of an ocular condition) (OR = 1.13; 95% CI, 1.09–1.18; $P < 0.01$) after adjusting for patient age, gender, race, and county.[11]

Transportation

Transportation is critical for accessing health care. In the United States, 3.6 million individuals do not obtain medical care because of transportation issues.[13] A lack of transportation also impacts an individual's ability to participate in the community, access healthy food, and employment.[14] Lack of transportation has been associated with decreased utilization of eye care and worse eye health outcomes. Wright et al.[15] found that individuals whose households did not own a car had a 14% decreased likelihood of having had an eye examination (within a 5-year period) compared to individuals who had household car ownership (risk ratio = 0.86; 95% CI, 0.86–0.87). Our group evaluated the association between neighborhood-level transportation access and presenting visual acuity among patients presenting to eye clinics for microbial keratitis.[16] There were increased odds of presenting with visual acuity less than 20/40 in patients with microbial keratitis when a patient's neighborhood had a higher percentage of households with no car (OR = 1.25 per 1 percentage point increase; 95% CI, 1.12–1.40; $P = 0.001$) and a lower average number of cars per household (OR = 1.56 per one less car; 95% CI, 1.21–2.02; $P = 0.003$) after adjusting for age, self-reported sex, and self-reported race and ethnicity.[16] Kim et al.,[17] utilizing the nationally representative National Health Interview Survey, found that transportation barriers were associated with delayed medical care in patients with glaucoma. Participants who reported delayed medical care for glaucoma had a 2.22 greater adjusted odds ratio (aOR) of reporting that their care was delayed due to a lack of transportation (aOR = 2.22; 95% CI, 1.68–2.91; $P < 0.0001$) after adjusting for age, gender, race and ethnicity, income, insurance coverage geographic region, and Charlson Comorbidity Index.[17] Research to date that has focused on accessible transportation has associated transportation with eye care utilization. Lack of accessible transportation may impact multiple aspects of a person's ability to meet their daily needs (e.g., access to employment or healthy food) that may affect eye care outcomes in other ways.

Green Spaces

Access to green spaces includes access to urban parks, nature reserves, and wilderness reserves.[18] Green spaces within a neighborhood have been shown to have several health benefits. Green spaces support active lifestyles and exercise opportunities, thus reducing chronic disease outcomes (e.g., diabetes, hypertension, cardiovascular disease) by improving blood sugar, blood pressure, and cholesterol levels.[19] The link between access to green spaces and the downstream prevalence of poor eye health from systemic chronic diseases, including diabetic retinopathy and hypertensive retinopathy, has yet to be made.

Green spaces impact mental health by reducing stress and enhancing attention and cognitive function.[20,21] For eye health, green spaces have been associated with decreased eye strain and decreased refractive error. Lu et al.[22] found that exposure to green space for 10 minutes improved eye strain among university students using a 15-minute eye strain stimulus task (post-stimulation eye strain level of 8.20 ± 8.15 vs. post-relax eye strain level of 5.85 ± 6.45; $P < 0.001$). Huang et al.[23] found that a higher neighborhood greenness level decreased the odds of having astigmatism in preschoolers' by 45% (aOR = 0.55; 95% CI, 0.43–0.70; $P < 0.001$) and myopia by 38% (aOR = 0.62; 95% CI, 0.38–0.99; $P < 0.05$) after adjusting for the child's age and gender, parental education, monthly household income, and parental vision status. Additional studies have found associations between green spaces and a decreased rates of myopia. Yang et al.[24] conducted a multicenter, longitudinal, school-based study of myopia incidence and found that for every 0.1-unit increase in green space exposure at the school, there was an associated 3.6% lower increase in the prevalence of myopia over 2 years (95% CI, 1.8%–5.5%; $P < 0.001$) after adjusting for school socioeconomic status and prevalence of myopia at baseline. Designing a trial with exposure to green spaces could advance our understanding of its impact on eye strain and refractive error.

