County-Level Perceived Vision Impairment and Unmet Need in Ohio: A novel approach to assessing vision loss and access to care utilizing public health databases

Thesis

Presented in Partial Fulfillment of the Requirements for the Degree Master of Science in the Graduate School of The Ohio State University

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2021

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Abstract

Vision impairment is a public health problem currently affecting over 10 million people in the United States. Established vision health surveillance mechanisms individually fail to capture the complexities of vision impairment at a granular level. The purpose of this study is to develop a county-level needs assessment for primary vision care services by assessing the relationship between vision impairment prevalence, unmet vision care need prevalence, and the distribution of optometrists in Ohio using multiple publicly available databases.

Data from the 2017 American Community Survey were used to determine county-level prevalence estimates for vision impairment. Data from the 2017 Ohio Medicaid Assessment Survey were used to estimate unmet vision care needs in each county. State licensure records were obtained from the Ohio Vision Professionals Board and used to determine the geographic distribution of optometrists. US Census Bureau data were used to determine county population estimates.

Correlations between vision impairment prevalence and unmet vision care need prevalence were assessed using linear regression. Vision impairment and unmet need prevalence differences between visually impaired and non-visually impaired cohorts were stratified by age, sex, and Medicaid eligibility (<138% Federal Poverty Limit, FPL) and compared using ANOVA and paired t-test analyses. Correlations between vision

impairment prevalence and unmet vision care need prevalence with available optometrists per 10,000 residents in each county were assessed using linear regression.

County-level vision impairment prevalence ranged from 1.1% to 5.2% and unmet vision care need prevalence ranged from 6.2% to 15.5%. Vision impairment and unmet vision need were positively correlated ($R^2 = 0.32$, $p < 0.001$). Adults at or below 138% FPL were significantly more likely to report unmet vision care needs than those above 138% FPL ($p < 0.001$). Women were more likely than men to be visually impaired ($p < 0.003$), though there was no difference in access to care ($p = 0.91$). There was also no statistically significant difference across age categories with respect to unmet need ($p = 0.46$), but vision impairment did vary ($p < 0.001$) with vision impairment prevalence increasing with age. County-level vision impairment and available optometrists were negatively correlated ($R^2 = 0.14$, $p < 0.001$). County-level unmet vision care need showed no correlation with the geographic distribution of optometrists ($R^2 = 0.00$, $p = 0.87$).

National and state-specific health surveillance data combined with state licensure data provide important insight into the underlying determinants of vision impairment and access to care. In Ohio, a higher number of optometrists is associated with a lower prevalence of vision impairment, but unmet vision care need persists. These data suggest that while provider availability is influential in reducing vision impairment, other social determinant barriers may play a role in addressing unmet vision care need. This hybridized approach to data analysis can serve as a template for broader vision care needs assessments to direct scarce vision care resources to locations with the greatest need.

Acknowledgments

I would like to thank the members of my thesis committee, Dr. Jacqueline Davis, Dr. Bradley Dougherty, and Dr. Andy Wapner, for the time and expertise they have provided to me. I am incredibly thankful to my colleague, Dr. Erica Shelton, for being a continual source of support and motivation as we embarked on our graduate journeys together in pursuit of advancing our profession. I would like to express my deep and sincere gratitude to Dr. John Crews who has generously contributed his unparalleled knowledge and enthusiasm for this research with me. Most importantly, I am extremely grateful for my research advisor, Dr. Dean VanNasdale. His constant mentorship and endless passion, patience, and encouragement for this work throughout my fellowship has been instrumental in my success.

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Chapter 1. Introduction

Vision Impairment as a Public Health Problem

Several investigators have defined dimensions of vision and eye health as a public health problem.[1-3] Three characteristics are often considered when determining a public health problem: (1) the problem is considered important to the population of interest, (2) it is amenable to prevention and intervention, and (3) it is controllable within the current health care system.[1,4] Vision impairment and blindness meet the first criteria because it affects an estimated 12 million people,[1,2,5,6] can negatively impact quality of life,[7-9] is increasing in prevalence,[5] and is a perceived threat to the public.[1,10] The sense people are most apprehensive to lose is their sight, which they perceive would considerably reduce their quality of life and independence.[10] Moreover, vision loss also leads to a significant economic burden on both the individual and the US economy, totaling an estimated $140 billion in 2014.[11] Vision loss meets the second criteria because regular dilated eye exams can lead to early detection and timely treatment of conditions that reduce visual quality, including disease and uncorrected refractive error. In regard to the third criteria, vision loss and impairment can be addressed within our healthcare system through optometrists, ophthalmologists, and other vision rehabilitation experts, and therefore can be controlled through the current health care system. Vision impairment and blindness satisfy these criteria and should be considered a public health concern.

The population of people with vision impairment increases as the US population continues to age. This trend is important because vision impairment and blindness can negatively affect an individual's physical and mental well-being and quality of life. In 2016, a study was conducted using the US definition of vision impairment and blindness and pooling prevalence estimates from six population studies estimated 3.22 million adults 40 years of age and older in the US were visually impaired and 1.02 million were blind.[5] The analysis also found that 8.2 million had vision impairment from uncorrected refractive error.[5] These prevalence estimates are expected to double by 2050 as the population ages.[5] This situation places vision impairment among the most common disabilities affecting Americans with decreased independence in performing daily tasks, decreased social participation,[12] higher likelihood of other comorbidities,[13] increased fall[14] and mortality rates,[15] increased financial strain,[11] and other negative outcomes.

Defining Vision Impairment and Estimating the Population

Persistent problems in vision and eye health research and policy emerge from varying case definitions, specific priorities of the sponsors, diverse stakeholders, and multiple, inconsistent study populations.[16] Consensus on accurate estimates of the prevalence of vision impairment and blindness is confounded by the multiple methods employed to collect and analyze data. An analysis of multiple federally sponsored national surveys demonstrated substantial differences in case definitions of vision impairment, resulting in differing population estimates as well as differences among high risk racial/ethnic categories.[16] Large population surveys may have one or two vision questions that do not capture many aspects of life affected by vision impairment

including visual function, disease, health-related quality of life, activities of daily living, social participation, and access to care. The complexities of defining vision impairment in national surveys makes it difficult to identify the magnitude of the public health burden of vision impairment. An analysis of 12 national surveys found nearly 100 different measures of vision with no consistent or comparable definition of vision or vision impairment when categorizing all survey items to one of five domains: condition, structure or function, activity, participation, and environment.[16] Only two surveys had questions in all five categories and most surveys only asked a question classified within one of the five.[16]

Because there is no widely agreed upon gold standard vision question in surveys, the terms vision impairment and blindness are often broadly defined with great variation in case definition. Policy makers, practitioners, and researchers often have differing needs that lead to differing measures of vision and eye health.[16] The International Classification of Diseases 10 overseen by the World Health Organization defines vision impairment as mild if visual acuity is better than 20/70, moderate if worse than 20/70, severe if worse than 20/200 and blindness is defined as worse than 20/400 for more precise medical coding. Most US studies have defined blindness as worse than 20/200 in the better seeing eye.[5] The US Social Security Administration defines blindness as best corrected acuity in the better seeing eye is 20/200 or worse or if your visual field is 20 degrees or less in the better seeing eye.[17] States have differing guidelines and restrictions regarding vision performance related to the ability to obtain a driver's license. Again, lack of consistency in case definition, methodology, and population leads to great variability in estimated

prevalence of vision impairment and blindness. A recent literature review by the non-partisan and objective research organization NORC at the University of Chicago (NORC) found vision impairment prevalence ranged from 0.27% to 7.5% and blindness ranged from 0.07% to 1.7%.[18] These widely varied ranges for vision impairment and blindness underscore the difficulty in making direct comparisons between surveys, studies, or agencies.

Surveillance Mechanisms for Vision Health

The Centers for Disease Control and Prevention (CDC) utilizes four steps to approach public health problems: surveillance, identifying risk factors, intervention development and evaluation, and implementation.[4] Surveillance data should be systematically and continuously gathered, analyzed in a timely, appropriate, and accurate fashion, and disseminated to public health officials, policymakers, healthcare workers, and the public.[4] Defining public health problems through surveillance is the first step required before appropriate actions can be taken to address the issues.[4] Population health surveillance through surveys has limitations because it is self-reported data and surveys are often poorly although thoughtfully designed. Population surveillance is designed to gather as much data as possible from large numbers of people, therefore survey items are often vague, non-specific, or repetitive. This approach makes data collection easy, but the limited, pre-determined questions and answers may leave much to be discerned from an individual response. Some surveillance mechanisms do provide objective data utilizing exams and electronic health records (EHR) data, but these too have many limitations.[19]

Proper and substantive surveillance is essential for understanding and defining public health problems.

Vision surveillance can be used to identify ways in which vision impairment and eye disease, regardless of severity, affect one's life. Traditionally, vision data have been collected via in-person, mail, or telephone surveys, medical records, and or registration records. The primary sources of vision health surveillance data include the National Health and Nutrition Examination Survey, Behavioral Risk Factors Surveillance System, National Health Interview Survey, American Community Survey, and National Survey of Children's Health. More recently, additional data sources have been added including EHR registries and medical claims data. NORC and the CDC's Vision Health Initiative (VHI) is in the process of compiling these data sources and information for statistical integration in the Vision and Eye Health Surveillance System.[20]

Five national surveys are often employed in vision and eye health research to identify characteristics of the population of people with vision impairment. Each of these surveys have distinct strengths and weaknesses. Selecting the best survey to answer discrete research questions represents a distinct challenge for public health investigations. Below are descriptions of these data sources providing information about the US adult population.

National Health and Nutrition Examination Survey (NHANES)

NHANES combines interviews and physical exams to assess systemic and nutritional health continuously since 1999 among US residents.[21] The sample includes roughly 5,000 participants each year. The interview focuses on demographic,

socioeconomic, dietary, and health related questions. The physical exam includes medical, dental, psychological, and laboratory testing. Vision exams and data were historically included but only collected from 1999-2008.[21] The vision data from this survey continues to be extremely valuable because it is the only national surveillance mechanism that collects objectively measured clinical outcomes, including visual acuity: with and without refractive error correction. NHANES, however, does not contain questions about health-related quality of life, social participation, and access and utilization of care. For all NHANES vision data collected from 1999-2008, the overall prevalence of those presenting with vision loss was 9.8%, the overall prevalence of blindness was 1.0%, the overall prevalence of uncorrected refractive error was 5.3%, and overall prevalence of those with uncorrected or corrected normal vision was 98.3%.[20]

Behavioral Risk Factor Surveillance System (BRFSS)

The BRFSS was established in 1984 and is considered the largest continuously conducted health-related telephone survey in the world.[22] The purpose of the survey is to collect information about health behaviors, chronic health conditions, and preventive services utilization from roughly 400,000 adults in the US, District of Columbia (DC), and three US territories each year. Vision and eye health have not been consistently addressed in the BRFSS. The core component consists of fixed, rotating, and emerging standard questions regarding demographics, health behaviors, and health status. The optional modules are added or retired based on utility and relevance which include a multitude of topics such as diabetes, cognitive decline, vaccinations, health care access, and vision, among others. States are not required at any point to administer any of the

available optional modules unlike the required annual administration of the core component questions. From 2005-2011, the vision module was utilized by 23 states – including Ohio – which asked nine questions related to vision impairment, access, utilization, and self-reported eye diseases.[22] In 2013, a single vision question was added to the core module where it remains today: "Are you blind or do you have serious difficulty seeing, even when wearing glasses?" The 2018 BRFSS reported the overall prevalence of US adults claiming difficulty with vision to be 5.3%.[20]

National Health Interview Survey (NHIS)

The NHIS is one of the largest sources of data collection for the National Center for Health Statistics and focuses on the collection of a broad range of health topics among the noninstitutionalized US and DC population.[21] First conducted in 1957, the NHIS has continuously provided health data and monitored trends in illness and disability characterized by demographic and socioeconomic status. This survey is conducted via in-person interviews with households and noninstitutionalized group quarters, but excludes those without a permanent address, in the military, nursing homes, and correctional facilities. Participant households are selected each month via clustered sampling designed to be nationally representative.[21] From 1999-2015, adults were asked two vision questions: 1) "Do you have any trouble seeing, even when wearing glasses or contact lenses?" and 2) "Are you blind or unable to see at all?" The second question was only asked following an affirmative response of the first. From 2016-2017, the questions expanded to include more questions regarding visual function, as well as, eye health

conditions and service utilization. The overall percentage of US adults reporting trouble seeing in 2014-2015 was 9.2% and increased to 10.66% in 2016-2017.[20]

American Community Survey (ACS)

The ACS is conducted annually by the US Census Bureau to provide granular population data regarding community household demographics including annual income, education, employment, internet access, insurance, utilization, and familial data. After 2000, the expansive, detailed census that went to a portion of the population traditionally called the "long form census" became known as the ACS.[23] Delivered annually to roughly 3.5 million households in the US, DC, and Puerto Rico (PR), the ACS provides local community officials, leaders, and business owners a detailed report on the state of their community. This allows decisions regarding federal and state funding and resources to be directed appropriately each year towards improving areas of need and or development. The ACS is unique from other health surveillance mechanisms because it does not focus on health specific questions, instead collecting disability information as it relates to socioeconomic factors. The ACS askes one vision question regarding visual function, "Are you blind or have serious difficulty seeing even when wearing glasses?" The overall percentage of US adults reporting vison difficulty in 2017 was 2.45%.[20]

Medical and Claims Data

Electronic health records, ophthalmic registries, and claims data are also being utilized to provide objective clinical data. This type of surveillance has many advantages as it provides real time data collection with consistent definitions using medical diagnostic and billing codes. These data provide demographic information and

prevalence rates for those utilizing vision and eye care services within a specific population. However, these data fail to address visual function, mobility, or social participation. While medical EHR, registries, and claims provide useful data, they only capture people who seek eye care; therefore, the findings are not nationally representative and likely exclude populations that lack insurance, financial resources, or do not live near an eye care provider.[19]

Data Compilation and Statistical Integration

Vision and Eye Health Surveillance System (VEHSS) is a recently established online national data system for vision and eye health supported by the CDC in a cooperative agreement with NORC. Currently VEHSS provides access to multiple data sources including the national surveys, medical claims data, and EHR registries mentioned above. Launched in 2018, VEHSS goals include identifying and collecting existing vision data, creating case definitions for consistent analysis, estimating prevalence, utilization, and disparities data, and disseminating the information to the public.[20] The creation of VEHSS is among the first steps taken by the CDC to centralize and establish a national surveillance system for vision impairment in the US.

