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Social and Policy Factors Influencing Spatial Accessibility of Hearing Healthcare Providers in the United States

DISSERTATION

submitted in partial satisfaction of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

in Public Health

by

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TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

LIST OF ABBREVIATIONS

2SFCA = two-step floating catchment area

ACLU = American Civil Liberties Union

ACS = American Community Survey

ADHD = attention-deficit/hyperactivity disorder

AIC = Akaike information criterion

API = application programming interface

ASHA = American Speech-Language-Hearing Association

AuD = Doctor of Audiology

BS = bachelor's degree

CMS = Centers for Medicare & Medicaid Services

COVID-19 = coronavirus disease 2019

DC = District of Columbia

Df = degrees of freedom

EHC = ear and hearing care

ENT = ear, nose, and throat

FPL = federal poverty level

GEOID = Census geographic identifier

GLMM = generalized linear mixed-effect model

HCP = healthcare provider

HIS = hearing instrument specialist

HIV = human immunodeficiency virus

HPSA = health professional shortage area

HS = high school

IRR = incidence rate ratio

IQR = interquartile range

KFF = Kaiser Family Foundation

LGBTQ+ = lesbian, gay, bisexual, transgender, queer, and other identities

LL = log-likelihood

LME = linear mixed effects

LMP = last menstrual period

ML = maximum likelihood

MPH = Master of Public Health

MUA/P = medically underserved areas/populations

N/A = not applicable

NHGIS = National Historical Geographic Information System

NIDCD = National Institute on Deafness and Other Communication Disorders

NPI = National Provider Identifier

NPPES = National Plan and Provider Enumeration System

OB/GYN = obstetrics and gynecology

PCP = primary care provider

PSLF = Public Service Loan Forgiveness

RUCA = Rural–Urban Commuting Area

SD = standard deviation

SE = standard error

SEM = social ecological model

SES = socioeconomic status

US = United States

USD = United States dollars

VIF = variance inflation factor

ZIP = Zone Improvement Plan

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ABSTRACT OF THE DISSERTATION

Social and Policy Factors Influencing Spatial Accessibility of Hearing Healthcare Providers in the United States

by

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Doctor of Philosophy in Public Health

University of California, Irvine, 2026

Associate Professor Alana LeBrón, Chair

Introduction

Hearing loss is common and treatable, but many individuals with hearing loss do not receive appropriate care. Spatial accessibility, having enough healthcare providers close enough to populations who need their services, is essential for hearing loss treatment. Ear and hearing care (EHC) healthcare providers (HCPs), including audiologists and hearing instrument specialists (HISs), are unevenly distributed across the United States, but the social, geographic, socioeconomic, and policy factors shaping this distribution remain poorly understood. This dissertation examines how place-based factors influence the spatial accessibility of EHC HCPs in the United States.

Methods

This dissertation includes three related studies. Chapter 2 was guided by the research question: What factors influence where geographically EHC HCPs choose to live and work among audiologists who relocate during their career? Semi-structured interviews were conducted with 19 audiologists who had relocated across state lines during their professional careers.

Chapter 3 was guided by the research question: Does census tract-level rurality or socioeconomic status predict the spatial accessibility of different classes of EHC HCPs in the contiguous United States? This study used geospatial methods and census tract-level linear mixed-effects models with rurality and socioeconomic data from 2017–2023. Chapter 4 was guided by the research question: Do variations in state-level reproductive healthcare or LGBTQ+ policies influence a state's supply of audiologists? This study used longitudinal LME and GLMM models with data from 2017 – 2024 to evaluate the influence of reproductive healthcare and LGBTQ+ policy on audiologist movement and where newly graduating audiologists initially registered to work.

Results

Chapter 2 found that audiologist siting was shaped by three overarching themes: occupational considerations, including compensation and financial incentives; local social and economic environments, particularly employment opportunities and resources needed by spouses, children, and aging parents; and state-level policies, which did not typically determine participants' practice locations but were potentially influential for some audiologists. Gender influenced these themes through household decision-making, spouse employment, and caregiving responsibilities. Chapter 3 found that spatial accessibility to EHC HCPs was lower in more rural areas, with rurality more strongly associated with audiologist accessibility than HIS accessibility. Socioeconomic patterns were mixed, but audiologist accessibility was generally greater in communities with higher income and educational attainment, while HISs were relatively more prevalent in rural and lower-income communities. Chapter 4 found that neither reproductive healthcare or LGBTQ+ policy was significantly associated with the proportion or number of established audiologists leaving or entering states or newly graduating audiologists initially registering in states in the following year. Additional analyses did not identify a

consistent pattern of audiologists moving toward states with more supportive policy environments or consistent associations with selected individual policies.

Conclusion

Together, these findings show that EHC HCP spatial accessibility is shaped by interacting occupational, family, socioeconomic, geographic, and policy contexts. Rurality and socioeconomic characteristics were associated with EHC HCP spatial accessibility, while state reproductive healthcare and LGBTQ+ policy environments were not independently associated with audiologist siting. These findings support conceptualizing EHC HCP siting through the SEM as a process in which factors across ecological levels interact to make communities and states more or less feasible and desirable for HCPs to live and practice.

Chapter 1: Introduction

Background

Hearing Loss

Hearing loss is an important health condition for policymakers, public health researchers, healthcare providers, and ordinary citizens to consider. Loss of hearing is the most common sensory disorder, affecting about 1.5 billion people globally (Haile et al., 2021; World Health Organization, 2021). In the United States alone, hearing loss has become 28.1% more common from 1990 to 2019 and in 2019 caused 37.9% of Americans to have difficulty hearing (Haile et al., 2021; Rein et al., 2024). Hearing loss is much more common at older ages, with the prevalence doubling every decade of life from age 20 to 70 and increasing even more quickly after age 80 (Deal et al., 2017; Humes, 2023a, 2023b; Jorgensen & Barrett, 2022; Nieman et al., 2022; Pierre et al., 2012; Rein et al., 2024; World Health Organization, 2021). The prevalence of hearing loss has been steadily increasing across the world, including in the United States, as declining birth rates and rising life expectancy is increasing the proportion of the population that is older (Bhattacharjee et al., 2024; J. Wang & Puel, 2020). These demographic shifts mean that by 2050, about 2.5 billion people worldwide will have hearing loss (World Health Organization, 2021).

For most Americans and most people globally, their hearing loss is untreated (Mamo et al., 2016; World Health Organization, 2021). Untreated hearing loss has significant economic costs to societies and to the individuals suffering from it, globally costing about $980 billion USD in lost productivity attributable to hearing loss annually and up to $194 billion USD in the United States alone, showing the importance of hearing loss in public health (Hjalte et al., 2012;

Huddle et al., 2017; World Health Organization, 2021). Hearing loss dramatically reduces the ability of individuals with the disorder to adequately communicate with their loved ones, healthcare providers (HCPs), and employers, leading to unemployment and underemployment being more common for people with hearing loss (Jung & Bhattacharyya, 2012; Vogelzang et al., 2021). Individuals living with untreated hearing loss can experience reduced income by up to $15,500 USD annually, with up to a 70% reduction in income over the life course for people with severe to profound hearing loss (Hjalte et al., 2012; Huddle et al., 2017; Jung & Bhattacharyya, 2012; Mossman et al., 2023). Despite the economic burden of untreated hearing loss, the causes of the observed rates of treatment remain unclear. Some sources point to the high cost of care to individuals, while other evidence suggests that poor access to the healthcare providers who treat hearing loss as depressing rates of appropriate hearing loss treatment (President's Council of Advisors on Science and Technology, 2015; Pudrith et al., 2024).

Ear and Hearing Care Healthcare Providers

Though hearing loss can be caused by many etiologies, most hearing loss is incurable. The gold-standard treatment for most hearing loss is hearing aids fit by an ear and hearing care (EHC) HCP (Cassel et al., 2016; Tran et al., 2024; Vos et al., 2015). EHC in the US is typically performed by licensed audiologists, nonmedical HCPs who diagnose and nonmedically treat hearing loss with hearing aids (McNeal, 2016). Alternately, hearing aids can be provided to individuals by hearing instrument specialists or hearing aid fitters, who have more limited education and scope of practice compared to audiologists (McNeal, 2016).

Having enough EHC HCPs nearby in time and space are a prerequisite to receiving healthcare services because most EHC services require specialized, bulky equipment and because policy limitations prevent many services from being provided by telehealth (Dixon et

al., 2025; Jilla et al., 2021). This means that geographic nearness of a community to EHC HCPs is linked to the rate of hearing loss treatment, and that travel times to the nearest hearing HCP can be used as a proxy for access to hearing healthcare with greater distances to HCPs resulting in poorer access to these HCPs (Arcury et al., 2005; Card et al., 2019; Cheung et al., 2023; A. G. Davis et al., 2023; F. Wang & Luo, 2005). Spatial access to HCPs considers the time and distance to nearby HCPs, usually measured as travel time from potential patients to HCPs and as distance to the nearest HCPs respectively (F. Wang & Luo, 2005).

Though little research exists comparing care provided by audiologists and by hearing instrument specialists, some evidence in the medical literature comparing physicians and nurse practitioners suggests that practice location may be different among professionals with significantly more vs. less education (Htay & Whitehead, 2021; Hughes et al., 2015; D. Johnson et al., 2019; Laurant et al., 2018; Virani et al., 2016). In an EHC context, audiologists have many years' more post-secondary education, greater average income, and larger scope of services that can be provided compared to hearing instrument specialists. The licensure requirements for hearing instrument specialists vary by state but in most states, hearing instrument specialists do not require any post-secondary education at all. California, for example, only requires a high school diploma and to pass the California Speech-Language Pathology & Audiology & Hearing Aid Dispensers Board exam for HIS licensure (California Speech-Language Pathology & Audiology & Hearing Aid Dispensers Board, 2024). The disparate entry, licensing, and income characteristics of each profession suggest that audiologists and hearing instrument specialists may have unique siting patterns across communities, states, and regions.

Public Health Issue

Disparities in hearing loss diagnosis and treatment are an urgent public health concern because untreated hearing loss can dramatically reduce an individual's ability to care for themselves and others. Untreated hearing loss reduces an individual's ability to participate in education, maintain employment, and meaningfully participate in one's community (Brodie et al., 2018; Malcolm et al., 2022). Hearing loss treatment, however, can mitigate or remove the negative effects of hearing loss on one's meaningful participation in important activities (Tang et al., 2024; Tsimpida et al., 2021). If hearing loss treatment is unequally available across communities, then individuals in communities with fewer EHC HCPs and less access to treatment will face a disproportionate, unequitable burden from hearing loss.

In an EHC context, unequal spatial accessibility to EHC HCPs may explain disparities in hearing loss treatment. For example, individuals with lower SES, in rural communities, and people of color are all less likely to receive timely hearing loss diagnosis and less likely to receive treatment for hearing loss (Jacobs & Ellis, 2025; Malcolm et al., 2022; Quimby et al., 2023). Most studies investigate rates of hearing loss treatment in terms of individual sociodemographic factors; however, if EHC HCPs show similar siting trends to other healthcare disciplines, differences in rates of hearing loss diagnosis and treatment may truly be at least partly influenced by low spatial accessibility of EHC HCPs in poorer and rural communities, and communities with a higher proportion of people of color. If EHC HCPs are unequally distributed among communities along these or other gradients, then people in less affluent communities, individuals living away from urban or suburban centers, and people of color may all have inequitably poorer spatial accessibility to EHC services.

Despite the ubiquitous nature of hearing loss and the importance of appropriate treatment, the siting patterns of the EHC HCPs who treat hearing loss are poorly understood. Investigations into other healthcare disciplines have identified many local and state-level influences that affect the local supply of HCPs, though the relevance of these factors to EHC HCPs remains unknown. For example, most EHC HCPs are cisgender, white English-speaking women (Abreu & Adriatico, 2015; American Speech-Language-Hearing Association, 2019; Joseph, 2022). Among medical disciplines, HCPs often work in communities with a higher proportion of people with a similar racial and ethnic identity to themselves and this relationship is stronger for women than for men (Stinson & Thurston, 2002; Xierali & Nivet, 2018). Physicians also tend to work in urban areas more often than rural areas, which partially contributes to rural regions being health professional shortage areas (HPSAs) and medically underserved areas/populations (MUA/P) more often than urban areas (Health Resources & Services Administration, 2024; McIsaac et al., 2015; K. B. Naylor et al., 2019a).

Another potential influence on the local spatial availability of EHC HCPs is state level policy. Reproductive healthcare policy, defined here broadly as policies affecting the ability of individuals to receive timely, high-quality abortion healthcare services when needed, has been repeatedly identified as an important consideration when HCPs in other disciplines choose where to study and work, often influencing siting within a year or less of policy changes (Hammoud et al., 2024; Mermin-Bunnell et al., 2023). Since the *Dobbs v. Jackson Women's Health Organization* supreme court ruling overturned federal abortion protections in 2022, medical students and residents across disciplines have endorsed a preference for living in states with reproductive healthcare protections and clear shifts in where medical students apply to work were visible within one year of the *Dobbs* decision (Hammoud et al., 2024; Mermin-Bunnell et

al., 2023; Orgera & Grover, 2024). Should EHC HCPs also preferentially provide care in states with reproductive healthcare protections, then EHC service accessibility will also be inequitably available across state lines, unjustly worsening EHC service access for individuals living in states with reproductive healthcare restrictions.

Another potential source of inequitable access to EHC HCPs at the state level is LGBTQ+ (lesbian, gay, bisexual, transgender, queer, and other identities) policy at the state level. Like reproductive healthcare, states have vastly different policy landscapes around the involvement of individuals with LGBTQ+ identities in everyday life. Unlike reproductive healthcare policy, however, less evidence is available to evaluate the potential role of LGBTQ+ policy (e.g., legal recognition of nonbinary gender identities, anti-discrimination protections on the basis of gender identity or sexual orientation, etc.) on HCP supply. Though there is substantial variation in each group, LGBTQ+ people and women are more likely to prefer living in a region with inclusive LGBTQ+ social policies (A. D. Fisher et al., 2017; Grant et al., 2018; Noah, 2023; Suen, 2021; Suen & Chan, 2021). Women are about twice as likely to identify as LGBTQ+ and are more likely to support greater inclusion of LGBTQ+ individuals, suggesting that healthcare fields such as EHC that have a larger proportion of women are more likely to be influenced by LGBTQ+ policy preferences than disciplines with a smaller proportion of women (A. D. Fisher et al., 2017; Greenburg & Gaia, 2019; Jones, 2024; Worthen, 2016). If EHC HCPs are located more often in states with more permissive or protective LGBTQ+ policies, then EHC service accessibility will also be inequitably available across state lines, unjustly worsening EHC service access for individuals living in states with LGBTQ+ policy restrictions.

Theoretical Framing

Each research question investigated in this dissertation contributes to the theoretical understanding of how multilevel factors may influence HCP siting and, in turn, local healthcare accessibility. The research questions examined here were informed by social ecological models (SEMs), which were developed in the 1970s to understand how individual behaviors and health outcomes are influenced by the social and environmental contexts in which people live and work (Bronfenbrenner, 1994). The core of SEMs frames individuals as embedded within interacting environments of increasing scope (Eriksson et al., 2025). Subsequent public health applications adapted this perspective to explain health behaviors, health services use, and community health promotion (Golden & Earp, 2012; Stokols, 1996). SEM frameworks are defined and operationalized differently based on the research context, but they often include individual, interpersonal, organizational, community, and policy influences and propose that factors within and across these levels act together rather than independently (Eriksson et al., 2025; Golden & Earp, 2012).

The focus of SEMs on interacting, multilevel influences makes this theoretical approach particularly well suited for examining HCP siting. HCPs do not choose where to live and work solely based on individual or occupational preferences, and their location patterns are not likely to be explained by a single characteristic of the communities where they practice. Instead, HCP siting appears to be shaped by individual and occupational priorities, interpersonal relationships and family needs, the availability and characteristics of local employment, broader social and economic conditions within communities, and state-level policies (Chatterji et al., 2024; Goddard et al., 2010; Levy et al., 2025). Influences at each of these levels can interact. For example, an occupational opportunity may only be feasible when it is also compatible with the employment

needs of a spouse, the needs of children or aging parents, the economic characteristics of the surrounding community, and the policies of the state where the opportunity is located. This dissertation uses an SEM to conceptualize spatial accessibility to EHC HCPs as a downstream outcome of interacting conditions that shape where HCPs are willing and able to live and practice.

This framing with an SEM advances current theory by conceptualizing spatial accessibility to EHC HCPs as a condition produced through influences operating across ecological levels, rather than as a fixed feature of the communities where providers do or do not practice. Previous healthcare workforce scholarship has examined policy conditions as potential influences on where HCPs train and practice, but policy has rarely been applied to explain the siting of EHC HCPs. In EHC services research, policy is more often considered in terms of its influence on patient access, reimbursement, licensure, or telehealth. Less attention has been given to whether a state's broader social and healthcare policy environment shapes whether EHC HCPs choose to enter, remain in, or leave a location. By examining reproductive healthcare and LGBTQ+ policy as state-level influences on audiologist supply, this dissertation extends scholarship on HCP siting to consider policy as an upstream component of the context that shapes spatial accessibility to EHC services, even when the policies being examined do not directly relate to EHC services (Hammoud et al., 2024; Mermin-Bunnell et al., 2023; Orgera & Grover, 2024).

This dissertation also develops the theoretical application of SEMs by separately examining two related professions that provide overlapping EHC services. Audiologists and HISs both provide hearing aid services, but they differ substantially in their education, licensure requirements, income, scope of practice, and employment opportunities. These professional

differences may affect how influences at each ecological levels affect siting. For example, the same rurality, socioeconomic, or employment context may present different opportunities and constraints to an audiologist than to a HIS. Prior research on EHC access and provider availability has almost exclusively focused on audiologists, even though HISs can also provide hearing aid services and may be differently affected by community and organizational contexts because of differences between the professions (Planey, 2019; Pudrith et al., 2024). Treating audiologists and HISs as a single EHC HCP workforce, or omitting HISs entirely, assumes that providers who offer related services respond similarly to the environments in which they live and work. That assumption could obscure meaningful differences in the communities served by each profession and provide an incomplete or inaccurate view of EHC service accessibility.

Separately evaluating audiologists and HISs creates a theoretically novel comparison within a shared healthcare service domain. Rather than using the SEM only to identify a list of influences at different levels, this approach evaluates whether the relationship between ecological context and spatial accessibility varies according to the characteristics of the profession being examined. Research across allied health professions suggests that workplace location decisions are influenced by interacting professional and nonprofessional considerations, including career development opportunities, access to amenities that are important for providers' families, and the local policy context (Chatterji et al., 2024; Goodfellow et al., 2016; Ullrich et al., 2015). In audiology, prior research has described the uneven spatial distribution of audiologists across communities and identified lower availability of audiologists in rural and lower-income areas, though as of the time of writing these models have not been used to separately compare audiologists with HISs (Planey, 2019; Pudrith et al., 2024). Other studies have also used SEMs or similar models to understand barriers to EHC service access, including

interpersonal support, affordability, local service infrastructure, travel, and policy barriers (Brothers et al., 2022; Ingram et al., 2016). Though this work indicates that audiologist distribution and hearing healthcare access are shaped by influences across multiple levels, few studies have directly applied SEMs to examine how these interacting influences affect where EHC HCPs choose to live and practice or whether those influences operate differently across the two professions.

The three analytic chapters apply this theoretical framing at complementary levels and through complementary methods. Chapter 2 explores intrapersonal, interpersonal, organizational, community, and policy considerations that audiologists describe when choosing where to live and work. Chapter 3 evaluates whether community-level rurality and socioeconomic characteristics are associated with spatial accessibility to audiologists and HISs and whether those associations differ between the two professions. Chapter 4 examines whether state-level reproductive healthcare and LGBTQ+ policies are associated with audiologist supply over time, including whether policy context is differently associated with the locations of established audiologists and newly graduating audiologists entering the profession.

Together, these analyses conceptualize EHC HCP siting as a multilevel and profession-contingent process. The theoretical contribution is therefore not only the application of an SEM to provider siting, but also the proposition that ecological influences may operate through different pathways for distinct professions providing related services. By identifying where siting patterns converge or differ between audiologists and HISs, this dissertation develops our theoretical understanding of how professional characteristics interact with community and policy contexts to shape spatial accessibility to hearing healthcare services across the United States.

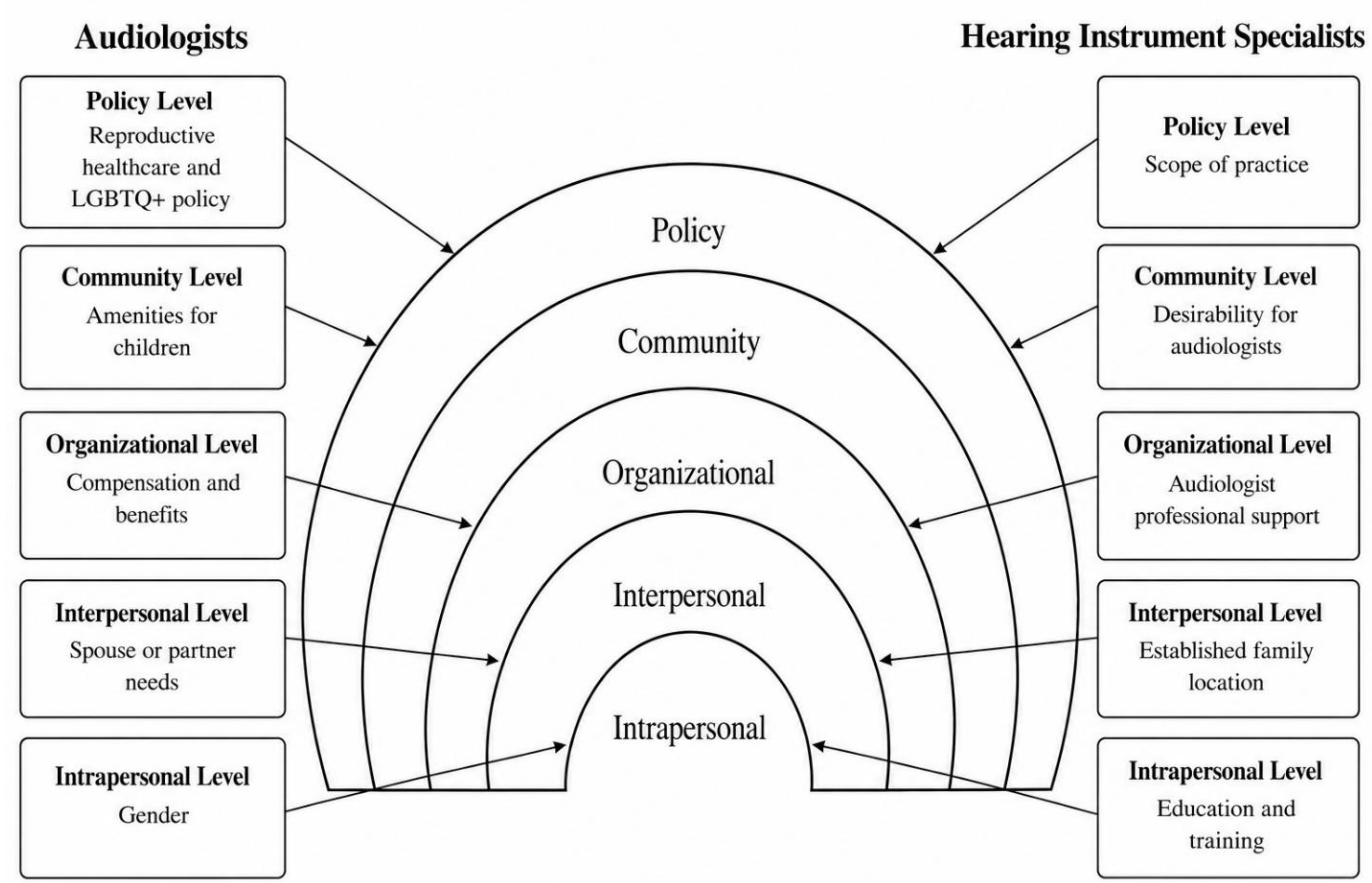

Figure 1, Social Ecological Model Applied to Ear and Hearing Care Providers with Potential Influences at Each Level

Objectives

Despite clear differences in hearing loss treatment across communities, it is not clear if or how the spatial accessibility of EHC HCPs contributes to hearing loss treatment rates. Other healthcare disciplines show gradients of access at a community level by rurality and community SES, and at a state level by reproductive healthcare policy, though little evidence currently shows if EHC HCPs follow these patterns or not. This dissertation uses qualitative and quantitative methods to investigate patterns of EHC HCP siting over time to elucidate disparities in access to EHC services. The results of this study will clarify the importance of assessing HCP spatial accessibility and of separately evaluating the spatial accessibility of separate healthcare workforces in health services research.

The first analytic chapter in this dissertation, the second chapter (Aim 1) analyzes exploratory qualitative interviews with audiologists to explore what audiologists believe influences EHC HCP siting. The third chapter (Aim 2) then utilizes census tract level rurality and socioeconomic data to investigate how these factors are related to EHC HCP siting in the US from 2017 to 2023. The fourth chapter (Aim 3) contains a state-level longitudinal policy analysis to study if reproductive healthcare or LGBTQ+ policy is associated with audiologist supply in the US from 2017 to 2024. Finally, the fifth chapter concludes with implications of the findings for research, policy, and practice.

Chapter 2 (Aim 1) seeks to understand how audiologists in the US choose a geographic region to live and work. The research question guiding this chapter is, what factors influence where geographically EHC HCPs choose to live and work among audiologists who relocate during their career? The research question guiding Chapter 3 (Aim 2) is: How does the spatial accessibility of different classes of EHC HCPs vary across community-level rurality and

socioeconomic characteristics in the contiguous United States? The specific hypotheses investigated in Chapter 3 (Aim 2) are:

- Hypothesis 2a: The spatial accessibility of EHC HCPs will decrease with increasing community rurality;
- Hypothesis 2b: Community socioeconomic characteristics will be associated with the spatial accessibility of EHC HCPs, with characteristics reflecting greater socioeconomic advantage generally associated with greater spatial accessibility; and
- Hypothesis 2c: Audiologists and HISs will each show distinct siting patterns during the study period.

Chapter 4 (Aim 3) then broadens the geographic unit of analysis from the census tract to states to explore state level policy and subsequent EHC HCP spatial accessibility. The overall research question guiding Chapter 4 (Aim 3) is: Do variations in state-level social policies influence a state's supply of audiologists across the US? Two sub questions guided the analyses in this study:

- Research Question 3.1: Do restrictive state-level reproductive healthcare policies reduce the local supply of audiologists in its respective state? The specific hypotheses relating to the first research question investigated in this study are:
    - Hypothesis 3.1a: Audiologists move away from states with restrictive reproductive healthcare policies within 1 year of their adoption;
    - Hypothesis 3.1b: Audiologists move to states with less restrictive reproductive healthcare policies within 1 year of their adoption; and
    - Hypothesis 3.1c: Graduating audiologists entering the profession selectively register to work in states with less restrictive reproductive healthcare policies.

- Research Question 3.2: Do restrictive state-level LGBTQ+ policies reduce the local supply of audiologists in its respective state? The specific hypotheses relating to the second research question investigated in this study are:
    - Hypothesis 3.2a: Audiologists move away from states with restrictive LGBTQ+ policies within 1 year of their adoption;
    - Hypothesis 3.2b: Audiologists move to states with less restrictive LGBTQ+ policies within 1 year of their adoption; and
    - Hypothesis 3.2c: Graduating audiologists entering the profession selectively register to work in states with less restrictive LGBTQ+ policies.

Conclusion

This dissertation examines EHC HCP siting with attention to community and state level factors that may influence which communities these HCPs provide their essential services in. The unique demographic makeup of EHC providers and the differences between the two disciplines providing EHC services in the US may result in HCPs in each of these disciplines being spread unevenly. Unequitable spatial accessibility to EHC HCPs may in turn help explain well-studied disparities in hearing loss diagnosis and treatment by rurality and SES. The findings from each of these analyses will clarify how EHC HCPs are distributed geographically and suggest avenues to improve the spatial accessibility of EHC services in currently underserved communities.

Aim 1 qualitatively investigates the factors and influences that EHC HCPs consider when choosing communities to live and work in, while aims 2 and 3 quantitatively examine how EHC HCPs are spread through communities and states respectively. The results from aim 1 are presented in chapter 2 and provide deep context through interviews with experienced

audiologists on the factors influencing EHC HCP siting and their relative importance. Aim 2, presented in chapter 3, then quantitatively examines how EHC HCPs are distributed through communities along rurality and SES gradients. Finally, in aim 3/chapter 4 the influence of state-level reproductive healthcare and LGBTQ+ policy on the state-level supply of EHC HCPs are evaluated. Together, the results of these three aims give essential context on the accessibility of hearing loss diagnosis and treatment in disparate communities and provides a foundation for future interventions seeking to improve the spatial accessibility of EHC HCPs in underserved communities in the US.

CHAPTER 2: Geographic Preferences of United States Audiologists: A Qualitative Analysis

Abstract

Introduction

Many individuals with hearing loss do not receive appropriate treatment. Spatial accessibility, having enough healthcare providers close enough to populations who need their services, is essential for receiving ear and hearing care services. Ear and hearing care healthcare providers are unevenly distributed across the United States, but the processes shaping where they live and practice remain poorly understood. Guided by a social ecological model of HCP siting, this study examined the individual, interpersonal, occupational, community, and policy factors that influence where audiologists choose to live and provide patient care.

Methods

This study involved semi-structured individual interviews conducted in January 2025 with 19 audiologists licensed to provide direct patient care and who relocated from practicing in one state to practicing in another state in the US at least once during their professional career. Interview topics included why they moved and why they settled where they did. Interviews were analyzed using a flexible coding approach involving trained coders who triple-coded a portion of the interviews until intercoder agreement measured as Krippendorff's alpha of .8 was reached. All coders iteratively engaged with and coded the interview data with frequent team collaboration, which informed categories and themes.