Pollution

Pollution is the "unwanted waste of human origin released to air, land, water, and the ocean" and can impact eye health.[25] Pollution can impact the air, land, and water quality of neighborhoods. Examples of air pollutants include particulate matter (PM) 2.5 and PM10, ozone, lead, carbon monoxide, sulfur oxides (e.g., SO_2), and nitrogen oxides. Both indoor and outdoor air pollution has been associated with adverse effects on the eye including increased prevalence of dry eye disease, ocular hospitalization, and cataracts. In China, Yu et al.[26] found that a number of air pollutants increased the risk of dry eye disease, including ozone (OR = 3.97; 95% CI, 3.67–4.29; $P < 0.0001$), PM2.5 (OR = 2.01; 95% CI, 1.79–2.26; $P < 0.0001$), and SO_2 (OR = 1.64; 95% CI, 1.50, 1.79; $P < 0.0001$) after controlling for relative humidity, mean air pressure, and air temperature. Air pollution has been associated with ocular hospitalization (primary or admitting diagnosis of an ocular condition). The study by French et al.,[11] previously mentioned, reported that communities with air pollutants (fine particulate matter) exceeding the national median of 11.62 μg/m^3 had increased odds of ocular hospitalization as compared to communities that did not exceed the national median (OR = 1.05; 95% CI, 1.01–1.08; $P < 0.01$) after adjusting for patient age, gender, race, and county.

Pollutants can also be land based and include pesticides, industrial waste, and heavy metals, all of which can impact the eye. The Centers for Disease Control and Prevention reported on illness experienced from a pesticide release of chloropicrin soil fumigant into a residential area in Kern County, California, in 2003. Of the 172 individuals who were exposed, 164 (95%) reported ocular irritation (e.g., lacrimation, pain/burning).[27] Longer term consequences of acute and chronic exposures to pesticides should be evaluated. Similarly, Tovalín-Ahumada et al.[28] found that people had a higher prevalence of eye and upper respiratory tract irritation (17.3% vs. 8.8%) if they lived near an industrial waste recycling plant in Mexico compared to those living outside of this area (prevalence ratio = 1.90; 95% CI, 1.5–2.6). Heavy metal pollutants and ground contamination affect food and water supplies.[29] Wang et al.[30] found an association between body heavy metal levels (lead and cadmium) and a need for cataract surgery. They found that every twofold increase in urinary cadmium led to 23% increased odds of having cataract surgery after adjusting for age, gender, race, ethnicity, body mass index, education, diabetes mellitus, cigarette smoking (serum cotinine and pack-years), and urine hydration (OR = 1.23; 95% CI, 1.04–1.46; $P = 0.021$) utilizing the NHANES data from 1999 to 2008. Exposure to heavy metal or other industrial waste may be associated with other eye conditions.

Water pollutants, such as crude oil, xenoestrogens, and polyfluoroalkyl substances, have been associated with ocular surface disease and visual impairment.[31] Studies assessing oil spills have reported higher rates of eye irritation.[32,33] In moderately and heavily soaked areas, residents had increased odds of reporting sore eyes (OR = 2.28; 95% CI, 1.17–4.42) as compared to residents of lightly oil-soaked areas (OR = 3.31; 95% CI, 1.62–6.76), after adjusting for age, gender, education, smoking, the perception of oil hazard, and anxiousness.[34] Perfluoroalkyl and polyfluoroalkyl substances (PFASs) have been associated with visual impairment and blindness. In a cross-sectional study in Shenyang, China, of 1202 participants, increased odds of visual impairment and blindness being reported from ophthalmic eye examinations were independently associated with linear perfluorooctane sulfonate (OR = 3.37; 95% CI, 2.50–4.56), linear perfluorooctanoic acid (OR = 1.79; 95% CI, 1.36–2.37), and branched perfluorooctane sulfonate (OR = 2.25; 95% CI, 1.72–2.93) exposures after adjusting for age, sex, body mass index, education, income, career, exercise time, drinking, and smoking.[35]

Sociodemographically disadvantaged communities are at a greater risk for having a contaminated water supply.[36] In a study of 8000 communities in 18 states across the United States, as the percentage of the population identifying as non-Hispanic Black or Hispanic/Latino rose by 1%, there were 3% to 6% increased odds of detecting perfluorooctanoic acid or perfluorooctanesulfonic acid in the community water system.[36] Non-Hispanic Blacks had increased odds of sharing a water system with landfills (OR = 1.06; 95% CI, 1.03–1.06), airports (OR = 1.07; 95% CI, 1.04–1.10), or wastewater treatment plants (OR = 1.13; 95% CI, 1.09–1.16) after adjusting for state-level fixed effects, and the standard errors are clustered at the county level.[36] Hispanic/Latino residents had increased odds of sharing a water system with landfills (OR = 1.04; 95% CI, 1.01–1.06) and wastewater treatment plants (OR = 1.07; 95% CI, 1.03–1.11) after adjusting for state-level fixed effects, and the standard errors are clustered at the county level.[36] Identifying effective strategies to combat inequitable environmental exposures is critical. When all communities are equally exposed, communities with more resources may be better able to leverage their resources to combat pollution for all.