Disparities in Vision and Eye Health

Demographic Disparities

While estimating the population of people with vision impairment is a critical first step, it is equally important to understand how the circumstances and health of people with vision impairment differs from the general population. Disparities have frequently been identified in terms of geography, race/ethnicity, sex, and socioeconomic status and

are more readily identified through robust surveillance mechanisms. Vision impairment, blindness, and undercorrected refractive error are most prevalent in African American individuals followed by non-Hispanic white individuals.[5,24] Women are 33% more likely to be visual impaired compared to men.[5] Vision impairment prevalence increases with age with those age 80 years and older most likely to be affected.[5,25] While the largest portion of those who experience vision impairment and blindness in the US are non-Hispanic white individuals, the minority populations individually experience a higher prevalence; these disproportionate trends are projected to remain true through 2050.[5,24]

Uncorrected refractive error is one of the leading causes of vision impairment in the US affecting more than an estimated 5% of the population age 12 years or older. A 2006 analysis of NHANES data suggests 14 million people age 12 and older had vision impairment; however, 11 of the 14 million could have adequate vision with proper refractive correction.[24] Risk factors for vision impairment from uncorrected or undercorrected refractive error in the US include being of a minority race and or ethnicity, being under 20 years old, having lower annual household income, having lower education, and lacking health insurance.[24] In 20-30 year old adults, those with low income and education levels were more likely to have uncorrected refractive error highlighting the socioeconomic barriers to good eye care and proper correction.[24] Among those without health insurance, non-Hispanic whites were 2 times more likely to have adequate correction than African Americans and 2.8 times more likely than Mexican Americans.[5,24]

Vision impairment from chronic eye diseases like age-related macular degeneration, diabetic retinopathy, glaucoma, and cataracts disproportionately affect well-defined populations in the US. Age is the biggest risk factor followed by gender in which women are more likely to experience vision impairment regardless of eye condition.[25] Race, ethnicity, and socioeconomic status are also strong predictors of vision and eye health.[25] Non-Hispanic whites are more likely to have had cataract surgery and age-related macular degeneration, but less likely to have diabetic retinopathy or glaucoma than non-Hispanic blacks.[26] Those with less education and lower income are less likely than their counterparts to have had an eye exam in the past year.[26,27] Another study found significant inequity in utilization and access to vision care in the US based on an analysis of the 2002 NHIS.[28] In the high risk populations for vision loss, people with increased age, education level, and income were more likely to have had a dilated eye exam in the last year.[28] Overall probability of having a dilated eye exam was highest for those who were insured, female, diabetic, and reported having vision problems.[28] Over 10% of the high-risk vision loss population alone was unable to afford eyeglasses when needed.[28]

Health-Related Quality of Life Disparities

Health-related quality of life is an important concept in public health as it looks beyond the often traditional definition of health - the absence of disease - and incorporates the physical and mental needs and perceptions of a population with health risks, health conditions, functional status, social networks, and socioeconomic status. Using the BRFSS survey to examine two population subsets ages 40 to 64 and 65 and older, a study measured six areas of health-related quality of life: life satisfaction,

disability, self-related health, physically unhealthy days, mentally unhealthy days, and activity limitations. For both age groups, those reporting moderate to severe vision impairment were about two times more likely to report poorer outcomes in all six measures compared to those reporting no difficulty seeing.[7,8]

Disparities in Chronic Conditions

Chronic disease is broadly defined as a condition that lasts more than 1 year, requires on-going medical treatment, and or limits activities of daily living. Risk factors associated with chronic disease such as heart disease, cancer, and diabetes include smoking, poor nutrition, and lack of exercise. Chronic conditions affect 60% of US adults and 40% have more than one chronic disease.[29] There has been significant analysis on the prevalence of chronic conditions for adults aged 65 and older with and without vision impairment in the US.[13] Conditions examined include: hypertension, heart disease, high cholesterol, stroke, arthritis, asthma, cancer, kidney disease, diabetes, hepatitis, depression, hearing impairment, and chronic obstructive pulmonary disease. Those with vision impairment had significantly higher prevalence of all chronic conditions analyzed as well as significantly worse reported overall health when compared to those without vision impairment. The population with vision impairment was 1.23 to 1.99 times more likely to report another chronic condition than the non-visually impaired population. As for overall reported health associated with chronic conditions, those with vision impairment were 1.66 to 2.70 times more likely than their counterparts to report fair or poor health.[13]

Disparities in Social Determinants of Health

Social determinants of health are conditions within an individual's environment having significant impact on overall health, well-being, and quality of life. There are five domains of social determinates including: education access and quality, healthcare access and quality, neighborhood and built environment, social and community context, and economic stability.[30] Some determinants include education level, job opportunities, socioeconomic status, neighborhood violence, racism, housing conditions, air pollution, and water quality, as well as, access to food and healthcare.[30] Social determinants of health are important factors in determining and addressing health disparities. Analysis of these determinants at various population health levels guides interventions to mitigate health disparities. Simply stating a region has a low socioeconomic status, no grocery stores, a poor school system, and high unemployment will have no impact on improving health status without addressing the determinants first. Research shows vision disparities exist across the social determinants of health domains. However, the limited investigations addressing potential upstream barriers to access and utilization of vision and eye care of vulnerable populations leaves insufficient detail for actionable programming and policy change. Improving social determinants of health has the potential to improve outcomes at the individual and the community level; however, improving these factors is a large and difficult task.

Disparities in Access to Medical Care

There are 39 states including Washington DC that have adopted the Medicaid expansion legislation passed in the Affordable Care Act (ACA) since 2012.[31] Before the

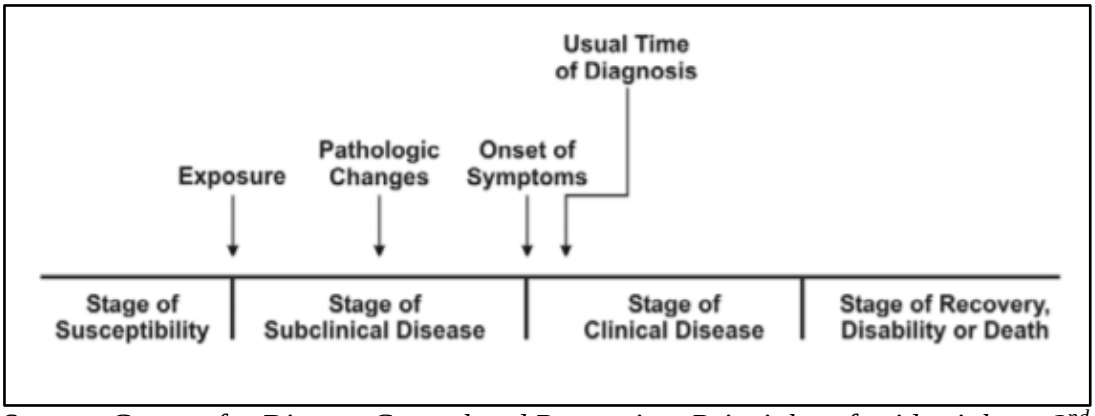
ACA, Medicaid qualification was based on income, household size, disability, family status, and other factors. As a Medicaid expansion state, qualifying is based on household income alone. Therefore, adults living at or below 138% of the Federal Poverty Limit (FPL) became eligible for coverage in their state. Medicaid benefits and coverage between states can have great variability as states can manage the funds with limited restrictions from the federal government. In Ohio, Medicaid benefits include coverage of refractive vision services, medical vision services, and refractive error correction for a small copay.[31] These benefits are limited based on age to every 12 or 24 months from eligibility.[31]

Not only are people with vision impairment or blindness more likely to have other comorbidities, they are also more likely to report difficulties with access to general medical care. An analysis of the 2002-2004 Medical Expenditure Panel Survey found that people who were visually impaired or blind are older females who report lower educational status, worse health status, and more likely to have Medicare or Medicaid coverage compared to their non-visually impaired counterparts.[32] Individuals with vision impairment or blindness were as likely as individuals without vision impairment to have a usual source of care, but they were significantly less likely to seek care from their provider for a new health problem, preventative care, referrals, or follow up care.[32] Individuals with vision impairment or blindness are significantly more likely to report access to care difficulties from the inability to obtain or needing to delay necessary care and prescription medications.[32] Cost of care, transportation, and insurance coverage were significantly larger barriers for the people with vision impairment or blindness compared

to those without vision impairment.[32] Those without insurance were up to three times less likely to receive necessary care or obtain necessary prescriptions and almost twice as likely to delay recommended care compared to those with insurance.[32] Decreased access to medical care due to cost, transportation, and insurance coverage are burdens for many people, but access is disproportionally more difficult for those with vision impairment and blindness.

Natural History of Disease

Most established diseases have known progression through unobserved and observed signs and symptoms. Defining this natural history of a disease in the absence of treatment is critical to help identify and treat diseases for each individual.[4] As shown in Figure 1, the first stage of this sequence is susceptibility which means the host presents an environment that is susceptible to a specific kind of disease, infection, or growth. Following the exposure or risk, the host enters the stage of subclinical disease. In this stage, the incubation or latency period, the host is asymptomatic, but the disease can be detected through pathologic changes found with laboratory, imaging, or screening methods. Most diseases are first diagnosed in the next stage of the natural history of a disease, stage of clinical disease. The transition from the subclinical to clinical disease is marked by the onset of symptoms. The final stage depends on the severity of the disease and the initiation of treatment. While some disease processes may not progress through all of the stages evenly or similarly, the stage of recovery, disability, or death refers to the final outcome of the natural disease history.



Source: Centers for Disease Control and Prevention. Principles of epidemiology, 2nd ed. Atlanta: U.S. Department of Health and Human Services; 1992.

Figure 1: Natural History of Disease Timeline

The best place to mitigate disease in this model is before the onset of symptoms when a person has already entered the clinical disease stage.[4] Mitigating exposure risk is the first step in decreasing disease prevalence, but this is often an impossible task as some risk factors are unchangeable, like genetics. Therefore, early detection of subclinical disease through screenings and routine examination is critical to minimize the downstream effects of disease. In vision care, the most common diseases that cause irreversible vision loss are painless and the patient can be asymptomatic throughout the natural course of the disease. This is why prevention of disease through early detection, intervention, and treatment are critical to reduce vision impairment.

Levels of Prevention

Preventing disease, promoting health, and prolonging life are the primary goals of public health initiatives.[33] These core functions involve the continued and cyclical assessment to define the problem or disease, policy development to establish

interventions, and assurance to enforce and evaluate intervention strategies. Preventing disease relies on timely interventions that vary in response to every natural disease process. No matter the disease, however, earlier intervention allows for better health outcomes. Accessible and routine vision exams and screenings allow for earlier intervention and prevention of vision loss. Prevention has been defined in four sequential stages: primordial, primary, secondary, and tertiary.[34]

Primordial prevention is the farthest upstream form of prevention. It targets the most basic health determinants and behaviors at the environmental, social, economic, and physical factors to decrease future health risks and behaviors.[34] Examples of primordial interventions include improving health literacy, housing, insurance coverage, and provider availability. Primary prevention focuses on proper education and promotion of healthy behaviors that will reduce risk of poor health outcomes.[34] Secondary prevention emphasizes identifying disease and initiating treatment during the subclinical stage of the disease process.[34] This prevention includes screenings and routine examinations to detect pathogenic changes. Tertiary prevention is the preservation of health and function through appropriate treatment and management of the disease.[34] This final stage of prevention occurs in the clinic following diagnosis and potential subsequent health loss due to a disease. The levels of prevention represent the different places where interventions can occur in the natural history of disease. Primordial prevention has not historically been a prevention category and fundamentally differs from the other levels because it addresses the very beginning of the disease timeline – potentially eliminating disease without the need for any clinical intervention.