Results

Three overarching themes described factors shaping audiologist siting: (1) occupational considerations, including compensation, financial incentives, and career opportunities; (2) family

and community considerations, including spouse employment, proximity to family, children's needs, cost of living, and local resources; and (3) state-level policies, including occupational licensing, reproductive healthcare policy, and LGBTQ+ policy. In this predominantly female sample, participants frequently described spouse employment, parenting, and caregiving responsibilities as constraining which employment opportunities and geographic locations were feasible. Reproductive healthcare policy was more salient for participants who could be directly affected, but generally did not outweigh established family and occupational ties. Participants' accounts suggested that urban, suburban, and more resource-rich communities may be more feasible when they simultaneously provide employment opportunities, schools, healthcare services, and other household resources, while rural or remote communities may face recruitment challenges when these resources are limited.

Conclusion

Audiologist siting reflects interactions between occupational, interpersonal, community, and policy conditions rather than a single geographic preference. Gender may shape these interactions through household employment decisions, parenting, and caregiving. These findings suggest that unequal spatial accessibility to EHC services may occur at least partly because communities differ in their ability to meet the occupational and family needs of providers. Efforts to improve EHC HCP recruitment and retention, particularly in rural and underserved communities, may need to address the broader conditions that make locations feasible for providers and their households.

Chapter 2 Introduction

Hearing loss is a serious international public health challenge and is likely to remain so for decades. With over 1.5 billion people worldwide and over 60 million people in the United States (US) suffering from reduced hearing sensitivity (Goman & Lin, 2016; World Health Organization, 2021), hearing loss is the fifth leading global cause of years lived with disability (Vos et al., 2015). Hearing loss becomes about twice as common with every decade of life (World Health Organization, 2021). Further, low birth rates and a higher population distribution of older adults in many nations is likely to increase the proportion of the population with hearing loss in in the coming decades (Bhattacharjee et al., 2024; A. Davis & Davis, 2010; Haile et al., 2023; World Health Organization, 2021).

Hearing loss adversely affects individuals with hearing loss, their communities, and a nation's health systems. For example, hearing loss reduces one's ability to perceive, understand, and respond appropriately in everyday situations such as social interactions with friends or family, workplace interactions, and with healthcare providers (Dalton et al., 2003; World Health Organization, 2023; Zazove et al., 2023). Fewer and poorer quality social connections with others, difficulty maintaining employment and income, and poorer mental and physical health are typical experiences for people with hearing loss (Denham et al., 2024; Huddle et al., 2017; Jørgensen et al., 2024; Slade et al., 2020; Tonelli et al., 2024). With appropriate treatment however, the social, socioeconomic, and health-related impacts of hearing loss can be reduced or eliminated (Bekele Okuba et al., 2023; Dawes et al., 2015; Hinderink et al., 2000; Savage et al., 2025). Typical hearing loss treatment requires visiting an ear and hearing care (EHC) healthcare provider (HCP), but emerging evidence suggests that EHC HCP practices are unevenly distributed along geographic, socioeconomic, and sociodemographic lines (Pudrith et al., 2024).

This study qualitatively examines multi-level and multi-sectoral factors that may affect the spatial distribution of EHC HCPs. The following sections review the literature and gaps in knowledge regarding educational, reimbursement, socioeconomic, social, and other factors that may influence the spatial distribution of EHC HCPs.

Hearing Healthcare Providers

Though some hearing loss is reversible or temporary, most cases are permanent but treatable (Tran et al., 2024). The treatment recommended for most hearing losses is prosthetics that amplify sound to compensate for reduced sound sensitivity (U.S. Food & Drug Administration, 2022). These prosthetics come in many varieties, but most can be classified as hearing aids or cochlear implants (henceforth referred to in this study as amplification) (U.S. Food & Drug Administration, 2022). With limited exceptions, in most countries amplification is prescribed and provided by specialized, licensed EHC HCPs (U.S. Food & Drug Administration, 2022). In the United States, hearing instrument specialists (HISs) and audiologists are the healthcare professionals who dispense amplification. HISs are also referred to by at least 10 other terms in official US policy contexts including hearing aid dealers and specialists in hearing instruments, though in this study this discipline will be referred to as HISs (International Hearing Society, n.d.). Only audiologists can provide the full range of nonmedical EHC services, though both classifications of EHC HCPs can legally provide some forms of amplification used to treat hearing loss. Audiologists have a graduate degree in audiology, usually a clinical doctorate, while HISs are typically permitted to work with only a high school diploma, an apprenticeship to a working HIS, and a passing score on a state licensing board's skills test. Differences in siting, cost of care, and quality of care may exist between HISs and audiologists, though this remains an open issue in the research literature (Gadbois et al., 2015; Htay & Whitehead, 2021). This study

exclusively included audiologists, as this group of EHC HCPs is hypothesized to be more mobile owing to their higher incomes, is several times the size of the HIS workforce so most EHC services are provided by audiologists, and because HISs' scope of practice, unlike audiologists is limited to a small number of EHC services (Amior, 2015; Grutters et al., 2007; U.S. Bureau of Labor Statistics, 2023b, 2023a; Wright & Ellis, 2019).

With limited exceptions, amplification is only available from an EHC HCP. This requires either a HIS or an audiologist to be located near individuals with hearing loss for treatment to take place. A dearth of EHC HCPs has been suggested as one possible reason that even when hearing loss treatment is provided at no cost to the individual, rates of appropriate hearing loss treatment are under 40% (Valente & Amlani, 2017). Few EHC HCPs practicing in some regions may partially explain why amplification is used less often by people with hearing loss in more rural regions (Bierbaum et al., 2020; Omar et al., 2022; Quimby et al., 2023) and among people with lower SES (Cheung et al., 2023; A. G. Davis et al., 2023; Omar et al., 2022; Quimby et al., 2023; Sorkin, 2013; Swords et al., 2024; Tolisano et al., 2020).

Having HCPs near enough to provide services and having enough HCPs to meet the needs of the local population together is spatial accessibility (McGrail & Humphreys, 2009; Wang & Luo, 2005). The literature is lacking on the scope and degree of spatial accessibility of EHC HCPs, but the available evidence suggests that EHC HCPs are unequally distributed, with EHC HCPs being less common and requiring individuals in rural or low socioeconomic status (SES) regions to travel longer distances to reach them (Krause, 2014; Malcolm et al., 2022; Planey, 2020; Planey et al., 2024; Pudrith et al., 2024; Shayman et al., 2019). Research and professional organization advocacy for improving spatial accessibility of EHC HCPs has traditionally focused on task-sharing with community health workers or telehealth, with little

focus on evaluating the current state or possible causes of the unequal distribution of EHC HCPs (for example, Academy of Doctors of Audiology, 2024; American Academy of Audiology, 2017; Coco et al., 2024; Frisby et al., 2022). Other possible influences for the unequal distribution of EHC HCPs could include the highly skewed sociodemographic characteristics of the EHC workforce; audiologists, for example, are predominantly white women, and the effects that this has on the communities where these professionals work is not known.

Distribution of Healthcare Providers

Unequal spatial accessibility of HCPs exists in many disciplines, but two lines of evidence suggest EHC HCPs may be spatially distributed differently than other healthcare disciplines. First is the position of hearing healthcare as a nonmedical allied health discipline, which prevents hearing US-based HCPs from receiving reimbursement for services and providing some services altogether without explicit approval from a licensed physician or advanced practice provider (Arena et al., 2011; Brown et al., 2025). This effectively requires EHC HCPs to be employed by physicians or an organization that also employs these physicians, only accept privately paid services which are catastrophically expensive for most people (Jilla et al., 2023; Nassiri et al., 2022), or to co-locate near primary care or otolaryngology HCPs who can then refer their patients with hearing concerns to EHC HCPs for diagnosis and treatment (Hawes et al., 2022; Planey, 2020). Due to this reimbursement model, EHC HCPs have different pressures when choosing the types of communities to live in and work in than healthcare disciplines with independently practicing HCPs, suggesting that the literature on HCP spatial accessibility may not generalize to EHC HCPs.

A second line of evidence suggests that hearing HCP spatial accessibility is different than other similar health professions due to the unique demographic composition of EHC HCPs.

Reliable statistics for HIS demographic characteristics are not available, but the discipline of audiology has different characteristics than other, similar health professions with about 87% audiologists being female and 92% identifying their race as white only (American Speech-Language-Hearing Association, 2023), much higher rates than other allied health professions in the US with a similar (i.e., post-bachelors professional doctorate) level of education such as physical therapy (68% female) and pharmacy (61% female).

Audiologists are similarly unequally distributed by race with, about 92% of audiologists identifying as white only compared to about 63% of pharmacists and 80% of physical therapists (American Physical Therapy Association, 2020; American Speech-Language-Hearing Association, 2023; El-Zein, 2024). The discipline of audiology in the US is less diverse in gender and race than healthcare disciplines with similar levels of education and professional autonomy. The unique demographic makeup of audiologists compared to similar healthcare disciplines may result in these professionals choosing where geographically to live and work differently than other professions. Though this has not been thoroughly examined in EHC HCPs, some evidence in other healthcare disciplines suggests that HCP racial and gender identities influence the communities where HCPs work through a preference for work in communities with racially concordant patient populations (Goodfellow et al., 2016; Spenny & Ellsbury, 2000; Stinson & Thurston, 2002). Some research on physicians shows that this preference appears to be stronger for women than for men, suggesting that for a workforce with a large predominance of women such as EHC HCPs may show a clear preference for working in communities with a higher proportion of racially concordant patients (Stinson & Thurston, 2002).

The reasons that EHC HCPs live and work in the communities that they do and the contributions of EHC HCP sociodemographic characteristics to their spatial distribution is

understudied in the research literature. The literature on the siting of other HCPs, however, is more developed and has identified several workforce and community characteristics that are linked to the local supply of HCPs. Both EHC HCPs and other HCPs often have a preference for living and working in more densely populated areas because less populous, rural areas often have lower pay, fewer education opportunities for children or work options for spouses, and fewer opportunities for professional development (Costa et al., 2024; Hou et al., 2016; Rosenblatt et al., 2006; Ullrich et al., 2015). Prior investigations of EHC HCPs, however, have been quantitative and most studies of HCP siting have focused on physicians who have quite different income and scope of practices compared to audiologists; differences have been identified but the reasons for EHC HCP siting is still uncertain. A preference for rural living among physicians appears stronger for men relative to women, suggesting that if this differential preference by gender is also present among other types of HCPs, then healthcare disciplines with unbalanced gender ratios in its workforce such as audiology may show differences in the availability of these HCPs along a rurality gradient (Brooks et al., 2002; Spenny & Ellsbury, 2000). In the context of the predominantly female audiology workforce, this preference for more urban workplaces among women may reduce the number of EHC HCPs in rural areas.

Like rurality, evidence across healthcare disciplines suggests that weather and natural disasters influence local supply of HCPs. The available evidence is mixed, however: some natural disasters reduce the local supply of HCPs for extended periods after they occur but not all HCPs appear equally affected, and not all disasters influence HCP siting to the same extent (Bell et al., 2020; Chang et al., 2025). Physician supply is lower after natural disasters showing that these disasters may influence HCP location, but other HCPs such as nurse practitioners appear less influenced by natural disasters, and there is little evidence for how natural disasters might

influence EHC HCP supply (Bell et al., 2020; Chang et al., 2025). Given the dearth of evidence on if or how weather-related or other natural disasters influence EHC HCP siting, a qualitative study investigating these factors with EHC HCPs would provide important data on how to ensure adequate EHC HCP spatial access in regions that experience natural disasters.

Several socioeconomic factors such as compensation and salary have been found to influence where HCPs choose to live, but less evidence is available on how cost of living influences HCP preferences (Bärnighausen & Bloom, 2009; Daniels et al., 2007). What evidence does exist suggests that some HCPs prefer to live in communities with lower relative cost of living (Cebula & Alexander, 2006; Gravelle et al., 2008; Sasser, 2010). Loan forgiveness and financial incentives can draw HCPs to areas with poorer accessibility of healthcare services (Bärnighausen & Bloom, 2009; Falcettoni, 2018). However, in the US many loan forgiveness programs such as the Pediatric Specialty Loan Repayment Program or National Health Service Corps loan repayment programs do not permit EHC HCPs to apply, despite allowing other allied health professionals to receive loan forgiveness through these programs (Health Resources & Services Administration, 2024; U.S. Department of Health and Human Services, 2024). Financial incentive programs that exclude EHC HCPs are unlikely to directly influence the siting of audiologists, though given the need to co-locate near physicians these incentive programs may indirectly draw audiologists to underserved areas by increasing the prevalence of physicians that audiologists work with in these regions.

State policy may also influence where EHC HCPs live and work in the US. Like many allied health professions, EHC HCPs in the US are occupationally licensed by state governments; these EHC HCPs are required by law to obtain a state license for each state that they provide services in (Jilla et al., 2021). Unlike disciplines with federal licensing or that have reciprocity

agreements between states with substantially similar licensing requirements that allow easily providing services in several states, EHC HCP licensing requirements vary widely between states with some states even requiring holding several distinct licenses to practice as an EHC HCP, possibly limiting EHC HCPs ability to easily relocate to different states (American Academy of Audiology, 2021; Bae & Timmons, 2023; Jilla et al., 2021; Johnson & Kleiner, 2020; taek Oh & Kleiner, 2024). For example, states vary widely in audiology licensing costs (e.g., $5 USD in Arkansas vs. over $1,000 USD in California as of the time of writing), though the impact of disparate licensing costs and requirements on state-level EHC HCP spatial availability is not known (Academy of Doctors of Audiology, 2025; Speech-Language Pathology & Audiology & Hearing Aid Dispensers Board, 2021).

Beyond reimbursement models, EHC HCP demographics, socioeconomic forces, and state licensing requirements, state-level social policies such as policies related to reproductive health care and LGBTQ+ protections may also factor into state-level spatial accessibility of EHC HCPs. States have had increasingly polarized reproductive healthcare restrictions since the 1990's, though until 2022 individuals in all states generally had a constitutional right to an abortion which limited reproductive policy differences between states (Roth & Lee, 2023). The 2022 US supreme court decision in *Dobbs v. Jackson* overturned this nationally protected right, creating a landscape of vastly different policies on if, when, and under which circumstances reproductive care may be legally provided (Zhu et al., 2024). The sudden restriction of rights that are particularly salient for women may influence the distribution of the female-dominated discipline of audiology, though research investigating this has thus far been lacking. Though this is the first study that examines the influence of reproductive healthcare policy on EHC HCPs, other HCPs generally endorse a preference for training and working in states with state-level

reproductive healthcare protections, and HCPs are generally more plentiful in these states (Bernstein et al., 2023; Chatterji et al., 2024; Levy et al., 2025).

Further, state-level policy could influence which states EHC HCPs are willing to live and work in through EHC HCPs selectively living in states with LGBTQ+ (lesbian, gay, bisexual, transgender, queer, and other identities) protections. Like reproductive healthcare policy, state-level LGBTQ+ policy has become increasingly divergent between states in the US in recent decades (Beaudin, 2017; Garrison & Cunningham, 2024). Also like reproductive healthcare, some evidence suggests that HCPs generally prefer to live and work in regions with LGBTQ+ protections, but no research currently exists evaluating this trend for EHC HCPs (Grant et al., 2018; Suen, 2021).

Theoretical Framework

The study presented in this chapter was informed by the social ecological model (SEM) of HCP siting introduced in Chapter 1. Rather than conceptualizing provider supply as a fixed characteristic of a community, this framework positions HCP siting as an outcome of interacting individual, interpersonal, organizational, community, and policy influences. This distinction is important because models of health services use have typically focused on the factors that influence whether individuals obtain healthcare services, with HCP location and supply generally treated as characteristics of the healthcare environment rather than as outcomes requiring explanation themselves (Andersen, 2008; Lederle et al., 2021; S. Zhang et al., 2019). The SEM framing used in this dissertation looks upstream to examine what makes workplaces, communities, and states more or less desirable places for EHC HCPs to live and practice.

Applied to audiologist siting, influences at each ecological level may affect geographic location in different but overlapping ways. Individual-level influences include an audiologist's

occupational goals, financial needs, personal preferences, and other characteristics that affect how potential locations are evaluated. Intrapersonal characteristics that influence audiologist location choices include gender and age. Interpersonal influences include the employment and preferences of spouses, the educational and healthcare needs of children, responsibilities toward aging parents, and other family relationships that can constrain relocation. Organizational influences include compensation, benefits, opportunities for career development, and characteristics of potential employers. Community-level influences include cost of living, housing, schools, local healthcare and other services, rurality, social environment, and other characteristics of the places surrounding potential workplaces. Policy-level influences include occupational licensing requirements and state social policy environments, including reproductive healthcare and LGBTQ+ policies. These levels are distinct but HCPs often evaluate them all when deciding where to live and work.

The interaction between ecological levels is important for understanding audiologist siting. A desirable position with adequate compensation may not result in an audiologist moving to a community if that location does not also provide employment for a spouse, preferred education and healthcare services for children, proximity to aging parents, or other resources important to the audiologist's household. In the same way, a community that is personally desirable may not be a feasible practice location if employment is unavailable or if state licensure creates substantial financial or administrative barriers to practice. State policies may also make a location more or less desirable without being sufficiently important to outweigh established family or occupational ties. The SEM does not presume that factors at one level operate independently or have equal influence, but that these influences across levels influence a HCPs' final siting decisions.

Understanding these processes is particularly important for EHC services because spatial accessibility to EHC HCPs depends on providers being located near enough to populations to provide services. Although some healthcare services can be effectively provided through telehealth or other arrangements involving a remotely located HCP, many EHC services used to diagnose and treat hearing loss require specialized equipment and an in-person EHC HCP (Butzner & Cuffee, 2021; Spankovich et al., 2020). Factors that make a community more or less feasible for an audiologist to live and practice can have downstream implications for the spatial accessibility of EHC services in that community.

This framework also provides a way to understand gender as a cross-cutting influence rather than as a separate siting factor. Audiology is a predominantly female profession, so individual occupational preferences may by constrained by the needs and preferences of spouses, children, and other family members. For example, an audiologist may value compensation and professional autonomy at the individual or organizational level but selects locations based on a spouse's employment, children's needs, or proximity to family. In the same way, reproductive healthcare policy may be personally salient to an audiologist without determining the final location when other interpersonal or occupational constraints are stronger. A social ecological framing allows gendered processes to influence siting through interactions among individual, household, workplace, community, and policy conditions rather than requiring gender to correspond to a single ecological level.

The qualitative approach used in this chapter is well suited to this theoretical framing because little available evidence in the literature points to which ecological influences EHC HCPs consider most important when choosing where to live and work or how influences at different levels interact during these decisions. Instead of testing whether one ecological level

independently predicts audiologist location, this study explores how audiologists describe the combination of occupational, family, community, and policy considerations that shaped their geographic decisions. The themes identified through these interviews can clarify both which influences are relevant to audiologist siting and the processes through which factors operating at different levels reinforce or compete with one another.

This aim examines these multilevel processes through the experiences of audiologists who relocated across state lines, and later aims evaluate selected community and policy influences quantitatively. Because only audiologists were interviewed in this study, the findings cannot establish that HISs evaluate these ecological conditions in the same way. This chapter identifies a set of multilevel mechanisms that may shape audiologist siting and provides context for analyses in Aims 1 and 3 examining whether community characteristics and provider type are associated with different patterns of EHC HCP spatial accessibility. In this way, Aim 1 develops the dissertation's SEM of provider siting by identifying how influences across ecological levels are experienced and negotiated by HCPs when making actual geographic location decisions.

Objectives for Aim 1

This study aims to understand how audiologists in the US choose a geographic region to live and work. A more complete understanding of factors that shape where EHC HCPs choose to live and work will both help explain the unequal spatial distribution of EHC HCPs and suggest policy changes that may be effective in improving the spatial accessibility of EHC HCPs in underserved areas. The research question guiding this study is, what factors influence where geographically EHC HCPs choose to live and work among audiologists who relocate during their career? The complex, multifaceted influences that individuals evaluate to choose where to live and work suggest that this research question is well suited to an exploratory qualitative

investigation where EHC HCPs can explain in their own words the nuanced reasons for their decisions.

Methods

For this analysis, I conducted semi-structured interviews with licensed clinical audiologists in the United States to understand if and/or how these professionals considered work, local environment, and broader policy contexts in deciding where geographically to provide direct patient care.

The institutional review board at the University of California, Irvine reviewed this research and granted it Exempt status, #6003. Participants who elected to participate in this research completed an online informed consent prior to scheduling an interview.

Sampling Strategy

The sample included licensed audiologists who had a history of relocating to another US state at least once during their professional career. This subset of audiologists was believed to have experience considering the myriad factors that may influence the uneven geographic distribution of these professionals.

The sampling frame for this study was created from Centers for Medicare and Medicaid Services (CMS) National Plan and Provider Enumeration System (NPPES) monthly files (Centers for Medicare & Medicaid Services, 2026) and audiology licensing board data from all 50 states and Washington DC. NPPES files for each month from May 2016 to December 2024 were downloaded from the official NPPES website (Centers for Medicare & Medicaid Services, 2026). Older NPPES files were not available from this source so additional NPPES files for five months from 2008 to 2011 were downloaded from the National Bureau of Economic Research

archive (National Bureau of Economic Research, 2019). NPPES records before May 2016 are not generally available with limited exceptions as CMS has not preserved this data.

The NPPES data files for May 2008, January 2010, and December each year from 2016 to 2024 were used to construct the sampling frame. Due to lack of data preservation, NPPES files before 2016 were not available with limited exceptions so files from 2008 and 2010 used months and years that had data available. Each data file was reduced to licensed clinical audiologists by selecting only providers with taxonomy codes corresponding to clinical audiologists: '231H00000X', '231HA2400X', '231HA2500X', and '237600000X' (National Uniform Claim Committee, 2025). Next, each dataset was compared to the previous year's dataset, or in the case of the December 2016 and January 2010 datasets, to the prior dataset from several years before. Individuals in each year's datasets were matched to the prior years' datasets based on NPI to create a merged dataset of individuals who were present in the NPPES system for at least two consecutive years. Finally, these results were filtered for individuals who listed their work address in two different states in subsequent years.

NPPES datasets do not contain email addresses, so the state boards regulating audiology in all 50 states and Washington DC were contacted (American Speech-Language-Hearing Association, 2025a). All are required to post rosters, lists, or otherwise provide information on the names of clinical audiologists licensed in that state. The rosters for each jurisdiction vary in the data they provide, from a comprehensive list of current and previously licensed professionals with full contact information, graduation school and date, and workplace address (e.g., Utah) to name and disciplinary action of currently licensed professionals only (e.g., Wyoming). Sixteen states included email addresses in their roster files, so the files for these states were combined into a roster of professionals with email addresses. These 16 states included Alabama, Arkansas,

Florida, Kentucky, Louisiana, Michigan, Montana, Nebraska, New Jersey, New Mexico, North Dakota, Oklahoma, Rhode Island, Utah, Virginia, and Wyoming. Though some regions like the Mountain West and New England are underrepresented in this sample, the nature of the sample including only individuals who have worked professionally in at least two states during their career broadens the geographic scope of the states discussed in the interviews by including individuals who lived and worked in states that did not include email addresses for HCPs in their rosters.

These results were filtered for individuals with active licenses as of December 2024 to exclude professionals not working clinically and individuals who retired or otherwise ceased work without updating their NPPES data. Though HCPs are required to update their data within 30 days of any change (Centers for Medicare & Medicaid Services, 2007), this does not always occur in practice (DesRoches et al., 2015; Levinson, 2013). By constructing the sampling frame from individuals who both have NPPES data and an active state license that must be renewed every 1 – 3 years, outdated and inaccurate data in the final sampling frame is minimized.

The NPPES data and the state board data were merged to create a single database of audiologists who moved states during their career and had available email addresses. The state board data varied in the information available but always contained first name, last name, and unique state license number. State board records were matched with NPPES data based on either matching first, middle, and last name in both data sources or by matching both state board license number and first name. No records contained two unique individuals with the same full name, and though some states use a similar numbering scheme for licensing the inclusion of first names when matching state license numbers uniquely identified every participant in the data.

Duplicate entries from individuals who moved several times during their career were removed by only keeping the most recent record for each NPI.

The final sampling frame contained 344 unique audiologists who moved to a different state at some point from 2008 to 2024 and had available email addresses. Not all states' EHC HCP licensing boards publish email addresses in their licensing roster, but participants in states that do not publish email addresses were contacted using the contact email address listed in the licensing roster in another state that did publish email addresses. These individuals were emailed at the addresses listed on their state board licensing roster and invited to participate in this research during January 2025. Groups of about 50 individuals at a time were randomly selected by randomly shuffling the order of all individuals and choosing the first 50 occurrences, in line with other interview studies' recruitment strategies (Dillman et al., 2014; Szabo-Reed et al., 2023). The chosen individuals were contacted by the email address listed in their state licensing board roster and invited to participate in this research. After four rounds of invitations separated by one week each, 16 individuals had invalid email addresses, 3 contacted SAK and clarified that they did not meet the inclusion criteria for this study because they had licensure in multiple states and worked on both sides of state borders without relocating, and 160 did not respond to the invitation to participate. 22 individuals scheduled interviews with SAK, and 19 of these completed interviews for a total response rate of approximately 11%. Recruitment ended after completing 19 interviews based on recommendations in the literature that around this number of interviewees is sufficient to reach theoretical saturation in a relatively homogenous sample such as in this study, and because the interviewer noted when initially analyzing the interview data that the final few interviews did not appear to introduce new nuance or themes not already present in other interviews (Bekele & Ago, 2022; Saunders & Townsend, 2016).

Data Collection

The semi-structured interview guide was informed by existing literature on HCP siting and SAK's experience as a clinical audiologist (for example, Goodfellow et al., 2016; Stidolph et al., 2025). The interview guide included prompts in 6 general domains (moving as part of a major life transition, prior experiences, desirability of locations, state policy, socioeconomic influences, and access and utilization of care) and is provided in appendix A. Participants were asked to share their own stories and perspectives, though participants were occasionally asked to compare their preferences and experiences with the wider discipline of audiology in the US.

Individuals who agreed to participate resided in over a dozen different states, so semi-structured interviews were conducted remotely (i.e., Zoom) by SAK in January 2025. The interviews lasted for under an hour (45 – 60 minutes, mean 54 minutes), was audio and video recorded, and was transcribed using Zoom proprietary transcription software.

Participant Sociodemographic Information

Gender data was from the NPPES data files, with one participant clarifying that they are gender diverse outside a strict male-female gender binary, so their current gender identity did not match their NPPES records which does not report genders outside male and female. Specialty and career length data was self-reported in each participant's interviews and supplemented with NPPES data. The setting where the participant primarily worked during their career was taken from each participant's description of their current work context in their interview.

Participant Relationship/Knowledge of Interviewer

Most participants were unacquainted with the interviewer. One participant was an acquaintance of SAK from several years prior and was generally aware of their work, and one participant had worked at the same location as SAK years before SAK had worked there and

knew some individuals in common but had not previously encountered SAK. All participants who were acquainted with or familiar with SAK were assured that their participation in this study was confidential, and no mutual acquaintances would be notified of their participation. The interviewer's experience as a clinical audiologist was disclosed to all participants to clarify their level of knowledge they had about discipline-specific jargon and the field of clinical audiology generally.

Reflexivity

This research was primarily conducted by SAK as part of their PhD dissertation, with guidance and mentorship by AL, JD, and BL. SAK is a licensed and board-certified clinical audiologist with several years' experience providing direct patient care in several contexts, including urban and rural clinics, hospitals and private practice settings, and both Appalachian and West Coast settings. Their clinical training and practice informed the development of the research question, interview guide, and interpretation of the results generated during this research.

The interviewer and interviewee's shared career served as a point of connection, creating a sense of collegiality and providing a source of easy topics of conversation to establish rapport. The shared knowledge base and experiences between the interviewer and the interviewees permitted discussions to include nuanced, technical information that might otherwise not appear if participants were interviewed by a layperson, such as details on the disparate scope of practice between audiologists and HISs. Simultaneously, SAK acknowledged that this project aimed to explore both the positive and negative aspects of their and the participant's chosen discipline. SAK emphasized to participants that their honest, genuine thoughts about the discipline of clinical audiology, flattering and unflattering, were welcome during the interview. Despite this, it

is possible that collegiate loyalty depressed interviewees willingness to discuss negative or unflattering perspectives about the interviewer and participant's chosen discipline out of concern that these might offend the interviewer.

Data Analysis

The automatically transcribed transcript for each interview was manually checked against the interview audio recording by SAK to ensure transcript accuracy, and transcription errors were manually corrected by SAK. SAK assigned a gender-neutral pseudonym to each participant to protect male and gender diverse participants from being identified given the relative scarcity of male and gender diverse audiologists increasing the possibility that these individuals could be identified by their responses, though the coders had access to the gender of each participant and coded the importance of gender where appropriate. Each participant's identifying information (e.g., the name of their employer, the city they reside in, etc.) was removed from their transcript. The transcripts were then imported into ATLAS.ti desktop version 25 for coding.

This project used a flexible coding approach for data analysis, following established methodological guidance (Deterding & Waters, 2021; Michelen et al., 2024). First, index codes were developed that aligned with the six domains in the interview guide: access and utilization of healthcare; desirability of locations; role of major life transitions; prior experiences; socioeconomic influences; and state-level policy. A codebook was developed by SAK that defined the boundaries around when to use each index, and example quotes for each index code. Two MPH students at the University of California, Irvine, MM and CT, coded indices alongside SAK. SAK, MM, and CT all independently coded approximately 20% (n = 4) of the transcripts to evaluate intercoder agreement following recommendations in the literature (O'Connor & Joffe, 2020). These three authors regularly met to assess intercoder agreement, discuss which

codes should be applied to specific quotations, and to clarify and refine the codebook. This process continued until four transcripts were coded and Krippendorff's Cu-α reached .917 when measured across all index codes, above the recommended threshold for intercoder agreement of index codes in flexible coding (O'Connor & Joffe, 2020). Each coder then individually index coded the remaining 15 transcripts, with SAK coding approximately 40% of the transcripts and the other coders each coding approximately 30% of the transcripts. After coding the full sample, the coding team met to discuss questions and explore consistency of codes across the fully coded dataset, and they determined that further changes to the index codes or index codebook were not necessary.