Safety

Safety within the neighborhood and built environment includes both perceived safety (hearing about crimes/violence, witnessing crimes/violence, and experiencing crimes/violence) and safety violations collated in neighborhood crime statistics (crime types and rates within a neighborhood).[37] Safety pertains to safety risks in both neighborhoods and people's place of residence. Aspects of neighborhood safety have been associated with eye conditions, as well as risk for chronic diseases that can lead to vision loss. French and colleagues[11] reported that neighborhood violent crimes (violent crimes per 100,000 people), as reported by the Federal Bureau of Investigation, were associated with increased odds of ocular hospitalizations involving a primary or an admitting diagnosis of an ocular condition (OR = 1.07; 95% CI, 1.02–1.11; $P < 0.01$) after adjusting for patient age, gender, race, and county. Violent crimes can also lead to ocular injuries from gun violence or intimate partner violence, or for other as yet unidentified causes.[38,39] Truong and colleagues,[40] using the 2008–2014 National Trauma Data Bank, reported that 3.7% of those in the databank had firearm-associated ocular injuries, including orbital fractures (38.6%) and open globe injuries (34.7%). Injuries most frequently occurred at home (43.8%) followed by on the street (21.4%). Almost half (45%) of intimate partner violence injuries involved an eye injury, a rate that increased during the COVID-19 pandemic.[38]

Neighborhood safety is associated with poor control of chronic diseases, such as diabetes, which can lead to poor secondary eye health outcomes. For example, Billimek and Sorkin[41] reported that, for adults with type 2 diabetes, those who self-reported residing in an unsafe neighborhood had increased odds of delayed prescription refills for diabetic medications after adjusting for age, sex, education, race/ethnicity, nativity, income, urbanicity, insurance status, number of visits to the doctor, access to an automobile, duration of diabetes, general health condition, and psychological distress (aOR = 1.69; 95% CI, 1.19–2.40; $P = 0.004$), likely raising the rates of diabetic retinopathy. Worse neighborhood safety is associated with missing medical appointments.[42] Individuals residing in neighborhoods with the greatest number of violent crimes versus the least number of violent crimes were found to have 27% increased odds of missing a medical appointment (OR = 1.27; 95% CI, 1.19–1.35) after adjusting for the same patient-level factors previously mentioned. The level of crime and the perception of lower safety in a neighborhood have an impact on attendance at medical appointments.[42] In the same study, patients who had a low level of perceived neighborhood safety had greater odds of missed medical appointments, even after adjusting for the same patient-level factors (OR = 1.06; 95% CI, 1.01–1.11).[42] Missed appointments impact long-term eye and vision health outcomes, especially for conditions that require active management, such as treatment for acute conditions (e.g., corneal ulceration) or chronic conditions (e.g., glaucoma, diabetic retinopathy). Individuals with visual impairment and blindness are more likely to experience violent crimes than individuals without visual impairment.[43] Those with visual impairment and blindness are significantly less likely to report to the police when they have been a victim of a violent crime.[43] Thus, addressing neighborhood safety may both improve eye health outcomes and ensure that those with visual impairment and blindness live in safe communities.

Neighborhood Measures of Inequity

Past Policies

Measures of neighborhood inequalities can provide a composite score for various social risk factors within a neighborhood. These scores can outline both past and present features of a neighborhood. One such past policy that can be measured as a score is historical redlining, a 1933 U.S. policy that deemed a neighborhood undesirable and a high risk for bank loans if the neighborhood had a higher proportion of Black individuals.[44] Redlining allowed preventing racial minorities from obtaining traditional insured mortgages to purchase homes. Our group found that people living in neighborhoods with worse historical redlining scores reported more visual impairment and blindness compared to those living in neighborhoods with better redlining scores.[44] For every 1-unit increase in redlining score, the odds increased 13% (OR = 1.13; 95% CI, 1.131–1.138; $P < 0.001$) for visual impairment and blindness, after controlling for age, race, ethnicity, population size, and state location.[44] Worse diabetes and hypertension are associated with worse neighborhood redlining scores which could have implications on eye health.[45] Though redlining was outlawed with the Fair Housing Act of 1968, redlining still adversely affects health.