Prevention is a key component to reducing disease prevalence and health care cost at both the individual and population level. However, preventive vision care is not readily understood, accessible, affordable, or included in insurance coverage. Coverage does not equate to care received or utilized. Health equity is the concept that resources, funds, and education are allocated in a way that the most vulnerable are given adequate resources to ensure equality across all individuals and populations. Health equality is a public health goal, but health equity is how equality can be ensured. There is a need for those in the vision health community to recognize and establish vision impairment as a public health problem in order to move towards vision health equity for all.

Public Health Policy Priorities and Vision and Eye Health

Healthy People 2030

Healthy People, first established in 1980, is a strategic planning process led by the US Department of Health and Human Services. The purpose of this national initiative is to guide health promotion and disease prevention efforts with a new 10 year timeline at the start of each decade. Healthy People establishes health topics, objectives, and baselines to be tracked for improvement throughout the decade. Healthy People 2030 emphasizes improved health equity in the US with a new, dedicated focus addressing social determinants of health through one of its five overarching goals: "Create social, physical, and economic environments that promote attaining the full potential for health and well-being for all."[30] There are 16 vision related objectives for Healthy People 2030 with about one quarter of the objective focusing on more upstream social determinants.[30] These objectives focus on increasing vision screenings for children, increasing dilated

exams for adults, increasing vision services in community health centers, and increasing the number of states tracking vision and eye health data.[30] By addressing the social determinants of health as a priority objective, Healthy People 2030 aims to change upstream factors having the greatest impact on improving health outcomes, decreasing health disparities, and achieving health equity.

Health Resources and Services Administration Priorities

Health Resources and Services Administration (HRSA) in the US Department of Health and Human Services has as its primary goal to decrease health disparities and improve health care services for those who are medically vulnerable because of geographic isolation, socioeconomic status, or health status. HRSA also monitors health trends and statistics in order to train and distribute providers to areas most in need of quality primary health care. In 2020, HRSA provided care to almost 30 million people through qualified health centers.[35] There are over 1,400 HRSA qualified health centers operating in nearly 12,000 locations providing care to 1 in 11 people in the US.[35]

The National Health Services Corps (NHSC), overseen by HRSA, provides the majority of the primary care medical, dental, and mental and behavioral health providers for medically underserved areas of the US. The NHSC was established in 1972 to recruit health care workers to serve in high-need areas often awarding providers with scholarships or loan repayment.[36] Since its inception, the NHSC has consisted of more than 63,000 primary care providers providing care to millions of Americans.[36] NHSC health care workers are required to serve in Health Professional Shortage Areas and

Medically Underserved Populations or Areas which consists of a geographic region, population, or facility in need of primary, dental, or mental health care providers.[36]

Estimates show more than 16,000 NHSC providers served 17 million patients in 2020 alone.[36] In 2019, vision services at HRSA qualified health centers provided care for less than 3% of patients serviced highlighting the limited vision care available in community health centers.[37] There were 46 ophthalmologists and 398 optometrists providing care for this nationwide patient population accounting for less than 0.2% of employees at national health centers, whereas physicians, nurse practitioners, and physician assistants make up roughly 11% of the workforce.[37] Dentists and dental hygienists account for 3% of the total workforce at health centers.[37] One potential explanation for the lack of eye care in federally qualified health centers (FQHC) is that optometry is not recognized by the NHSC as an eligible discipline for loan repayment or scholarships. Optometry's re-instatement into the NHSC has been a priority for professional organizations and non-profit agencies for nearly two decades, but little progress has been made in advancing policy that would incentivize optometrists to work in many medically underserved populations.[34]

2016 National Academies of Sciences, Engineering and Medicine Report

In 2016 the National Academies of Sciences, Engineering and Medicine (NASEM), formerly the Institute of Medicine, issued a report of the public health of vision and eye health called *Making Eye Health a Population Health Imperative: Vision for Tomorrow*. NASEM released this comprehensive consensus report concluding vision impairment is a significant public health problem affecting more than 140 million adults

over 40 years of age in the US each day, whether it be from chronic conditions, disease, or simply uncorrected refractive error.[34] NASEM concluded that a coordinated population health approach effort is needed to establish a plan to achieve better health equity and improve vision and eye health in the US. This approach will require efforts in five key areas: facilitating public awareness, generating evidence, expanding access to clinical care, enhancing public capacity, and promoting community action. The promotion of vision and eye health can positively impact many important aspects of public health including poverty, health care costs, and avoidable mortality and morbidity.[34]

The NASEM report specifically recommends improvements for vision health and access related to the social determinants of health. Making vision impairment a public health priority by increasing public awareness and surveillance will help to achieve equity for underserved populations.[34] Creating and utilizing a surveillance system to establish coordinated population health research efforts will allow for better clinical guidelines for all primary care providers.[34] By incorporating vision health in primary care public health policy and facilities, better overall health outcomes can be achieved for the patients in underserved populations.

Access, Utilization, and Barriers to Vision Care

There have been three major workforce studies regarding vision care providers conducted since 1995 by three different organizations: RAND Corporation, Abt Associates, and The Lewin Group. The RAND study released in 1995 found there would be an excess of optometrists and ophthalmologists meeting and then exceeding eye care

demands after the year 2000.[38] The American Optometric Association later partnered with Abt Associates in 2000 to conduct an updated survey to examine the contributions of optometry more closely and accurately to the overall eye care workforce.[38] The Abt Associates study also concluded there would be an excess in the optometry workforce, however smaller than previously reported by RAND.[39] The recommendation from this study was to increase demand for vision health services by addressing the underlying public health need for eye care.[39] The Lewin Group released a report on the eye care workforce while taking into account eye care demand and unmet need in 2014. This study found with a baseline market study there are not enough eye care providers to meet the estimated demand including all adults and children covered under the ACA Medicaid expansion and the increasing prevalence of diabetes.[40] However, this study formally concluded there to be an excess of providers when considering actual demand and utilization of patient perceived needs and provider availability, including reported current excess capacity.[40] All of the previous workforce studies addressed national provider estimates and did not address geographic variability of provider availability, but noted that closer consideration of provider distribution was warranted.

In 2011, there were an estimated 5.7 ophthalmologists and 14.3 optometrists per 100,000 residents in the US.[41] Of the 3,143 counties or county-equivalents in the US, roughly 24% had neither an ophthalmologist nor an optometrist available.[41] As a result, 2.1% of the US population was living in a county without an eye care provider.[41] People are more likely to reside in a county with an optometrist than with an ophthalmologist. Counties with the fewest eye care providers were significantly more socioeconomically

disadvantaged, had lower population densities, had larger rural populations, and higher proportions of residents age 65 years and older.[41] Another study found that 90% of the Medicare population lives within 30 minutes of driving time from an ophthalmologist and within 14 minutes of an optometrist.[42] This indicates that proximity to a vision care provider may not be the only limiting factor with respect to access for the majority of the population.

In addition to counties with limited access to ophthalmology and marginal access to optometry, it is important to identify other potential barriers to vision care. There are many contextual, environmental, and personal factors to consider in determining access to health care services. A 2016 analysis found county-level characteristics to be important influencer on utilization of eye care services, regardless of the individual's characteristics.[43] County demographics such as race and ethnicity, annual household income, education level, unemployment rates, vision impairment rates, and provider availability are associated with a reported eye care visit. Residents of counties with a higher African American population, higher provider density, lower annual household income, and lower vision impairment were found to be 12.1-20.3% more likely to report an eye care visit within the last year.[43] These findings may not be generalizable to all locations due to targeted interventions implemented to increase care for specific populations. The geographic variability of vision and eye care demands shows that producing granular data is essential to improve access to needed care.

Many studies have addressed potential barriers to access and utilization of eye care. One 2006 study conducted focus groups with older African Americans in Alabama

to identify perceived barriers to eye care including reliable transportation, communication problems, cultural mistrust of doctors, and general poor knowledge of vision and eye health.[44] Of the available eye care providers in Alabama, there were ten counties without optometrists or ophthalmologists and most of these counties were clustered in a part of the state known for having large African American populations as of 2010.[45] A study conducted on a population in Columbus, Ohio found that half of high risk individuals screened at a free clinic and recommended for a free eye exam did not attend their scheduled appointment.[46] The main reasons for failing to attend their earliest available appointment were lack of transportation, forgetting, and scheduling conflicts.[46] One quarter of the participants reported not being able to afford transportation regardless of availability and would have found same day appointments, reminder calls, and free transportation helpful in keeping the appointment.[46] Clinic staff report making reminder calls, but often fail due to no answer, inability to leave a message due to language barriers, or the line is disconnected.[46] These findings suggest that providing eye services to medically vulnerable populations is complex, involving many barriers including transportation, mistrust, poor knowledge and understanding, and scheduling logistics.

Broader Impact of Vision Impairment and Need to Identify Actionable Steps

As previously noted, vision impairment and vision loss place a significant burden on an individual socially, mentally, and physically. It is also important to note how vision impairment can place a tremendous burden on individuals and the US economy. In 2004, it was estimated the burden of eye care and problems in the US among those 40 and older was $54.1 billion. Only nine years later, another analysis by the same investigators

employing an expanded methodology and data collection concluded the economic burden of eye disorders and vision loss among the same population was estimated to be over $139 billion.[11] Over 55% of the total economic burden calculated can be attributed to the age group that is 65 years and older.[11] This estimate accounts for direct costs and indirect costs of eye care with the largest proportion of costs going to diagnostic testing and exams or nursing home care rather than vision aids, education, or assistance programs. It was estimated $27.5 billion was the total cost of eye care for individuals younger than 40 years of age.[11]

In 2013, patients and their families covered 52% of the financial burden for diagnosing and treating vision and eye problems for all those in the US.[11] The government paid for approximately 34% of the total economic burden consisting mostly of medical costs and long-term care costs.[11] Private insurers pay for the remaining economic expenditures. The economic burden for those 65 and older is less as the government accrues more burden for Medicare and Medicaid beneficiaries. However, it is important to note that Medicare does not cover routine eye exams and optometry services except in rare circumstances.[20] Refractive error was the most expensive eye and vision condition totaling $16.1 billion per year.[11] Cataracts were the most expensive medical diagnosis and the second most expensive condition overall at $10.7 billion.[11] Those with retinal problems related to diabetes totaled $4 billion with an additional $4.6 billion for other retinal disorders including age-related macular degeneration.[11] Glaucoma and other optic nerve disorders totaled $5.8 billion overall.[11]

Effectiveness of Vision and Eye Care

Varma estimated that 71.9% of the US population who are visually impaired and 22.1% who are blind would benefit from proper refractive correction.[5] This observation supports the finding that uncorrected refractive error is a leading cause of vision impairment in the US.[5,47] Vision screenings and exams could be essential to access and utilize eye care to detect eye conditions leading to vision loss. In a 2014 national poll, over 87% of respondents believed good vision was crucial to overall health, and just under 50% of respondents feared losing vision more than any other health outcome including loss of hearing, memory, or a limb.[10] The low cost of screenings as a preventive health measure could save the US economy millions and lead to better mental and physical health by addressing vision loss and risk factors for vision loss earlier. Coordination of care and ensuring that those with significant screening findings can access comprehensive care remains a significant obstacle. This may require facilitation of vision care services that could vary based on geography or population characteristics.

Characteristics of the Population of People with Severe Vision Impairment in Ohio

The BRFSS provides state level data on health behaviors and chronic conditions for the adult population age 18 years and over. Because the BRFSS uses the ACS vision disability question, “Are you blind or do you have serious difficult seeing, even while wearing glasses,” it is possible to build a profile of the adult population in Ohio especially with respect to how that profile differs from those without vision impairment.

Table 1: Characteristics of Adults with Vision Impairment in Ohio, BRFSS

	Prevalence	Confidence Interval
Total Population	5.1%	(4.4, 5.7)
Sex		
Male	5.0%	(4.1, 5.9)
Female	5.1%	(4.3, 5.9)
Age		
18-24 Years	4.2%	(2.2, 6.1)
25-34 Years	2.7%	(1.5, 3.9)
35-44 Years	2.8%	(1.5, 4.1)
45-54 Years	6.1%	(4.0, 8.1)
55-65 Years	6.9%	(5.4, 8.4)
65 + Years	6.6%	(5.6, 7.7)
Race/Ethnicity		
White non-Hispanic	4.7%	(4.2, 5.3)
Black non-Hispanic	5.8%	(3.6, 8.1)

Source: CDC BRFSS Prevalence & Trends Data, Ohio 2019

An examination of the 2018 and 2019 Ohio BRFSS data (Tables 1 and 2) illustrates that prevalence of vision impairment is greater among older populations, is more likely to affect women than then men, and has a higher prevalence among racial/ethnic minorities. These findings illuminate key concerns about the prevalence of chronic conditions, health-related quality of life, and social determinants of health. The BRFSS captures some elements of social determinants of health, including health care access, education, and poverty.