Next, SAK chose the specific index codes to be analytically coded for this study (i.e., desirability of locations, prior experiences, socioeconomic influences, and state policy) by coding all quotations in approximately 15% of the transcripts with an additional "Research Question Relevance" code denoting relevance to the research questions in this study (Michelen et al., 2024). This code was used to identify segments of the interviews that are most highly related to the research question for this project. Overlap between the Research Question Relevance code and all index codes was evaluated and the four index codes with the highest overlap with the Research Question Relevance code (access and utilization of healthcare, the desirability of locations, socioeconomic influences, and state-level policy) were chosen for the analytic coding (Michelen et al., 2024). Every quotation that the coders coded with one of these index codes were extracted from the transcript, and quotations were grouped by index code.

An analytic codebook that involved inductive and deductive codes was then developed by SAK. Deductive codes were developed from SAK's clinical audiology experience and from the literature (e.g., access to care, cost of living, family) (Goodfellow et al., 2016; Stidolph et al.,

2025). Inductive codes were informed by emerging patterns in the interview data (e.g., telehealth, private practice). A total of 15 analytic codes were defined, in line with recommendations for the number of analytic codes in the literature not to exceed 20 or not to exceed the number of interviews; both conditions were satisfied in this study (O'Connor & Joffe, 2020). SAK, MM, and CT then applied analytic codes to approximately 20% of each index code file and regularly met to assess intercoder agreement, discuss which codes should be applied to specific quotations, and to clarify and refine the codebook. Codebook refinement and iterative changes to the coding continued until intercoder agreement reached above Krippendorff's cu-α for every analytic code was above .8 calculated from the 20% of all content in each index code that all coders coded. After ensuring intercoder agreement and finalizing the codebook, SAK, MM, and CT then applied the analytic codes to the remaining content with SAK coding approximately 40% and the other coders each coding approximately 30% of the remaining data. Once all interviews were coded with analytic codes, the research team met again to explore questions about coding and potential codebook refinements. The codebook was subsequently modified slightly and several transcripts re-coded, after which the coders agreed that further refinements and changes to the codebook were not necessary. A final data file with all quotations for each of the 15 analytic codes was constructed, with quotations grouped by analytic code. Some quotations appeared multiple times if they were coded with several analytic codes.

Throughout the index and analytic coding process, SAK, MM, and CT completed reflective memos on each transcript individually, and on emerging patterns across transcripts. These coders reviewed guidance in the literature on writing reflective memos in qualitative research, and completed memos discussing the transcript content, changes to their understanding

and to the coding process over the course of the project, and how each coder relates to the content in the transcripts (Reyes et al., 2024).

Results

Participant Characteristics

Sociodemographic information for participants is presented in Table 1. Fifteen participants (79%) were women, three were men, and one was gender diverse. This distribution is generally consistent with the broader demographic composition of audiology and is important for interpreting the findings because gender emerged across themes rather than as a discrete siting factor. The small number of participants who did not identify as women prevented systematic comparisons between gender groups. The gendered findings presented below describe how participants understood the influence of gender on household relocation decisions, caregiving responsibilities, children's needs, and responses to state policy. Most participants (68%) had worked as an audiologist for over 10 years and were in their 30's to 40's, likely because individuals who were older and had worked longer had more time to move between states and qualify for inclusion in this study. The participants in this study moved between states at some point between 2010 and 2023, resulting in a variable timeframe from around one year to several years from the move date to the interview for this study.

Specialties within audiology are not strictly delineated, and do not require certifications or registration with professional bodies for an individual to work in a specialty. Accordingly, participants self-identified their specialties (or lack of specialty). Likewise, strict definitions for work settings are not generally available in clinical audiology, and many audiologists split their time or subcontract in multiple settings, such as one participant who primarily worked in a small audiologist-owned private practice but also contracted with a local hospital to work in the

hospital for one day per week. For participants who had worked in several specialties and work settings, the specialty and setting that they stated they primarily currently worked in is listed in Table 1.

Table 1, Audiology Participant Characteristics, 2025

Characteristic	*N*
Gender	
Female	15
Male	3
Gender Diverse	1
Years working as an audiologist	
1 – 5 years	3
6 – 10 years	3
11 – 20 years	7
21+ years	6
Audiology Specialty	
Pediatrics	4
Intraoperative monitoring	1
Implantables	1
Post-secondary education	2
Geriatrics	4
Generalist	7
Audiology Practice Setting	
Private audiology or ENT practice	6
Hospital	8
Active-duty military	1
Primary and secondary education	1
Post-secondary education	2
No single setting	1

Note: ENT = ear, nose, and throat.

At the time of the interview, at least one participant lived in each U.S. Census Bureau division except the East South Central and Middle Atlantic divisions, although several participants described prior experiences living and working in both divisions, Table 2 (Centers for Disease Control and Prevention, 2023). Participants currently lived and worked in Arizona, California, Colorado, Florida, Georgia, Illinois, Indiana, Massachusetts, Michigan, Minnesota, North Carolina, Texas, Virginia, Washington, West Virginia, and Wyoming. This distribution provided perspectives from a broad range of states and regions. However, Table 2 reports participants' locations at the time of the interview rather than each participant's origin and

destination states. The regional counts should not be interpreted as evidence of overall audiologist movement toward or away from a particular region.

Table 2, Audiology Participant Current Locations, 2025

Region	***N***
Midwest	5
East North Central	3
West North Central	2
Northeast	1
New England	1
Mid Atlantic	0
South	8
South Atlantic	4
East South Central	0
West South Central	4
West	5
Mountain	2
Pacific	3

Key Themes

Analysis of interview data yielded three overarching themes that characterize how participants described the factors shaping where they lived and practiced as clinical audiologists: (1) occupational considerations, including compensation, financial incentives, and the presence of HISs; (2) the local social and economic environment, particularly employment opportunities and resources needed by spouses, children, and aging parents; and (3) state-level policies did not directly influence participants choice of where to practice, though they acknowledge that state social and healthcare policies may influence the siting choices of some audiologists. Together, these themes can be conceptualized as an area-based hierarchy in which workplaces are located within communities that are located within states, Figure 2.

Gender influenced all three themes rather than emerging as a separate influence. Participants repeatedly described audiologists' employment decisions as part of household decisions involving a spouse's employment, caregiving responsibilities, and children's educational and healthcare needs. These responsibilities shaped which occupational opportunities

were realistically available even when the audiologist personally preferred another workplace, community, or state. Participants' accounts connected gender to geographic siting through the characteristics of communities' employment opportunities, appropriate schools and pediatric healthcare services, affordable housing, and proximity to family, which were often viewed as more feasible. In contrast, rural, remote, and less affluent communities were frequently described as having fewer of these resources. State reproductive healthcare and LGBTQ+ policies could affect whether a location felt safe or desirable, but established family and occupational ties usually carried greater weight in participants' actual siting decisions. Participants did not identify one Census region as uniformly preferred; instead, they evaluated locations according to the occupational, family, community, and policy conditions available within particular places.

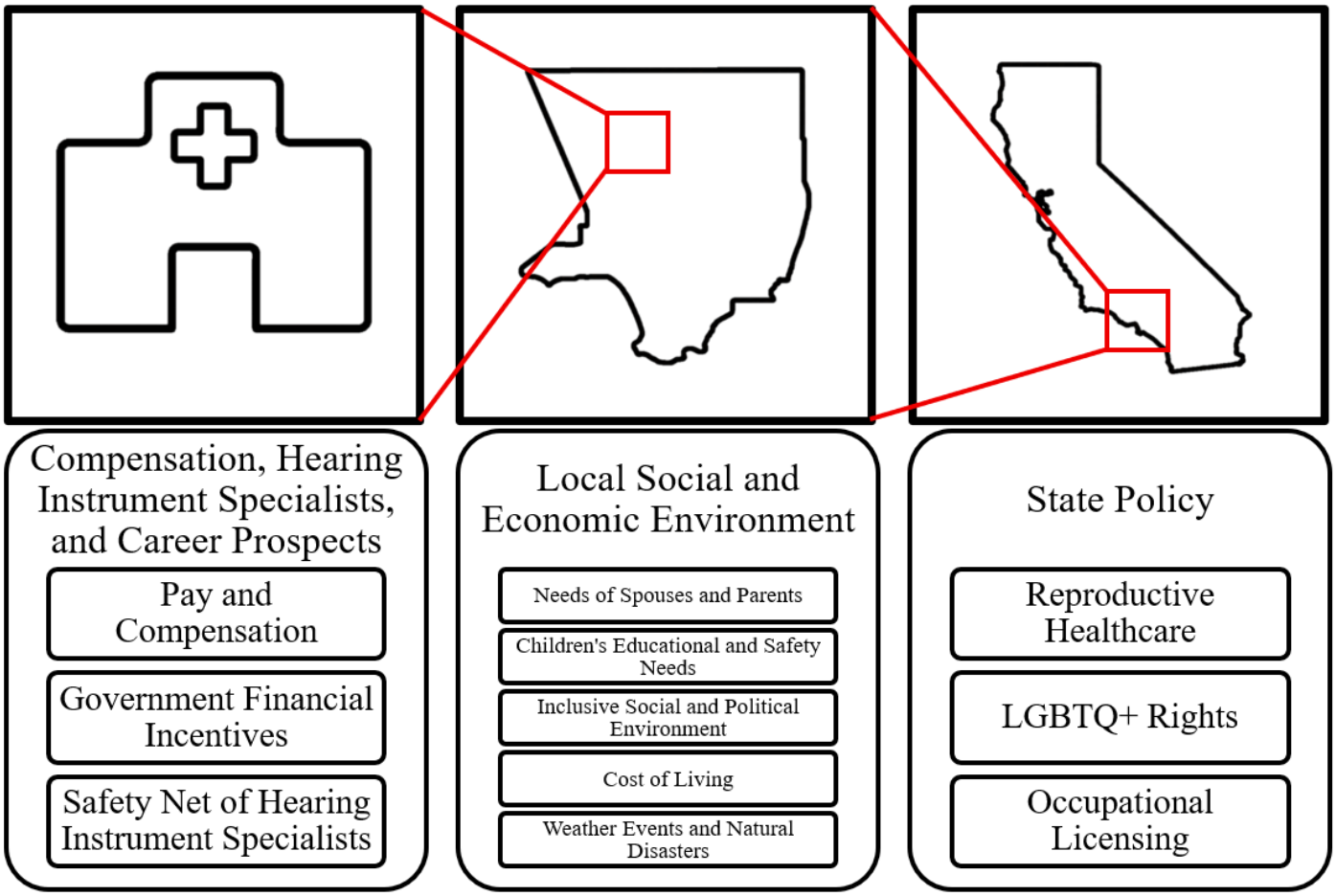

Figure 2, Key Themes Emerging About Audiologist Siting Factors

1. Theme 1: Compensation, Hearing Instrument Specialists, and Career Prospects

Participants described a range of work-related economic conditions that shaped how they evaluated possible locations to live and work, and/or that they believed would influence other audiologists. These factors included: direct pay and compensation for patient care, the influence of state or federal financial incentive programs, and the presence of hearing instrument specialists in the region. Participants' reflections show that practice-location decisions were tied to expected financial stability and long-term career prospects. Although most participants were married or in long-term relationships and many disclosed that their partners also worked, discussions of salary generally focused on the audiologist's own earnings. Participants appeared to value their own financial stability and occupational autonomy even when the final location decision was constrained by a spouse's employment or other household responsibilities. In this predominantly female sample, participants often wanted adequate compensation and professional independence, but the location in which they could pursue those goals was frequently negotiated at the household level.

1.1 Pay and Compensation

Most participants believed that pay and compensation are highly important when audiologists considered where to work. Their comments emphasized how salary, benefits, and work life balance affect the desirability of specific practice settings. This sub theme reflects how compensation is usually an important consideration, alongside other forms of renumeration. For example, Avance stated, *"I wanted competitive pay [after I graduated]."*

In discussing job postings for audiologists in rural areas, one audiologist stated:

> *"Those job postings [in rural and remote areas] are usually up for like a year or more, and the pay is fairly low. The cost of living is low, but the pay is too. So there's really no incentive there."*
>
> (Senso, Colorado)

A handful of participants acknowledged that compensation was less important to them personally compared to their family's needs, career advancement, or state policy. For example, Claro explained, *"I was never really worried about the [compensation]. I mean, you had to get compensated, but it was never like the money was never the driver. It was always what could I learn? Could I continue to learn?"* (Claro, Michigan)

Several participants who had worked as audiologists for over 5 years commented that compensation for clinical audiology is generally too low considering the amount of education required to work in the discipline, suggesting that low wages are discouraging new people from entering the discipline of audiology potentially contributing to reduced spatial accessibility of EHC HCPs generally across regions: *"I think I think that obviously we're not paid enough as far as what we should be."* (Aero, Indiana)

Other participants across demographic groups shared a similar sentiment, saying:

> *"We talk about this a lot within the profession that for a doctoral profession our salaries really don't reflect that, compared to other fields and our insurance reimbursement rates are also pretty abysmal."* (Prisma, Virginia)

Cetera, who has been an established audiologist for several years, concurred:

"Going to school for audiology is not looked at as profitable in the end. You go to school. You work. You're not getting paid enough to pay for the loans." (Cetera, California)

Several participants, typically individuals established in their careers who conveyed that caring for their children or aging parents was important to them, discussed how work-related forms of compensation other than salary such as health insurance benefits were important in choosing where to work. Non-salary forms of workplace benefits such as health insurance, retirement matching, and on-site childcare all featured in their considerations:

"When people are in good, well-paid jobs, with good benefits and autonomy, you know, that does go a long way for people for sticking around." (Prisma, Virgina)

Phonica, who has children, discussed how this was a core consideration in their evaluation:

"There is a $30,000 pay difference between the educational audiology position in Kansas versus the hospital position. But it still entered the running for me as something that was worthwhile because… what is the cost of childcare in a year. How much would it cost to have a babysitter for after pickup, after school pickups? Because childcare is incredibly expensive." (Phonica, Minnesota)

Likewise, another participant stated that compensation was somewhat less important to them than work-life balance, suggesting that simply increasing salaries may be less effective at audiologist recruitment and retention compared to more comprehensive benefits packages:

> *"It's actually more important that you have more flexibility and a little bit better work life balance. I would choose that over pay at this point."* (Supero, Georgia)

Taken together, these audiologists are not all influenced by compensation equally, but most believed compensation is an important consideration for audiologists generally.

1.2 Government Financial Incentives

Participants noted that financial incentive programs, including loan forgiveness, could influence where audiologists choose to work, although others held the opposite view and the perceived salience of these programs varied. Interestingly, no participants were currently or had previously participated in these incentive programs, and those that believed it could influence where audiologists are sited also acknowledged that audiologist relocation to participate in financial incentive programs may not lead to lasting changes to siting after the program ENDS. Participants usually discussed the role of state or federal programs in improving the spatial accessibility of EHC HCPs in terms of loan forgiveness programs such as the Public Service Loan Forgiveness (PSLF) program. Though the government and nonprofit facilities where HCPs can qualify for PSLF are less commonly found in rural communities hinting that PSLF may be less effective at recruiting to rural locations, the participants in this study focused on areas underserved by EHC services more generally (C. Davis et al., 2023). Several participants who discussed loan forgiveness described that loan forgiveness in exchange for working in an underserved region could be an effective way to incentivize EHC HCPs to relocate to underserved areas, at least temporarily:

"I think that would be a good thing, I think, loan forgiveness. But the question is, will they stay? And that's the big trick, you know. Are they going to get up there, work 3 years, and then say, I don't like this anymore". (Infiniti, Florida)

Another participant stated that financial incentives in this form or another could be beneficial:

"Maybe some audiologists would want their loan repaid, you know, maybe from the facility where they work, like well we agreed to pay this much toward your student loan if you travel here. So maybe that would be an incentive. But it's gonna come down to money either way." (Perseo, Illinois)

Other participants showed skepticism that the PSLF program, the primary mechanism for the federal government to compensate EHC HCPs for working in underserved areas, was effective in improving spatial accessibility of EHC HCPs. The long duration of service before receiving loan forgiveness and difficulty in earning enough in underserved communities even with this PSLF were concerns:

"I would be a little more intrigued on the idea personally, if I was a fresh grad, [I might] take on that kind of potential program if the forgiveness program was maybe 5 years rather than 10. When you really sit down and think about it 10 years is a very, very long time to commit to something that truthfully has always kind of been threatened to be pulled out from under us." (Amio, Illinois)

Phonica, who has worked for several years as an audiologist, gave their perspective:

> *"I think when [PSLF] first came out there would be a little bit of a boom, but I think the sustainability of actually making a business that could thrive would be the bigger challenge."* (Phonica, Minnesota)

Together, these reflections suggest that government financial incentives such as loan forgiveness programs are evaluated in relation to broader financial pressures and families' needs. Government financial incentives such as PSLF were not typically viewed as effective long-term solutions to low EHC HCP spatial accessibility. This sub theme illustrates how government assistance is considered within a larger assessment of long term economic and personal goals.

1.3 Safety Net of Hearing Instrument Specialists

Several participants discussed how differences between hearing instrument specialists and audiologists result in differential access to these HCPs in some communities. Several participants, for example, explained how rural communities and communities with relatively lower affluence have fewer patients who can afford audiologists' services and are thus less attractive to audiologists, so HISs provide a greater proportion of the EHC services in some rural and less affluent communities. Surprisingly, instead of conceptualizing HISs as a competing discipline to audiologists that may shape where audiologists choose to practice, the participants in this study typically viewed HISs instead as an alternative pathway to EHC services when audiologists are not available. This sub-theme highlights how, in the context of limited available care from audiologists, HISs serve as a possible alternative route to EHC services for individuals who would not otherwise be able to access care from audiologists, a safety net of sorts enabling access to EHC services even when audiologists are not locally prevalent. Amio, in Illinois framed this by stating, *"I think that something is better than nothing. If somebody knows that*

they're having a hard time communicating with their family, and they need something to help, they're able to kind of have a quick fix for lack of a better phrase."

One participant, Canta, discussed how differences in the qualifications for audiologists and HISs may cause HISs to be well positioned to provide care in rural regions and other locations that are unattractive for audiologists, instead of competing with audiologists for patients:

> *"That is how I think that a lot of these, especially in South Texas, a lot of how they get providers in that area. Yeah, is people who are already local (sic). They can stay local, get trained. [HISs] are not having to move somewhere to get a degree."* (Canta, Colorado)
>
> *"Remote support for clinics that just have HIS's, I think it's great. I think it's perfect, especially for these communities that you're not going to get an audiologist to move there for whatever reason, you know, it's rural, it's remote. It's nowhere anybody wants to live unless your family is there type situation."* (Canta, Colorado)

2. Theme 2: Local Social and Economic Environment

All participants explained how at least one aspect of the local community social and/or economic context would be important for themselves and other audiologists choosing where to live and work. The proximity to important resources such as healthcare and education featured prominently and often included considerations for their family's needs, with many participants also identifying local cost of living as an important component of the local economic landscape. These subthemes include familial considerations, such as the occupational needs of spouses and

caregiving needs for aging parents and the educational needs of children, local social context, cost of living, and influence of weather events and disasters.

2.1 Needs of Spouses and Parents

Participants frequently described their partner's employment and aging parents' care needs as major influences on their relocation decisions. Many explained that employment opportunities for spouses often narrowed the range of possible locations, especially in dual career families. Likewise, emotional and practical considerations in caring for older family members frequently featured in participants' reflections, particularly for older participants. These family considerations did not merely accompany occupational decisions; they often determined which job opportunities were feasible. Participants connected this pattern to rural and remote siting because communities with fewer employment opportunities for spouses and greater distance from family networks could be more difficult for an audiologist's household to select. This sub-theme reflects how broader family needs such as a spouse's employment can overshadow or constrain other considerations, perhaps biasing EHC HCPs away from rural and remote communities with fewer employment opportunities for their spouses.

Most participants were women who were married or in long-term relationships, most often with men. Participants frequently described an asymmetry in household decision-making that was consistent with traditional gender roles: a husband's employment or preferred location was often treated as a relatively fixed condition, while the female audiologist's employment was expected to adapt to that location. This pattern was described even when participants did not indicate that the spouse earned more than the audiologist. For example, Canta in Colorado noted, *"I think [audiology being a female dominated profession] makes [audiologists] more likely to go where their spouse has a job."* Similarly, Supero who was in Georgia stated, *"Most of*

audiologists are women. So if you are married and you have to move for your family, maybe like your husband's getting a new job."

Military households provided a particularly clear example of how an audiologist's practice location could be determined by another household member's employment In the sample for this study, one participant was active-duty military and two had spouses who were currently or had been active-duty military in the US armed forces. Participants in military households described little control over the states or communities to which their families relocated. Canta summarized this constraint by stating, *"Ultimately the navy says where we go.* (Colorado)" Another member of a military family concurred, noting that the branch that their partner was in typically had postings in states with less burdensome professional licensing requirements:

> *"The licensing process in California is very difficult… thankfully, there's not a ton of military postings [in California] for army [as] there are for other branches."* (Prisma, Virgina)

The need to remain near participants' own parents or their spouse's parents was also a recurring influence, particularly among middle-aged participants. Participants of multiple genders described obligations to provide care to aging family members or to support a partner who was providing that care. The small number of participants who did not identify as women prevented a direct comparison of caregiving expectations by gender. Nevertheless, the accounts showed that caregiving responsibilities could reduce mobility and encourage participants to remain in or return to locations near established family networks. For example, Personic, noted: *"Certainly my parents are getting older. So I think I might want to stay, you know, like relatively closer by.* (Massachusetts)*"*

Canta again discussed the role of gender in a couple's decision-making when relating how a female audiologist colleague's clear preference to live away from a politically conservative region with limited reproductive healthcare rights was overridden by her husband's location choices:

> *"[My colleague] very much wanted to move, wanted to move to Colorado, get out of Texas. [My colleague's] partner has a dad whose health is not good, and her partner said, I'm not leaving Texas." So, despite where she would want to live, that wasn't an option."* (Canta, Colorado)

Another reoccurring pattern was wanting social contact with parents and other family members at social events to maintain close family ties. Avance who lived in Texas emphasized this by stating, *"You could offer me a job with quite competitive pay, and I still wouldn't [relocate], because my family is here."* Personic who resided in Massachusetts similarly noted, *"It's relatively close to my parents, which I think is good cause I was far away from them for a while. Certainly they missed me. So it's nicer being close to them."*

Together, these accounts show that audiologist siting was often a household outcome rather than an individual occupational choice. In this predominantly female sample, spouse employment and family caregiving could determine the state or region first, after which the audiologist sought an acceptable position within that location. This process may favor urban and suburban communities that contain employment opportunities for both members of a couple and may disadvantage rural or remote communities with fewer options for spouses. Alternately, a strong family connection to a rural or otherwise less-preferred area could keep or draw an

audiologist to that location even when occupational opportunities or state policy were less favorable.

2.2 Children's Educational and Safety Needs

For participants with children, school quality, pediatric healthcare and developmental services, community safety, and exposure to social and cultural diversity influenced whether a location was considered feasible. About half of participants disclosed that they had at least one child, and about half of these participants were caring for at least one minor child. Every participant caring for children described their children's needs as a consideration in relocation. Decisions about the audiologist's workplace were made alongside decisions about where children could receive education, healthcare, and other forms of support.

Implicit or explicit in participant's reflections was a preference for more affluent communities that have greater spending on primary and secondary education, suggesting that this may result in a reduced number of audiologists in lower-income regions. For example, Gaia who lived in Florida discussed how audiologists may be dissuaded from living in urban Miami, Florida: *"There's some great school systems in little pockets, but primarily, I think it's so variable. It might prohibit some folks from looking at Miami."* Canta shared a similar perspective about her own decision-making, with an implicit preference for more suburban regions with higher education spending: *"We did wanna move to an area that had better schools.* (Colorado)*"*

In addition, two participants expressed a personal preference for raising children in more diverse or liberal areas. Though some participants appeared reticent to explicitly describe the types of diversity they want their children to experience, race and/or ethnicity appeared to be a common focus. For example, Canta shared:

> *"Salt Lake City was an option, and I didn't really want to go there because I felt like our children were gonna leave all this exposure [to different cultures]… We didn't end up where I would have chose (sic) for a diversity for my children. So we did have to compromise a little bit."* (Canta, Colorado)

Claro later continued on this topic in terms of the dominant political orientation at a state level, saying, *"I have a daughter that's 15. I would not want to move her to Florida or any of these other sorts of places that denied women's rights."* A minority of participants reported seeking a generally rural location to settle down because of the social opportunities these areas can present. These professionals and others, however, also acknowledged the challenges that living in less populous areas causes, particularly when raising children and needing access to supportive developmental and/or educational community services:

> *"I tend to like rural areas. But when we started to have kids, we sort of realized that there wasn't a lot of opportunity in some of these places. [My daughter is] on the autism spectrum, then my son has ADHD. So these rural areas sometimes were hard for them to get the services that they need."* (Aero, Indiana)

Participants with children evaluated potential locations not only according to the available audiology position, but also according to whether the surrounding community could meet their children's needs. Participants commonly associated preferred schools and a wider range of pediatric, developmental, and social resources with more affluent, urban, or suburban communities. Rural communities could still be personally desirable and could offer lower housing costs or proximity to family, but participants described limited schools, specialized

services, and other opportunities for children as barriers to rural siting. These findings suggest that parenting responsibilities may channel some audiologists toward communities with more resources even when the audiologist personally prefers rural living or when rural areas have a need for additional EHC services. This sub-theme highlights how parenting responsibilities among audiologists influence their assessments of potential places to live.

2.3 Inclusive Community Social and Political Environment

Participants discussed how community-level social and political climates influenced where they were willing to live. Their comments highlighted preferences for communities that aligned with their values, supported diversity, and felt socially welcoming.

All but one participant who discussed political orientation, diversity, and social acceptance expressed a preference for living near people whose attitudes aligned with their own or were more accepting of diversity, though participants generally did not discuss views of audiologists as a whole. Among participants who preferred living in regions more accepting of diversity, most focused on safety and education for their families. For example, Canta put it like this: *"Salt Lake City was an option, and I didn't really want to go there because I felt like our children were gonna leave all this exposure [in Kansas] and obviously Salt Lake City is a big white Mormon population, and I just wanted them to have more exposure.* (Colorado)*"* Claro echoed these considerations: *"Yeah, [moderately sized racially diverse midwestern town] is perfect. It's as liberal as you get. So it's comfortable to us.* (Michigan)*"* Aero framed it in terms of a more general alignment of values: "*You want to settle where… the people are like-minded.* (Indiana)" Another participant who is a person of color, Supero who lived in Georgia during the interview, explained that (a lack of) diversity influenced their reason for leaving their position in a highly politically conservative region of their state: *"I don't know if it's still like this, but [there*

were] Confederate flags everywhere, and just very like stuck in time. So that was probably the main thing was just kind of the racism and just the lack of diversity." This sub theme captures how perceptions of safety, belonging, and community at both a state policy and a local community diversity level inform decisions about place.

2.4 Cost of Living

The participants in this study represented a wide range of low- to high- cost of living communities and regardless of the cost of living in their current community, nearly universally identified cost of living as a key influence on their geographic siting decisions. Many participants described how housing affordability and other living expenses in the context of local expected salaries affected whether a specific area felt desirable to them. This subtheme underscores how economic pressures outside the workplace shape where audiologists feel able to reside. One participant, for example, acknowledged the link between cost of living and salary by noting that salary must be sufficient to meet the local cost of living:

> *"If I'm not able to make enough money to offset the cost of living and to not live paycheck to paycheck. Even if I'm living in a warm place, I'm still gonna be probably unhappy, And I'm gonna struggle."* (Gaia, Florida)

As Tympanette put it, *"Cost of living is always a concern."* Senso shared a similar perspective, saying *"I would say, the biggest [factor] that catches your eye is cost of living to buy a house.* (Colorado)*"* Phonica was the only participant to explicitly link cost of living with rurality, suggesting that lower cost of living drew their family to a rural, cheaper community:

"[Town] has the potential for basically flat property that can be developed. So their housing market is a lot better than big cities in order to have a nice yard." (Phonica, Minnesota)

2.5 Weather Events and Natural Disasters

When asked about weather, climate, or natural disasters as factors they might have considered when deciding where to live, most participants focused on natural disasters. Participants were divided on how they incorporated natural disasters into their relocation plans and intentions. When asked about how they personally thought about these factors, with some exceptions most respondents discussed natural disasters in terms of states, not regions or cities. Some individuals expressed confidence in handling any natural disasters, because they have past experience with occasional natural disasters:

"Earthquakes we also kind of thought about but again, both of my family live in Southern California and they were in San Francisco prior to that, and although they get them occasionally, that's not on my radar of a concern. It's really hurricanes and tornadoes is not someplace I want to live." (Senso, Colorado))

Like Senso, Canta had lived in regions with natural disasters and was relatively confident in their ability to live in regions with these events:

"We had a tsunami warning in Hawaii and earthquakes in California. So no, the specific, severe weather never really [was a deal breaker]… and maybe it's because I'm just used to living in Tornado Alley that I was like, yeah, this stuff happens." (Canta, Colorado)

Other participants, however, relayed that they were concerned enough about natural disasters disrupting their lives that they would not move to certain locations that have a higher chance of experiencing various types of natural disasters, and thought that other audiologists might feel similarly:

> *"I think people who don't grow up [in Florida] would be very fearful. Seeing the storms… Why would you move to a place that… your home could be totally destroyed? I'm certain that if you don't have any experience or previous relationship with living in an area like that, that it would probably dissuade you."* (Gemini, Florida)

Phonica, who had not lived in regions with hurricanes before, shared a similar sentiment:

> *"With tornadoes, it's ripped and gone. With hurricanes, it may not be entirely gone, but you're gonna get mold. And I couldn't deal with that."* (Phonica, Minnesota)

Participants' reflections showed variation in how individuals assessed potential environmental risks based on personal experience and expected consequences. Most discussed this at a state level, and most expressed that prior experience with natural disasters and weather events would increase their confidence in living in regions with these events. This sub theme demonstrates how environmental context and an individual's prior experiences contribute to siting decisions.

3. Theme 3: State Policy

Participants had nuanced thoughts about how policy might influence where audiologists work. Participants described a range of state level policies that shaped how they assessed different locations. When discussing policy, all participants described policies at the state level,

with little discussion of how local context influences the implementation of state and federal policy. Most participants who discussed personal political alignment endorsed a preference for liberal or progressive policy. However, among participants there was no clear consensus on whether political orientation would consistently influence the states that audiologists would study, live in or work in. While some participants felt that state policy was a prime determinant of audiologist siting, others expressed that local concerns such as compensation or nearness to family would be more impactful than policy in siting decisions. Of note, the siting decisions for participants in this study were not generally personally influenced by state-level policy. Overall, participants' reflections illustrate how state-level policy environments may influence family planning and perceptions of personal safety. This theme highlights how state contexts either support or limit audiologists' willingness to practice in a given area. The sub-themes include state-level reproductive healthcare, LGBTQ+ policies, and professional credentialling and licensing.