Measures

Current neighborhood measures of inequity include the Area Deprivation Index (ADI), Social Vulnerability Index (SVI), and Theil's H Index. ADI is a measure of neighborhood (census block group-level) disadvantage. This measurement comes from the Neighborhood Atlas and encompasses aspects of employment, income, housing quality, and education.[46] The ADI is measured on a scale from 1 to 100 nationally and from 1 to 10 in each state, where higher numbers represent higher levels of neighborhood deprivation. Our group has reported on the association between ADI and presenting visual acuity in patients with corneal ulcers.[16] Among 2990 patients with corneal ulcers, for every 10-unit worse ADI score (measured on a 100-unit scale) there were 30% increased odds of presenting with best corrected visual acuity of less than 20/40 (OR, 1.30; 95% CI, 1.25–1.35; $P < 0.001$), after controlling for age, self-reported sex, self-reported race, and self-reported ethnicity.[16] Yusuf and colleagues[47] reported that patients who lived in the 30% most disadvantaged neighborhoods had 44% increased odds of non-adherence to initial diabetic retinopathy screening compared to patients living in more advantaged neighborhoods (OR = 0.65; 95% CI, 0.44–0.97; $P = 0.035$) after adjusting for age, race, and insurance status. Our group also found that, among participants in the Michigan Screening and Intervention for Glaucoma and Eye Health Through Telemedicine (MI-SIGHT) program, those who screened positive for glaucoma or suspected glaucoma, compared to those who screened negative, lived in neighborhoods with worse ADI (7.7 ± 2.8 vs. 7.0 ± 3.2; $P = 0.002$).[48]

The SVI, a measure reported by the Centers for Disease Control and Prevention, is a composite score of 14 different social risk factors from the U.S. Census.[49] These factors focus on aspects of socioeconomic status, household composition and disability, housing and transportation, and minority status and language. The SVI ranges from 0 (lowest vulnerability) to 1 (highest vulnerability). Scanzera and colleagues[50] evaluated the relationship between SVI and missed ophthalmology appointments in a single-center study and found that a 0.1-unit increase in neighborhood SVI was associated with 146% increased odds of missing an ophthalmology appointment after adjusting for age, sex, appointment status (new or established), race, and distance from clinic (aOR = 2.46; 95% CI, 1.99–3.06; $P < 0.01$). Tseng and colleagues[51] examined the association between neighborhood SVI and the prevalence of glaucoma and incidence of glaucoma surgery for California Medicare beneficiaries. They found that those in the highest quartile (worse SVI) had 17% decreased odds of having a diagnosis of glaucoma (aOR = 0.83; 95% CI, 0.84–0.87; $P < 0.001$, quartile 4 vs. quartile 1). They also reported that individuals with any glaucoma had 19% increased odds of having glaucoma surgery compared to those in the lowest SVI quartile (aOR = 1.19; 95% CI, 1.12–1.26; $P < 0.001$, quartile 4 vs. quartile 1), after adjusting for age, sex, race/ethnicity, Charlson Comorbidity Index score, and ocular comorbidities. It could be concluded that eye disease progresses more commonly for individuals in worse SVI neighborhoods due to lack of resources. Such progression and/or lack of routine follow-up may result in greater need for surgical intervention. This study highlights the need to study social risk factors for eye and vision care overall, but also within individual eye conditions and procedures.

The ADI and SVI are composite measures of overall neighborhood deprivation, but the Theil's H Index is a composite measure that assesses a single variable: residential segregation. The Theil's H index is measured on a scale from 0 to 1, where higher values indicate more racial residential segregation.[52] This metric differs from the Theil Index, which is commonly used in international studies as a measure of economic inequality.[52] Higher levels of residential segregation are associated with worse outcomes in ophthalmic conditions, such as microbial keratitis. Our group previously reported that, for every 0.1-unit increase in the Theil's H index, representing higher levels of residential segregation, the odds increased for presenting with visual acuity less than 20/40 in patients with microbial keratitis after adjusting for age, race, sex, and ethnicity (OR = 1.44; 95% CI, 1.30–1.61; $P < 0.001$).[16] Racial segregation has been associated with health outcomes that can influence eye health, such as retinopathy of prematurity.[53] Mehra and colleagues[53] conducted a meta-analysis of the literature and found that when Black mothers lived in more racially segregated neighborhoods their babies had increased odds of both preterm birth (OR = 1.17; 95% CI, 1.10–1.26) and low birth weight (OR = 1.20; 95% CI, 1.05–1.37).