Table 2: Chronic Conditions and Social Determinants of Adults with and without Vision Impairment in Ohio, BRFSS

	Vision Impairment		No Vision Impairment	
	Prevalence	Confidence Interval	Prevalence	Confidence Interval
Chronic Conditions				
Smoking*	7.32%	(5.79, 9.23)		
Diabetes*	9.72%	(8.1, 11.7)		
Social Determinants of Health				
Education Level				
Less than HS	13.5%	(9.7, 17.3)	86.5%	(82.7, 90.3)
HS or GED	5.4%	(4.4, 6.4)	94.6%	(93.6, 95.6)
Some post-HS	4.3%	(3.4, 5.1)	95.7%	(94.9, 96.6)
College Graduate	2.1%	(1.6, 2.7)	97.9%	(97.3, 98.4)
Household Income				
<$15,000	11.3%	(8.5, 14.1)	88.7%	(85.9, 91.5)
$15,000 - $24,999	7.7%	(6.1, 9.2)	92.4%	(90.8, 93.9)
$25,000 - $34,999	8.2%	(5.1, 11.4)	91.8%	(88.6, 94.9)
$35,000 - $49,999	3.5%	(2.3, 4.8)	96.5%	(95.2, 97.8)
$50,000+	2.2%	(1.6, 2.8)	97.8%	(97.2, 98.5)

Source: CDC BRFSS Prevalence & Trends Data, Ohio 2019;[22]
**VEHSS data for Ohio, BRFSS 2018*[20]

The profile from the Ohio BRFSS provides considerable insight into the circumstances of people with and without vision impairment. However, the BRFSS does not provide county-level data regarding the prevalence of vison impairment, and it does not have questions about perceived access to vision care. Those questions are the topic of this investigation.

Study Aims

The purpose of this investigation is to assess whether primary vision care availability is associated with the prevalence of vison impairment and unmet vision and

eye health need in the state of Ohio. There is no coordinated vision and eye health surveillance mechanism available to monitor simultaneously vision impairment and disease prevalence, comorbidities, and or access to care at any local, state, or national level. We have uncoordinated data from multiple sources suggesting access to vision care is a public health challenge, but these sources are uniquely analyzed and innately incompatible. There is strong evidence to support the need for better population health surveillance of vision and eye care at all levels, however geographic granularity will allow for the best allocation of scarce resources.

Ohio currently collects data regarding overall health status, access to care, and utilization in a survey conducted approximately every two years. The Ohio Medicaid Assessment Survey (OMAS) was designed to help assess the underlying health-related needs in the state of Ohio in order to best address the state's health disparities. The survey collects data across the entire socioeconomic spectrum and the Medicaid population is over-sampled to better understand that population's needs**.** There are three vision-related questions included in the OMAS. The purpose of the OMAS vision questions is to address vision care access and utilization. In contrast, the ACS vision question addresses visual function, but does not provide any information about any of the underlying causes of vision impairment or whether access is a potential contributing factor. We can utilize these data unique to Ohio in combination with nationally available data through the ACS to answer important questions regarding potential barriers to vision care in Ohio at the county-level. Our secondary goal is to build a template for other states

to utilize or expand their vision and eye health surveillance mechanisms to address their individual state's needs.

Chapter 2. Methods

Data Sources

In order to address our research questions regarding primary vision care, vision impairment, and perceived unmet vision needs, we utilized three publicly available data sources in Ohio. These data sources included the American Community Survey, the Ohio Medicaid Assessment Survey, and the Ohio Vision Professionals Board. Of the three data sources, the American Community Survey is the only national survey. The Ohio Medicaid Assessment Survey and the Ohio Vision Professionals Board are unique to Ohio. No Institutional Review Board approval was required to analyze these data because they are all publicly available following collection.

American Community Survey

The American Community Survey (ACS) has been conducted annually since 2005 by the US Census Bureau to collect information on demographic, social, economic, and housing characteristics of the US, Washington DC, and Puerto Rico.[48] The ACS survey differs substantially from the US census in many ways. The ACS survey is conducted every month of every year as opposed to every 10 years by the decennial census. The ACS samples households annually regarding topics not typically included in the census, such as education, employment, and access to internet, transportation, and other services.[48] The census addresses fewer topics and counts every citizen among the

US, Washington DC, and all of the US territories. Therefore, the ACS defines the social and economic needs of the community, whereas the census provides an official count of the entire US population for congressional representation.[48] The information gleaned from the ACS helps public officials and planners determine how to distribute over $675 billion in federal and state funding each year for community improvements.[48]

The ACS consistently has a very high response rate of over 90% and a sample size of approximately 3.5 million households annually, including roughly 130,000 from Ohio.[48] Because the ACS is part of the census, all addresses randomly selected for the sample each year are required by law to respond to the survey.[49] Responses are collected by internet, mail, telephone, and if necessary, in-person interviews. The ACS surveys both the general non-institutionalized population and group housing – colleges, nursing homes, and correctional facilities – to ensure representation of the US population.[49] Military members as well as civilians are considered in residence if time away from their home during the sampling period is less than two months. More detail regarding ACS survey design can be found in their Design and Methodology Report found at https://www.census.gov/programs-surveys/acs/methodology/design-and-methodology.html.

The ACS is completely confidential and asks demographic information from the current residents at each sampled address plus 44 additional questions regarding social, economic, employment, education, and other status.[48] The ACS does not ask questions about health or access to health care. There are three standard disability questions with six parts addressing vision, hearing, mobility, cognition, and self-care.[48] These questions,

added to the ACS in 2008, are used to identify limitations to independent living. Severe vision impairment is considered one of the disabilities and is assessed through the following question, "Are you blind or have serious difficulty seeing even when wearing glasses?" Response categories include "yes" and "no."

Ohio Medicaid Assessment Survey

The Ohio Medicaid Assessment Survey (OMAS) is a state-specific mail, web, and random digit dial survey with a focus on collecting data on health care access and utilization, chronic and acute health conditions, mental health, health risk behaviors, and health demographics.[50] The Ohio Department of Medicaid, the Ohio Department of Health, The Ohio Colleges of Medicine Government Resource Center, The Ohio State University, and other State of Ohio health-associated agencies collaborate on this survey fielded by Research Triangle Institute International with the purpose to better serve Ohio's vulnerable populations. The OMAS provides state, regional, and county-level data by oversampling Medicaid, Medicaid-eligible, and non-Medicaid populations. First conducted in 1998, the OMAS has since completed eight surveys: 1998, 2004, 2008, 2010, 2012, 2015, 2017, and 2019.[50] The surveys are intended to track Ohio's health system and status over time. The results allow the Ohio Department of Medicaid and other agencies to determine where improvements in the state's health strategies can be made for underserved populations.

The 2017 OMAS sampled over 2.27 million landlines and cell phones via a stratified random digit dial sampling design completing almost 40,000 interviews.[50] Calls resulting in completed or partially completed interviews, refusals, break-offs, and non-

contact (i.e. answering machines) were deemed eligible participants and totaled just under 95,000.[50] The overall reported response rate for the 2017 OMAS was 20.5%.[50] The target population for the OMAS includes non-institutionalized adults and children residing in Ohio residential households. Ohio residents were excluded if living within correctional facilities, group homes, or military housing, living in Ohio less than one month, and failing to complete an interview (i.e. language, physical, or mental barriers). More detail regarding OMAS sampling design can be found in their Methodology Report found at http://grc.osu.edu/sites/default/files/inline-files/2017_OMAS_MethRept_10-18-2018_RTI.pdf.

The OMAS questionnaires are comprised of questions from validated surveys including previous OMAS, BRFSS, ACS, Medical Expenditure Panel Survey, National Survey of Children's Health, and other federal and state health surveys.[51] The OMAS questionnaire asks three questions addressing vision care access and utilization, but does not address visual function. The first question: "Do any of your current insurance plans cover vision care?" Response categories include "yes," "no," "don't know," and "refused." The second question: "About how long has it been since you last had your eyes examined by any doctor or eye care provider?" Response categories include "within 12 months," "1-2 years," "more than 2 years," "never had eyes examined," "said they are blind," "don't know," and "refused." The third question: "During the past 12 months, was there a time when you needed vision care or eye glasses, but could not get it at that time?" Response categories include "yes," "no," "don't know," and "refused."

Ohio Vision Professionals Board

The Ohio Vision Professionals Board oversees all licensure requirements for optometrists, opticians, and ocularists.[52] State licensure records for all optometrists registered with an Ohio license from 2019 were requested directly from the board. The registry provided names, address, license number, issue data, and expiration data, as well as, the county associated with each active optometry license in the state of Ohio. All active licenses held by optometrists with an out of state address were excluded from the Ohio provider analysis. Ophthalmologists were excluded from this analysis considering the optometric workforce is larger and more likely to provide primary vision care. Each active registered optometrist has one address on record with the board providing a county-level distribution of providers. Census Bureau population estimates for 2019 were used to determine the resident population for each county in Ohio. This was used to calculate available optometrists by 10,000 residents in each county.

Analysis

In order to answer our research question, our analysis required vision impairment data from the ACS and vision care access data from OMAS to assess the correlation between unmet vision impairment needs in Ohio at the county-level. Because there is no systematic data collection that tracks provider shortage areas for vision care, we have to rely on hybrid analysis from multiple sources. Ohio is unique for its state-specific population health survey that oversamples the population most at risk for vision impairment demonstrating the importance of incorporating vision-oriented questions into state-specific health surveys.

American Community Survey

For our analysis, we used the ACS to determine the prevalence and distribution of severe vision impairment for the adult population in each Ohio county. To determine vision impairment prevalence at the county-level, raw data tables were pulled from the US Census Database (data.census.gov). The ACS defines vision difficulty as those who responded yes to the question, "Are you blind or have serious difficulty seeing even when wearing glasses?" The 2017 ACS five year estimates for vision difficulty by age and sex in Ohio counties was downloaded and utilized for analysis. We also compared vision impairment prevalence between males and females, as well as, age categories: 18-34 years, 45-64 years, and 65+ years for each county in Ohio. Data provided for those under 18 years of age were excluded from this analysis.

Ohio Medicaid Assessment Survey

To assess vision care need for this investigation, we analyzed responses to one of the three vision questions embedded in the OMAS survey, "During the past 12 months, was there a time when you needed vision care or eye glasses, but could not get it at that time?" An affirmative answer to this question was considered to be an indication of unmet vision care needs. Those who answered "don't know" or "refused" were excluded from analysis. We determined unmet access to care prevalence for each Alcohol, Drug, and Mental Health (ADAMH) Board region in Ohio. ADAMH regions were used because some counties did not have sufficient data for individual analysis in 2017. There are 88 counties in Ohio and 50 ADAMH regions represented at the state level by the Ohio Association of County Behavioral Health Authorities.[53] For ADAMH regions made

up of multiple counties, the same prevalence rate was used for each county within the region. We further compared unmet need prevalence in each county between men and women, above and below 138% FPL, and age categories: 19-39 years, 40-64 years, and 65+ years. These age categories were chosen to mirror previous vision and eye population studies effectively separating young adults, working aged adults, and the Medicare population. Data provided for those under 19 years of age were excluded from this analysis. Data analysis based on race and ethnicity were excluded from our investigation as multiple counties had insufficient data for appropriate analysis.

We conducted our analysis using Microsoft Excel Data Analysis ToolPak for statistical analysis. Statistical comparisons were considered significant at the $p = 0.05$ level. Specifically, we compared: the prevalence of vision impairment across different age cohorts using Analysis of Variance (ANOVA); the prevalence of vision impairment between sex using t-test; the rate of unmet vision care need across different age cohorts using ANOVA; the rate of unmet need between sex using t-test; the rate of unmet need above and below 138% Federal Poverty Limit (FPL) using t-test; the county-level prevalence of vision impairment and county-level rate of unmet need using linear regression; the county-level prevalence of vision impairment and county-level number of optometrists using linear regression; and the rate of unmet need and county-level number of optometrists using linear regression.

Chapter 3. Results

Ohio County-Level Vision Impairment

Figure 2 depicts the prevalence of vision impairment in the adult population in the state of Ohio with an overall prevalence of 2.8%. There was considerable variability in reported vision impairment among the counties ranging from 1.1% in Delaware County to 5.2% in Morgan County (Appendix A and D).