3.1 Reproductive Healthcare Policy

Most participants described state-level reproductive healthcare policy as relevant to themselves or to other audiologists, particularly individuals who could become pregnant. However, the salience of reproductive healthcare policy was generally lower than the salience of family location, partner employment, compensation, and children's needs. Participants distinguished between preferring access to reproductive healthcare services and using reproductive healthcare policy as a deciding factor in relocation. All but one participant who identified as a woman expressed support for access to reproductive healthcare services such as abortion care and in-vitro fertilization and preferred to have those services available if needed.

However, most did not describe reproductive healthcare policy as the primary determinant of the state in which they lived or worked.

Participants generally discussed reproductive healthcare access rather than the 2022 Dobbs decision specifically. Several believed that restrictive policies could make some states less attractive to audiologists because the profession is predominantly composed of women. However, participants' siting decisions focused on other factors which overshadowed the relevance of reproductive healthcare policy for them and many participants questioned how influential reproductive healthcare policy would be for audiologist siting generally. One participant, discussing politically conservative Southern states, observed:

> *"I see a lot of these job openings that are staying open and sitting in some of these more restrictive states. I'm like, Hmm, gee! Maybe I might have an idea why, when we're in a field… that's predominantly female. Gee! I wonder why there might not be a ton of applicants to certain states."* (Prisma, Virginia)

Another resident in a state with reproductive healthcare restrictions shared their concerns:

> *"I do have some friends that are like, I would never get pregnant here. I have friends in Ohio that are weighing the options as far as whether they should stay there during their pregnancy, or whether they should go somewhere else during the pregnancy. With audiology being like so predominantly female, I'm sure I'm sure* [*sic*] *that plays a part."* (Supero, Georgia)

The contrast between policy preference and actual siting was clearest among participants who could become pregnant but remained in states with restrictive policies. These participants

did not dismiss the personal risk created by reproductive healthcare restrictions. Instead, they described that risk as one consideration within a larger household decision in which family location, employment, and other responsibilities carried greater immediate weight. Avance, who was pregnant and living in Texas, stated:

> *"I do feel more at risk being someone who's pregnant. If something did go wrong, and if it were limiting my own like ability to live that that would be intense, and it's kind of a risk. I actively know that I'm taking a risk by being in Texas right now."* (Avance, Texas, woman)

In contrast Epica, who also lived in Texas which has restrictive reproductive healthcare policies, was less concerned. He explicitly agreed that the low likelihood for him to be personally affected by reproductive healthcare restrictions was partly responsible for his willingness to live in Texas:

> *"The reality is no, I am not leaving because my state made bad decisions on women's reproductive care and so no, I don't think that that would factor into if I were moving. That being said, I'm lucky that has not applied to me. I'm very fortunate to be… a white male, and most of these issues don't affect me as a straight white male."* (Epica, Texas, man)

Tympanette, who likewise could not become pregnant, noted, *"There would be no state law that would want me to move from one state to the other."* (Tympanette, Midwest, woman, age 60+).

One participant also suggested that reproductive healthcare policy might influence audiologist siting less than other disciplines, because although some audiologists feel that they do not receive pay commensurate with their training and education, most audiologists have relatively high pay compared to the national average which she believed would allow audiologists to travel and access reproductive healthcare services in another region if needed:

> *"Probably audiologists as a whole, we're probably in a socioeconomic status group that… fortunately, if we needed to make a decision and go outside of our state to [get reproductive healthcare], typically, we have resources with a doctoral degree. We're being paid well enough that resource wise we likely could be able to do that."* (Gaia, Florida, woman)

Overall, reproductive healthcare policy produced a gendered, conditional influence on siting. Participants who could become pregnant generally viewed restrictive policies as more personally consequential, while participants who could not become pregnant were less concerned about those policies when choosing a state. The gendered finding was not that women uniformly relocated away from restrictive states. Rather, reproductive healthcare policy affected how safe or desirable a state appeared, while established family relationships, spouse employment, caregiving obligations, and financial resources often determined whether relocation was practically possible. Participants anticipated that restrictive policies might make some states less attractive to younger audiologists and audiologists who could become pregnant, but their own accounts showed why this preference may not produce immediate relocation among established professionals. Together, this suggests that younger and female audiologists may be more likely to prefer working in states with reproductive healthcare policy protections, and that this

preference may often be overshadowed by more pertinent concerns about compensation and family needs.

3.2 LGBTQ+ Policy

Policies affecting LGBTQ+ individuals shaped whether some participants viewed a state as welcoming or safe for long-term residence, though among the participants who were concerned about LGBTQ+ policy most also stated that other considerations such as proximity to family overshadowed a preference for living in a state with permissive LGBTQ+ policies. Interviewees were also divided on if they believed restrictive LGBTQ+ policy would influence the preferred state of residence for audiologists generally. This sub-theme illustrates how social policy context can influence geographic decision making, particularly for individuals likely to be affected by the policies, how personal identity and community acceptance informs evaluations of different locations, and the relatively lower importance of LGBTQ+ policy compared to other influences.

Participants were not required to disclose their sexual orientation during the interviews, but several discussed how their LGBTQ+ identity could influence where they or others lived and worked. For example, Infiniti described a colleague leaving Florida, stating, *"[A] big audiologist, and one we loved, in our practice left because of the LGB [policy] in Florida is awful."* In contrast, another participant disclosed how she and her partner did not relocate away from a state with LGBTQ+ policy restrictions because other concerns outweighed their opinions about LGBTQ+ policy:

> *"I am bisexual. But I have a husband. So I'm essentially straight passing. So, I think it would be great if laws were more accepting and inclusive in Texas. I definitely don't politically align with the*

state within which I live. However, it got to the point where it was just like family first. That's what's important to me." (Avance, Texas, woman)

Personic, who also endorsed an LGBTQ+ identity, had a similar perspective. In their interview Personic stated that while living somewhere such as their community in Massachusetts with supportive LGBTQ+ policies would be preferrable, it was not a sufficiently strong preference to influence their chosen location: *"Certainly it's more comfortable to live in [LGBTQ+ friendly] spaces. That's not necessarily always reality. I don't mind at all working with or living near people who have different political viewpoints from mine.* (Massachusetts)*"* Amio, who lived in Illinois and did not explicitly report having an LGBTQ+ identity, likewise noted that LGBTQ+ and other social policy was not the primary driver of their siting choices, saying, *"Politics in general were not at the forefront of my mind when I was completing this move [to Illinois]."*

Several participants were skeptical that LGBTQ+ policies would negatively influence the overall number of audiologists in a state. Like other discussions about policy, LGBTQ+ policy was typically discussed at a state level, with little discussion of intrastate differences in urban vs. rural regions or along other gradients. Tympanette was skeptical that these policies would prompt relocation, stating, *"I would say only if they had children where it was a problem for, otherwise I don't think they would move out of state just through principles."* Canta similarly stated that state policy on LGBTQ+ topics was not likely to influence individuals who did not have an LGBTQ+ identity themselves or in their immediate family, saying: *"I think it's like the general population. It's a concern to some people and those people it does affect. And other people it's not a concern."* (Canta, Colorado)

Though there was agreement among most participants that permissive LGBTQ+ state-level policies were preferred, these policies did not significantly affect most participant's siting decisions and there was disagreement whether LGBTQ+ policy might affect other audiologists' siting or if this preference is overshadowed by more salient influences such as family location.

3.3 Occupational Licensing

Occupational licensing requirements emerged as a meaningful factor shaping some audiologists' relocation decisions. Many noted that processing times, costs, and dual licensure requirements affected both the feasibility and timing of moves for themselves and other audiologists, and that licensure varies widely in initial cost, renewal cost, and the difficulty of the process to obtain licensure. Other interviewees acknowledged the difficulty getting licensed as an audiologist in certain states but also discussed how these factors would not preclude moving to a state with challenging licensing procedures. Participants often cited California as an example of a particularly expensive, difficult, and time-consuming state in which to pursue audiology licensing, perhaps because the interviewer disclosed that they were licensed in the state of California. This sub-theme highlights how administrative and regulatory conditions can shape the mobility of audiologists.

Interviewees were divided on whether the monetary costs of licensure would influence the availability of professionals in a state. One participant explained how licensing costs prevented them from pursuing licensure in additional states, which is legally required to provide telehealth services across state lines:

> *"I would say it [licensure costs] is restrictive. Not so sure I could expand what I do with the virtual side of this. I would if I could be*

open myself up to more states, and I'm not doing that because it's too expensive." (Aero, Indiana)

Perseo, who had a history of travelling and working in Europe and across the US and lived in Illinois at the time of the interview, was less concerned about licensing fees, perhaps because they valued varied experiences more highly: *"I don't think that would have deterred me. I think if I wanted to move to California I would find a way to pay the $1,000 [licensing fees], you know, if I wanted to move to Texas I would do the same thing."*

Audiologists expressed a shared set of frustrations with long application times and difficult licensing processes that delayed when they could begin working in a new state. This frustration was particularly noteworthy among audiologists with spouses in the military who regularly moved between states which they noted had consequences for their household income and scope of practice. Prisma, who lived in Virginia and whose partner was currently in the military, explained: *"The licensing process in California is very difficult, so we might need to consider that if we go there and I can't find a job like you have to be okay with, we're going to be back to single income."* Canta, whose partner was also in the military discussed licensing barriers for military families specifically, given the potential for frequent relocation across states for members of the military and their families:

> *"I will say at least as part of the military spouse community, I know a few spouses who moved to California and just didn't work while they were there, because it was so difficult and time consuming, and yeah, not worth the money for the amount of time they would have had the license."* (Canta, Colorado)

Another participant who had to delay starting work due to licensing barriers explained:

> *"The length of time it took to get your license was difficult. Some like DC, I think I had to wait over a month, maybe 2. Yeah, might have been San Diego, too. I had to do a lot of observation, because I didn't have a license at the time. It was frustrating that I couldn't just transition in."* (Triano, Ohio)

Further compounding these licensure challenges is the work involved in securing dual licensure, which in some states involves applying for both an audiology and a hearing aid dispensing license, often including an additional practical skills examination. Interviewees were unified in expressing that dual licensure was frustrating and disincentivized audiologists from working in those states, though some acknowledged that these concerns could be overridden by other considerations. Avance described this concern, stating, *"I've read things about getting licensed, I want to say in like New York and California, and those both sound like a nightmare. I would not want to do a practical exam* (Texas)*."* Cetera shared this sentiment, focusing on testing requirements for licensure: *"I've never taken a dispensing test until I moved [to California]. So I had been working in an audiology for almost 11, 12 years, and now I have to take a test. Oh, gosh! I think that that makes people not come here.* (California)*"* Perseo who lived in Illinois, in contrast, reiterated that licensing requirements were not their primary concern: *"I don't think that [dual licensure requirements] would have deterred me. If I wanted to move Virginia, I would go ahead and take both exams."* Overall, licensing barriers and requirements were frequently a concern for participants though for many licensure did not weigh as heavily on relocation decisions as other factors.

Discussion

This qualitative study examined the motivations of clinical audiologists in the US when choosing where geographically to provide direct patient care, and their perceptions of the motivations of other audiologists. Taken together, the findings indicate that audiologist siting is not solely an individual occupational decision, but a multilevel process in which employment opportunities, family relationships, community characteristics, and state policy are considered together with state policy having a weaker influence compared to everyday concerns such as spouse employment and children's education or healthcare. Participants generally preferred locations that offered adequate compensation, proximity to family, employment and other opportunities for spouses, and educational, healthcare, and other resources important to children. In contrast lower pay, limited employment opportunities for spouses, fewer resources for children, burdensome occupational licensure requirements, and restrictive social policy environments could make locations less desirable. State policy was generally less influential than occupational and family considerations among these participants but was important for some participants and influenced how desirable or safe they perceived a state to be.

These findings support the social ecological framing of HCP siting used in this dissertation because influences at individual, interpersonal, organizational, community, and policy levels did not operate independently. Compensation could make an employment opportunity attractive, for example, but that opportunity was not necessarily feasible if a spouse could not find appropriate work, children could not access needed services, or the location was too far from family members requiring care. Likewise, participants could strongly prefer a state's reproductive healthcare or LGBTQ+ policy environment without being willing or able to relocate away from established family and occupational ties. The relative importance of influences

depended on the participant's personal circumstances and life stage rather than following a fixed hierarchy across ecological levels.

Gender was important to how these levels interacted. Most participants were women, and participants repeatedly connected the female-dominated composition of audiology to spouse employment, parenting, family caregiving, and reproductive healthcare. Gender did not directly result in a preference for one state, region, or type of community. Instead, gender shaped how occupational and geographic choices were made. Several participants described household decisions in which a male partner's employment or location was treated as relatively fixed while the female audiologist sought employment within the location near the household. Parenting and caregiving responsibilities further constrained which communities were feasible though access to local educational and health-related resources. In a female-dominated profession, these processes may have workforce-level geographic implications even when individual audiologists do not explicitly identify gender as a reason for choosing a particular community.

The geographic implication of these findings is less that audiologists consistently prefer one region over another and more that some types of places may be better able to accommodate the combination of occupational and family needs participants described. Urban and suburban areas may offer more employment opportunities for two-career households and more educational, healthcare, and other services for children, while more affluent communities may offer combinations of compensation, schools, services, and amenities that participants value. Rural, remote, and less affluent communities may face greater recruitment challenges when they cannot provide these combined opportunities, although proximity to family, lower housing costs, or a strong preference for rural living could make these locations attractive to some audiologists.

Participants living in different regions described similar considerations, and the data presented in this study do not establish net movement toward or away from any particular region.

Rurality

Audiologists and other HCPs appear to evaluate rurality through the occupational, family, and community conditions associated with rural versus urban places rather than rurality acting as an isolated preference. Healthcare and educational resources for children and employment opportunities for spouses draw some audiologists and other HCPs toward more urban regions, as HCPs perceive rural regions as having fewer of these resources (K. Fisher et al., 2024). Participants in this study likewise described rural communities as potentially less feasible when they offered fewer employment opportunities for a spouse, fewer schools or specialized services for children, or lower compensation. At the same time, some participants preferred rural living or described proximity to family and lower housing costs as reasons that a rural location could be attractive. Rural siting reflected the interaction of community characteristics with the needs of the audiologist and their household rather than a uniform preference against rural communities.

This pattern has implications for a predominantly female profession such as clinical audiology. Participants frequently described location decisions as household decisions in which spouse employment, children's needs, and caregiving obligations constrained the set of communities in which an audiologist could realistically work. If larger labor markets and communities with more relevant resources make it easier to satisfy these multiple household needs at once, the gendered organization of family and employment decisions may indirectly contribute to lower audiologist supply in some rural areas. However, these findings do not suggest that women inherently prefer urban places. The results from this aim identify a pathway

through which interpersonal responsibilities can interact with community-level resources to make some locations more feasible than others.

In contrast to findings for some other HCPs, participants did not commonly identify professional isolation or reduced opportunities for continuing education as major barriers to rural practice (K. Fisher et al., 2024; Heneghan et al., 2005). Physicians often consider opportunities for career advancement and continued development of clinical skills when evaluating rural positions, while these considerations were less salient among the audiologists interviewed here (Heneghan et al., 2005; X. Hu et al., 2022). Taken together, the findings suggest that interventions focused only on professional opportunities may overlook important interpersonal and community-level barriers to rural audiologist recruitment. Strategies intended to increase EHC HCP supply in rural communities may also need to consider whether those communities and employers can accommodate the employment, caregiving, and family needs that accompany the provider.

Occupational Earnings

Compensation was one of the clearest influences on siting decisions in this study, with participants of all ages and practice areas consistently describing a preference for higher pay and lower cost of living. Much like physicians, both direct compensation and nonmonetary work-related benefits are key elements influencing the willingness of audiologists to work generally, and in rural or underserved regions specifically (McIsaac et al., 2019; Scott et al., 2013). Audiologists in the US are rarer in lower-income communities, and these results help explain why: audiologists, like other HCPs, believe that less affluent communities represent lower earning potential, reducing these communities' ability to attract and retain audiologists (Pudrith et al., 2024). The importance of other benefits such as health insurance and work-life balance

have been examined for the first time in audiologists, and these workplace-related factors are also important components of compensation particularly for audiologists with a spouse and/or children, another trend identified first among physicians (Scott et al., 2013). On the whole, the results from this study generally align with findings from research on physicians and other HCPs that although it is potentially outweighed by family, social policy, or other considerations, compensation is one of the key predictors of HCP's willingness to live and work in a given location (Bärnighausen & Bloom, 2009; Gravelle et al., 2008; McGrail et al., 2017; Scott et al., 2013). The present study extends this literature to audiologists, a comparatively understudied workforce.

Compensation also interacted with family and community considerations rather than functioning as an independent determinant of siting. Participants evaluated salary in relation to local cost of living, but benefits and work-life balance were especially relevant when they were balancing employment with parenting or caregiving responsibilities. This interaction is important for interpreting possible socioeconomic gradients in audiologist siting. More affluent communities may be attractive not simply because of community SES itself, but also because higher compensation, employment opportunities for spouses, schools, services for children, and other resources can occur together within the same locations. Because of this, increasing salary alone may not be sufficient to recruit an audiologist to a less affluent or underserved community if other household needs cannot also be met. In the context of a predominantly female workforce, compensation and family-supportive employment conditions may operate together in shaping which communities are feasible places to practice.

Much like compensation, views about Public Service Loan Forgiveness among audiologists are generally similar to perspectives from other HCPs. Audiologists generally view

loan forgiveness as a potentially useful strategy for drawing EHC HCPs to underserved communities, and though the influence of PSLF on audiologist siting has not been quantitatively examined, this is the dynamic observed among physicians (C. S. Davis et al., 2023). Similarly, both audiologists and other professionals are skeptical that the Public Service Loan Forgiveness program is effective because of the long 10-year service commitment before receiving any reduction in their loans through the PSLF program and the difficulty in sustaining a practice in an underserved region (J. B. Miller et al., 2023). Though audiologists in this study did not raise practice type as a barrier to PSLF participation, of note is that an increasing proportion of audiologists report working in private practice settings over recent decades, which precludes participating in PSLF; should this trend continue, PSLF will be unavailable to an increasing proportion of all audiologists in the US (American Speech-Language-Hearing Association, 2025b). Taken together, audiologists and other HCPs appear to evaluate direct and indirect financial compensation similarly; physicians, non-physician HCPs, and audiologists all view compensation for their work as an important, but not always the most important, consideration in choosing where geographically to live and work.

Perceived Local Ear and Hearing Care Service Need

One somewhat suprising finding was that participants did not describe local hearing loss prevalence as a major factor distinguishing attractive from unattractive practice locations. Participants generally assumed that there would be substantial need for EHC services across possible location. In other words, a participant could believe that patients needed EHC services in rural, urban, affluent, and less affluent communities alike, while compensation, spouse employment, family proximity, schools, or other characteristics differed substantially between those locations.

This distinction has implications for spatial accessibility. If HCPs perceive high demand for their services across locations, provider siting may be driven more strongly by differences in the conditions of places than by differences in perceived patient need. Communities with high need for EHC services may remain underserved if they are simultaneously less able to satisfy the occupational and family conditions that make a location feasible for providers. Population need and provider siting are consequently related but distinct processes, where need may create demand for EHC services without determining where HCPs are willing and able to locate.

Reproductive Healthcare Policy

Among audiologists, reproductive healthcare restrictions were a consideration when evaluating states to work in, but participants' accounts distinguish between viewing a policy environment as undesirable and actually relocating because of that policy environment. Physicians often feel that states with reproductive healthcare limitations make patient care more difficult and violate the autonomy of their patients, but audiologists in this study contributed important nuance about when and how reproductive healthcare restrictions may affect siting (Levy et al., 2025; Rovner, 2023). Participants who could become pregnant generally described restrictive reproductive healthcare policies as more personally consequential than participants who could not become pregnant. However, even participants who strongly preferred reproductive healthcare access often described family location, spouse employment, caregiving responsibilities, and other established ties as more immediate constraints on where they lived. Reproductive healthcare policy appeared to have a gendered but conditional influence on siting rather than a uniform effect on women's interstate relocation. Overall, these findings suggest that reproductive healthcare restrictions may not influence all audiologists equally but may be a

barrier to recruiting and retaining HCPs who are more likely to need reproductive healthcare services (i.e., younger and female audiologists).

The tension between a predominantly female workforce expressing concern about reproductive healthcare restrictions and participants rarely relocating because of those restrictions is an important finding. Policy preference and geographic mobility represent different processes. An established audiologist can view a policy as personally harmful while remaining in a state because a spouse's employment, children, parents, housing, or professional position makes relocation costly or impractical. This finding is consistent with the SEM framing because a strong policy-level preference can be constrained by interpersonal, organizational, and community-level conditions. It also suggests that policy effects may vary across the life course. Most participants in this study had been practicing for more than 10 years and many had established partners, children, or family responsibilities. Audiologists entering practice, younger audiologists, or audiologists without established household ties may have greater geographic flexibility and may weigh reproductive healthcare policy differently when initially selecting a state.

LGBTQ+ Policy

LGBTQ+ policy protections emerged as an important factor for some audiologists evaluating whether a state would feel safe and welcoming for themselves and their families, although like reproductive healthcare policy, the salience of these policies was typically low. A minority of audiologists in this study reported if they had an LGBTQ+ identity but audiologists who did endorse an LGBTQ+ identity, particularly those in a same-sex marriage, were the most likely to describe restrictive LGBTQ+ state policies as a deterrent to living and working in a given state. However, even among audiologists with a preference for living in a state with more

permissive LGBTQ+ policies, other factors such as family location were often rated as more important. Audiologists who were less likely to be personally affected by these policies (i.e., those that do not possess an LGBTQ+ identity) were mixed in their assessment of how strongly LGBTQ+ policy influences the siting of EHC HCPs.

This pattern of greater salience for HCPs with LGBTQ+ identities mirrors similar trends in medical healthcare disciplines, where LGBTQ+ policy appears potentially important for LGBTQ+ HCPs and, to a lesser extent, for others (Grant et al., 2018). Though the literature on how LGBTQ+ policy influences HCP location is less developed than the literature on reproductive healthcare restrictions, audiologists and other HCPs generally agree that LGBTQ+ legal restrictions are most impactful on individuals who personally have an LGBTQ+ identity and can negatively influence HCPs with LGBTQ+ identities and their families (Insalaco & Stamm, 2025; Yu et al., 2025). Even among audiologists with an LGBTQ+ identity who prefer states with stronger LGBTQ+ protections, more immediate concerns such as family ties or partner employment could outweigh policy context when deciding where to put down roots. Overall, the findings suggest that LGBTQ+ policy is most influential for audiologists who are most directly affected by it and that LGBTQ+ policy is not typically among the most important considerations when audiologists evaluate a location to live and work in.

State Professional Licensure

Professional licensure emerged as a potentially meaningful barrier to interstate relocation for audiologists, with high licensure costs, long processing timelines, and dual-licensure requirements for direct patient care serving as barriers that discourage audiologists from providing care across state lines or applying for licensure in states with more burdensome processes. These concerns are particularly salient for military families who have an audiologist

or their spouse working in the US military, as frequent relocations based on military need made licensing differences more consequential. For other audiologists, however, occupational licensing challenges were overshadowed by family and community considerations. Given the gendered composition of the audiology workforce with a greater proportion of women than other healthcare disciplines, occupational licensing barriers may be particularly likely to affect female audiologists relocating with male spouses.

Burdensome licensure requirements appear secondary to other factors for physicians, nurses, and audiologists, as these HCPs view compensation and proximity to family as generally more impactful on state of residence disciplines (Bae & Timmons, 2023; DePasquale & Stange, 2016; Fannin, 2020; J. E. Johnson & Kleiner, 2020). Overall, these findings suggest that licensure policy can shape the geographic distribution of EHC HCPs by reducing workforce mobility, though other factors are typically more impactful in audiologist location.

Theoretical Implications

The results of this study contribute to the social ecological model (SEM) of HCP siting used throughout this dissertation. SEMs conceptualize individuals as embedded within interacting environments, with influences within and across individual, interpersonal, organizational, community, and policy levels acting together to influence outcomes (Bronfenbrenner, 1994; Eriksson et al., 2025; Golden & Earp, 2012; Stokols, 1996). Applied to HCP siting, this framework conceptualizes spatial accessibility as a downstream outcome of the interacting conditions that shape where HCPs are willing and able to live and practice. The findings from this study support this framing because participants rarely described geographic decisions as resulting from a single preference or characteristic of a location. Instead,

occupational opportunities, family needs, community resources, and state-level conditions interacted to make potential locations more or less feasible.

The findings also suggest that influences at different ecological levels can reinforce or compete with one another rather than operating independently. Compensation and career opportunities could make a position desirable, while spouse employment, children's needs, proximity to family, or the availability of community resources could make the surrounding location more or less feasible. In the same vein, occupational licensing and reproductive healthcare or LGBTQ+ policies could affect how participants evaluated states without necessarily outweighing established employment or family considerations. This is consistent with research across healthcare professions showing that HCP location decisions reflect interacting professional and nonprofessional considerations rather than occupational factors alone (Chatterji et al., 2024; Goddard et al., 2010; Levy et al., 2025). The findings support conceptualizing HCP siting as a process of evaluating multiple conditions across ecological levels rather than assuming that any one level independently determines where HCPs practice.

Gender demonstrates how influences may operate across ecological levels rather than fitting within a single level of the SEM. In this predominantly female sample, gender was reflected in participants' descriptions of spouse employment, parenting, caregiving, compensation, and reproductive healthcare policy rather than emerging as an independent siting factor. Participants often described geographic decisions as household decisions in which occupational opportunities were evaluated alongside the needs of spouses, children, and aging parents. This suggests that individual characteristics such as gender may shape how interpersonal, organizational, community, and policy conditions are experienced and weighted when HCPs make geographic decisions. For a predominantly female profession such as

audiology, these interactions may contribute to geographic patterns in provider supply when some communities are better able than others to simultaneously accommodate providers' occupational and household needs.

Taken together, the Aim 1 findings provide qualitative support for conceptualizing EHC HCP siting as a multilevel process in which factors across ecological levels can reinforce, constrain, or outweigh one another. This framing moves beyond treating provider supply as a fixed characteristic of communities and instead considers spatial accessibility as partially resulting from the decisions HCPs make within their unique occupational, household, community, and policy contexts. These findings provide a theoretical basis for examining community characteristics and policy environments in Aims 2 and 3 and for considering how the interaction of these conditions may contribute to differences in the spatial accessibility of EHC services.

Policy Implications

These results have implications for health systems and local, state, and federal policy. A deeper understanding of what motivates EHC HCPs to live and work in a state or community may improve health system administrators recruiting HCPs to rural, low-income, and other locations that are underserved by EHC HCPs (Bärnighausen & Bloom, 2009).

Health systems may use the findings from this study to improve the recruitment and retention of EHC HCPs, and potentially other classes of HCPs. The strong focus on compensation in the form of both salary and other benefits for many audiologists clearly shows that compensation is an important factor when many audiologists choose a workplace, and simply increasing salary and other compensation can be effective at increasing the local supply of HCPs (Scott et al., 2013). Many audiologists also viewed family-related amenities such as

healthcare services and educational opportunities for their children and aging parents as a key consideration, suggesting other areas that hospitals, clinics, and health systems may provide focused benefits such as flexible time off or childcare services for employees to make their workplaces more attractive to audiologists and likely other HCPs.

At the state level, the results of this study show that reproductive healthcare policy has the potential to influence the state-level supply of EHC HCPs. Though state-level reproductive healthcare restrictions do not appear universally important for audiologists and are often overshadowed by other considerations, access to reproductive healthcare when needed was often important for audiologists who are likely to become pregnant. Given that over half of audiologists currently practicing are under 44 years old and nearly nine in ten are women, nearly half the current audiology workforce could be capable of becoming pregnant and are thus more likely to view reproductive healthcare access as at least somewhat important in choosing a state to settle in (American Speech-Language-Hearing Association, 2023). These findings suggest that reproductive healthcare policy may influence healthcare services not only through direct effects on patients but also have the potential to influence the availability of healthcare services through indirect effects on provider recruitment and retention. Policymakers concerned with ensuring their constituents have adequate healthcare access should recognize that restrictive reproductive healthcare policy contexts at a state level could function as a deterrent for some providers and may reduce the appeal of practicing in already underserved states or regions.

At the state level, these findings suggest that LGBTQ+ policy could matter for workforce recruitment for HCPs with LGBTQ+ identities though compared to other influences LGBTQ+ policy importance in siting decisions is often low. Though it appears unlikely for LGBTQ+ policy restrictions to significantly influence the siting decisions of most audiologists, LGBTQ+

rights can be an important consideration for audiologists who have an LGBTQ+ identity themselves. This suggests that states with more restrictive LGBTQ+ policy environments may face greater difficulty attracting EHC HCPs with LGBTQ+ identities; given the dearth of audiologists in rural and lower-income communities, any barriers that contribute to poor spatial accessibility of EHC HCPs in a state should be carefully considered in context of the unmet EHC needs of a state's population. If this pattern of LGBTQ+ HCPs preferring states with LGBTQ+ policy protections holds for other healthcare fields, then state-level policies alienating the approximately 10% of HCPs with LGBTQ+ identities may somewhat depress the availability of care across disciplines in states with LGBTQ+ rights restrictions (Jones, 2024). For policymakers, the implication is that social policy climate may indirectly shape access to hearing healthcare by influencing whether providers are willing to train, settle, or remain in a given state.

In contrast to reproductive healthcare and LGBTQ+ policies, high licensure fees, long processing timelines, and dual-licensure requirements are relevant for many audiologists moving between states, so policymakers may target these policy areas when attempting to increase the state-level supply for EHC HCPs for their constituents. For state licensing boards, this may point to the value of streamlining application timelines, reducing fees, and reconsidering the need for dual licensure that makes relocation difficult for EHC HCPs. One avenue to accomplish this would be joining the new interstate audiology licensing compact, which establishes a unified standard for audiology license and will enable audiologists in the 37 member states to more easily transfer licensure between states in the coming years.