Additional Measures of Neighborhood and Built Environment

Unexplored areas include neighborhood walkability, access to playgrounds, and access to healthy foods. Neighborhood walkability is defined by urban planners as "the extent to which neighborhood design supports walking." Decreased neighborhood walkability has been associated with a higher prevalence of risk factors for eye disease, including diabetes, hypertension, and cardiovascular disease.[54–56] Access to neighborhood playgrounds has increased physical activity and reduced obesity for children and improved mental health for both children and parents.[57] These associations may have many implications for eye health as children grow up at increased risk of diabetes, hypertension, and cardiovascular disease.[58–60] Making playgrounds safe and available in all communities could improve both overall health and eye health. A lack of access to healthy foods is associated with multiple chronic conditions. Food insecurity is both a social and economic condition of either limited or uncertain access to adequate food.[61] It has been associated with various conditions that can put individuals at an increased risk for eye conditions, such as diabetes, hypertension, and cardiovascular disease.[62–64] Studies have found an association with prevalence of certain conditions, such as diabetes, as well as with the management of these conditions.[65,66] Thus, it may be more difficult to manage diabetes and prevent diabetic retinopathy if an individual is food insecure.

Geocoding Inequalities to Advance Eye Health Equity

Geocoding can be used to assess how neighborhood-level social risk factors relate to eye health and vision outcomes. Geocoding is usually done at one of the geographical units defined by the census or by the postal system. In the census, the smallest geograghical unit is the census block, which are aggregated to form a census block group, then a census tract, county, and a state. Additional geograghic measures include Zip Code and cities. The states are then aggregated to generate statistics for the entire country. Understanding whether disparities in eye health outcomes exist at the neighborhood level is useful in determining how to best allocate resources to improve equity in health outcomes.

Geocoding has been used to identify geographic inequities in eye surgery, including glaucoma surgery and cataract surgery.[65–67] For example, Ma and colleagues[66] reviewed the 2017 Medicare Part B Summary Files and found that there were geographical differences in rates of glaucoma surgery in the United States. The highest rate of trabeculectomies was in the Northeast (5.58 per 10,000 people), the highest rate of glaucoma drainage implants was in the Southeast (4.66 per 10,000 people), and the highest rate of micro-invasive glaucoma surgeries was in the Southwest (28.05 per 10,000 people). The study gives a basis for further research into how these interventions may influence glaucoma outcomes nationally. Shahbazi and colleagues[67] identified disparities within the state of Florida, where, in two counties, African American patients were less likely to receive medically necessary cataract surgery (only including extracapsular cataract removal with insertion of intraocular lens prosthesis, *current procedural terminology codes* 66882–66984) than White patients. This type of research highlights how geocoding analyses can identify locations that require programmatic intervention to improve eye health outcomes.

Future Directions

Epigenetics

Epigenetics is the study of how an individual's behavior and environment modulate how their genes are expressed. Examples of environmental and behavioral factors that have been studied include diet, smoking, and drugs/medications.[68] These exposures can modulate gene expression through histone modifications, cytosine–phosphate–guanine methylation, and microRNAs/long noncoding RNAs. For example, Jee and colleagues[68] studied glaucoma risk and carbohydrate intake by utilizing a polygenic risk score and exploring the nutrient-by-gene interaction. The study found that the odds of developing glaucoma were greater for those in the high carbohydrate intake group who also had a high polygenic risk score as compared to those in the high carbohydrate intake group who had a low polygenic risk score after adjusting for age, gender, body mass index, smoking, alcohol, education, job, income, energy, physical activity, hypertension, milk, fat percent intake, carbohydrate percent intake, and arthritis and dementia medicine intake (OR = 3.74; 95% CI, 2.14–6.54; $P = 0.008$). The specific interaction between where a person lives and what exposures they might have in their home or neighborhood has been severely understudied in the epigenomics of eye disease and outcomes.[69] Adverse neighborhood environments have been associated with accelerated DNA methylation, which occurs in aging, of both stress-related and pro-inflammatory genes. Future research is needed that looks beyond commonly studied behavioral factors of diet, smoking status, and drugs/medications to include exposure to pollutants and mold, lack of green space, and chronic stress.