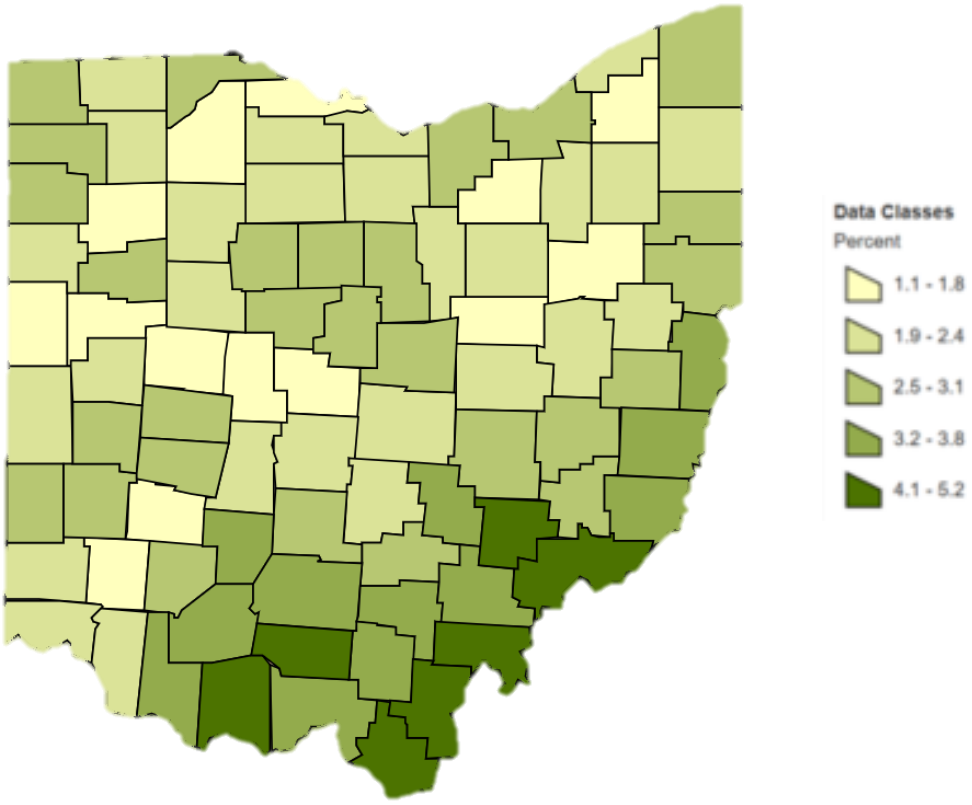


Figure 2: 2017 ACS Ohio Vision Impairment Prevalence by County

Vision impairment increased with age ($p < 0.001$) with the youngest cohort experiencing the lowest prevalence of vision impairment, followed by the middle age cohort, and then the oldest cohort. In the 18-34 year old age category, the overall prevalence of vision impairment was 1.1%, ranging from 0.1% in Monroe County to 6.0% in Morgan County. In the 35-64 year old category, the overall vision impairment rate was 2.5% ranging from 1.1% in Putnam County to 6.7% in Pike County. In the 65 years and older category, the overall vision impairment rate was 6.1% ranging from 3.1% in Delaware County to 11.1% in Vinton County.

Women were more likely to report vision impairment compared to men ($p < 0.003$) in Ohio. Overall vision impairment prevalence among women is 3.0%, ranging from 1.3% in Putnam County to 6.7% in Pike County. Overall vision impairment prevalence for men is 2.6% ranging from 1.2% in Delaware County and 6.2% in Morgan County. Women reported higher prevalence of vision impairment in 67 of the 88 counties in Ohio. Refer to Table 3 and Appendix B for all ACS data.

Ohio County-Level Unmet Vision Care Needs

Figure 3 depicts the overall prevalence of unmet vision care need in the state of Ohio with an overall prevalence of 10.3%. There was considerable variability in reported unmet vision care need among the counties ranging from 6.2% in Preble County to 15.5% in Gallia, Jackson, and Meigs Counties (Appendix A and D).

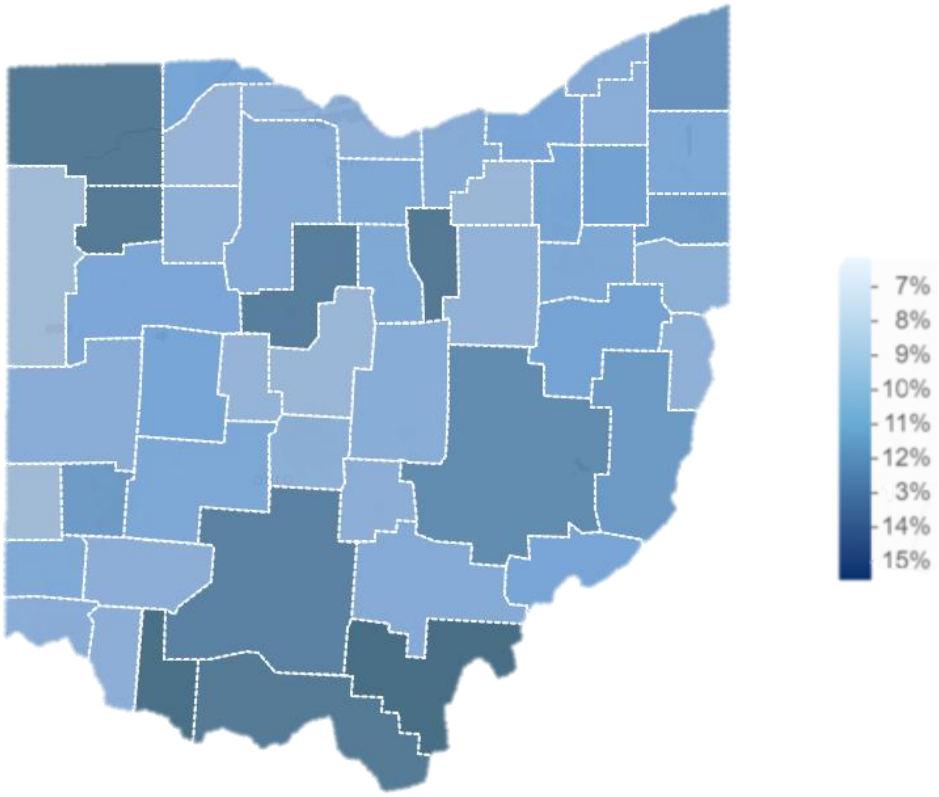


Figure 3: 2017 OMAS Ohio Unmet Need Prevalence, by Alcohol, Drug and Mental Health (ADAMH) Region

There was no statistical difference found in prevalence of unmet vision care needs between age cohorts ($p = 0.46$) when comparing those 19-39 years old, 40-64 years old, and 65 years and older. In the 19-39 year old cohort, the lowest reported prevalence of unmet need was 0% in Adams, Carroll, Monroe, and Morgan Counties, next lowest in Hardin with 1.33%, and the highest prevalence was 27.7% in Harrison County. In the 40-65 year old cohort, the lowest reported prevalence of unmet need was 2.4% in Paulding County and the highest prevalence was 42.6% in Gallia. In the 65 years and older cohort, the lowest reported prevalence of unmet need was 2.7% in Harrison County (Pickaway

and Vinton County had zero observations in this age category resulting in 0% unmet need) and the highest prevalence was 41.1% in Brown County.

There was no statistical difference found in prevalence of unmet vision care needs between men and women ($p = 0.91$). Overall unmet need prevalence reported by women ranged from 2.6% in Paulding County to 23.5% in Harrison County. Overall unmet need prevalence reported by men ranged from 3.3% in Allen County to 37.1% in Gallia County.

Those who live below 138% of the Federal Poverty Level were significantly more likely to report unmet vision care needs than those who live above the 138% FPL ($p < 0.001$). Unmet vision care needs for those living below 138% FPL ranged from 0% in Carroll County with no observations followed by 1.5% in Paulding County to 45.1% in Gallia County. Unmet vision care needs for those above 138% FPL ranged from 1.2% in Hardin County to 19.5% in Gallia County. Those living below 138% FPL reported higher rates of unmet vision care need in 77 of 88 Ohio counties. Refer to Table 4 and Appendix C for all OMAS data.

Ohio County-Level Optometry Provider Distribution

There were 2,321 active optometry licenses reported by the Ohio Vision Professionals Board in October of 2019. Of the active licensures, 260 optometrists were determined to be residing and or currently practicing in another state. There was a wide range of total optometrists reported in each county. Morgan and Vinton Counties each had no optometrists with an active license reported in their county. Franklin County had the highest number of optometrists reporting 370 active licenses. US Census Bureau 2019

county-level population estimates were used to find the number of optometrists per 10,000 residents. Optometrists ranged from 0/10,000 in Morgan and Vinton Counties to 3.9/10,000 in Mercer County. The median number of optometrists per 10,000 residents in each county was 1.6 optometrists. Refer to Appendix A for all licensure data.

Figure 4 shows county-level vision impairment prevalence and unmet vision care needs were positively correlated ($R^2 = 0.32$, $p < 0.001$). Figure 5 shows county-level vision impairment and the number of available of optometrists for the Ohio population were negatively correlated ($R^2 = 0.14$, $p < 0.001$). Figure 6 shows county-level unmet vision care needs showed no correlation with available optometrists in each county ($R^2 = 0.00$, $p = 0.87$).

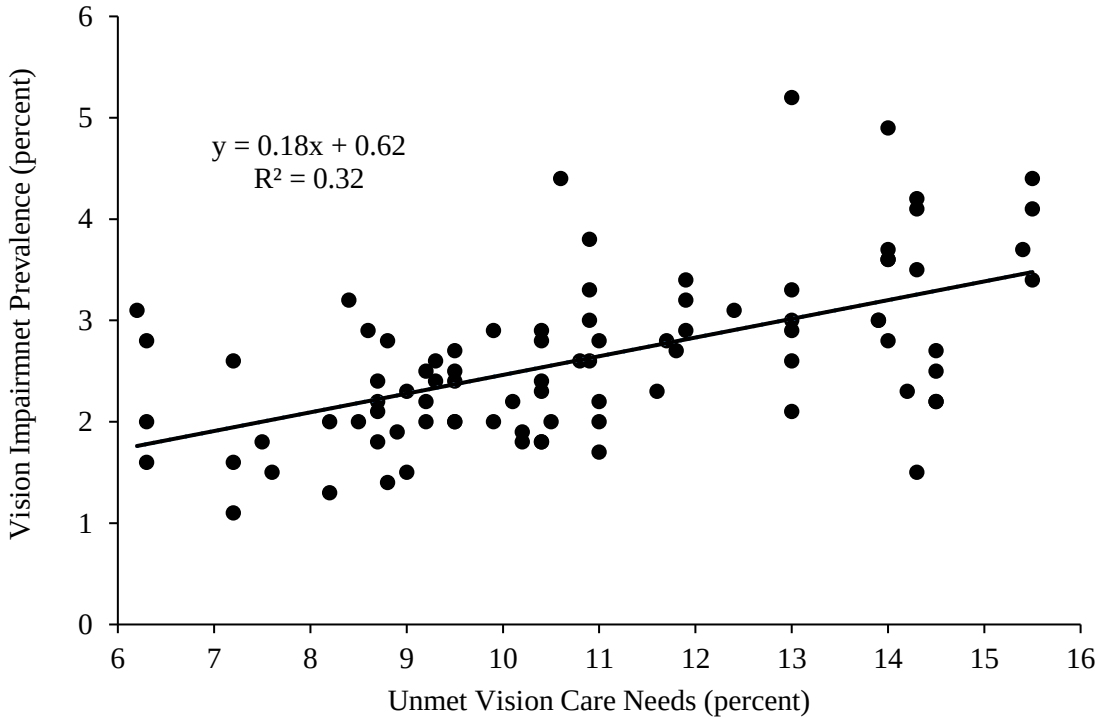


Figure 4: Positive Correlation between Ohio County-Level Unmet Vision Care Needs and Vision Impairment

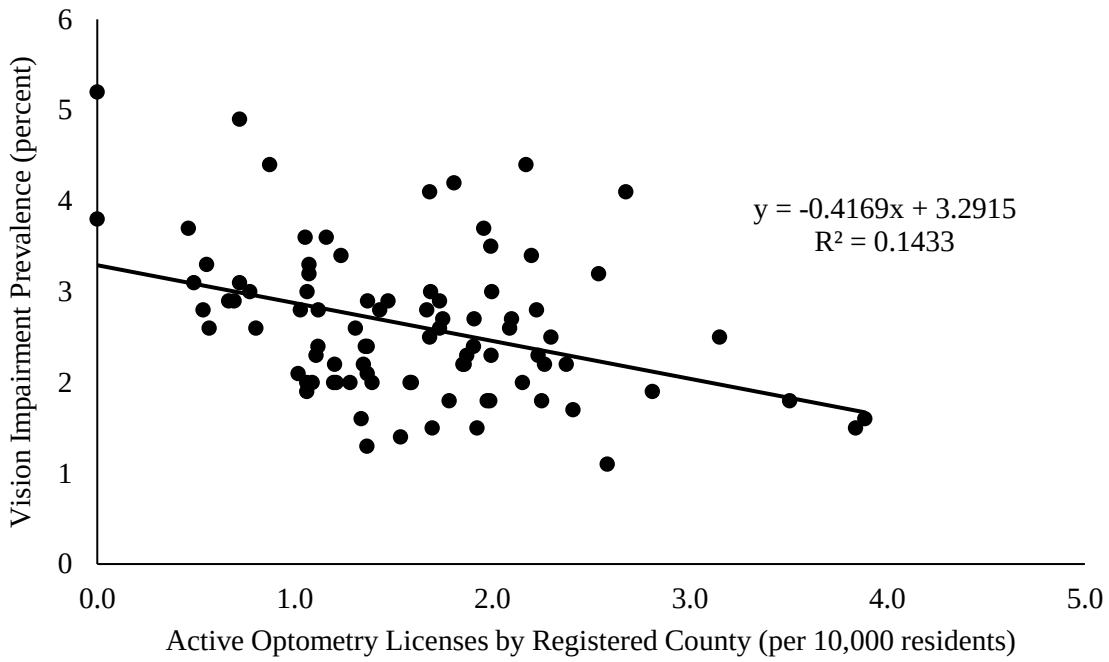


Figure 5: Negative Correlation between Ohio County-Level Optometric Provider Density and Vision Impairment