Finally, PSLF and similar loan forgiveness programs may be important tools for recruiting HCPs to underserved areas, though the PSLF may benefit from revisions to make it more accessible and acceptable to EHC HCPs. These findings suggest that policymakers should

consider whether shorter service periods or simpler eligibility requirements would make loan forgiveness a more realistic recruitment tool for this workforce. Taken together, these results suggest that improving spatial accessibility of EHC HCPs may require policy that extends beyond the policies that are obviously related to healthcare workforces to include social policy, administrative policy, and economic incentives.

Strengths and Limitations

This study has several strengths that are important for interpreting the findings. First, it addresses an understudied area of healthcare by examining how audiologists think about where they live and work, which complements the extensive literature on this topic investigating physicians and other medical healthcare disciplines, which is important because siting preferences between physicians and allied healthcare professionals are not entirely comparable (see, for example, Couch et al., 2021; El Koussa et al., 2016). Semi-structured interviews were well suited to exploring this issue because they allowed participants to describe how professional, family, and policy related factors shaped their decisions. Second, the use of a flexible coding approach allowed a systematic and transparent analytic process that permitted identification of both anticipated and emergent patterns in the data. The strong intercoder agreement achieved during both index and analytic coding grants readers confidence that the themes identified are consistent across coders and grounded in the data.

Several limitations should guide interpretation of the results. First, interviews were collected during a specific moment in time (January 2025) and the policy contexts discussed by participants including reproductive healthcare policy, occupational licensing rules, and cost of living continue to evolve dynamically. These shifting conditions mean that the findings should

be understood as reflecting the perspectives of audiologists during that period rather than as fixed or exhaustive descriptions of these HCPs perspectives.

Second, the sample includes only audiologists who relocated to another state at least once during their career, and not all states and regions were equally represented. This sampling strategy allowed for reflections on the factors that influence relocation but may not fully represent the experiences of audiologists who choose to remain in a single state for most or all of their careers and/or audiologists who weighed social factors into their siting decisions before beginning their practice. The perspectives of audiologists who do and do not relocate between states during their professional careers or that relocate among states not included in this study may differ in meaningful ways and should be investigated in future studies.

Third, the inclusion of only audiologists in this sample, excluding HISs, also limits the interpretation of the results from this study. HISs provide much of the hearing healthcare services in the US and several participants suggested that these EHC HCPs have a distinct siting pattern compared to audiologists, so only including audiologists in this sample may provide an incomplete picture of the factors influencing the spatial accessibility of EHC HCPs in the US. The sample used in this study ultimately limits the generalizability of the findings, though interviews in this study discussing perspectives of colleagues and other EHC HCPs gives some perspective on trends among subpopulations not sampled in this study.

Fourth, the interviewer's identities as an audiologist and someone with an LGBTQ+ identity may have influenced participant's willingness to discuss some topics. Though conversations were frequently critical of challenges and problems with the profession of clinical audiology, it is nonetheless possible that a sense of collegiate fraternity influenced if and how participants were willing to criticize their and the interviewer's chosen profession. SAK's

openness about having an LGBTQ+ identity could have influenced interviewees willingness to discuss LGBTQ+ policy and how they answered questions on this topic, though this was minimized by assuring participants that their responses were completely confidential and asking participants for open, honest responses after building rapport.

Future Research

This research identified occupational, family, community, policy, and other influences that may contribute to the spatial distribution of audiologists in the US. Further research should clarify which providers are most affected by each influence, how the relative importance of ecological levels changes across the life course, and how these processes generalize to other EHC HCPs. Future qualitative research should intentionally include larger samples of men, gender-diverse audiologists, audiologists with LGBTQ+ identities, and audiologists at different stages of family formation so that differences associated with gender, parenting, and caregiving can be examined more directly.

The findings also suggest the importance in specifically studying early-career audiologists and recent graduates. Many participants in this study had established careers and family relationships that limited their geographic flexibility. Audiologists selecting their first post-graduation position may have fewer established occupational and household ties and could place greater weight on state reproductive healthcare or LGBTQ+ policy and the local social environment. Comparing early-career and established audiologists would help determine whether the relative importance of policy changes over the life course.

This study included audiologists who had relocated across state lines, making the sample useful for understanding how relocation decisions are made but less useful for clarifying why audiologists remain in the same place. Future research should examine audiologists who had

opportunities to relocate but chose not to do so. Comparing movers and non-movers could clarify whether family ties, homeownership, community attachment, occupational stability, or other factors are important for retention and may explain why non-preferred social policy or other disliked conditions do not necessarily cause interstate movement.

Future work should also directly characterize origin and destination locations. The present study included participants currently living across all four Census regions, but current location alone cannot establish whether audiologists systematically move toward or away from particular types of states, regions, rural communities, or socioeconomic contexts. Studies linking qualitative accounts with origin-destination geographic data could test whether the processes described by participants correspond to measurable patterns of provider movement.

Finally, audiologists generally believed that HISs occupy a different niche in the US EHC service landscape, including working in communities and regions that may be less attractive to audiologists, partly because of structural differences between the two professions. Qualitative research should explore how HISs choose the workplaces, communities, and states in which they provide services and whether the individual, interpersonal, organizational, community, and policy influences identified among audiologists operate similarly for HISs. Comparing these related but distinct professions would provide a more complete understanding of how professional characteristics interact with ecological context to shape spatial accessibility to EHC services.

Conclusions

This qualitative study identified factors that may influence the regions in which EHC HCPs live and provide patient care. Compensation-related and social influences were often important for how this sample of audiologists chose where and where not to provide healthcare

services, with a weaker effect of policy on audiologist location. Based on the results from this study, audiologists may be more spatially accessible in more urban communities with employment opportunities and amenities for their spouses and more affluent communities with higher HCP pay and more educational and healthcare related amenities for children. These results have the potential to inform policy strategies to improve the recruitment of EHC HCPs to underserved areas by showing that provider access is shaped by compensation-related and community-level conditions that make particular places more or less feasible for providers and their families. For healthcare administrators, this suggests that competitive compensation and benefits that support the needs of workers caring for their parents and children such as flexible time off and an intentional workplace culture promoting work-life balance may all matter in attracting and retaining EHC HCPs.

CHAPTER 3: Spatial Accessibility of Audiologists and Hearing Instrument Specialists in the United States: An Analysis of Socioeconomic and Geographic Disparities

Abstract

Introduction

Hearing loss is common and treatable, but most individuals with hearing loss do not receive appropriate care and treatment disparities persist by geography and area-level socioeconomic context. Guided by a social ecological model of healthcare provider (HCP) siting, this study evaluates whether community-level rurality or socioeconomic characteristics are associated with spatial accessibility to ear and hearing care (EHC) HCPs in the contiguous United States from 2017–2023, and whether these relationships differ between audiologists and hearing instrument specialists (HISs). The specific hypotheses investigated in this study are: one, the spatial accessibility of EHC HCPs will decrease with increasing community rurality; two, community socioeconomic characteristics will be associated with the spatial accessibility of EHC HCPs, with characteristics reflecting greater socioeconomic advantage associated with greater spatial accessibility; and three, audiologists and HISs will each show distinct siting patterns during the study period.

Methods

A geospatial analysis was conducted analyzing audiologist and HIS locations in the contiguous US from 2017 to 2023. Spatial accessibility for each type of HCP and for any EHC HCP was estimated at the census tract level using Gaussian two-step floating catchment area (2SFCA) measures. Rural–Urban Commuting Area (RUCA) codes from the US Department of Agriculture were used to operationalize rurality, socioeconomic context was measured using

multiple indicators from American Community Survey longitudinal data, and proximity to audiology training programs from the American Speech-Language-Hearing Association accreditation database was included as a covariate. Associations were estimated using longitudinal census tract-level spatial-lag mixed-effects models that accounted for repeated observations over time and spatial dependence among neighboring census tracts. Separate models were estimated for overall EHC HCP, audiologist, and HIS spatial accessibility.

Results

Spatial accessibility was lower with increasing rurality for EHC HCPs overall, audiologists, and HISs, with a substantially stronger rurality gradient for audiologists (b = -0.04, $p < .001$) than for HISs (b = -0.01, $p < .001$). Relationships between community socioeconomic context and spatial accessibility were more complex. For all three provider groups, individual measures of income, educational attainment, housing, employment, insurance coverage, poverty, and transportation access showed different directions and statistical significance rather than a consistent gradient of greater EHC HCP accessibility with increasing community affluence. The specific socioeconomic characteristics associated with spatial accessibility also differed between audiologists and HISs, supporting distinct siting patterns between the two professions. Sensitivity analyses using 5-year census tract-level socioeconomic estimates generally supported the primary findings while demonstrating that some socioeconomic relationships were sensitive to the geographic and temporal resolution of the socioeconomic measures.

Conclusion

Spatial accessibility to EHC HCPs is strongly patterned by rurality, particularly for audiologists, while relationships with community socioeconomic context are multidimensional and differ across individual socioeconomic measures and provider types. These findings provide

the strongest support for lower EHC HCP spatial accessibility in rural communities and for distinct siting patterns between audiologists and HISs, and provide more mixed support for a single socioeconomic gradient in EHC HCP accessibility. Consistent with a social ecological model of HCP siting, the findings suggest that community characteristics represent related but distinct conditions associated with HCP spatial accessibility and that their relationships may depend on characteristics of the profession being examined. Healthcare workforce research and policies seeking to improve EHC spatial accessibility should consider provider type and specific community conditions rather than treating EHC HCPs as a single workforce or community socioeconomic status as a single dimension of affluence

Chapter 3 Introduction

Background

Hearing loss is a common, treatable health condition that is not appropriately treated for most individuals who have it (Carr & Kihm, 2022; Orji et al., 2020). Disparities in both rates of hearing loss and hearing loss treatment are clearly documented by socioeconomic status (SES) with lower SES associated with later diagnosis and treatment (He et al., 2018; Reed et al., 2023). Additionally, hearing loss and hearing loss treatment are spatially patterned, with individuals living away from urban centers being less likely to receive appropriate hearing loss treatment (Bessen et al., 2024; Chan et al., 2017). Research examining disparities in hearing loss treatment often focuses on analyses of personal factors, attempting to identify sociodemographic factors such as an individual's race, income, or age that influence an individual's likelihood of receiving hearing loss treatment (for example, see reviews by Vestergaard Knudsen et al., 2010; Ziemska-Gorczyca et al., 2025). Evidence has emerged, however, that rurality, regional SES, and other community characteristics such as the frequency of natural disasters and occupational opportunities for spouses may influence the local supply of healthcare providers (HCPs) in some disciplines and nations, though this has not been adequately examined among ear and hearing care healthcare providers (EHC HCPs) in the US (Costa et al., 2024; Hou et al., 2016; Stidolph et al., 2025). This study evaluates how community-level rurality and socioeconomic characteristics are associated with local ear and hearing care healthcare provider (EHC HCP) spatial accessibility, to clarify the role that spatial accessibility to EHC HCPs may play in disparate rates of hearing loss treatment.

Hearing

Most people will experience hearing loss if they live long enough. This disorder becomes about twice as common with each decade of life as loud noise exposures, age-related changes to the peripheral hearing system and central nervous system, and other health conditions that negatively impact hearing accumulate (Tran et al., 2024; World Health Organization, 2021). Most hearing loss is incurable but treatable, most often by fitting hearing aids to artificially amplify the intensity of sounds to a level that the individual with hearing loss can perceive (Tang et al., 2025; Vos et al., 2015).

Both the prevalence of hearing loss and hearing loss treatment vary by individual and community-level influences, both in the US and internationally. One possible pathway linking geography to the prevalence of hearing loss is the greater presence of farming, firearm, and recreational noise in some rural contexts that may increase the rate of hearing loss in rural regions where these noise sources occur most often (Chou et al., 2015; Cruickshanks et al., 2010). Though rural areas have a greater burden of hearing loss, these regions are also less likely to have EHC HCPs . A dearth of nearby healthcare providers (HCPs) qualified to treat hearing loss in some communities has been identified as a possible cause of lower rates of hearing loss treatment in some regions (Pudrith et al., 2024). Likewise, SES, a fundamental cause of health disparities for many conditions, is closely linked to the development and treatment of hearing loss (Cheung et al., 2023; Link & Phelan, 1995; Quimby et al., 2023).

Looking at global patterns, literature suggests that the relative prevalence of hearing loss in rural and urban areas varies by national context. Though hearing loss appears more common in urban areas among people living in China (Gong et al., 2018; Li et al., 2023), Western countries demonstrate the opposite pattern, with hearing loss being more common in rural

regions (Brennan-Jones et al., 2016; Pierre et al., 2012; Rein et al., 2024). In Australian, European, and American contexts, higher rates of hearing loss in rural communities are typically attributed to noise-induced hearing loss from noisy industries like farming and similarly noisy recreational activities such as hunting that are more common in rural communities (Ivory et al., 2014; Lie et al., 2016; Themann & Masterson, 2019). Despite higher EHC need in rural communities, EHC HCPs are typically located in more urban communities. Research across high- and low-income countries including the US, China, and Thailand has found that HCPs, including EHC HCPs, are located near rural communities less often than more developed, urban communities (Cyril et al., 2013; Planey, 2019, 2020; Yimtae et al., 2018; X. Zhang et al., 2017). Some studies have suggested that in an American context this may be partly attributed to the relative dearth of HCP training programs in rural communities, or an unwillingness for HCPs to live in rural or remote communities (K. B. Naylor et al., 2019a; Planey, 2020). A lack of EHC HCPs in rural regions causes barriers for individuals seeking EHC services due to the necessity of owning a vehicle to travel to EHC providers, a greater time commitment to travel to and from EHC HCP appointments, and associated costs in receiving care from more distant HCPs in both the US and in other nations (Agency for Healthcare Research and Quality, 2022; Chan et al., 2017; Syed et al., 2013).

Theoretical Framework

The study presented in this chapter was informed by the social ecological model (SEM) of HCP siting introduced in Chapter 1. SEMs conceptualize individuals as embedded within interacting environments of increasing scope, commonly including individual, interpersonal, organizational, community, and policy levels (Bronfenbrenner, 1994; Eriksson et al., 2025; Golden & Earp, 2012). Applied to HCP siting, this framework positions spatial accessibility to

healthcare providers as a downstream outcome of conditions that shape where HCPs are willing and able to live and practice rather than as a fixed characteristic of a community. HCP location may reflect the interaction of occupational and individual priorities with family needs, employment opportunities, characteristics of communities, and broader policy environments (Chatterji et al., 2024; Goddard et al., 2010; Levy et al., 2025).

This study focuses specifically on the community level of this framework by evaluating rurality and socioeconomic characteristics as features of communities that may be associated with EHC HCP spatial accessibility. Rurality may represent a collection of geographic and community conditions relevant to HCP siting, such as population density, distance from larger population centers, employment opportunities, and the availability of services for children or aging parents and other amenities. Socioeconomic context is also multidimensional. Income, educational attainment, housing costs and conditions, employment, health insurance coverage, poverty, and transportation access represent related but distinct characteristics of the communities where HCPs may live and practice. These community characteristics may influence the feasibility or desirability of locations through different pathways rather than operating as interchangeable measures of a single socioeconomic gradient. This distinction is consistent with an SEM because ecological context is composed of multiple conditions that may interact with influences at other levels rather than exerting a single uniform influence on HCP location.

Community characteristics also may not influence all EHC HCPs in the same way. This study separately evaluates audiologists and hearing instrument specialists because these professions provide overlapping EHC services but differ substantially in education, licensure requirements, income, scope of practice, and employment opportunities. These professional characteristics may change the opportunities and constraints associated with the same

community context. For example, rurality or a particular socioeconomic characteristic may be associated differently with the availability or attractiveness of employment for an audiologist than for a HIS. Prior research has identified uneven spatial distribution of audiologists, including lower availability in rural and lower-income communities, but has rarely evaluated audiologists and HISs separately despite both professions providing hearing aid services (Planey, 2019; Pudrith et al., 2024). Treating the two professions as a single workforce could obscure differences in how community context is related to the spatial accessibility of each profession.

Aim 1 provides additional context for how these community-level conditions may operate within the broader SEM. Audiologists interviewed in Aim 1 described geographic decisions as involving combinations of occupational opportunities, compensation, spouse employment, children's needs, family proximity, cost of living, and availability of community resources rather than responding to any single characteristic of a location. This suggests that rurality and socioeconomic characteristics evaluated quantitatively in the current study should not be interpreted as isolated determinants of provider siting. Instead, rurality and community SES represent characteristics of the community environments within which occupational, interpersonal, and individual considerations operate. Research across allied health professions suggests that workplace location decisions reflect interacting professional and nonprofessional considerations, including career opportunities and access to amenities important to providers and their families (Chatterji et al., 2024; Goodfellow et al., 2016; Ullrich et al., 2015).

This study uses the SEM to evaluate two related theoretical propositions about the community context of EHC HCP siting. First, community rurality and socioeconomic characteristics may be associated with spatial accessibility to EHC HCPs because communities differ in the conditions that make them feasible locations for providers to live and practice.

Second, these relationships may be profession-dependent, such that the same community characteristics are differently associated with spatial accessibility to audiologists and HISs. Evaluating rurality and multiple dimensions of socioeconomic context separately for each profession therefore allows this study to examine not only whether community context is associated with EHC HCP spatial accessibility, but also whether the relationship between ecological context and spatial accessibility differs according to the characteristics of the profession being examined.

Ear and Hearing Care Providers: Audiologists and Hearing Instrument Specialists

Programs and interventions seeking to provide EHC services to populations with unmet hearing healthcare needs tend to do so by focusing on reducing the cost of hearing aids, which still requires proximity to EHC HCPs and does not resolve the influence of EHC HCP siting in leading to inequities in hearing loss treatment (Hotton et al., 2023). This suggests that ensuring access to EHC HCPs in communities with unequitable access to EHC HCPs may be an important intervention to improve the health and economic productivity of communities in the United States. Other researchers have evaluated other pathways to hearing healthcare, through community health workers or telehealth EHC services, though both of these pathways are limited by licensing barriers that require in-person EHC HCPs for most hearing healthcare services (Blyth & Saunders, 2024; Coco et al., 2024; Dixon et al., 2025; Jorgensen & Barrett, 2022).

Hearing healthcare in the United States is typically performed by licensed audiologists, nonmedical allied health HCPs who diagnose and nonmedically treat hearing loss by fitting hearing aids and other hearing prosthetics (McNeal, 2016). Hearing instrument specialists (HISs), however, can also provide hearing healthcare services. Hearing aids, the gold-standard treatment for most hearing losses, can be legally dispensed by both doctors of audiology, which

requires around 8 years of post-secondary education including a clinical doctorate, and by HISs, also known as hearing aid fitters, specialists in hearing instruments, or nearly a dozen other terms depending on jurisdiction (International Hearing Society, n.d.). Throughout this study, these non-audiologist EHC HCPs are referred to as 'HISs' regardless of jurisdiction. The licensure requirements for HISs vary by state but in most states, HISs do not require any post-secondary education at all, instead relying on an apprenticeship model for on-the-job training followed by a skills exam. For example, at the time of writing California only requires a high school diploma and to pass the California Speech-Language Pathology & Audiology & Hearing Aid Dispensers Board exam for HIS licensure (California Speech-Language Pathology & Audiology & Hearing Aid Dispensers Board, 2024).

Despite the similarity in the hearing aid services these HCPs can provide, the vastly different education and licensure requirements between these professions suggests that siting for each category of HCP may be influenced by area-level factors differently. Audiology requires a clinical doctorate and these HCPs have a median hourly pay nearly twice that of the general working population, meaning that EHC HCPs are more mobile and more able to determine the regions where they live and work than workers in other disciplines (U.S. Bureau of Labor Statistics, 2023b, 2024). Compared to HISs, the median salary for audiologists is nearly 50% higher, suggesting that audiologists compared to HISs are more able to afford to live in affluent areas and in communities of their choosing (U.S. Bureau of Labor Statistics, 2023a, 2023b).

Though little research exists comparing audiologists and HISs, medical literature suggests that when similar types of care are provided by professionals with significantly more vs. less education there are differences in patient outcomes, cost of care, and referrals to other HCPs (Htay & Whitehead, 2021; Hughes et al., 2015; D. Johnson et al., 2019; Laurant et al., 2018;

Virani et al., 2016). The vast majority of this research compares physicians to midlevel providers (also referred to as advance practice providers) such as nurse practitioners or physician assistants who in some contexts can provide the same services as physicians despite disparate education, training, and scopes of practice. Physicians have longer education, more stringent in-person education requirements, and more direct patient contact before independent practice compared to midlevel providers (Smith, 2023). Responsive to this, the scope of what direct patient care physicians may legally provide and the other HCPs they are permitted to supervise is broader than midlevel HCPs though in the US precise differences in scope of practice vary widely by state and over time (Perloff et al., 2019). Despite these differences in training and experience, a recent Cochrane review found no clear evidence for poorer patient outcomes across specialties when care is provided by midlevel HCPs when compared to care provided by physicians (Butler et al., 2026). A growing body of other evidence, however, has found that midlevel providers are more likely to specialize in certain disciplines, work in more rural areas, and see patients that are younger and wealthier when compared to physicians (Bellon et al., 2015; M. D. Naylor & Kurtzman, 2010; Perloff et al., 2019). Differences between physicians and midlevel providers likely result from scope of practice differences between physicians and midlevels that limit the disciplines and settings that midlevels can legally work in. The disciplines and workplace contexts that midlevels are permitted to provide direct patient care in appear to be more likely to have younger, wealthier patients compared to physician-dominated specialties that see a wider range of population ages and sociodemographic characteristics (Bellon et al., 2015; M. D. Naylor & Kurtzman, 2010; Perloff et al., 2019). When comparing outcomes and healthcare costs between physicians and these midlevel providers, differences in patient satisfaction, health outcomes, and care costs have been identified in various disciplines, though the magnitude and

direction of these differences is inconsistent between studies (Butler et al., 2026; Htay & Whitehead, 2021; D. Johnson et al., 2019; Laurant et al., 2018).

Virtually no research has evaluated whether, like other medical disciplines, there are differences in the availability or quality of care provided by each type of EHC HCP. In an EHC context, the more educated class of HCP with a broader scope of practice is audiologists, while the less educated HCPs with a more limited scope of practice would be HISs though training length for audiologists is more similar to nurse practitioners than to physicians (Arenberg et al., 2020; Smith, 2023). Prior investigations have examined audiologist siting and found fewer audiologists in rural and poorer areas and farther from audiology graduate programs, though most research on EHC HCP siting is on a limited geographic area such as a handful of counties or a single US state, assumes that individuals would not cross administrative boundaries to reach audiologists, only operationalizes SES with a single measure, or used multiple linear regression that failed to appropriately account for spatial autocorrelation between geographic administrative units, limiting the conclusions that can be drawn (Kissling & Carl, 2008; Malcolm et al., 2022; Pudrith et al., 2024).

Prior studies have used individual measures such as income, poverty, educational attainment, or insurance coverage, while others have used composite measures or indices of socioeconomic disadvantage (A. G. Davis et al., 2023; M. A. Davis et al., 2018; Trinidad et al., 2022). In EHC specifically, available evidence generally suggests poorer spatial accessibility to audiologists or hearing healthcare services in less affluent communities, but studies have typically examined limited geographic areas or operationalized SES using a single measure (for example, Malcolm et al., 2022; Pudrith et al., 2024). As a result, describing a community as having higher or lower SES may obscure the distinct pathways through which individual

socioeconomic characteristics could be associated with whether HCPs are able or willing to practice there.

Income and poverty, for example, both describe the financial resources available within a community but capture different aspects of economic context. Median household income characterizes the financial resources of the typical household and may also reflect the economic base available to support healthcare services. Communities with greater household resources may provide a larger population able to pay for healthcare services, which may be particularly relevant to EHC because hearing healthcare often includes substantial out-of-pocket costs for services not typically covered by health insurance (Jilla et al., 2023; Nassiri et al., 2022). The proportion of the population below 200% of the federal poverty level instead identifies the concentration of residents experiencing economic constraints. A community could have a relatively high median income while still containing a substantial population with limited financial resources, meaning these measures do not necessarily characterize the same aspect of local economic conditions. Prior research identifying lower HCP supply or poorer hearing healthcare access in economically disadvantaged communities suggests that these financial characteristics may be relevant to provider distribution, but does not establish that income and poverty should have equivalent relationships with HCP spatial accessibility (A. G. Davis et al., 2023; M. A. Davis et al., 2018; Malcolm et al., 2022).

Educational attainment may represent another dimension of community socioeconomic context. High school completion and bachelor's degree completion are related measures, but they distinguish different portions of the educational distribution and may therefore characterize communities differently. High school completion may distinguish communities with relatively high levels of fundamental educational disadvantage, whereas bachelor's degree completion may

identify communities containing larger proportions of highly educated professionals. This distinction may be particularly relevant to HCP siting because audiologists themselves have extensive postsecondary education, and HCPs in other disciplines often practice in communities with sociodemographic characteristics similar to their own (Stinson & Thurston, 2002; Xierali & Nivet, 2018). Educational attainment may also occur alongside other community characteristics important to providers and their households, including professional employment opportunities, schools, healthcare services, and other resources. Because of this, high school and bachelor's degree completion may capture different aspects of community context even though both are commonly treated as measures of education within broader definitions of SES.

Housing characteristics similarly capture multiple dimensions of community context. Median rent can indicate the cost of living and therefore the financial resources required for a provider and their household to reside in a community. Higher housing costs could make a location less financially feasible, particularly when compensation does not increase proportionately. At the same time, higher rent may occur in communities with greater employment opportunities, population density, healthcare infrastructure, and other resources that make those communities attractive locations for healthcare practices and HCP households. Crowded housing captures a different aspect of housing context and may more directly identify communities experiencing housing or material disadvantage rather than the market cost of living. These measures may have relationships with HCP siting: housing costs can function as a constraint on where providers can afford to live while also characterizing communities containing other occupational and household resources that providers value.

Employment and health insurance coverage may more directly characterize the economic stability of communities and their capacity to support healthcare services. Higher unemployment

can indicate fewer employment opportunities and fewer economic resources within a community, potentially affecting both demand for healthcare services and employment opportunities for HCP households. This may be especially relevant given that audiologists in Aim 1 frequently described spouse employment as an important constraint on relocation. Health insurance coverage represents a related but distinct characteristic because insurance is often, but not always received from one's workplace and affects the ability of residents to pay for healthcare services. However, EHC reimbursement differs from many other healthcare services, and substantial portions of hearing healthcare remain privately paid or subject to restrictions on reimbursement (Arena et al., 2011; Brown et al., 2025; Jilla et al., 2023). Insurance coverage should not be assumed to operate as an interchangeable proxy for income or poverty in its relationship with EHC HCP spatial accessibility.

Finally, vehicle access represents both socioeconomic resources and the transportation environment through which residents reach services. Households without a vehicle may have fewer financial resources, but vehicle ownership is also related to community geography and transportation infrastructure. In dense communities, households may be able to access employment and healthcare without owning a vehicle, while lacking a vehicle in less densely populated areas may create a substantial barrier to reaching distant healthcare services. Vehicle access may consequently capture a different combination of socioeconomic and geographic conditions than income, education, or housing measures. This is particularly important for spatial accessibility because the ability of patients to travel and the geographic distribution of HCPs jointly determine whether healthcare services can realistically be reached (Arcury et al., 2005; F. Wang & Luo, 2005).

Taken together, the literature does not support treating these socioeconomic indicators as interchangeable measures of a single community characteristic. Income and poverty describe different aspects of financial resources; high school and bachelor's degree completion distinguish different levels of educational context; rent and crowded housing characterize different dimensions of housing and material conditions; unemployment reflects local economic and employment conditions; insurance coverage relates to residents' ability to finance healthcare; and vehicle access reflects both material resources and transportation context. These dimensions may also operate simultaneously and in different directions. A community with high housing costs, for example, may also have high educational attainment, greater employment opportunities, and greater access to services, while a community with lower housing costs may provide fewer occupational or household resources. Consistent with the social ecological framework guiding this dissertation, these socioeconomic characteristics are conceptualized in this aim as related but distinct features of the community environment that may interact with occupational, interpersonal, and other community-level influences on HCP siting rather than as a single continuum of community advantage.

This distinction is important for EHC HCPs because audiologists and HISs may respond differently to the same socioeconomic environment. Audiologists have substantially greater educational requirements, broader scopes of practice, and different occupational opportunities than HISs, while both professions can provide hearing aid services. Prior healthcare workforce research suggests that providers with different education and professional characteristics can have different geographic distributions (Barnes et al., 2018; Graves et al., 2016), but nearly all existing research on EHC HCP spatial accessibility has focused on audiologists and excluded HISs (Coco et al., 2018; Planey, 2020; Pudrith et al., 2024). Evaluating individual

socioeconomic characteristics rather than assuming a uniform SES gradient provides an opportunity to determine both which dimensions of community socioeconomic context are associated with EHC HCP spatial accessibility and whether those relationships differ between the two professions.

Having enough HCPs nearby in time and space is a necessary but not sufficient condition to receive healthcare services because most healthcare services require specialized training only available to a limited number of licensed professionals. Spatial access to HCPs in any healthcare field considers the time and distance to nearby HCPs, usually measured as travel time from potential patients to HCPs and as distance to the nearest HCPs respectively (F. Wang & Luo, 2005). Accordingly travel times to the nearest HCP can be used as a proxy for access to healthcare services with greater distances to HCPs resulting in poorer access to these HCPs; though most spatial accessibility research is in other healthcare disciplines, it can be assessed for EHC services as well. (Arcury et al., 2005; Card et al., 2019; A. G. Davis et al., 2023; F. Wang & Luo, 2005).

Objectives for Aim 2

The overall research question guiding this study is:

Research Question 2: How does the spatial accessibility of different classes of EHC HCPs vary across community-level rurality and socioeconomic characteristics in the contiguous United States? The specific hypotheses investigated in this study are:

Hypothesis 2a: The spatial accessibility of EHC HCPs will decrease with increasing community rurality;

Hypothesis 2b: Community socioeconomic characteristics will be associated with the spatial accessibility of EHC HCPs, with characteristics reflecting greater socioeconomic advantage generally associated with greater spatial accessibility; and

Hypothesis 2c: Audiologists and HISs will each show distinct siting patterns during the study period.