Leveraging Big Data

Large national surveys provide national, longitudinal publicly available data. Datasets can be used to identify what types of interventions are necessary to address disparities. In some instances, data can be linked to geographic data to understand target programs for communities with the highest need. As new metrics measuring aspects of the neighborhood and built environment become available and linked with eye health and vision outcomes, implementation of appropriate programs can become more nuanced and tailored to meet the needs of communities.

Within the American Academy of Ophthalmology (AAO) Task Force on Disparities in Eye Care, the

Leveraging Data Sub-Task Force has outlined five key components to improving large data for evaluating health disparities in ophthalmology.[70] These improvements can aid in assessing the neighborhood and built environment, as well as eye care and vision health. First, they suggested that more data could be collected from existing data sources.[70] Data sources may not provide any geographical information, so the eye and vision variables cannot be assessed with certain neighborhood social risk factors. For example, in the American Community Survey, visual impairment and blindness are reported at the census tract level, but the ADI is only recommended to be utilized at the census block group level, thus making it difficult to study the association between these two metrics. Social risk factor metrics only available at the Zip Code level also have limitations. Zip Codes can cross into different state boundaries and counties, which can make assessing the implication of state or county policies on eye and vision outcomes very difficult.[71] Both census tracts and census blocks stay within a county and within one state.[71] The disadvantage of reporting data at a census block or tract level is that some blocks or tracts may have such small populations that the data from a particular area will have to be suppressed to protect respondents' identity. Second, the AAO task force called for collection of data utilizing standardized tools and definitions.[70] There are multiple metrics that assess the same neighborhood-level factor, including neighborhood walkability scores such as Walk Score and the National Walkability Index.[72,73] Both provide neighborhood walkability scores but differ in how the score is calculated.[72,73] Third, the task force highlights the need for democratized access to datasets.[70] If researchers can access current data but not past data, it is impossible to assess the impacts of policy change over time. If past data are accessible but current data are inaccessible, then it is not possible to identify new areas of concern. Fourth, they highlight the need to ensure trust in the data collection.[70] Researchers collecting individual-level data on the neighborhood and built environment and eye and vision outcomes should be aware that discussing social risk factors and social needs can be emotionally charged. Using a community-engaged framework is critical to carrying out the research in a sensitive, culturally competent way and ultimately, in making a positive impact for participants and their community. Finally, the taskforce highlights the importance of increased funding for the creation of new datasets.[70] Although big data can provide important insights into how eye health, eyecare utilization, and vision differ by neighborhood and region, there is still a need to better understand individual patient experiences with neighborhoods and built environments and how they impact the utilization of eye care to inform appropriate interventions.

Assessment at the Patient Level

The National Academy of Medicine states that in order to meaningfully address social risk factors, including aspects of the neighborhood and built environment, genuine relationships need to be built with the communities with the highest prevalence of poor outcomes.[74] Research at the patient-level provides both qualitative and quantitative data to understand the impact of aspects of social risk factors that impact eye health and vision.[5] Using community-engaged research methods allows researchers to identify which aspects of the neighborhood that those who live there think are the most important barriers to health care and eye care. Quantitative measures can include mapping patient addresses to evaluate the percentage of individuals in a neighborhood who are burdened by their rent, the percentage of households that do not own a vehicle, the number of parks in a neighborhood, the lead exposure risk in neighborhood, the number of violent crimes in a neighborhood, and the walkability of neighborhood streets, as some examples. It is important to ask community members which of these quantitative metrics they feel may be most important in impacting their ability to access eye care. The dynamic exchange with people in communities is often lost in large datasets.[75]

Conclusions

Social risk factors related to the neighborhood in which people live and the built environment affects access to care, eye care utilization, and the prevalence of eye disease, all of which can lead to poor eye health and vision outcomes. We have yet to understand how pollutants inside and around the home from the air, water, and land impact eye health. There also remain gaps in our understanding in how access to stable housing, the quality of that housing, and the quality of the neighborhood in terms of safety, walkability, accessible transportation, and access to green space impact eye health. Future research is needed to improve and tailor policies and programs for eye disease screening, detection, and care in neighborhoods with higher levels of need to improve eye health equity in the United States.

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