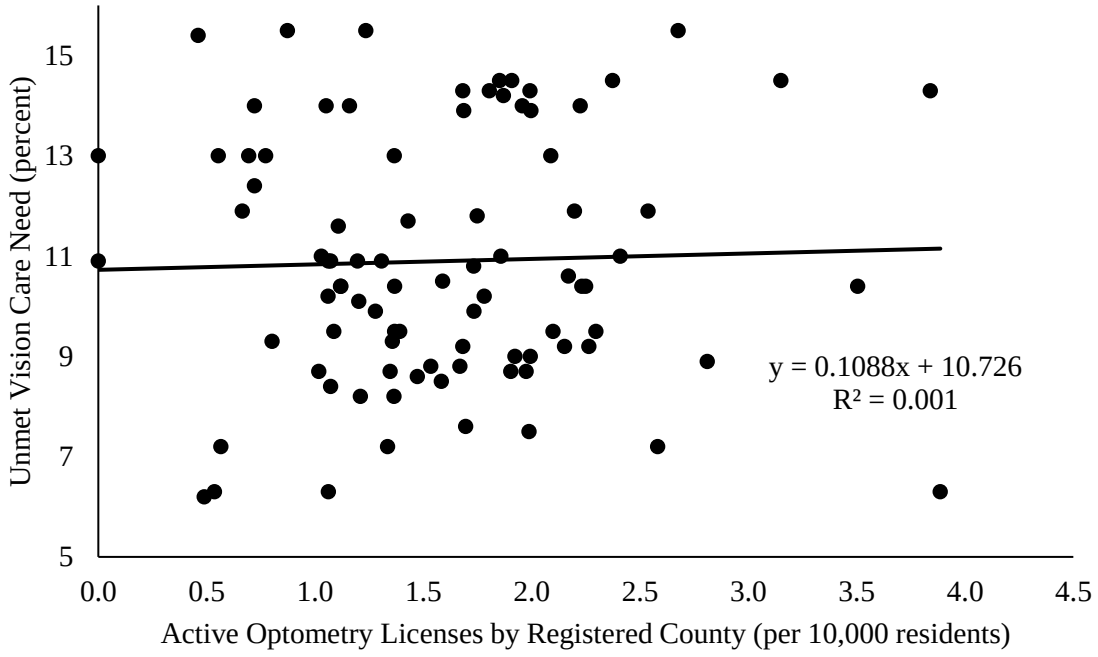


Figure 6: No Correlation between Ohio County-Level Optometric Provider Density and Unmet Vision Care Need

Table 3: 2017 ACS Ohio Adult Population Demographic Results

	Total	**Prevalence**
Adult Population	9,056,612	
Age		
18-34	2,600,128	28.7%
35-64	4,516,868	49.9%
65+	1,939,616	21.4%
Sex		
Male	4,377,403	48.3%
Female	4,679,209	51.7%
Race/Ethnicity		
White	9,480,074	81.3%
Black	1,441,353	12.4%
Hispanic	436,762	3.7%
Asian	324,372	2.8%
**includes children*		
Poverty Level		
Below	1,070,020	12.2%
Above	7,707,020	87.8%
Insurance		
with	8,165,163	93.6%
without	560,619	6.4%
**19 and older*		
Vision		
Vision Impairment	249,231	2.8%

Source: United States Census Bureau. data.census.gov

Table 4: 2017 OMAS Ohio Adult Population Demographics Results

	Total	Prevalence
Adult Population	8,869,200	
Age		
19-39	3,149,569	35.5%
40-64	3,833,939	43.2%
65+	1,885,691	21.3%
Sex		
Male	4,288,528	48.3%
Female	4,580,671	51.6%
Race/Ethnicity		
White or other	7,398,432	83.4%
Black	1,030,755	11.6%
Hispanic	257,120	2.9%
Asian	182,892	2.1%
Poverty Level		
Below 138% FPL	2,642,989	29.7%
Above 138% FPL	6,226,211	70.2%
Insurance		
Employer-Sponsored	3,638,289	41.0%
Exchange	156,834	1.8%
Medicaid	1,738,744	19.6%
Medicare only	1,892,975	21.3%
Other/Private	782,955	8.8%
Uninsured	659,403	7.4%
Vision		
Unmet Vision Care	913,528	10.3%

Source: The Ohio Medicaid Assessment Survey Dashboard. grcapps.osu.edu/omas/

Chapter 4. Discussion

This analysis utilized national vision impairment data from the ACS and Ohio-specific vision care access data from the OMAS in combination with state licensure data to provide insight into overall vision and eye health and access to care for Ohioans. This investigation found great variability in reported vision impairment, reported unmet vision care needs, and density of eye care providers throughout the counties in Ohio. This variability highlights the complexities, burden, and underlying social determinants of vision impairment in at the county-level. This analysis found reported vision impairment to be positively correlated with poor access to vision care. This correlation confirms previous findings demonstrating that areas with higher vision impairment also report higher unmet vision care need.[32,43,54]

Adequate access to care is an important social determinant of health to consider when addressing unmet need or poor utilization of health care services. We determined whether provider availability within the county could explain this positive correlation between vision impairment and unmet need. Our analysis found a predictable negative correlation between available optometrists and reported vision impairment. Surprisingly, there was no correlation between available optometrists and reported unmet need. These findings suggest that increased provider availability has a positive impact on reducing vision impairment, but does not reduce the perception of unmet need. Therefore, other

barriers and social determinants of health must be considered when addressing unmet need for vision and eye care services in the state of Ohio.

Our analysis included a brief investigation of other determinants for reported unmet vision need, including sex, age, and income above and below 138% of the Federal Poverty Limit. There was no statistical difference between men and women or any age category; however, adults living below 138% FPL were significantly more likely to report unmet need in all but eleven rural counties. This finding is a particularly significant for Ohio, because Ohio became a Medicaid expansion state in 2014 under the Affordable Care Act.[31] As a result, low income adults without dependents qualified for Medicaid benefits which include vision and eye care coverage, including glasses.[31] This analysis shows that having vision insurance coverage does not translate to perceived or utilized access to care. This finding underscores the importance of addressing more upstream barriers and social determinants of health when assessing vision impairment and unmet need, beyond the availability of providers and insurance coverage.

The NASEM report outlining the need to make eye and vision health a public health priority specifically recommends addressing these upstream barriers and social determinants through more integrated primordial prevention. Federal, state, nonprofit, for-profit, professional organizations, and other public health entities must work together to create effective changes through coordinated and sustained surveillance, inclusion of vision care services and screenings within all populations, and prioritize vision and eye health policy reform. Some examples of actions already taken to improve vision and eye health care coordination and surveillance capacity include the efforts of the CDC's

Vision Health Initiative accessible VEHSS and state-specific educational profiles.[20,55] The CDC and the National Association of Chronic Disease Directors also created a vision health toolkit to help public health agencies and their partners achieve better vision outcomes.[56] Nearly every federally qualified health center (FQHC) provides vision screenings to their patients, however only 18% provide on-site vision care services through a licensed professional.[57]

This county-level needs assessment is possible in Ohio because of established and unique surveillance mechanisms not typically available in other states. The OMAS specifically addresses perceived access and utilization of vision care services through three questions asked to both the child and adult population. The first addresses if the individual knows their current vision insurance coverage status. The second question addresses if the individual has utilized eye care services within the last two years. The third question addresses whether or not the individual needed eye care, but did not go within the last year. Like many survey items, these questions can be problematic because they fail to capture all aspects of an individual's overall visual health. These questions do not capture data on visual function, quality of life, and may continue to underestimate actual eye care needs. A person may not perceive a need for vision care if they are in the asymptomatic and in the subclinical stage of the natural history of disease paradigm.[4] Identifying individuals in this stage would be considered secondary prevention, but secondary prevention continues to fall short of addressing more upstream, social determinants including improved access to care and vision health knowledge and attitudes that can prevent vision impairment at the primordial prevention level.

Addressing those challenges will require additional surveillance outside of the traditional national mechanisms to develop actionable interventions with geographic granularity to be effective.

Further analysis of these OMAS questions together with the ACS, BRFSS, and other surveys can provide additional insight into vision and eye health prevalence, comorbidities, access and utilization, general knowledge, and health literacy around eye care needs. For example, Gallia County, Ohio reports one of the highest prevalence rates for unmet vision care need and vision impairment in all categories, but also falls within the top six counties for the number of optometrists per 10,000 residents (See appendices). Gallia County is within the Southeast Appalachian region of Ohio which is of lower socioeconomic status and reports higher rates of health disparities. It is likely there is not enough provider accessibility or general knowledge and health literacy regarding vision care to meet the incredibly high reported vision impairment and unmet need. Another important consideration in determining provider availability and accessibility includes insurance coverage. Not all optometrists and ophthalmologists accept all insurance carriers further impacting unmet vision care needs.

National objectives, like the Healthy People Initiative, could play a significant role in promoting vision health in ways to advance policies that address unmet need. Healthy People goals and objectives for this decade are now in its fifth iteration and overseen by the Office of Disease Prevention and Health Promotion (ODPHP), within the US Department of Health and Human Services.[30] First established with a Healthy People report from the Surgeon General in 1979, each decade a committee puts forth a list of

prioritized national population health goals and objectives for public health officials and healthcare providers to achieve over the next ten years. Vison health has become an emerging priority in the Healthy People objectives, but additional emphasis is still needed.

Healthy People 2000 first addressed vision and eye health in three objectives: 1) Extend requirement of the use of effective head, face, eye, and mouth protection to all organizations sponsoring sporting and recreation events that pose risks of injury, 2) increase the number of people with diabetes who had a dilated eye exam in the past year, and 3) provision of recommended eye exam for strabismus and amblyopia by pediatricians, nurse practitioners, and family physicians.[58] Only the dilated eye exam for diabetes was monitored and measured for the Healthy People 2000 report. As for Healthy People 2010, there was an increase in vision objectives to include tracking visual impairment, occupational injuries, eye examinations, vision rehabilitation services, and the use of protective equipment. Healthy People 2020 objectives added a new objective to measure the proportion of FQHCs providing comprehensive vision services. Healthy People 2020 vision objectives saw more than 50% of the 13 trackable vision objectives improve, meet, or exceed target goals.[58] It is important to note, there were 14 objectives and increasing vision services in FQHCs was not a trackable objective, but instead considered a Developmental Objective. Developmental objectives represent a high-priority public health issue that is associated with evidence-based interventions but does not yet have reliable baseline data.[30] Prioritizing the identification of data sources and compiling vision-specific information within FQHCs is an important future step in

improving access to vision care services in underserved populations, including many with complex medical needs.

Healthy People 2030 was released in August of 2020 with a new set of population health goals and objectives for the United States. The release came with a strong emphasis on improving social determinants of health and health literacy.[30] Healthy People 2030 amended the definition of health literacy to emphasize the importance of a person's ability to understand and use health information to make informed decisions about their health. There is also a new emphasis placed on health organizations to take responsibility in providing equitable information enabling all to make informed choices.[59] Previous work discusses the importance of health literacy in improving a person's control over modifiable social determinants of health and overcoming barriers to health.[60]

A few notable developmental vision objectives have been added to Health People 2030 including reducing vision loss from refractive error and increasing the number of states and Washington DC that track eye health and access data. The objective to increase vision services in community health centers, introduced in Healthy People 2020, remains a Developmental Objective and is not trackable at this time. The very addition of these two new objectives regarding vision impairment from refractive error and improving surveillance to Health People 2030 indicates the importance of vision impairment to the ODPHP. It also demonstrates how difficult it is to provide adequate vision care to the people in the current health care system, as well as, track vision and eye health data without appropriate surveillance systems in place. This research is an initial step towards better defining vision impairment and unmet need at a granular, county-level which can

be used in other states to direct funds and care to the areas that are in the greatest need of vision care services.

Although tracking data for vision care providers are limited, FQHCs can be the access point in which medically underserved populations can receive the care they require, but may not realize is needed. HRSA reported most patients who received care at FQHCs in 2019 had Medicaid coverage, accounting for over 47% of the care provided. Patients reporting no insurance made up 22% of the care provided – the second largest population.[37] With over two-thirds of all FQHC patients having Medicaid or no insurance, coordinated care between primary care providers and vision providers can address the gap in health literacy and perceived versus actual need. People with diabetes are sent to vision providers in FQHCs as part of the holistic approach to individual care. Patients in FQHCs are seen because they meet certain requirements regarding their socioeconomic and insurance status. Therefore, providing care to these patients via examinations alone may not be enough. Vision impairment that requires treatment through the prescribing of refractive error correction with glasses or contacts, ophthalmic drops, injections, and or surgeries can still be costly for FQHC patients who have insurance, and even more challenging for those who do not have insurance.[11] The economic barrier of vision impairment can be greatly reduced with the FQHC model, but it does not eliminate disparities completely. Many patients at FQHCs may not have a high level of formal education, may not speak English, and may not fully understand how and why treatment is necessary increasing barriers and complexities to care.[61] These

determinants along with the financial burdens of vision care continue to perpetuate disparities even when vision care is accessible.