Methods

This study used a census tract level, national-scale geospatial analysis to investigate differences in spatial accessibility to EHC HCPs. Two-step floating catchment area (2SFCA) values were used as the dependent variables while area-level measures of rurality and SES were used to evaluate whether 2SFCA for each provider group varied by these community characteristics from 2017 to 2023 after controlling for the nearness of audiology training programs. All data sources used in this study are freely available. As such, The University of California, Irvine institutional review board determined that full board review of this proposal was not required.

United States Census Bureau cartographic boundary files for 2020 census tracts were downloaded from the United States Census Bureau official website (United States Census Bureau, 2024). These were reduced to census tracts in the contiguous 48 United States and Washington DC, excluding US territories, and the states of Alaska and Hawai'i as the statistical analyses to handle the unique geographic position of these states are not in the scope of this study. Dependent, independent, and covariate variables were matched to the census tracts and data for tracts outside the contiguous 48 states and Washington DC were removed from all analyses. As some study data was from before 2020 when census tracts were redefined with 2020 United States decennial census data, crosswalk files from the National Historical Geographic

Information System (NHGIS) were used to convert all census-tract level data from before 2020 to 2020 census tract definitions (National Historical Geographic Information System, n.d.).

Dependent Variables

Healthcare Provider Locations

The dependent variables were census tract-level two-step floating catchment area (2SFCA) values computed using multiple provider groupings for the years 2017 to 2023. The registered workplace addresses for EHC providers were downloaded from the Centers for Medicare and Medicaid Services (CMS) National Plan and Provider Enumeration System (NPPES) data archive to calculate 2SFCA (Centers for Medicare & Medicaid Services, 2026). The NPPES is a dataset containing all HCPs who have a National Provider Identifier (NPI) which includes essentially all EHC providers providing direct patient care in the US. Full NPPES files for July 2017, July 2018, etc. through July 2023 were downloaded from the official CMS website (Centers for Medicare & Medicaid Services, n.d.). The NPPES files were reduced to only EHC providers by selecting only HCP taxonomy codes that correspond to EHC providers: codes "231H00000X", "231HA2400X", "231HA2500X", and "237600000X" for clinical audiologists and code “237700000X” for HISs (National Uniform Claim Committee, 2025). These codes have not changed or been redefined in the study period. The address for each included HCP and training program was geocoded using the ArcGIS geocoding API (esri, 2026). Street address, city, state, and ZIP code were used for geocoding.

Two-Step Floating Catchment Area

The 2SFCA variables were calculated using the geocoded addresses for each EHC HCP. This methodology accounted for both for travel time to EHC HCPs across administrative boundaries, and for how spatial accessibility decays with increased distance to the HCP (Chen &

Jia, 2019). This methodology does not account for differential hearing loss need by community, only the availability of healthcare providers. This refinement of gravity models is often used in geospatial research to measure spatial accessibility of HCPs in a two-step process (for example, Dai, 2010; McCrum et al., 2022; Pérez-Fernández & Michel, 2025, p. 202). The catchment area, the region from which patients may originate, was calculated using a gaussian decay function to weigh nearby HCPs higher than more distant HCPs. Refinements of the basic 2SFCA method are theoretically useful because base 2SFCA assumes that all people inside the distance threshold have equal access, ignoring how individuals who are closer to a given HCP will likely have less difficulty reaching the HCP compared to individuals in the distance threshold but somewhat farther away (S. Hu et al., 2020). Gaussian 2SFCA resolves this by using a gaussian-based decay function to weight locations farther from the HCP lower and was used in this study.

For each census tract included in the study, gaussian 2SFCA scores were calculated based on the geometric centroid of that tract. 2SFCA scores were calculated for audiologists only, HISs only, and for the full dataset containing both types of EHC providers. Because of the very large number of HCPs and national-scale road network used in this study, it was not computationally feasible to assign average speed based on road type to calculate routes to each HCP individually (Xiang et al., 2024).

As there is no clearly established measure for evaluating spatial access to specialty HCPs in studies utilizing 2SFCA, several drive time thresholds from 30 to 60 mph were tested in line with recommendations from prior research (Chen & Jia, 2019; Dai, 2010; Rauch et al., 2021). As in other studies, average speed resulted in generally similar model fit statistics so an average speed of 40 mph was chosen as an average value between lower-speed residential roads and higher-speed highways (Kaushik et al., 2018; Rauch et al., 2021).

Likewise, there is a dearth of recommendations for travel time thresholds in national-scale analyses so travel time estimates from 30 to 120 minutes were calculated to allow sensitivity analyses (Chen & Jia, 2019; Fransen et al., 2015). These thresholds were explored based on prior research that suggests that individuals regularly travel significant distances to pursue specialty healthcare services such as hearing healthcare, and that individuals in rural areas often need to travel distances of this magnitude to receive healthcare services. The strongest correlations were between 2SFCA values calculated with 30- and 60-minute drive time results for a given profession as the values for the 30- and 60-minute estimates were calculated from the same population of HCPs. The correlations between 2SFCA values for a given profession calculated with various distance thresholds were similarly strong, suggesting that the final 2SFCA measure included in the analyses be chosen based on theory, which typically seems to recommend using a 60-minute threshold as a reasonable real-world estimate of the distance people are willing to travel for specialty healthcare services. All correlations were positive but were smaller between audiologist and HIS results.

The models using 30-, 60-, 90-, and 120-minute 2SFCA distance thresholds show similar patterns of significant predictors, with the relative magnitude of the effects for the measures of rurality and SES and which predictors are statistically significant being generally the same across distance thresholds (data not shown). The models using the 60-minute estimates show generally equivalent or better model fit on the AIC and log-likelihood metrics and prior research suggests a 60-minute threshold is a reasonable threshold for the distance that patients are willing to travel for specialty care, so further analyses investigating individual covariate importance was performed for the models using 60 minute outcomes (Fu et al., 2025; Guagliardo, 2004; Shayman et al., 2019). The stepwise and fully adjusted 60-minute models for audiologists and

HISs are identical, showing that stepwise model construction did not meaningfully improve the fully adjusted model constructed based on theory so the fully adjusted models constructed based on theory were evaluated for all further analyses.

Independent Variables

The independent variables were area-level measures of rurality and SES. Rurality at the census tract level was operationalized with Rural-Urban Commuting Area (RUCA) codes from the U.S. Department of Agriculture (U.S. Department of Agriculture, 2023). Socioeconomic data were accessed from the American Community Survey (ACS).

Because SES measures were obtained from county-level ACS estimates, all census tracts within the same county were assigned the same value for each SES measure. This approach does not capture socioeconomic variation among census tracts within the same county and reduces the geographic resolution of the SES measures relative to the census tract-level outcomes used in these analyses. As a result, census tracts with meaningfully different socioeconomic characteristics may have been classified as having the same socioeconomic context. This flattening of within-county variation may have reduced the ability of the models to detect associations between local SES and EHC HCP spatial accessibility, particularly in counties containing socioeconomically heterogeneous communities. Estimated associations between SES and spatial accessibility may be attenuated relative to associations that would be observed using census tract-level SES measures. However, the direction and magnitude of any resulting bias cannot be determined from these analyses. ACS 5-year estimates are available at the census tract level and were evaluated to provide a more geographically granular assessment of these relationships.

ACS 5-year estimates are available at the census tract level and would provide greater geographic resolution than the county-level 1-year estimates used here. However, 5-year estimates pool data collected across the entire five-year period rather than representing socioeconomic conditions during a single year. The US Census Bureau recommends against comparing overlapping 5-year estimates because consecutive estimates share four years of underlying data and therefore do not provide independent measures of annual change (United States Census Bureau, 2022). The Census Bureau recommends using non-overlapping 5-year periods when evaluating change over time. Because the present analyses examined annual changes in EHC HCP spatial accessibility and SES from 2017 through 2023, using sequential census tract-level 5-year estimates would have substantially overlapped the measurement periods assigned to successive study years and could have obscured year-to-year changes. County-level ACS 1-year estimates were selected to preserve annual temporal resolution and comparability across study years, with the tradeoff of reduced geographic resolution within counties.

Rurality

2020 RUCA codes and definitions were used to operationalize rurality in this study as they represent the most methodologically sound estimation of census-tract level rurality available for the study period at the time of writing. 10-point primary RUCA codes were used to define each census tract in this study on an ordinal scale from more to less rural (U.S. Department of Agriculture, 2023). This ordinal variable is treated as continuous in these analyses; bias from treating RUCA as continuous is minimal given the number of levels in the variable and large samples sizes in these analyses (Norman, 2010; Rhemtulla et al., 2012).

Although prior studies have identified differences in hearing loss by rurality and have suggested that differential exposure to noise sources as a possible explanation for this difference,

assessing the noise sources present in each census tract is beyond the scope of this study (Cruickshanks et al., 2010; Lie et al., 2016; Themann & Masterson, 2019). Likewise, rates of hearing loss may differ by location but assessing the role of the prevalence of hearing loss in the siting of these EHC HCPs is beyond the scope of these analyses (Brennan-Jones et al., 2016; Rein et al., 2024).

Socioeconomic Status

One-year averages for 2017 to 2023 at the county level were used, with the exception of 2020 where ACS data collection was temporarily discontinued due to the COVID-19 pandemic. County-level data was the smallest administrative unit available for one-year averages, so the data for each county was converted to the census tract level by applying county values to all tracts in that county using 2020 census tract definitions.

SES was conceptualized as a multidimensional characteristic of communities rather than as a single underlying construct that could be adequately represented by one socioeconomic indicator or index. No clear theoretical basis was identified for selecting one individual SES measure, such as the percentage of the population below a specified federal poverty level, as the primary measure of community SES in relation to EHC HCP spatial accessibility. Similarly, there was not a clear theoretical justification for selecting or constructing a particular composite SES or deprivation index for these analyses. Different socioeconomic indicators capture related but distinct characteristics of communities that may be relevant to HCP siting and spatial accessibility.

For this reason, multiple SES measures identified in the literature as potentially relevant to healthcare access, HCP distribution, or community socioeconomic context were evaluated separately rather than combined into a single index. The specific measures used were selected

based on prior literature and based on data availability. These measures included median household income, median rent, high school completion, bachelor's degree completion, health insurance coverage, percentage of the population under 200% of the federal poverty level, unemployment, households without a vehicle, and crowded housing. Evaluating these measures separately allowed the analyses to assess whether different dimensions of community SES were differently associated with EHC HCP spatial accessibility and avoided imposing an unsupported assumption that the included indicators represented interchangeable measures of the same socioeconomic construct or should receive predetermined weights within a composite index. This approach also permitted comparison of whether the socioeconomic characteristics associated with spatial accessibility differed between audiologists and HISs.

The percentage of individuals over age 25 with a high school diploma and the percentage with at least a bachelor's degree were taken from ACS Table DP02. Median rent, and the percentage of households without access to a vehicle and that lived in crowded housing as defined by more than 1.51 individuals per room in the home were from Table DP04. Median household income was taken from data Table S1901, unemployment rate and proportion of the population under 200% of the federal poverty level were taken from Table S1701, and the proportion of individuals with health insurance was taken from Table S2701.

Crowded housing was notably right-skewed but was retained on its original percentage scale. This measure represents the percentage of households with more than 1.51 individuals per room and reflects household crowding rather than the geographic density of housing units within a community. Normality of independent variables is not an assumption of linear mixed-effects models, and skewness of an independent variable alone does not require transformation.

Retaining the original percentage scale also preserves the direct interpretation of crowded housing as the proportion of households experiencing this condition.

Because 2020 SES data was unavailable, this year contributes outcome information but lacks SES variables. Although mixed-effects modeling accommodates unbalanced data, this gap may slightly influence year-to-year SES trend estimation. I did not attempt missing data imputation to synthetically generate approximate values for this year's data based on surrounding years because societal disruption resulting from the COVID-19 pandemic during this year likely make surrounding years inaccurate estimates of actual conditions during 2020. As year-to-year trends were not evaluated for this study, the effect of missing 2020 data on the conclusions of this study were expected to be minimal. Separate models were fit for each outcome for the period before (2017 to 2019) and after (2021 to 2023) the onset of the COVID-19 pandemic in the USA to evaluate similarities and differences in the trends throughout the study period.

Covariates

Audiology training program addresses were retrieved from the American Speech-Language-Hearing Association (ASHA) EdFind, a database of all audiology graduate training programs in the United States that are certified by ASHA, the accrediting body for this discipline (ASHA EdFind, n.d.). Research attempting to operationalize the influence of university training programs on downstream HCP location often uses a simple binary factor for administrative units that contain a university with the relevant program, though this approach does not adequately model the arbitrary construction of most administrative units used in this research or how HCPs often choose to work in regions near where they studied (Costa et al., 2024; K. B. Naylor et al., 2019b; Wan et al., 2012). To better account for the compounding influence of several nearby universities on local downstream audiologist supply, 2SFCA was used to account for movement

across administrative boundaries and to account for local capacity to graduate new audiologists. Gaussian 2SFCA using various distance thresholds in 250 km bands from 250 km to 2,000 km were calculated and tested as measures of relative distance to all audiology training programs in the region to evaluate the influence of various distance thresholds in line with recommendations in the literature (Chen & Jia, 2019).

For audiology training program access, the 2SFCA results calculated with a 1,000 km distance threshold was used. This value was chosen because the distance thresholds within several steps of the 1,000 km threshold gave similar results in the final models, so the middle value at an easily interpreted threshold was used in the final analyses (Dai, 2010; S. Hu et al., 2020). Likewise, several thresholds for federal poverty level from 50% to 400% were tested, with the final variable to include in the model chosen based on minimizing covariance with other covariates and maximizing predictive power based on standardized estimates (Daling & Tamura, 1970).

Statistical Analyses

Statistical analyses were conducted in R version 4.4.2. Longitudinal spatial-lag mixed-effects models were used to estimate associations between census tract rurality, SES measures, and EHC HCP spatial accessibility while accounting for both repeated observations of census tracts over time and spatial dependence between geographically proximate census tracts. Models were estimated using the lmerTest and lme4 packages. Separate models were estimated for overall EHC HCP, audiologist, and HIS spatial accessibility.

Spatial dependence was incorporated by calculating a spatially lagged value of the dependent variable for each census tract and study year. Census tract internal-point latitude and longitude coordinates were used to identify the eight nearest neighboring census tracts for each

tract using a k-nearest-neighbor approach. For each census tract-year observation, the spatial lag was calculated as the mean spatial accessibility value among those eight neighboring census tracts during the same year. This produced a row-standardized spatial lag in which each neighboring tract contributed equally to the lagged value. The spatial lag of the dependent variable was then included as a fixed effect in each model to account for similarity in EHC HCP spatial accessibility among geographically proximate census tracts.

All models also included year as a categorical fixed effect to account for differences across study years and a census tract-specific random intercept to account for repeated observations of the same census tract from 2017 through 2023. The fully adjusted models included the spatially lagged outcome, year, RUCA code, and the SES measures: median household income, median rent, high school completion, bachelor's degree completion, health insurance coverage, percentage of the population under 200% FPL, unemployment, households without a vehicle, and crowded housing. The same model specification was used separately for overall EHC HCP, audiologist, and HIS spatial accessibility to facilitate comparison across provider groups.

Models were fit using maximum likelihood for model-comparison procedures and restricted maximum likelihood for final coefficient estimation. In addition to models using the complete 2017–2023 study period, period-specific models were estimated for 2017–2019 and 2021–2023 to evaluate whether associations differed before and after 2020.

Before model building, descriptive statistics were calculated, including distributions of individual variables and bivariate correlations between variables of interest. All variables for all years had statistically significant results on the Kolmogorov-Smirnov normality test with p's $< .001$, though visual histogram analysis of independent variables revealed most appear to be

generally normally distributed and non-normal independent variables are not likely to bias (data not shown, Kéry & Hatfield, 2003). Bivariate correlations were explored with Spearman's rank correlation coefficient (data not shown). The strongest correlations were between variables calculated from similar values and are conceptually similar, such as the strong inverse relationship between median income and the number of households making below 200% of the federal poverty level. *P*'s were < .001 for each bivariate correlation for each year and when outcomes were pooled across years, potentially partly an artifact of the very large sample sizes used. The very small *p* values seen in the Kolmogorov-Smirnov analyses and in the bivariate correlations may be partly an artifact of the very large sample sizes used in this study, but given the limited importance of these results in answering the research questions guiding this study the analyses proceeded with the assumption that these *p* values represented true departures from a normal distribution.

Residual Q-Q plots were visually evaluated for each final model evaluated in this chapter, which revealed a mild trend towards a leptokurtic distribution. Given the large size of the sample and the generally normal distribution of residuals, the dependent variables were not log transformed in these analyses.

Global Moran's I of residuals for each model evaluated was above 0.6 with *p*'s < .001, indicating that geographically nearby census tracts had more similar EHC HCP spatial accessibility than would be expected under spatial independence, so spatial dependence was incorporated into the regression models. Spatial dependence was addressed by including the within-year spatial lag of the dependent variable described above. Residual spatial autocorrelation was subsequently assessed using Moran's I as a diagnostic of remaining spatial structure after model estimation.

For each outcome, the base model included a tract-specific random intercept to account for repeated measures across years:

$$Y_{it} = \beta_0 \ + \beta_L L_{it} + X'_{it}\beta + a_i + y_t + \varepsilon_{it}$$

where:

- Y_{it} is the two-step floating catchment area spatial accessibility measure for census tract (i) in year (t),
- β_L is the coefficient for the spatially lagged outcome,
- L_{it} is the spatial lag of the dependent variable, calculated as the mean spatial accessibility among the eight nearest neighboring census tracts during year (t),
- X' represents the rurality, SES, and other prespecified covariates included in the model,
- a_i represents categorical year fixed effects,
- y_t is the census tract-specific random intercept, and
- ε_{it} is the residual error term.

In addition to the primary (unstandardized) models, the entire procedure was repeated after z-standardizing numeric outcomes and numeric covariates. Year was not standardized because it entered as a factor. For all analyses, Satterthwaite-approximated degrees of freedom were used for fixed effects and Wald 95% confidence intervals are reported. The reader may note that more complex models including interaction terms between time and each covariate were not generated or interpreted, because of the complexity of the existing analyses and because changes in each covariate over time are not in the scope of the research question guiding this study.

Results

Descriptive Statistics

Descriptive statistics for this study are presented in Table 3. In this sample, audiologists outnumber HISs for every year in the study period, 2017 to 2023, in line with workforce data across sources that shows that there are more audiologists than HISs in the US (Table 3). The number of each type of EHC HCP and the total number of EHC HCPs increased year over year through the study period. Audiologists had, on average, higher spatial accessibility across census tracts compared to HISs due to the larger number of audiologists in this sample. EHC HCP results representing both audiologists and HISs predictably had the highest average spatial accessibility. All SES variables varied widely, a result of the large geographic area with diverse local conditions included in these analyses. Most tracts were relatively urban, corresponding to lower Rural-Urban Commuting Area values, as the majority of the US population is located in areas with urban Rural-Urban Commuting Area codes (Table 3). Variance inflation factors were below 10 for all independent variables in each model, suggesting that multicollinearity is not a concern in these models (Kim, 2019).

Table 3, Descriptive Statistics for Dependent and Independent Variables in 60 Minute LME Models, 2017 – 2023

Variable	Mean	SD	Median	IQR	Range
Number of EHC HCPs	27516.71	2739.08	27619.00	3848.50	7573.00
Number of audiologists	20181.29	1652.23	20123.00	2326.00	4608.00
Number of HISs	7335.43	1093.81	7496.00	1522.50	2965.00
Two-step floating catchment area for EHC HCPs	7.75	2.61	7.50	3.23	22.46
Two-step floating catchment area for audiologists	5.91	2.06	6.00	2.75	18.12
Two-step floating catchment area for HISs	1.84	1.19	1.54	1.26	11.82
Rurality	1.48	1.46	1.00	0.00	9.00
Median income (USD)	62879.22	16323.84	58863.00	19426.00	104277.00
Median rent (USD)	1036.27	257.11	1011.00	339.00	1364.00
HS completion (%)	88.98	4.69	89.90	5.40	39.80
BS completion (%)	33.80	10.23	32.40	12.20	68.60
Health insurance coverage (%)	91.16	4.76	92.40	6.30	31.40
Under 200% FPL (%)	30.28	8.79	31.09	12.06	54.91
Unemployment (%)	26.13	4.69	25.72	5.70	55.96
Households with no vehicle (%)	9.66	10.49	6.68	4.81	76.72
Crowded housing (%)	12.02	31.24	0.75	1.07	100.00

Note: BS = bachelor's degree; EHC HCPs = ear and hearing care healthcare providers; FPL = federal poverty level; HIS = hearing instrument specialist; HS = high school; IQR = interquartile range; SD = standard deviation; USD = United States Dollars.

Hypothesis 2a: Rurality Results

Presented in Table 4 are tests of the hypothesis (Hypothesis 2a) that spatial accessibility of EHC HCPs would be lower in rural regions than in urban regions. Overall, the findings supported this hypothesis. Across the final models with all independent variables, rurality was negatively associated with spatial accessibility for audiologists, HISs, and for any EHC HCP, but the magnitude of this relationship was stronger for audiologists than for HISs (Table 4).

Table 4, LME Model Overall Results for 60 Minute Two-Step Floating Catchment Area with All Rurality and SES Measures, 2017-2023

Variable	Model 1, EHC HCPs				Model 2, Audiologists				Model 3, HISs				VIF
	b	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**	
Intercept	0.07	0.001	0.02	< .001	0.07	0.000	0.01	< .001	0.01	-0.000	0.01	.344	
Rurality	-0.05	-0.02	0.001	< .001 ***	-0.04	-0.02	0.001	< .001 ***	-0.01	-0.01	0.000	< .001 ***	1.03
Median income (USD)	-0.000	-0.001	0.000	.010 **	-0.000	-0.001	0.000	< .001 ***	-0.000	-0.000	0.000	.355	9.77
Median rent (USD)	0.000	0.002	0.000	< .001 ***	0.000	0.001	0.000	< .001 ***	0.000	0.001	0.000	< .001 ***	7.17
HS completion (%)	-0.001	-0.001	0.000	< .001 ***	-0.000	-0.001	0.000	< .001 ***	-0.000	-0.001	0.000	< .001 ***	1.75
BS completion (%)	0.000	0.002	0.000	< .001 ***	0.000	0.002	0.000	< .001 ***	0.000	0.001	0.000	.010 **	3.16
Health insurance coverage (%)	0.000	0.000	0.000	.017 *	0.000	0.000	0.000	.721	0.000	0.001	0.000	< .001 ***	1.38
Under 200% FPL (%)	0.000	0.001	0.000	.006 **	0.000	0.001	0.000	< .001 ***	-0.000	-0.000	0.000	.569	2.05
Unemployment (%)	-0.000	-0.000	0.000	.274	-0.000	-0.001	0.000	< .001 ***	0.000	0.001	0.000	< .001 ***	1.38
Households with no vehicle (%)	-0.000	-0.000	0.000	.765	0.000	0.001	0.000	.090	-0.000	-0.001	0.000	< .001 ***	1.10
Crowded housing (%)	-0.000	-0.000	0.000	.007 **	-0.000	-0.000	0.000	.760	-0.000	-0.000	0.000	< .001 ***	1.01
Audiology training program	0.000	0.001	0.001	.200	0.000	0.000	0.001	.624	0.000	0.002	0.000	< .001	1.03

*Note: BS = bachelor's degree; EHC HCPs = ear and hearing care healthcare providers; FPL = federal poverty level; HIS = hearing instrument specialist; HS = high school; IQR = interquartile range; SE = standard error; USD = United States Dollars; VIF = variance inflation factor. * = p under .05, ** = p under .01, *** = p under .001.*

Hypothesis 2a: Ear and Hearing Care Providers

For EHC HCPs, the LME results supported hypothesis 2a. In the combined models with both audiologists and HISs, as tracts became 1 Rural-Urban Commuting Area unit more rural, two-step floating catchment area decreased by .05, indicating poorer spatial accessibility as rurality increased (b = -0.05, p < .001; Table 4, Model 1). Among the predictors, rurality was most strongly associated with two-step floating catchment area measured by standardized coefficient (β = -0.02; Table 4, Model 1).

Hypothesis 2a: Audiologists

For audiologists, the LME results strongly supported hypothesis 2a. In the fully adjusted model, as tracts became one Rural-Urban Commuting Area unit more rural, two-step floating catchment area decreased by .04, indicating poorer spatial accessibility as rurality increased (b = -0.04, p < .001; Table 4, Model 2). In the audiologist models, rurality had the largest standardized estimate, indicating that rurality was the most influential predictor of audiologist spatial accessibility (β = -0.02; Table 4, Model 2). Audiologist results are most similar to EHC HCP results, suggesting that audiologist siting is driving trends in the all EHC HCP model (Table 4, Models 1 and 2).

Hypothesis 2a: Hearing Instrument Specialists

For HISs, the LME results supported hypothesis 2a. In the fully adjusted HIS model, as tracts became 1 Rural-Urban Commuting Area unit more rural, two-step floating catchment area decreased by .01, indicating poorer spatial accessibility as rurality increased (b = -0.01, p < .001; Table 4, Model 3).

Hypothesis 2b: Socioeconomic Status Results

Presented in Table 4 are tests of the hypothesis (Hypothesis 2b) that spatial accessibility of EHC HCPs would be lower in communities with relatively lower SES. Patterns depended on both the provider type and the specific socioeconomic indicator included. Overall, the results suggested that audiologist special accessibility was generally higher in communities with greater SES across measures, whereas HIS accessibility followed a more complex pattern that did not align consistently with a single socioeconomic gradient (Table 4).

Hypothesis 2b: Ear and Hearing Care Providers

For all EHC HCPs, the results generally supported hypothesis 2b. In the fully adjusted 60-minute EHC HCP model, spatial accessibility was statistically significantly higher in higher SES census tracts on most measures, and significantly higher in lower SES tracts on fewer measures. The independent variables indicating greater EHC HCP presence in higher SES communities included median rent where an increase of 1 USD corresponded to a 0.0002 increase in two-step floating catchment area (b = 0.0002, p < .001), bachelor degree completion where an increase of 1 percentage point resulted in an increase in two-step floating catchment area of 0.0005 (b = 0.0005, p < .001), health insurance coverage where an increase of 1 percentage point resulted in an increase in two-step floating catchment area of 0.0003 (b = 0.0003, p = .017), and crowded housing where a decrease of 1 percentage point resulted in an increase in two-step floating catchment area of 0.00002 (b = -0.00002, p = .007; Table 4, Model 1).

The independent variables indicating greater EHC HCP presence in lower SES communities included median income where an increase of 1 USD corresponded to a 0.000001 increase in two-step floating catchment area (b = -0.000001, p = .010), and high school

completion where 1 percentage point resulted in a decrease in two-step floating catchment area of 0.0004 (b = 0.0004, p < .001; Model 1). Households with no vehicle (b = -0.00003, p = .30) and unemployment (b = -0.00014, p = .27; Table 4, Model 1) were not statistically significantly associated with EHC HCP two-step floating catchment area. Taken together, these findings suggest that EHC HCPs are generally more accessible in more affluent communities for most measures of SES, and that some measures of SES have the opposite relationship to ear and hearing care provider spatial accessibility.

Hypothesis 2b: Audiologists

For audiologists, the results partially supported hypothesis 2b. In the fully adjusted audiologist model, spatial accessibility was statistically significantly higher in higher SES census tracts on some measures, and significantly higher in lower SES tracts on other measures. The independent variables indicating greater audiologist presence in higher SES communities included median rent where an increase of 1 USD corresponded to a 0.00001 increase in two-step floating catchment area (b = 0.00001, p < .001), bachelor degree completion where an increase of 1 percentage point resulted in an increase in two-step floating catchment area of 0.0004 (b = 0.0004, p < .001), and unemployment where a decrease of 1 percentage point resulted in an increase in two-step floating catchment area of 0.0003 (b = -0.0003, p < .001; Table 4, Model 2).

Three measures of SES showed the opposite relationship, with median income showing an increase of 1 USD corresponding to a 0.000001 decrease in two-step floating catchment area and an increase of 1,000 USD corresponded to a 0.001 decrease in two-step floating catchment area (b = 0.000001, p < .001), high school completion where an increase of 1 percentage point resulted in a decrease in two-step floating catchment area of 0.0004 (b = -0.0004, p < .001), and

percent below 200% FPL where an increase of 1 percentage point resulted in an increase in two-step floating catchment area of 0.0002 (b = 0.00023, p < .001; Table 4, Model 2). Health insurance coverage (b = 0.00003, p = .36), households with no vehicle (b = 0.0001, p = .09), and crowded housing (b = 0.000001, p = .76; Table 4, Model 2) were not significantly associated with audiologist 2SFCA.

Only some SES variables had positive associations with audiologist two-step floating catchment area, partially supporting hypothesis 2b. Audiologist results are most similar to EHC HCP results, suggesting that audiologist siting is driving trends in the all EHC HCP model (Table 4, Models 1 and 2). Taken together, these findings suggest that audiologists are generally more accessible in more affluent communities when measured by rent price, college education, and unemployment, and that other measures of SES have the opposite relationship or are not significantly related to audiologist spatial accessibility.

Hypothesis 2b: Hearing Instrument Specialists

For HISs, the results partially supported hypothesis 2b. In the fully adjusted 60-minute HIS model, spatial accessibility was statistically significantly higher in lower SES census tracts on the measure most strongly associated with HIS two-step floating catchment area. For other measures, HIS spatial accessibility had either a positive or negative association depending on the measure.

The independent variables indicating greater HIS presence in higher SES communities included rent price where an increase of 1 USD resulted in an increase in two-step floating catchment area of 0.00001 (b = 0.00001, p < .001), bachelor's degree completion where 1 percentage point resulted in an increase in two-step floating catchment area of .0001 (b = 0.0001, p = .01), health insurance coverage where 1 percentage point resulted in an increase in two-step

floating catchment area of 0.003 (b = 0.0032, p < .001), households with no vehicle where 1 percentage point resulted in a decrease in two-step floating catchment area of 0.0002 (b = -0.0002, p < .001), and crowded housing where 1 percentage point resulted in a decrease in two-step floating catchment area of 0.0001 (b = -0.0001, p = .005; Table 4, Model 3).