A 2009 analysis of eye care in community health centers found that less than 20% of the health centers staff on-site eye care professionals to provide vision-specific care for their patients.[57] These FQHCs rely on referring their patients in need of vision care to outside providers. Previous research defines multiple barriers to care, including transportation, language, affordability, and potentially most important, trust and comfort that may be lacking outside of the health center for which the patient receives all other care.[44,46,62] A potential solution to these barriers would include placing additional primary vision care services within the FQHCs. The National Health Services Corps incentivizes many professions to provide care to medically underserved populations through loan forgiveness and scholarship programs.[36] Optometry's exclusion from providers eligible for loan repayment represents a barrier to primary care services for patients as well as a barrier to more coordinated, holistic approaches to care. A study conducted by UnitedHealthcare evaluated the impact of eye care providers in identifying systemic health conditions through claims data analysis.[63] The study found that eye care professionals were responsible for initiating over 5% of diagnoses made for systemic diseases including diabetes, multiple sclerosis, Juvenile Rheumatoid Arthritis, Crohn's disease, Grave's disease, rheumatoid arthritis, hypertension, and hypercholesterolemia.[63] Arguably, patients with any of these diseases should be regularly followed in close communication with both their primary care provider as well as their eye care provider. Diabetes, the most common cause of irreversible vision loss in work age adults, was

found initially by vision care providers 15% of the time.[63] This only strengthens the argument to include and incentivize the inclusion of optometry and vision care in FQHCs to prevent, diagnose, and treat sight threatening conditions effectively, efficiently, and affordably for all.

There are many limitations to vision data collection based on study design, methodology, and analysis. Population health data are difficult to obtain because they are costly to develop, implement, collect, and analyze. Most vision health data are collected within national health surveys that only address one or two facets of the complex construct that is vision and eye health.[16] Survey items can be difficult to interpret accurately and consistently among the surveyors and those surveyed. Analysis of information in large datasets tends to be over simplified and vague. Previous analysis used Medicare claims data to determine access to eye care; however, optometrists often do not bill medically as consistently as ophthalmologists skewing provider access data. Population specific analyses like claims, insurance, or EHR registries fail to include the large portion of the populations with the greatest health care needs, due to lack of insurance or other access challenges, making conclusions from these less generalizable.

Study Limitations

While this study provides the first analysis of the perception of unmet eye care need by county in Ohio, and is, in fact, the first study of its kind in the US, this investigation remains subject to several limitations. The ACS and OMAS along with the BRFSS are self-reported responses, and the accuracy of responses might be affected by recall bias, social desirability bias, or other factors. The vision impairment questions,

though used in multiple surveys, are likewise self-report and do not provide information about acuity, visual field, disease, or account for vision in one or both eyes. These data are cross-sectional and do not permit causal inference. These estimates do not account for differences such as health behaviors or chronic conditions that might be associated with vision impairment.

Our study limitations also include only analyzing optometric providers based on their licensed county of record. This does not include optometrists working in multiple office locations or counties, which could overestimate the unmet need. This study does not include any ophthalmology providers in Ohio who also provide vision services. The primary focus for this study was the optometric workforce, which is larger than the ophthalmology workforce, and is more likely to be the providers of primary vision care services. It is also important to note access to ophthalmology does not automatically equate to care rendered. Ophthalmologist may not accept all cases due to insurance or specialization in all fields (i.e. retina, cornea, glaucoma). Patients may not be willing or able to travel to another location, city, state or pay any out of pocket costs. Our study was also limited by available data resources. The ACS provides information in a different way than the OMAS. For example, available age categories for the ACS and OMAS were not completely compatible. One example is the categorization of the pediatric population, which includes those 18 years of age in the OMAS, but 17 years of age in the ACS. Other age categories are not directly comparable, but do provide some broad distributions that include a younger, middle, and older adult population.

Conclusion

The purpose of public health research is to identify the magnitude and dimensions of a problem so resources can be allocated to develop and implement effective solutions. It is clear that social determinants of health can positively or negatively impact an individual's overall health and well-being. This novel study provides granular, analytic insight to the assumption that social determinants of health have an impact on vision impairment and unmet vision care needs. Where vision impairment is most prevalent in Ohio, unmet vision care need is also more commonly reported. Our analysis of optometric providers within these parameters shows that provider availability is not the only barrier in providing care to all of Ohio, but especially, the underserved and vulnerable populations. It is unique that Ohio has been collecting vision data through the OMAS since 1994, however, this data collection has not been previously utilized to inform policy solutions to our knowledge.

Further analysis beyond this study is needed to better describe and quantify vision impairment and unmet need in Ohio. The remaining two OMAS questions can provide insight in to general public knowledge of vision insurance and utilization of eye care. The OMAS also collects data on the pediatric population which can be used to better understand pediatric vision impairment and barriers to direct school screenings or the American Optometric Associations InfantSEE programming. More analysis is needed on the county-level characteristics with respect to reported vision impairment and unmet vision care needs. County characteristic data are readily available for analysis through the ACS and include determinants of health like race/ethnicity, education level, annual

household income, and employment status. Associations found within these county characteristics would provide more specific insight to underlying barriers to vision and eye health.

As an optometrist who works in multiple community health centers, I can attest to the personal, professional, and healthcare struggles of patients seeking care at FQHCs. Individuals in underserved populations seek care at FQHC because it is affordable and convenient as a single location to address most healthcare needs. As a provider, there is easy discourse with other providers and pharmacists to provide the best care for the patients. Vision services in FQHCs are limited nationwide. However, FQHCs with vision services are successfully operating and providing care as established and attainable examples for other centers. Eye care providers and FQHCs could allocate funds to establish on-site vision care services, however there are many barriers to consider including cost, available office space/equipment, perceived lack of reimbursement, and business plan development.[57] With over 100 optometry schools and ophthalmology residencies, there is little exposure of optometrists, ophthalmologists, and students to FQHC patient care models to incentivize a career within community health centers.[57] Optometry is a large and capable workforce that can provide highly skilled vision and eye health care to health professional shortage areas and medically underserved populations. The inclusion of optometry as an eligible primary care profession in the National Health Services Corps (NHSC) should be among the first steps in addressing correctable and preventable vision loss.

Vision care providers within the NHSC and FQHCs could allow for improved overall health for patients in many ways. Primary care providers working directly with vision care providers can collaborate and establish continuous care ideally delivering consistent health messaging for those with complex chronic conditions. Patients would not have to overcome new barriers regarding affordability, transportation, or trust by receiving all health care needs in one location. Optometrists - like all newly graduated medical professionals - are money conscious navigating student loan debt repayment making working in underserved populations, if desirable, an impractical career move. However, there is an apparent need for more vision care in underserved populations even with projections of optometric provider surplus. Therefore, considering an incentive through the NHSC to redistribute available optometrists to underserved areas would be a mutually beneficial solution.

The NASEM report outlined five areas for improving vision and eye health and increasing health equity especially for the most vulnerable populations by generating awareness and increasing access to care. Healthy People objectives continue to include the expansion of vision services in FQHCs, yet there is no discernable data collection to measure progress. Healthy People recognizes the social determinants of health as an effective way to create the most change for medically vulnerable populations. FQHCs inherently address the social determinants of health by providing accessible, affordable, quality care in underserved populations. Combining improved vision health surveillance and analysis with granular county specific data will allow for the vision and eye health

and equity goals of NASEM, Healthy People, and the NHSC to be more attainable than ever before.

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Appendix A. Ohio County Population, Optometrists, Vision Impairment and Unmet Need Summary Data Table

County	2019 Total Population Estimate	2019 Active Optometrist Licenses	Optometrists per 10,000 Residents	2017 Total Vision Impairment (%)	2017 Unmet Vison Care Need (%)
Adams	27,698	5	1.8	4.2	14.3
Allen	102,351	14	1.4	2.9	10.4
Ashland	53,484	10	1.9	2.3	14.2
Ashtabula	97,241	7	0.7	3.1	12.4
Athens	65,327	7	1.1	3.3	10.9
Auglaize	45,656	16	3.5	1.8	10.4
Belmont	67,006	17	2.5	3.2	11.9
Brown	43,432	2	0.5	3.7	15.4
Butler	383,134	49	1.3	2.0	9.9
Carroll	26,914	5	1.9	2.2	11.0
Champaign	38,885	4	1.0	2.8	11.0
Clark	134,083	15	1.1	2.8	10.4
Clermont	206,428	21	1.0	2.1	8.7
Clinton	41,968	7	1.7	2.8	8.8
Columbiana	101,883	15	1.5	2.9	8.6
Coshocton	36,600	5	1.4	2.1	13.0
Crawford	41,494	7	1.7	3.0	13.9
Cuyahoga	1,235,072	214	1.7	2.6	10.8
Darke	51,113	11	2.2	2.0	9.2
Defiance	38,087	12	3.2	2.5	14.5
Delaware	209,177	54	2.6	1.1	7.2
Erie	74,266	10	1.3	2.2	8.7
Fairfield	157,574	30	1.9	2.4	8.7
Fayette	28,525	3	1.1	3.6	14
Franklin	1,316,756	370	2.8	1.9	8.9
Fulton	42,126	10	2.4	2.2	14.5
Gallia	29,898	8	2.7	4.1	15.5
Geauga	93,649	18	1.9	1.5	9.0
Greene	168,937	38	2.2	1.8	10.4

Guernsey	38,875	3	0.8	3.0	13.0
Hamilton	817,473	163	2.0	2.3	9.0
Hancock	75,783	12	1.6	2.0	8.5
Hardin	31,365	7	2.2	2.3	10.4
Harrison	15,040	1	0.7	2.9	11.9
Henry	27,006	5	1.9	2.2	14.5
Highland	43,161	5	1.2	3.6	14.0
Hocking	28,264	3	1.1	3.0	10.9
Holmes	43,960	6	1.4	1.3	8.2
Huron	58,266	7	1.2	2.2	10.1
Jackson	32,413	4	1.2	3.4	15.5
Jefferson	65,325	7	1.1	3.2	8.4
Knox	62,322	5	0.8	2.6	9.3
Lake	230,149	32	1.4	2.0	9.5
Lawrence	59,463	10	1.7	4.1	14.3
Licking	176,862	24	1.4	2.4	9.3
Logan	45,672	11	2.4	1.7	11.0
Lorain	309,833	65	2.1	2.7	9.5
Lucas	428,348	56	1.3	2.6	10.9
Madison	44,731	5	1.1	2.4	10.4
Mahoning	228,683	40	1.7	2.7	11.8
Marion	65,093	13	2.0	3.0	13.9
Medina	179,746	24	1.3	1.6	7.2
Meigs	22,907	2	0.9	4.4	15.5
Mercer	41,172	16	3.9	1.6	6.3
Miami	106,987	18	1.7	2.5	9.2
Monroe	13,654	3	2.2	3.4	11.9
Montgomery	531,687	76	1.4	2.8	11.7
Morgan	14,508	0	0.0	5.2	13.0
Morrow	35,328	2	0.6	2.6	7.2
Muskingum	86,215	18	2.1	2.6	13.0
Noble	14,424	1	0.7	2.9	13.0
Ottawa	40,525	8	2.0	1.8	8.7
Paulding	18,672	1	0.5	2.8	6.3
Perry	36,134	2	0.6	3.3	13.0
Pickaway	58,457	13	2.2	2.8	14.0
Pike	27,772	2	0.7	4.9	14.0
Portage	162,466	18	1.1	2.3	11.6
Preble	40,882	2	0.5	3.1	6.2
Putnam	33,861	13	3.8	1.5	14.3
Richland	121,154	21	1.7	2.9	9.9
Ross	76,666	15	2.0	3.7	14.0

Sandusky	58,518	8	1.4	2.4	9.5
Scioto	75,314	15	2.0	3.5	14.3
Seneca	55,178	6	1.1	2.0	9.5
Shelby	48,590	11	2.3	2.2	9.2
Stark	370,606	66	1.8	1.8	10.2
Summit	541,013	86	1.6	2.0	10.5
Trumbull	197,974	21	1.1	1.9	10.2
Tuscarawas	91,987	11	1.2	2.0	10.9
Union	58,988	10	1.7	1.5	7.6
Van Wert	28,275	3	1.1	2.0	6.3
Vinton	13,085	0	0.0	3.8	10.9
Warren	234,602	36	1.5	1.4	8.8
Washington	59,911	13	2.2	4.4	10.6
Wayne	115,710	14	1.2	2.0	8.2
Williams	36,692	7	1.9	2.7	14.5
Wood	130,817	26	2.0	1.8	7.5
Wyandot	21,772	5	2.3	2.5	9.5
Total	**11,689,100**	**2,061**	**1.6 (median)**		

Appendix B. American Community Survey County Data Table

Reported Vision Impairment Prevalence (%) in Ohio Adult Population, ACS 2017						
		Sex		Age		
County	**Total**	**Male**	**Female**	**18-34**	**35-64**	**65+**
Adams	5.30	5.90	4.72	1.74	5.15	5.92
Allen	3.57	3.41	3.72	0.48	2.01	4.67
Ashland	2.75	2.66	2.82	1.11	2.98	8.57
Ashtabula	3.76	3.67	3.85	3.47	3.50	8.08
Athens	3.56	3.22	3.89	0.88	2.37	5.36
Auglaize	2.20	1.96	2.44	1.07	2.04	6.15
Belmont	3.88	3.67	4.07	2.60	2.23	6.97
Brown	4.48	3.89	5.04	1.66	3.32	5.93
Butler	2.42	2.26	2.57	0.95	2.29	6.14
Carroll	2.81	2.94	2.68	1.83	2.74	6.75
Champaign	3.37	3.44	3.30	1.23	3.04	6.79
Clark	3.48	3.46	3.49	0.89	2.21	4.82
Clermont	2.67	2.49	2.83	2.03	3.31	5.11
Clinton	3.31	4.19	2.46	1.08	2.78	6.56
Columbiana	3.50	3.54	3.46	1.59	1.75	4.56
Coshocton	2.49	2.40	2.56	1.76	1.68	7.09
Crawford	3.45	3.95	2.99	0.63	1.17	3.13
Cuyahoga	3.09	2.79	3.34	1.01	2.02	5.68
Darke	2.38	1.71	3.01	1.61	2.44	6.61
Defiance	2.87	3.41	2.36	1.45	3.36	9.90
Delaware	1.37	1.15	1.58	0.87	2.31	6.06
Erie	2.69	2.59	2.78	0.95	2.64	5.22
Fairfield	3.03	2.74	3.32	0.15	5.38	10.53
Fayette	4.26	3.80	4.67	1.61	1.27	3.57
Franklin	2.32	2.04	2.57	0.69	1.80	5.37
Fulton	2.74	2.47	2.99	1.59	3.31	6.82
Gallia	5.09	4.49	5.66	0.97	2.65	6.17
Geauga	1.89	1.47	2.29	1.18	2.10	4.96
Greene	2.16	2.13	2.20	0.42	2.39	8.81
Guernsey	3.69	3.59	3.78	1.26	2.54	7.64
Hamilton	2.75	2.64	2.86	0.92	1.42	7.24

Hancock	2.39	2.49	2.30	1.46	3.92	7.37
Hardin	2.94	2.30	3.55	1.53	2.42	9.02
Harrison	3.50	3.94	3.07	0.30	1.27	5.78
Henry	2.55	2.04	3.03	1.26	2.70	5.11
Highland	4.07	3.68	4.43	0.79	4.76	7.18
Hocking	3.69	3.15	4.19	1.03	3.01	7.48
Holmes	1.74	1.75	1.72	0.93	2.79	7.74
Huron	2.80	2.77	2.84	0.91	1.96	5.01
Jackson	4.19	3.32	5.01	1.43	4.68	9.80
Jefferson	3.61	3.99	3.26	1.16	3.02	5.31
Knox	3.29	3.23	3.35	1.01	1.48	4.78
Lake	2.40	2.19	2.60	1.30	2.92	5.73
Lawrence	5.01	5.00	5.01	1.16	3.11	5.97
Licking	2.97	2.81	3.12	1.12	1.98	7.50
Logan	2.07	1.69	2.43	1.48	2.76	5.85
Lorain	3.11	2.82	3.38	2.25	3.34	6.27
Lucas	3.06	2.97	3.15	0.70	1.64	4.54
Madison	2.90	2.41	3.37	2.42	6.41	7.11
Mahoning	3.18	2.68	3.64	1.20	1.26	5.16
Marion	3.71	4.07	3.37	1.83	2.20	6.95
Medina	2.02	1.60	2.41	0.13	3.24	8.38
Meigs	5.62	5.43	5.80	1.11	3.08	6.89
Mercer	2.09	1.56	2.61	5.97	5.24	7.27
Miami	3.18	3.00	3.35	3.49	1.59	7.03
Monroe	3.95	4.52	3.38	1.10	2.84	6.83
Montgomery	3.32	3.11	3.51	2.02	3.25	4.12
Morgan	5.90	6.19	5.60	0.77	1.22	4.61
Morrow	3.15	2.48	3.81	0.71	3.02	7.15
Muskingum	3.21	2.91	3.49	1.73	3.46	7.61
Noble	3.41	4.49	2.25	1.06	3.05	7.76
Ottawa	2.07	2.15	1.99	2.07	6.66	8.57
Paulding	3.37	3.05	3.70	0.80	2.53	6.33
Perry	3.83	2.94	4.72	3.21	2.76	6.61
Pickaway	3.47	2.64	4.25	0.45	1.11	5.43
Pike	5.88	5.08	6.66	1.58	2.49	7.24
Portage	2.63	2.48	2.77	1.29	3.88	9.22
Preble	3.73	2.85	4.58	1.50	2.58	5.56
Putnam	1.84	2.39	1.29	2.00	3.21	8.91
Richland	3.43	3.00	3.81	1.07	1.84	5.66
Ross	4.36	4.75	3.99	1.85	1.68	6.37
Sandusky	2.96	2.83	3.09	0.71	1.96	4.36
Scioto	4.11	4.01	4.21	0.83	1.86	5.66

Seneca	2.41	1.99	2.82	1.10	1.59	5.20
Shelby	2.65	3.23	2.08	0.50	1.97	5.61
Stark	2.17	2.00	2.32	1.00	1.17	5.96
Summit	2.36	2.22	2.48	1.09	2.10	4.88
Trumbull	2.37	2.36	2.38	0.62	4.27	11.08
Tuscarawas	2.45	2.37	2.52	0.53	1.41	4.71
Union	1.88	1.72	2.05	2.72	5.44	7.29
Van Wert	2.47	2.89	2.07	1.11	1.90	5.41
Vinton	4.76	5.08	4.44	1.42	2.76	6.12
Warren	1.79	1.76	1.81	1.24	1.31	5.64
Washington	5.19	5.06	5.31	1.51	2.72	4.39
Wayne	2.42	1.71	3.09	1.74	5.15	5.92
Williams	3.19	2.44	3.91	0.48	2.01	4.67
Wood	2.03	1.88	2.18	1.11	2.98	8.57
Wyandot	2.80	3.41	2.22	3.47	3.50	8.08
Total	**2.83**	**2.64**	**3.0**	**1.10**	**2.52**	**6.08**

Appendix C. Ohio Medicaid Assessment Survey County Data Table

Reported Unmet Vision Care Need Prevalence (%) in Ohio Adult Population, OMAS 2017							
	Federal Poverty Level		Sex		Age		
County	Below 138%	Above 138%	Male	Female	19-39	40-64	65+
Adams	23.29	8.51	11.44	16.72	0.00	18.94	21.11
Allen	21.21	4.95	3.33	17.04	12.62	7.11	12.29
Ashland	20.01	11.63	14.06	14.42	6.26	21.56	13.69
Ashtabula	16.38	9.71	13.13	11.74	12.65	11.28	13.64
Athens	16.05	5.34	7.32	13.49	9.91	12.77	5.30
Auglaize	25.85	7.29	4.55	17.97	7.92	16.32	6.83
Belmont	18.42	8.91	9.88	13.51	19.12	7.40	10.87
Brown	20.08	13.38	22.34	11.37	8.57	8.32	41.13
Butler	17.08	7.24	8.00	11.67	10.91	9.32	9.04
Carroll	0.00	6.19	7.22	3.52	0.00	3.59	12.29
Champaign	7.39	11.57	14.22	7.63	5.95	12.19	15.92
Clark	19.66	10.10	11.31	15.14	8.66	18.39	11.07
Clermont	16.03	6.42	6.53	10.63	8.70	8.61	8.73
Clinton	26.04	3.87	7.13	16.03	6.16	16.65	5.00
Columbiana	12.50	6.45	3.62	12.74	3.73	9.25	14.81
Coshocton	21.73	4.93	15.30	4.46	4.50	13.77	6.36
Crawford	19.62	10.61	14.88	12.23	6.67	18.07	11.45
Cuyahoga	18.16	6.85	9.97	11.53	9.33	11.22	13.11
Darke	17.13	7.42	7.83	12.44	16.57	7.28	6.38
Defiance	17.83	6.61	3.89	14.43	7.36	12.24	3.19
Delaware	12.30	4.77	4.43	7.62	5.63	5.70	7.00
Erie	19.41	5.05	8.49	9.02	6.34	8.53	12.28
Fairfield	19.78	5.05	8.05	9.28	6.23	6.87	16.31
Fayette	13.55	15.04	22.09	6.61	4.37	20.50	13.47
Franklin	12.78	7.23	9.86	8.03	7.15	10.65	9.88
Fulton	37.55	3.54	17.58	14.14	22.47	17.61	7.61
Gallia	45.13	19.48	37.14	17.46	10.17	42.56	3.00
Geauga	16.82	6.84	6.46	11.66	5.10	7.78	15.90
Greene	18.36	5.10	8.06	8.68	8.31	8.09	9.10

Guernsey	21.70	8.43	7.90	16.55	14.09	10.59	15.04
Hamilton	13.78	6.72	9.36	8.71	7.17	11.17	8.50
Hancock	15.90	6.32	10.67	7.04	10.31	8.93	5.26
Hardin	24.45	1.19	14.79	4.83	1.33	17.11	7.09
Harrison	8.42	18.93	4.46	23.53	27.70	11.72	2.67
Henry	41.39	13.04	25.35	15.91	22.96	11.81	33.82
Highland	32.81	9.07	13.37	21.32	19.49	20.09	10.63
Hocking	20.57	7.72	20.76	5.09	5.42	4.78	33.12
Holmes	10.84	4.34	6.21	5.27	4.53	6.82	6.70
Huron	17.13	7.74	13.32	7.40	13.49	9.94	6.14
Jackson	26.40	4.80	16.79	9.83	10.18	14.92	11.35
Jefferson	12.29	5.39	7.88	8.89	15.97	8.25	3.48
Knox	10.00	9.06	11.36	6.63	7.81	9.36	11.15
Lake	22.19	6.68	8.27	10.69	11.84	6.78	11.91
Lawrence	19.80	11.98	11.01	18.49	11.50	15.86	15.92
Licking	17.34	6.11	9.91	8.65	8.85	8.93	10.44
Logan	7.62	12.40	17.60	4.33	3.66	18.92	7.17
Lorain	14.75	7.49	9.10	9.77	8.15	9.73	10.67
Lucas	17.45	7.65	7.05	14.30	11.16	13.90	3.63
Madison	28.04	2.93	3.99	11.63	13.25	3.30	7.91
Mahoning	15.79	9.84	10.25	13.19	11.03	10.41	15.48
Marion	18.79	10.76	14.30	13.85	12.46	17.93	10.32
Medina	17.96	5.26	9.02	5.21	4.50	9.02	7.23
Meigs	13.32	6.50	5.92	11.16	7.26	9.91	9.68
Mercer	20.16	3.69	6.41	6.58	11.30	4.77	5.53
Miami	10.05	10.66	11.51	9.49	14.18	9.49	8.06
Monroe	17.91	4.89	6.09	9.50	0.00	14.92	6.34
Montgomery	22.60	6.48	10.42	12.82	10.87	13.64	9.43
Morgan	19.79	6.29	3.72	15.24	0.00	14.46	15.48
Morrow	12.60	12.68	14.11	10.68	23.10	4.29	10.82
Muskingum	13.64	14.60	13.83	14.64	16.26	14.07	11.72
Noble	8.67	10.72	5.99	16.19	4.80	14.75	4.89
Ottawa	20.16	5.08	8.11	8.96	12.01	6.84	8.13
Paulding	1.45	5.46	4.70	2.61	2.80	2.42	7.50
Perry	21.15	12.67	20.23	11.61	5.28	19.29	17.94
Pickaway	28.50	4.82	10.94	11.47	11.93	14.93	0.00
Pike	12.03	11.94	18.16	7.72	7.89	14.02	14.44
Portage	13.53	10.97	12.60	10.47	14.51	10.18	10.05
Preble	5.14	6.67	8.65	3.06	2.72	4.33	10.61
Putnam	27.99	10.91	7.49	18.52	4.80	15.47	19.72
Richland	10.73	9.03	17.89	5.54	9.59	11.37	8.13
Ross	18.36	11.87	17.69	10.67	24.01	12.68	9.19

Sandusky	16.15	7.27	8.83	10.62	7.84	10.51	10.11
Scioto	16.90	12.50	19.64	9.39	23.35	6.25	20.71
Seneca	26.40	3.23	6.80	12.84	7.02	13.49	8.25
Shelby	15.38	2.80	6.32	4.73	6.66	2.56	10.38
Stark	15.09	8.09	10.07	10.28	11.58	10.71	7.52
Summit	19.04	6.97	11.31	9.79	12.81	8.42	10.95
Trumbull	13.86	8.57	4.92	14.64	11.23	11.20	7.45
Tuscarawas	20.62	9.47	11.73	13.48	16.74	12.20	7.42
Union	12.19	6.41	9.89	4.57	3.88	10.38	6.96
Van Wert	24.17	2.83	6.66	10.75	16.29	2.52	7.86
Vinton	15.61	10.24	11.06	12.68	26.72	5.95	0.00
Warren	15.68	6.13	8.99	6.93	7.56	8.76	7.11
Washington	11.13	10.38	15.13	6.61	16.00	6.46	11.61
Wayne	12.46	7.63	8.12	9.58	11.50	5.87	10.65
Williams	20.43	13.21	13.89	16.74	18.02	15.73	11.71
Wood	17.52	4.55	8.28	6.69	8.25	9.40	2.79
Wyandot	11.17	4.66	4.35	9.00	5.37	6.94	6.25

Appendix D. Labeled County Map of Ohio