The independent variables indicating greater HIS presence in lower SES communities included high school completion where 1 percentage point resulted in a decrease in two-step floating catchment area of 0.0004 (b = 0.0004, p < .001) and unemployment rate where 1 percentage point resulted in a decrease in two-step floating catchment area of 0.0002 (b = 0.0002, p < .001; Table 4, Model 3). Median income (b = 0.00000, p = .36) and the percentage under 200% federal poverty level (b = -0.00003, p = .57; Table 4, Model 3) were not significantly associated with HIS siting.

Only some SES variables had positive associations with HIS two-step floating catchment area, partially supporting hypothesis 2b. Taken together, these findings suggest that HISs, like audiologists, are generally more accessible in more affluent communities when measured by rent price, college education, and health insurance coverage, and that other measures of SES have the opposite relationship or are not significantly related to HIS spatial accessibility.

Across provider groups, the magnitude of the associations between individual SES measures and EHC HCP spatial accessibility was relatively small. Although many SES coefficients were statistically significant, the standardized coefficients were generally close to zero, indicating that changes in any single SES characteristic corresponded to relatively small differences in spatial accessibility after accounting for the other variables in the models and spatial dependence among neighboring census tracts. For EHC HCPs, audiologists, and HISs the standardized associations for individual SES measures were relatively small. The results provide

evidence that EHC HCP spatial accessibility varies along multiple dimensions of community SES, but no individual SES measure was strongly associated with spatial accessibility on its own. The statistical significance of many of these estimates should be interpreted alongside their relatively modest magnitude.

Hypothesis 2c: Audiologist vs. Hearing Instrument Specialist Siting Results

Presented in Table 4 are tests of the hypothesis (Hypothesis 2c) that spatial accessibility of audiologists and HISs would show distinct patterns. Overall, the results supported the hypothesis, with differences in the direction and magnitude of the relationships between rurality and SES with two-step floating catchment area values between provider groups (Table 4).

In the fully adjusted audiologist model, rurality was the independent variable most strongly associated with audiologist two-step floating catchment area resulting in a decrease in two-step floating catchment area of 0.04 as Rural-Urban Commuting Area increased by 1 unit, indicating poorer spatial accessibility as rurality increased (b = -0.04, p < .001; Table 4, Model 2). In contrast, HIS siting showed a weaker negative relationship with rurality, with two-step floating catchment area decreasing by only 0.01 with every increase in Rural-Urban Commuting Area (b = -0.01, p < .001; Table 4, Model 3).

Siting patterns between audiologists and HISs show different patterns depending on the SES measures evaluated. Though income and percent under 200% FPL were significantly related to audiologist location, neither were significantly related to HIS siting (Table 4, Models 2 and 3). Similarly, health insurance coverage, households with no vehicle, and crowded housing significantly predicted HIS but not audiologist siting (Table 4, Models 2 and 3). Both professions had mixed results around being present in more affluent communities, with some measures of SES suggesting greater HCP presence in more affluent communities and other measures of SES

suggesting the opposite. Taken together, these findings suggest that audiologists were more accessible in relatively urban communities while HISs are found relatively more often in rural communities compared to audiologists.

Other Analyses

Model Fit Results for Two-Step Floating Catchment Area Models

Among models 1 to 3 corresponding to results for EHC HCPs, audiologists, and HISs, respectively the HIS model showed the best model fit (Table 5, Model 3). Models 1 to 3 showed superior model fit measured by AIC and log-likelihood compared to models using 30-minute distance thresholds (data not shown).

Table 5, LME Model Fit Statistics for 60 Minute Two-Step Floating Catchment Area with All Rurality and SES Measures, 2017-2023

Model	Satterthwaite F	df	AIC	LL
Model 1, EHC HCPs	1588654.34	16, 192333.32	-541332.85	270686.42
Model 2, Audiologists	1287761.20	16, 193945.19	-745239.66	372639.83
Model 3, HISs	1894797.37	16, 193403.30	-975920.84	487980.42

Note: AIC = Akaike information criterion; df = degrees of freedom; LL = log-likelihood; EHC HCP = ear and hearing care healthcare providers; HIS = hearing instrument specialist.

Sensitivity Analyses with 5-Year ACS Data

Results using 5-year census tract-level ACS estimates were generally consistent with the primary models using 1-year county-level ACS estimates, particularly for rurality and the socioeconomic measures most consistently associated with audiologist spatial accessibility (Table 6). Rurality remained negatively associated with spatial accessibility in all three models (p's < .001; Table 6, Models 1 - 3), and median rent and high school completion also remained statistically significant predictors of EHC HCP, audiologist, and HIS spatial accessibility. Bachelor's degree completion remained positively associated with EHC HCP and audiologist

spatial accessibility (p's < .001), but was no longer associated with HIS spatial accessibility (p = .939; Table 6, Models 1 - 3). For audiologists, median income, median rent, high school completion, bachelor's degree completion, population under 200% of the federal poverty level, and unemployment remained statistically significant in both analyses (Table 6, Model 2). Health insurance coverage and crowded housing remained nonsignificant, while households with no vehicle changed from nonsignificant in the 1-year model (p = .090) to positively associated with audiologist spatial accessibility in the 5-year model (p < .001; Table 6, Model 2).

Several differences were present between the 1-year and 5-year results for the combined EHC HCP and HIS models. For EHC HCPs, median income, health insurance coverage, population under 200% of the federal poverty level, and crowded housing were statistically significant using 1-year estimates but were not significant using 5-year estimates (Table 6, Model 1). In contrast, unemployment and households with no vehicle were not significant in the 1-year model but became significant using 5-year estimates (Table 6, Model 1). Median income also changed from a small negative relationship in the 1-year EHC HCP model to a small positive relationship in the 5-year model, although the latter was not statistically significant (Table 6, Model 1). Differences were more pronounced for HISs: bachelor's degree completion, health insurance coverage, unemployment, households with no vehicle, and crowded housing were statistically significant using 1-year estimates but were not significant using 5-year estimates, while high school completion and median rent remained significant (Table 6, Model 3). No predictors that were nonsignificant in the 1-year HIS model became significant using 5-year estimates. Taken together, the 5-year census tract-level analyses support the primary finding that rurality and several measures of SES are associated with EHC HCP spatial accessibility,

particularly for audiologists, and that some SES relationships are sensitive to the geographic and temporal resolution of the ACS estimates used.

Table 6, LME Model Overall Results for 60 Minute Two-Step Floating Catchment Area with All Rurality and SES Measures using 5-Year Census Tract SES Data, 2017-2023

	Model 1, EHC HCPs				Model 2, Audiologists				Model 3, HISs			
Variable	***b***	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**
Intercept	0.25	-0.01	0.01	< .001	0.21	-0.01	0.01	< .001	0.03	0.000	0.01	< .001
Rurality	-0.06	-0.05	0.001	< .001 ***	-0.05	-0.04	0.001	< .001 ***	-0.02	-0.03	0.001	< .001 ***
Median income (USD)	0.000	0.001	0.000	.062	0.000	0.001	0.000	< .001 ***	0.000	0.000	0.000	.314
Median rent (USD)	0.000	0.002	0.000	< .001 ***	0.000	0.002	0.000	< .001 ***	0.000	0.002	0.000	< .001 ***
HS completion (%)	-0.000	-0.001	0.000	< .001 ***	-0.000	-0.001	0.000	< .001 ***	-0.000	-0.001	0.000	.020 *
BS completion (%)	0.000	0.002	0.000	< .001 ***	0.000	0.002	0.000	< .001 ***	-0.000	-0.000	0.000	.939
Health insurance coverage (%)	0.000	0.000	0.000	.334	0.000	0.000	0.000	.330	0.000	0.000	0.000	.365
Under 200% FPL (%)	0.000	0.000	0.000	.165	0.000	0.001	0.000	.003 **	-0.000	-0.000	0.000	.840
Unemployment (%)	-0.000	-0.001	0.000	.002 **	-0.000	-0.001	0.000	< .001 ***	-0.000	-0.000	0.000	.227
Households with no vehicle (%)	0.000	0.001	0.000	.003 **	0.000	0.001	0.000	< .001 ***	0.000	0.000	0.000	.475
Crowded housing (%)	-0.000	-0.000	0.000	.075	-0.000	-0.000	0.000	.300	-0.000	-0.000	0.000	.182
Audiology training program	0.000	0.01	0.001	< .001	0.000	0.01	0.001	< .001	0.000	0.01	0.001	< .001

*Note: BS = bachelor's degree; EHC HCPs = ear and hearing care healthcare providers; FPL = federal poverty level; HIS = hearing instrument specialist; HS = high school; IQR = interquartile range; SE = standard error; USD = United States Dollars. * = p under .05, ** = p under .01, *** = p under .001.*

Subperiod Analyses

Results from the 2017–2019 and 2021–2023 subperiod analyses were generally consistent with each other and with the primary 2017–2023 models (Tables 7 and 8). Rurality remained negatively associated with spatial accessibility for EHC HCPs, audiologists, and HISs in both subperiods (p's < .001; Tables 7 and 8), with the magnitude of the association remaining stronger for audiologists than for HISs, consistent with the primary models. Several socioeconomic measures also retained similar directions and statistical significance across the two subperiods, although some smaller associations differed in statistical significance. For example, crowded housing was negatively associated with audiologist spatial accessibility in 2017–2019 (b = -0.000, p = .029; Table 7, Model 1) but was not significantly associated with audiologist spatial accessibility in 2021–2023, consistent with its nonsignificant association in the overall 2017–2023 audiologist model (p = .760; Table 4, Model 2). Taken together, the subperiod analyses did not indicate consistent differences in the patterns of EHC HCP spatial accessibility between the earlier and later study periods.

Table 7, Results for 60 Minute Two-Step Floating Catchment Area with All Rurality and SES Measures, 2017-2019

	Model 1, EHC HCPs				Model 2, Audiologists				Model 3, HISs			
Variable	***b***	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**
Intercept	0.05	-0.000	0.001	.942	0.06	-0.000	0.001	.768	0.000	-0.000	0.000	.522
Rurality	-0.05	-0.03	0.001	< .001 ***	-0.04	-0.03	0.001	< .001 ***	-0.01	-0.01	0.000	< .001 ***
Median income (USD)	-0.000	-0.001	0.000	< .001 ***	-0.000	-0.001	0.000	.035 *	-0.000	-0.002	0.000	< .001 ***
Median rent (USD)	0.000	0.001	0.000	.106	0.000	0.001	0.000	.079	-0.000	-0.000	0.000	.758
HS completion (%)	-0.000	-0.000	0.000	.448	-0.000	-0.000	0.000	.184	-0.000	-0.000	0.000	.848
BS completion (%)	0.001	0.002	0.000	< .001 ***	0.000	0.002	0.000	< .001 ***	0.000	0.002	0.000	< .001 ***
Health insurance coverage (%)	0.000	0.000	0.000	.260	0.000	0.000	0.000	.312	0.000	0.001	0.000	.017 *
Under 200% FPL (%)	0.000	0.000	0.000	.670	0.000	0.000	0.000	.148	-0.000	-0.001	0.000	.095
Unemployment (%)	-0.000	-0.001	0.000	.013 *	-0.000	-0.001	0.000	< .001 ***	0.000	0.000	0.000	.173
Households with no vehicle (%)	0.000	0.001	0.000	.002 **	0.000	0.002	0.000	< .001 ***	0.000	0.000	0.000	.494
Crowded housing (%)	-0.000	-0.000	0.000	< .001	-0.000	-0.000	0.000	.029 *	-0.000	-0.000	0.000	.006 **
Audiology training program	0.000	0.001	0.001	.402	0.000	0.000	0.001	.736	0.000	0.001	0.000	.009

*Note: BS = bachelor's degree; EHC HCPs = ear and hearing care healthcare providers; FPL = federal poverty level; HIS = hearing instrument specialist; HS = high school; IQR = interquartile range; SE = standard error; USD = United States Dollars. * = p under .05, ** = p under .01, *** = p under 001.*

Table 8, Results for 60 Minute Two-Step Floating Catchment Area with All Rurality and SES Measures, 2021-2023

	Model 1, EHC HCPs				Model 2, Audiologists				Model 3, HISs			
Variable	***b***	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**	***b***	***β***	**SE**	***P*-value**
Intercept	0.15	0.000	0.001	.868	0.11	-0.000	0.001	.925	0.04	-0.000	0.000	.857
Rurality	-0.06	-0.03	0.001	< .001 ***	-0.04	-0.03	0.001	< .001 ***	-0.01	-0.01	0.000	< .001 ***
Median income (USD)	0.000	0.000	0.000	.236	0.000	0.000	0.000	.448	0.000	0.000	0.000	.596
Median rent (USD)	-0.000	-0.000	0.000	.262	-0.000	-0.000	0.000	.123	-0.000	-0.000	0.000	.877
HS completion (%)	-0.001	-0.001	0.000	< .001 ***	-0.000	-0.001	0.000	< .001 ***	-0.000	-0.001	0.000	.017 *
BS completion (%)	0.000	0.001	0.000	.018 *	0.000	0.001	0.000	< .001 ***	-0.000	-0.000	0.000	.603
Health insurance coverage (%)	-0.000	-0.000	0.000	.217	-0.000	-0.000	0.000	.149	0.000	0.000	0.000	.203
Under 200% FPL (%)	0.000	0.000	0.000	.141	0.000	0.001	0.000	.008 **	-0.000	-0.000	0.000	.165
Unemployment (%)	-0.000	-0.000	0.000	.297	-0.000	-0.000	0.000	.135	0.000	0.000	0.000	.224
Households with no vehicle (%)	0.000	0.001	0.000	.017 *	0.000	0.001	0.000	< .001 ***	-0.000	-0.000	0.000	.237
Crowded housing (%)	-0.000	-0.000	0.000	.290	0.000	0.000	0.000	.034 *	-0.000	-0.000	0.000	< .001 ***
Audiology training program	0.000	0.001	0.001	.258	0.000	0.000	0.001	.835	0.000	0.002	0.000	< .001

*Note: BS = bachelor's degree; EHC HCPs = ear and hearing care healthcare providers; FPL = federal poverty level; HIS = hearing instrument specialist; HS = high school; IQR = interquartile range; SE = standard error; USD = United States Dollars. * = p under .05, ** = p under .01, *** = p under 001.*

Discussion

The purpose of this study was to evaluate how the spatial accessibility of audiologists and hearing instrument specialists in the US varies across community-level rurality and socioeconomic characteristics. There are three key findings from this study. First, in examining the spatial accessibility of EHC HCPs across community rurality, there was clear clustering of EHC HCPs away from rural regions and this patterning was stronger for audiologists compared to HISs, supporting hypothesis 2a which proposed that the spatial accessibility of EHC HCPs would decrease with increasing community rurality. Second, the relationship between community-level SES and EHC HCP spatial accessibility was more complex. Across EHC HCPs overall, audiologists, and HISs, some measures of greater community affluence were associated with greater spatial accessibility, but other measures showed the opposite relationship or were not significantly associated with spatial accessibility. These findings partially support hypothesis 2b, which proposed that community socioeconomic characteristics would be associated with the spatial accessibility of EHC HCPs, with characteristics reflecting greater socioeconomic advantage generally associated with greater spatial accessibility, but do not support a simple socioeconomic gradient where EHC HCPs are consistently more spatially accessible as community affluence increases. Third, in examining differences in siting patterns between audiologists and HISs, hypothesis 2c stated that each class of EHC HCP would show distinct siting patterns, which was supported by differences in the direction and magnitude of associations with rurality and individual measures of SES.

The results of this national-scale analysis provided the strongest support for the first and third hypotheses, and mixed support for the second. For hypothesis 2a, spatial accessibility decreased with increasing community rurality for audiologists, HISs, and EHC HCPs overall,

and the effect of rurality was substantially stronger for audiologists than for HISs. For hypothesis 2b, no single measure of community affluence adequately described the pattern of EHC HCP spatial accessibility. Audiologist accessibility was greater in communities with higher rent, greater bachelor's degree completion, and lower unemployment, but other SES measures showed associations in the opposite direction or no statistically significant relationship. HIS spatial accessibility also varied across measures of SES rather than consistently increasing or decreasing with community affluence. The subperiod analyses supported the stability of these findings, as the primary patterns of EHC HCP spatial accessibility were generally consistent between 2017 – 2019 and 2021 – 2023 and with the overall 2017 – 2023 models, although some smaller socioeconomic associations varied in statistical significance across periods. These findings suggest that the individual socioeconomic characteristics of communities may be more informative for understanding EHC HCP spatial accessibility than treating SES as a single gradient from less to more affluent.

Rurality

Emerging evidence has suggested that audiologist are less common in rural regions of the US when compared to more urban regions (Planey, 2019, 2020; Pudrith et al., 2024; Yimtae et al., 2018). Before this study, however, there was limited evidence to assess if differences by rurality are confounded by other factors such as community SES or training program location, or how EHC HCPs other than audiologists (i.e., hearing instrument specialists) spatial patterning varies along a rurality gradient. The results of this study show confirm the findings of other studies that were more limited in geographic scope or that relied on cross-sectional data: audiologists are less common in rural communities consistently over time independently of community affluence and the proximity to training program location (Krause, 2014; Planey,

2020; Pudrith et al., 2024). In addition, these findings suggest that HISs, unlike audiologists, do not follow the same rurality gradient identified among audiologists, providing important nuance on EHC HCP spatial accessibility and clearly showing the need for EHC HCP workforce research to include HISs, not just audiologists, to fully account for EHC HCP spatial accessibility.

Community Socioeconomic Status

Some evidence suggests that audiologists are less common in communities with lower SES, though like with rurality, studies in this topic area are often conducted for specific communities and regions or for specific subtypes of hearing loss treatment, leaving open questions about national patterning (Cheung et al., 2023; A. G. Davis et al., 2023; Malcolm et al., 2022). The findings from this study provide a more nuanced view of the relationship between community SES and EHC HCP spatial accessibility. Rather than identifying a consistent gradient in which EHC HCPs were increasingly accessible as community affluence increased, the direction and statistical significance of these relationships depended on both the specific measure of SES and the type of EHC HCP evaluated. This pattern of significantly associated predictors is important because the individual SES measures evaluated in this study characterize different dimensions of community socioeconomic context and their associations should not be interpreted as interchangeable evidence that providers are located in either higher- or lower-SES communities.

Median income and poverty represent related but distinct measures of the financial resources available within communities, and neither produced evidence of a simple relationship between community financial resources and EHC HCP spatial accessibility. Higher median income was associated with lower audiologist spatial accessibility, while the proportion of the

population under 200% of the federal poverty level was associated with greater audiologist accessibility. Neither measure was significantly associated with HIS accessibility. These findings run counter to the expectation that EHC HCPs, and audiologists in particular, would simply be more accessible where residents have greater financial resources available to purchase healthcare. The nonsignificant HIS findings are also important because they suggest that neither the resources of the typical household, represented by median income, or the concentration of residents experiencing substantial economic constraint, represented by the population under 200% of the federal poverty level, independently distinguished communities with greater HIS spatial accessibility. Income and poverty do not appear to neatly characterize the community conditions associated with the spatial accessibility of either type of EHC HCP when considered alongside the other socioeconomic and geographic characteristics included in these models.

The education measures demonstrate why individual SES indicators should not be treated as interchangeable. Greater bachelor's degree completion was associated with greater spatial accessibility to both audiologists and HISs, while greater high school completion was associated with lower spatial accessibility to both professions. These measures characterize different portions of the educational distribution. High school completion may distinguish communities experiencing fundamental educational disadvantage, and bachelor's degree completion identifies communities containing more relatively highly educated individuals. The positive association with bachelor's degree completion may identify communities containing professional employment opportunities and other resources associated with highly educated populations. In contrast, the opposite association with high school completion shows that these findings should not be interpreted as evidence that educational attainment generally predicts greater EHC HCP accessibility; the level of educational attainment being measured appears to matter.

Housing measures in the same way appear to represent different community conditions rather than a single dimension of affluence. Higher median rent was associated with greater spatial accessibility to audiologists and HISs. Although higher housing costs can make communities less financially feasible for HCP households, they may also be present in communities with greater population density, employment opportunities, healthcare infrastructure, and other resources important for audiologists' children, spouses, and aging parents. This interpretation is consistent with Aim 1, where audiologists described cost of living as a consideration but also described weighing it against employment opportunities for themselves and their spouses, schools, healthcare, and other community amenities. Crowded housing, in contrast, is more indicative of material or housing disadvantage. Less crowded housing was associated with greater HIS accessibility but was not significantly associated with audiologist accessibility. Taken together, the housing results suggest that the market cost of housing and housing-related material disadvantage capture different features of communities and have different relationships with the two EHC professions.

Employment, insurance coverage, and vehicle access provide additional evidence of profession-specific relationships with community socioeconomic context. Lower unemployment was associated with greater audiologist accessibility, consistent with audiologists being more accessible in communities with stronger employment conditions that may have more resources needed to access EHC services. This may be particularly relevant given the Aim 1 finding that spouse employment could substantially constrain which locations were feasible for audiologists and their households. The direction of the unemployment relationship was different for HISs, however, demonstrating that the same community characteristic may have different relevance to different EHC professions. Health insurance coverage was significantly positively associated

with HIS accessibility but was not associated with audiologist accessibility. Insurance coverage may characterize residents' ability to finance healthcare, but the absence of an audiologist association suggests that it does not function as a general proxy for a community's ability to support all EHC services, perhaps because many EHC services are not covered by common health insurance programs. Similarly, greater vehicle access was associated with greater HIS accessibility but was not significantly associated with audiologist accessibility. Because vehicle access represents both household resources and the transportation environment of a community, its relationship with HIS accessibility may reflect community conditions that are not captured by conventional measures such as income or education.

The nonsignificant findings are also informative. Health insurance coverage, vehicle access, and crowded housing were not significantly associated with audiologist spatial accessibility after accounting for the other characteristics included in the model, while median income and the proportion of the population under 200% of the federal poverty level were not significantly associated with HIS accessibility. These findings suggest that no single measure of economic resources or material disadvantage adequately characterizes where either profession is spatially accessible. This interpretation is reinforced by the 5-year census tract sensitivity analyses. The audiologist relationships were comparatively stable across the two approaches to measuring SES, whereas several HIS relationships, including bachelor’s degree completion, insurance coverage, unemployment, vehicle access, and crowded housing, were no longer significant when SES was measured using the more geographically granular 5-year census tract estimates. Thus, some of the apparent relationships between HIS accessibility and community socioeconomic characteristics should be interpreted cautiously and may be sensitive to the geographic resolution at which community SES is measured.

Taken together, these findings demonstrate the importance of how community SES is operationalized in healthcare workforce research. A community may be relatively advantaged according to one socioeconomic characteristic and relatively disadvantaged according to another, and these characteristics may have different relationships with whether a community is feasible or attractive for different types of EHC HCPs to practice in. The results provide only partial support for the hypothesis that EHC HCP spatial accessibility is lower in less economically advantaged communities and do not support conceptualizing SES as a single continuum. Instead, income, poverty, educational attainment, housing costs and conditions, employment, insurance coverage, and transportation access capture distinct dimensions of community context whose relationships differ across EHC professions. Evaluating these measures separately provides information that would have been obscured by operationalizing SES using a single measure or composite index.

Differences in Audiologist and Hearing Instrument Specialist Siting

The literature on differences in spatial accessibility among different HCPs providing similar healthcare services has largely focused on physicians and midlevel providers such as nurse practitioners, with no published research comparing audiologists and HISs as of the time of writing (Gadbois et al., 2015; McCleery et al., 2016). Existing literature comparing different HCPs in the same discipline has identified that, compared to physicians, nurse practitioners have shorter training periods, lower incomes, and are found in rural regions more often (Barnes et al., 2018; Graves et al., 2016). This study identified a similar trend: compared to audiologists, HISs who have shorter training periods and generally lower incomes are found in rural regions more often. Similarly, nurse practitioners like HISs are often found in relatively lower-SES communities compared to physicians; the same pattern was not clearly visible in this study, with

EHC HCPs appearing to have a complex relationship with community SES depending on precisely which measure of community SES is evaluated (Buerhaus et al., 2015; M. A. Davis et al., 2018). Interestingly, audiologist training program was positively associated with HIS location but not audiologist or EHC HCP location, suggesting that HISs cluster slightly around audiologist training programs; this should be evaluated further in future research.

Theoretical Implications

In addition to implications for EHC healthcare delivery, the results of this study are important for healthcare workforce research. With some exceptions, many analyses evaluating the availability of healthcare services either analyze only a single type of HCP that is assumed to provide these services, or groups all HCPs who provide services of interest into a single population. For example, Health Professional Shortage Areas which tracks the availability of primary care services entirely omits midlevel providers who provide primary services (Bichell, 2024). However, the results of this study agree with other analyses that find differences in the distribution of HCPs in a given discipline by type of HCP (Shah et al., 2017). The results of the current study highlight that different classifications of HCPs who provide similar healthcare services can have very different geospatial siting patterns, possibly because the differential training process and income for each type of HCP have downstream effects on the types of communities these HCPs are willing to live and work in. These results suggest that health workforce research that fails to include all HCPs that provide services of interest or that fails to evaluate differences in outcomes of interest by type of HCP may not observe differences by HCP classification that are important to understand the comprehensive picture of healthcare service availability.

The findings of this study support the social ecological model (SEM) of HCP siting used to frame this dissertation by demonstrating that spatial accessibility is associated with characteristics of the communities in which EHC HCPs live and practice, but that these relationships are not uniform across community characteristics or across professions. Rurality had a consistent negative association with spatial accessibility to audiologists, HISs, and EHC HCPs overall, although this relationship was stronger for audiologists than for HISs. Community SES showed a more complex pattern. Individual measures of education, income, housing, employment, insurance, poverty, and transportation were associated with EHC HCP spatial accessibility in different directions and with different magnitudes, and these relationships also differed between audiologists and HISs. These findings support conceptualizing community context as a collection of related but distinct conditions that may shape HCP siting rather than positioning communities along a single continuum from more to less advantaged.

The differences between audiologists and HISs develop the application of the SEM to HCP siting. Audiologists and HISs provide overlapping EHC services but differ substantially in their education, scope of practice, income, licensure, and employment opportunities. The finding that the same community characteristics were differently associated with spatial accessibility to each profession suggests that influences on HCP siting may be profession-dependent. Rurality, for example, was negatively associated with spatial accessibility for both professions but more strongly for audiologists, while individual socioeconomic characteristics also differed in their relationships with audiologist and HIS spatial accessibility. Community characteristics do not appear to operate independently of the professional context of the HCP being considered. The opportunities and constraints associated with a particular community may have different

relevance for HCPs with different training requirements, occupational opportunities, and scopes of practice.

These findings also complement the individual, interpersonal, and organizational influences identified in Aim 1 and demonstrate how influences across ecological levels may contribute to the geographic distribution observed in Aim 2. Audiologists in Aim 1 described evaluating potential locations through interacting considerations including compensation, spouse employment, family proximity, children's needs, cost of living, and the availability of community resources. The mixed socioeconomic relationships observed in this study are consistent with the complexity that participants in Aim 1 identified. For example, a community characteristic such as higher housing costs may represent an economic constraint while occurring alongside employment opportunities, schools, healthcare services, or other resources that make the same community more feasible for a provider and their household. The SEM provides a framework for understanding why individual community characteristics do not necessarily have uniform relationships with HCP spatial accessibility: community conditions operate within a larger set of occupational, interpersonal, and individual considerations rather than determining provider location independently.

Policy Implications

These findings have several important implications for understanding and planning future hearing healthcare delivery in the US. First, EHC services are less accessible in rural regions, particularly EHC services provided by audiologists. This confirms other studies that have found higher travel times to audiologists for people living in rural communities (Planey, 2019, 2020; Planey et al., 2024; Pudrith et al., 2024). For models of all EHC HCPs, the negative relationship between rurality and spatial accessibility after controlling for other covariates was the second

strongest predictor of hearing healthcare access, mirroring trends in other healthcare disciplines (Costa et al., 2024; Hou et al., 2016). This relationship was largely driven by audiologists, who both outnumber HISs in this sample and have a stronger relationship between rurality and spatial accessibility. For HISs, a weaker negative relationship was observed, suggesting that while HISs are not located in rural communities as often as in urban communities, HISs are generally more available in rural communities than audiologists. The observed relatively greater presence of HISs in rural communities compared to audiologists in rural communities suggests that HISs' shorter training pathways and lack of a need for several years of potentially expensive graduate training may allow HISs to enter markets that are less accessible or less desirable to audiologists.

The dearth of audiologist services in rural areas also suggests that financial incentive programs for HCPs working in underserved areas may expand EHC services in these communities if incentive programs are expanded to include audiologists or HISs. Financial incentives are generally effective in increasing the prevalence of HCPs in underserved areas where their services are needed (Bärnighausen & Bloom, 2009; Goodfellow et al., 2016). Many state and federal financial incentive programs that provide funding or loan repayment for HCPs working in underserved areas such as the National Health Service Corps and Pediatric Specialty Loan Repayment Program exclude audiologists (American Association of Medical Colleges, 2024; Health Resources & Services Administration, n.d.; U.S. Department of Health and Human Services, 2024).

Though these and similar programs in the US regularly include allied HCPs with similar levels of education and scope of practice to audiologists, EHC HCPs are often omitted, perhaps due to the relatively more recent advent of audiology as a healthcare field after World War II compared to allied health disciplines such as psychology or midwifery that have been established

for longer and are included in these and similar incentive programs. Expanding financial incentive programs to audiologists and/or HISs may incentivize audiologists to live and work in communities that otherwise would not be financially feasible for an audiologist to work in due to a relatively smaller population of potential patients.

Future Research

Future research directions based on this work may further elucidate the spatial accessibility of hearing healthcare services and evaluate interventions to improve equitable spatial access to these services. Each type of EHC HCP having unique patterns of associations with measures of rurality and SES in this study suggests that future research evaluating healthcare workforces where HCPs with disparate training and education requirements (e.g., primary care workforce which contains both physicians and midlevel providers) should both include all HCPs providing these services, and should evaluate group differences between different types of HCPs. The role of HISs in providing hearing healthcare services in the US deserves additional attention, as most current research on the availability of hearing healthcare services entirely omits this type of HCP (for example, Pudrith et al., 2024). Questions persist about the cost and quality of care provided by audiologists and HISs; research is needed to evaluate if patient outcomes are similar among each type of HCP, if HISs can provide similar care to audiologists with shorter and cheaper training periods, and other questions that can guide future hearing healthcare delivery in the US.

Future work is also needed to expand our understanding of which aspects of SES are most salient to HCP siting. Only some measures of SES were significantly associated with HCP spatial accessibility in this study, and the direction of the relationship was not consistent for a single HCP group or between different types of HCP. Further work should investigate which

constructs of SES are most closely related to HCP location and evaluate if different measures of SES are important to the siting of different disciplines of HCPs.

Limitations and Strengths

There are several limitations to these analyses that should be addressed. Data accuracy is a known issue for the NPPES and ACS data sources used in this study. Though the NPPES is composed of self-reported information and has documented limitations, CMS verifies that the social security number and business addresses of submissions are valid and requires HCPs to update business address and other information within 30 days of the information changing (Bindman, 2013; Pérez Medina, 2022). In addition, the NPPES remains the most complete data source available on the locations of the allied health providers evaluated in this study. These factors together mean that the NPPES is a reasonable sampling frame for geospatial analyses of HCPs. Likewise, the self-reported nature of the ACS and large margins of error for less populated regions contribute to imprecision in ACS data. Nonetheless, the ACS remains the most complete data source for the covariates evaluated in this study and is generally considered adequate for health services research. High-quality data on hearing loss need by community during the study period is lacking, so EHC need was not incorporated in these models. It is possible that incorporating rates of untreated hearing loss may further clarify how EHC HCPs are spread through communities that need their services, and future research may evaluate this.

An additional limitation concerns the use of NPPES data to identify EHC HCPs and their practice locations. NPPES does not distinguish between providers who are actively practicing and providers who remain registered in the system but are no longer actively providing patient care. The presence of an audiologist or HIS in NPPES does not necessarily indicate that the provider was actively practicing at the listed location during the corresponding study year. This

may result in overestimating the number of practicing EHC HCPs and EHC service spatial accessibility in some communities. If inactive providers are not geographically distributed in the same manner as active providers, this limitation could also affect estimated geographic and socioeconomic patterns in spatial accessibility. The direction and magnitude of this potential bias cannot be determined from the NPPES data used in this study.

An additional limitation is the geographic resolution of the SES measures. Although spatial accessibility and rurality were measured at the census tract level, SES measures were derived from county-level ACS estimates and therefore assigned the same socioeconomic characteristics to all census tracts within a county. Counties can contain substantial socioeconomic heterogeneity, including affluent and economically disadvantaged communities located in close geographic proximity. Assigning a single county-level SES value to these different census tracts obscures within-county socioeconomic variation and may not accurately represent the socioeconomic context immediately surrounding the populations and EHC HCPs represented by each tract. This geographic flattening may have reduced the ability of the models to identify relationships between local socioeconomic conditions and EHC HCP spatial accessibility and could have contributed to the relatively modest associations observed for individual SES measures. Census tract-level SES estimates would provide greater geographic resolution and may reveal socioeconomic gradients in EHC HCP spatial accessibility that cannot be detected using county-level measures, though this data is not currently available in 1-year estimates as of the time of writing.

The values used to calculate 2SFCA values in this study may limit the validity of these results. The 60-minute threshold and 40 mph average speed, for example, are somewhat arbitrary values and it is possible that different values may yield different results. However, similar values

are routinely used in health services research and sensitivity testing not presented here suggests that different values around the chosen values have similar results, suggesting that the values used for these analyses are reasonable for this study.

The aggregation of county-level data to the census tract level may also introduce bias. Because ACS 5-year estimates at the census tract level with overlapping data ranges cannot be meaningfully compared in longitudinal research, 1-year estimates which are provided at the county level, not the census tract level, were used (United States Census Bureau, 2022). Applying a larger unit's values (i.e., counties) to smaller subunits (i.e., census tracts) may mask differences in the smaller unit by smoothing the rurality and SES gradients examined here, reducing the strength of observed effects. Nonetheless, the lack of alternative data sources and large sample sizes used in this study means that this approach remains the most reasonable approach to answer the research question in this study.

Conclusion

This study shows that spatial accessibility to hearing healthcare services varies systematically by rurality and community socioeconomic context in the contiguous United States from 2017–2023. Accessibility is consistently lower in rural areas, and the pattern is especially pronounced for audiologists, while HISs are comparatively more prevalent in rural and lower-income communities. Proximity to audiology training programs is not associated with audiologist accessibility, suggesting that training infrastructure may not meaningfully shape downstream healthcare workforce spatial accessibility. Taken together, the findings indicate that provider siting is a pathway through which geographic and socioeconomic disparities in hearing loss treatment may persist. Policies that expand sustainable rural service delivery such as financial incentives or expanded telehealth authority and reimbursement for EHC HCPs are

likely to be important for improving equitable access, particularly to hearing healthcare services delivered by audiologists.

CHAPTER 4: Social and Policy Factors Influencing Spatial Accessibility of Ear and Hearing Care Healthcare Providers in the United States: A State-Level Longitudinal Analysis

Abstract

Introduction

State-level policies affecting reproductive healthcare and LGBTQ+ rights vary widely across the United States and may influence where healthcare providers choose to live and work. No research has evaluated whether reproductive healthcare or LGBTQ+ state-level policies influence the supply of audiologists, healthcare providers who diagnose and treat hearing loss. Two research questions guide this study: does reproductive healthcare policy influence the supply of audiologists in a state; and does LGBTQ+ policy influence the supply of audiologists in a state?

Methods

I used CMS National Plan and Provider Enumeration System (NPPES) data to construct a state-year panel for the 50 US states and Washington, DC from 2017–2024. I constructed annual reproductive healthcare and LGBTQ+ policy scores from state statutes and other primary documents and included the number of active audiology graduate programs by state-year. Outcomes included the proportion and number of audiologists leaving a state, entering a state, and newly graduating audiologists initially registering in a state. I estimated associations using state-level longitudinal linear mixed-effects models for proportion outcomes and Poisson generalized linear mixed-effects models for count outcomes, lagging covariates by one year. Additional analyses evaluated the direction of interstate movement relative to policy

environments, the influence of individual policies, and pretrends preceding changes in state policy scores.

Results

A one-point increase in the reproductive healthcare policy score was not significantly associated with the proportion of audiologists leaving (b = 0.00, p = .989), entering (b = 0.00, p = .874), or newly graduating audiologists initially registering in a state (b = 0.00, p = .072), or with the corresponding numbers of audiologists leaving (IRR = 1.02, p = .589), entering (IRR = 0.99, p = .825), or newly graduating audiologists initially registering in a state (IRR = 1.04, p = .123. A one-point increase in LGBTQ+ policy score was also not significantly associated with the proportion of audiologists leaving (b = 0.00, p = .406), entering (b = 0.00, p = .528), or newly graduating audiologists initially registering in a state (b = 0.00, p = .426), or with the corresponding numbers of audiologists leaving (IRR = 1.01, p = .696), entering (IRR = 1.03, p = .205), or newly graduating audiologists initially registering in a state (IRR = 1.00, p = .837). Descriptive movement analyses did not identify a consistent tendency for audiologists to move toward states with more supportive reproductive healthcare or LGBTQ+ policy environments. Individual policy analyses identified few significant associations without a consistent pattern across policies or outcomes. Pretrend analyses identified significant pre-policy differences across all six outcomes preceding meaningful decreases in reproductive healthcare policy scores and increases in LGBTQ+ policy scores, while five of six outcomes showed no significant pre-policy differences preceding decreases in LGBTQ+ policy scores.

Conclusion

These findings suggest that state reproductive healthcare and LGBTQ+ policy environments were not consistently associated with audiologist movement or where newly

graduating audiologists initially registered to work during the study period. Additional analyses did not identify a consistent pattern of audiologists moving toward more supportive policy environments, while pre-policy differences preceding some policy changes limit temporal interpretation of these relationships. These findings suggest that state policy represents one influence within a broader set of individual, interpersonal, organizational, and community conditions that shape where audiologists are willing and able to practice.

Chapter 4 Introduction

In recent years, the US faced and continues to experience serious attacks on access to reproductive healthcare services such as abortion, and on equal participation in US society for individuals with LGBTQ+ (lesbian, gay, bisexual, transgender, queer, and other gender, sexual, and relational minoritized) identities (Garrison & Cunningham, 2024; Roth & Lee, 2023). People who can become pregnant have lost access to many essential healthcare services in certain states since the 2022 Supreme Court decision in *Dobbs v. Jackson Women's Health Organization* allowed individual states to enact policies restricting or banning reproductive healthcare services (Zhu et al., 2024). State-level policy efforts also limit full participation of LGBTQ+ individuals in many areas of US society by restricting nondiscrimination protections, legal recognition, and access to healthcare services for people with these identities (Garrison & Cunningham, 2024; Goldenberg, Reisner, et al., 2020). The purpose of this study is to investigate the influence of state-level reproductive healthcare and LGBTQ+ policies on the subsequent state-level supply of audiologists, essential hearing healthcare providers.

Emerging evidence suggests that state-level policies on socially contentious topics such as reproductive healthcare may have downstream consequences for the number of healthcare workers present in a state. A steadily growing body of research has found that healthcare providers (HCPs) often selectively study in, move to, and register to work in states with policies that align with their preferences. Researchers have identified this trend in HCPs whose work these policies immediately and obviously affect, such as OB/GYN (obstetrics and gynecology) physicians who prefer states with fewer restrictions on abortion services (Chatterji et al., 2024). Perhaps more surprising, HCPs and HCP students across disciplines whose work is less likely to be personally impeded by reproductive healthcare policy also prefer less restrictive policy

environments, potentially because HCPs across disciplines value their family having access to reproductive healthcare services and/or because HCPs view policy prohibiting best practice evidence-based medicine as unethical (Bernstein et al., 2023; Chatterji et al., 2024; Hammoud et al., 2024; Mermin-Bunnell et al., 2023; Orgera & Grover, 2024; Peters et al., 2023; Traub et al., 2022). Most research to date has focused on the impact of reproductive healthcare policy on physicians and medical students across disciplines, so it remains unclear how other classes of HCP and other publicly controversial policy areas influence HCP supply at a state level. The research presented here extends the literature on social state-level policy influencing HCP supply to a previously unexamined population of HCPs, audiologists, and an underexplored policy area, LGBTQ+ policy. This longitudinal, state-level study investigates how reproductive healthcare and LGBTQ+ policies influence the number of audiologists in a state.

Reproductive Health Policy

The literature on reproductive healthcare policy and healthcare workforces has grown a great deal in recent years as policymakers, media, and activists have engaged with these policies. Policy in this area typically focuses on abortion timing, methods, and insurance coverage, and is tracked by several independent, nonprofit organizations such as the Kaiser Family Foundation and Guttmacher Institute (Guttmacher Institute, 2026a; Kaiser Family Foundation, 2026). Reproductive healthcare policies, however, often encounter popular and legal resistance, and are heterogenous between states. As an example of the highly variable nature of reproductive healthcare policies between states, at the time of writing, bans currently exist prohibiting abortion after 6 weeks since last LMP (last menstrual period) (e.g., South Carolina), 12 weeks (e.g., North Carolina), 15 weeks (e.g., Arizona), 18 weeks (e.g., Utah), 22 weeks (e.g., Wisconsin), 24 weeks (e.g., Pennsylvania), ‘fetal viability’ (e.g., Maine), or no restriction at all

exists (e.g., Maryland) (Kaiser Family Foundation, 2026). The reproductive policy landscape is further complicated by the 2022 *Dobbs* decision, which removed a nationwide minimum level of access to certain reproductive healthcare services and permitted individual states to limit abortion care more strictly than previously permitted. Many states had trigger laws set to ban or restrict reproductive healthcare services such as abortion if federal restrictions on these state policies established by the 1973 *Roe v Wade* verdict were ever overturned (Nash & Guarnieri, 2022). These dormant laws, dynamic court challenges and decisions, referendums, and state constitution amendments that affect access to safe essential reproductive healthcare services are, like LGBTQ+ policies, challenging to operationalize in research.

Researchers evaluating different types of HCPs and operationalizing reproductive healthcare policy differently (e.g., including different policies, evaluating single policies or creating policy indices, etc.; Filippi et al., 2021) have consistently found that greater reproductive healthcare policy restrictions in a state reduce the number of medical students and medical residents across disciplines (Chatterji et al., 2024; Levy et al., 2025; Mermin-Bunnell et al., 2023). Recent evidence suggests that the relationship between reproductive healthcare policy and HCP geographic preferences may differ across specialties. Residency applications across medical and surgical specialties before and after the Dobbs decision decreased to programs in states that enacted new or intensified abortion restrictions compared to states without these restrictions (Ganguly et al., 2026). These differences were greater among abortion-related specialties, including obstetrics and gynecology, family medicine, internal medicine, and emergency medicine, which may diagnose pregnancy and provide abortion care, and smaller among other specialties. These findings suggest that the influence of reproductive healthcare

policy on where HCPs locate may influence HCPs that do not directly interface with reproductive healthcare services less strongly.

LGBTQ+ Policy

In contrast to reproductive healthcare policy, the landscape of research on the impact of state-level LGBTQ+ policy on HCP siting is sparser. Several factors make assessing the influence of LGBTQ+ policies on HCP supply challenging. Many people with LGBTQ+ identities attempt to conceal their identities, particularly when participation in a survey or research study may reveal their identity and lead to subsequent prejudice or discrimination in their communities (McCann & Brown, 2019; The Fenway Institute, 2016; Velasco et al., 2022). Researchers face additional challenges because many individual policy areas specifically affect LGBTQ+ individuals, from insurance coverage for transgender healthcare, religious exemptions permitting explicit discrimination against LGBTQ+ individuals, and nondiscrimination policies protecting LGBTQ+ individuals and families (ACLU, 2024; Movement Advancement Project, 2026c). Finally, the rapidly changing legal landscape in many states requires constant, careful tracking of statutes, regulations, and judicial decisions in every state to create an accurate picture of these policies.

The socially stigmatized nature of LGBTQ+ identities in contemporary US society makes accurate measurement of the prevalence of these identities methodologically challenging, but most estimates converge on around 10% of the population of the United States identifying as LGBTQ+, with about 10% of those (about 1% of the general population) identifying as transgender (Boyon, 2023). The specific terms used by LGBTQ+ individuals to refer to themselves can change rapidly, so for the purposes of this study the term LGBTQ+ is used as a

catch-all term for all individuals who identify as having a minoritized gender, sexual, or relationship identity.

When considering LGBTQ+ identities, dozens of individual policy areas are specifically relevant to or target this group, creating difficulty operationalizing policy in a research context for cross-state analyses. This difficulty comparing policies across states may be one reason for a dearth of published research on how LGBTQ+ policies across states influence HCP siting. Organizations such as the Movement Advancement Project, a nonprofit independent think tank, illustrates the complex policy landscape in their reports on over 50 unique policy areas across seven LGBTQ+ related domains: LGBTQ+ youth, relationship and parental recognition, healthcare, nondiscrimination, criminal justice, religious exemptions, and identity documents (Movement Advancement Project, 2026c). Another layer of complexity emerges from the heterogenous approach that individual states take to limit or preserve LGBTQ+ rights across these domains, which creates further difficulty consistently operationalizing LGBTQ+ policy across states for national-level research. For example, differences between state restrictions on LGBTQ+ rights are clearly visible in religious exemption laws, where unequal treatment of individuals with LGBTQ+ identities is justified as an important religious practice that would be violated by requiring equal treatment of people with and without LGBTQ+ rights. In the realm of policies allowing the refusal of service or other discrimination against LGBTQ+ individuals based on the religion of the individual providing a service, some states have broad exceptions across workforces while other states have specific exemptions for HCPs, businesses, state and local government employees who marry couples, or other exceptions (Movement Advancement Project, 2026b). Michigan, as one example, has religious exemption policies that apply only to agencies that are licensed by the state of Michigan and do not receive state funding, while

Tennessee initially included only specific HCPs in its policies before later expanding them to most HCPs licensed in the state of Tennessee (Movement Advancement Project, 2026b). The heterogenous foci and scope of state-level policies on LGBTQ+ inclusion makes comparisons across states methodologically challenging; perhaps this helps explain why relatively little research evaluating the impact of LGBTQ+ policies on HCP state-level supply currently exists.

Finally, the dynamic nature of LGBTQ+ policy makes this a challenging research area. Most LGBTQ+ policies originate in each state's legislature, though the socially contentious nature of these policies regularly results in court challenges, judicial stays, and partial injunctions that block all or part of these policies. Arkansas, for example, passed a transgender youth medical care ban prohibiting HCPs from providing gold standard evidence-based transition care to gender diverse youth in 2021 that a court blocked in 2023 until an appeal, which remains ongoing at the time of writing, is resolved; this resulted in transition care for youth being legally permissible in Arkansas at the moment but created uncertainty as to if these healthcare services would remain legal in the future (Movement Advancement Project, 2026a). Indiana passed a similar law in 2023, but a court blocked portions of the law that applied to medications and assisting youth to receive this care in 2023 before a later decision removed that block in 2024 allowing the policy to be enacted in full (Movement Advancement Project, 2026a). Tracking and interpreting when policies are passed, when courts enact or stay them wholly or in part, and comparing the specific provisions across states remains a substantial challenge. Difficulty comparing LGBTQ+ policies across states may at least partially explain why the impact of proposed, enacted, or judicially blocked state-level LGBTQ+ policies on HCP location and relocation intention is almost entirely absent from the literature.

Hearing Healthcare Providers

The sociodemographic composition of the profession of clinical audiology suggests that state reproductive healthcare and LGBTQ+ policy may influence these HCP's preferred state of residence. Hearing healthcare is a significantly segregated profession, with audiologists being almost exclusively cisgender, white English-speaking women (American Speech-Language-Hearing Association, 2023). Although scholarship has not yet examined how sociodemographic characteristics of audiologists is related to their siting in the US, research has shown that the sociodemographic characteristics of highly educated HCPs influence where these professionals choose to live and work (B. F. Miller et al., 2014; Naik et al., 2024; Noah, 2023; Peters et al., 2023). This preference is particularly acute for HCPs who identify as women, which includes most audiologists (Hammoud et al., 2024; Mermin-Bunnell et al., 2023; Orgera & Grover, 2024).

Though hearing loss can be caused by a diverse set of etiologies, most hearing loss is incurable. The gold-standard treatment for incurable hearing loss is hearing aids or other hearing prosthetics prescribed and dispensed by audiologists (Cassel et al., 2016; Tran et al., 2024; Vos et al., 2015). Licensed audiologists are nonmedical allied health HCPs who diagnose and nonmedically treat hearing loss and balance disorders (McNeal, 2016). Because of the nature of the testing and treatment for hearing loss, patients nearly always receive hearing healthcare through in-person clinics that they must personally visit (Jilla et al., 2021). Access to audiologists is essential for most people to receive appropriate hearing healthcare services. Audiologists, however, are not equally distributed throughout the US. Prior work at the census block and county level has identified several factors such as area-level socioeconomic status (SES) indicators or the distance from audiology graduate training programs that are significantly

related to HCP siting (Planey, 2020; Pudrith et al., 2024). To date, little research has investigated state-level supply of these essential HCPs in the context of state policy.

Although there is no research evaluating how reproductive healthcare or LGBTQ+ policy influences audiologist location, some evidence evaluating the influence of these policies on other populations suggests that audiologist state-level supply may be influenced by reproductive healthcare or LGBTQ+ policy. Though there is substantial variation in each group, LGBTQ+ people and women are typically more tolerant of people with LGBTQ+ identities, and are more likely to prefer living in a region with inclusive reproductive healthcare and LGBTQ+ policies when compared to non-LGBTQ+ individuals and men, respectively (A. D. Fisher et al., 2017; Grant et al., 2018; Noah, 2023; Suen, 2021; Suen & Chan, 2021). These state-level policies influence migration among the general population of LGBTQ+ individuals, with upticks in interstate migration among LGBTQ+ individuals occurring within one year of these policies being passed, though research has not specifically evaluated migration among HCPs (Marcén & Morales, 2022). In addition, women are about twice as likely to identify as LGBTQ+ themselves and are more likely to support greater inclusion of LGBTQ+ individuals when compared to men, suggesting that female-dominant healthcare fields such as audiology are more likely to be influenced by LGBTQ+ policy preferences in the siting of healthcare providers than disciplines with a smaller proportion of women (A. D. Fisher et al., 2017; Greenburg & Gaia, 2019; Jones, 2024; Worthen, 2016). The available literature on non-HCP interstate migration suggests that, if audiologists' siting is influenced by social policies such as reproductive healthcare or LGBTQ+ policies, then movement will likely happen within about a year of the policy's implementation, allowing comparing policy data to HCP locations from the following year to evaluate if an effect is present (Beaudin, 2017; Kan, 1999). Because of the gender segregation of the hearing HCP

workforce, reproductive healthcare and LGBTQ+ policies are likely more impactful in the siting of hearing HCPs than other state-level policies.

Other factors also influence the regions where HCPs work. Most HCPs choose to work near the institutions where they received their training, likely because HCPs choose to pursue training at universities that are either near them or in regions where they want to live after graduation (Kristiansen & Førde, 1992; Planey, 2020). There are currently under 100 academic programs certified to train audiologists in the US, and these programs are clustered away from Western and Midwestern states, suggesting that analyses of hearing HCP siting preferences should control for academic program proximity in a region to avoid the confounding effect of academic program proximity (ASHA EdFind, n.d.; Planey, 2020).

Theoretical Framework

The study presented in this chapter was informed by the social ecological model (SEM) of HCP siting introduced in Chapter 1. SEMs conceptualize individuals as embedded within interacting environments of increasingly large scope, often including individual, interpersonal, organizational, community, and policy levels (Bronfenbrenner, 1994; Eriksson et al., 2025; Golden & Earp, 2012). Applied to HCP siting, this framework positions spatial accessibility to healthcare providers as a downstream outcome of conditions that shape where HCPs are willing to live and practice. HCP location may reflect the interaction of occupational and individual priorities with family needs, employment opportunities, characteristics of communities, and broader policy contexts (Chatterji et al., 2024; Goddard et al., 2010; Levy et al., 2025).

This study focuses specifically on the policy level of this framework by evaluating state reproductive healthcare and LGBTQ+ policy context as potential influences on audiologist siting. State policies may affect the desirability of a location even when they do not directly

regulate the practice of audiology. Reproductive healthcare policies may affect audiologists' access to healthcare for themselves and their families, and LGBTQ+ policies may contribute to whether a state is perceived as supportive or restrictive for LGBTQ+ audiologists and their family members. These policy environments may influence whether audiologists are willing to enter, remain in, or leave a state even though the policies do not directly affect providing EHC services.

The SEM does not assume that policy-level influences operate independently, or that these policies have equal importance for all HCPs. A preferred policy environment may not result in relocation if moving would conflict with employment opportunities, spouse employment, proximity to family, children's needs, cost of living, or other conditions important to an HCP and their household. In the same vein, an audiologist may remain in or move to a state with an undesirable policy environment when occupational, interpersonal, or community conditions make that location more feasible. State policy is conceptualized as one component of the broader ecological context in which geographic decisions occur rather than as an isolated determinant of audiologist location.

Objectives for Aim 3

The overall research question guiding this study is: Do variations in state-level social policies influence a state's supply of audiologists across the US? Two sub questions guided the analyses in this study:

Research Question 3.1: Do restrictive state-level reproductive healthcare policies reduce the local supply of audiologists in its respective state? The specific hypotheses relating to the first research question investigated in this study are:

Hypothesis 3.1a: Audiologists move away from states with restrictive reproductive healthcare policies within 1 year of their adoption;

Hypothesis 3.1b: Audiologists move to states with less restrictive reproductive healthcare policies within 1 year of their adoption; and

Hypothesis 3.1c: Graduating audiologists entering the profession selectively register to work in states with less restrictive reproductive healthcare policies.

Research Question 3.2: Do restrictive state-level LGBTQ+ policies reduce the local supply of audiologists in its respective state? The specific hypotheses relating to the second research question investigated in this study are:

Hypothesis 3.2a: Audiologists move away from states with restrictive LGBTQ+ policies within 1 year of their adoption;

Hypothesis 3.2b: Audiologists move to states with less restrictive LGBTQ+ policies within 1 year of their adoption; and

Hypothesis 3.2c: Graduating audiologists entering the profession selectively register to work in states with less restrictive LGBTQ+ policies.

Methods

This study used a state-level longitudinal observational design to evaluate whether state policy contexts predicted changes in the audiology workforce over time. The dataset built for this study is available to other researchers (Kirjava, 2026). I created a state-year panel for the 50 US states and Washington, DC using the Centers for Medicare & Medicaid Services (CMS) National Plan and Provider Enumeration System (NPPES) files for the years 2016 through 2024 due to earlier data being lost, and no longer archived by CMS. I defined the primary outcomes as annual measures of audiologist supply and movement, including the total number of audiologists in each

state, the number of newly graduating audiologists, and counts of state-to-state migration based on changes in registered practice state between consecutive years. I defined the main exposures as annual state policy scores for reproductive healthcare and LGBTQ+ topics, and I included the number of active audiology graduate programs in each state-year. I estimated associations using state-level longitudinal mixed-effects models selected according to the distribution of each outcome, including Poisson log-link mixed models for provider count outcomes and linear mixed-effects models for continuous outcomes. Models included year fixed effects and state random intercepts, and I lagged covariates by one year so policy and other state characteristics predicted the following year's outcomes. The final analytic sample I used in this study was restricted to the 50 US states and Washington DC, and to the years 2017 to 2024.

All data sources used in this study are freely available. As such, The University of California, Irvine institutional review board determined that full board review of this proposal was not required. HCP location data was from the CMS databases, policy data was initially collected from nonprofit policy trackers and verified by reviewing primary documentation from each state, and audiology program location was from this discipline's certifying body.

Dependent Variables

I accessed HCP information for each year from 2016 to 2024 from the CMS NPPES monthly data downloads (Centers for Medicare & Medicaid Services, 2026). NPPES data files from before mid-2016 were not available from this or other databases, so I downloaded monthly files for every December from 2016 through 2024. I based all year comparisons on December NPPES data, so results for a given year reflected changes that occurred at some point between December of the previous year and December of the listed year.

To calculate the primary outcomes, I reduced the NPPES files to audiologists by selecting only HCP taxonomy codes that corresponded to audiology: “231H00000X”, “231HA2400X”, “231HA2500X”, and “237600000X”. I used each provider’s National Provider Identifier (NPI) to deduplicate and uniquely identify each HCP. I calculated several outcomes for each state and each year. First, I calculated the total number of audiologists in each state-year. Second, I treated individuals who appeared in a given year’s file but not in previous years as graduating audiologists who began providing ear and hearing care (EHC) services for the first time that year. Newly graduating audiologists were identified based on their initial appearance in the NPPES data rather than continued presence in each subsequent year. Providers may be removed from the NPPES registry upon death or if they intentionally deactivate their record, such as after retiring from practice. However, each provider is assigned a unique NPI that is not reused. If an audiologist was present in the data, subsequently absent, and later reappeared, the provider retained the same NPI and was not counted as a newly graduating audiologist a second time. This approach prevented temporary or later absence from the registry from creating an additional new-graduate observation.

I used changes in registered state between year Y and year Y + 1 to calculate movement outcomes: I counted audiologists registered in a state in year Y who registered in another state in year Y + 1 to estimate the number and proportion who left each state, and I counted audiologists registered in a different state in year Y who registered in a given state in year Y + 1 to estimate the number and proportion who moved to each state. Finally, I treated audiologists who appeared in year Y but not in year Y + 1 as retiring audiologists who no longer provided patient care services. HCP data from 2016 was used to identify newly graduating and established audiologists in 2017.

CMS did not permit HCPs to self-report gender codes other than men and women in the NPPES system until 2024, so in this sample NPPES (mis)classified gender diverse audiologists who do not have a binary gender identity, including this author, as either men or women except for a small number of individuals in 2024. Because of this data limitation, I used binary gender categories for all analyses and excluded the four individuals who reported another gender identity in 2024 from the following analyses.

Independent Variables

I calculated reproductive healthcare and LGBTQ+ policy scores using similar methods. I calculated reproductive policy scores by assigning +1 to policies that supported or expanded access to reproductive healthcare and -1 to policies that limited access or created barriers to care. For LGBTQ+ policy, I assigned a value of +1 when a policy item was inclusive, expanded access, preserved rights, or was generally regarded as a positive development for LGBTQ+ people in that state (e.g., gender diverse people could receive a driver's license with an X gender marker). I assigned a value of -1 when a policy item excluded people, reduced rights or access, or otherwise harmed full inclusion of LGBTQ+ people in society (e.g., bathroom bans based on sex assigned at birth). I calculated a score for every state in each year from 2017 to 2024.

I weighted each component policy equally when constructing the reproductive healthcare and LGBTQ+ policy scores. Equal weighting is typically used when constructing policy indices, and there is currently no consensus or clear theoretical basis for determining which individual policies should receive greater or lesser weight when characterizing the overall state policy context (Akré et al., 2025; Brady et al., 2025; Rice et al., 2022). Equal weighting avoids imposing assumptions about the relative importance of individual policies that are not supported by the available evidence. However, an equally weighted index may obscure an association with

an individual policy if some component policies are more consequential to audiologist siting than others. To provide additional context beyond the summary policy scores, I conducted additional analyses using the individual reproductive healthcare and LGBTQ+ policies as predictors to evaluate which component policies showed the strongest associations with audiologist movement and initial registration.

Reproductive Healthcare Policy

I obtained reproductive healthcare policy data for each state and each year of the study period from the Kaiser Family Foundation (KFF) and the Guttmacher Institute. I accessed data on insurance coverage for reproductive healthcare services, ultrasound requirements, and gestational and general limits on abortion services from the KFF reproductive healthcare policy dashboard (Kaiser Family Foundation, 2026). I reviewed the original statute, regulation, or other policy documents for every state and policy topic to verify the KFF data. I accessed additional data on counseling and waiting period requirements before receiving abortion services from the Guttmacher Institute's by-state policy dashboard (Guttmacher Institute, 2026b). I reviewed the original policy documents for every state to verify the Guttmacher Institute data. I constructed a by-state database that listed each state's policy on each topic and the year(s) each policy was enacted, repealed, or modified. I selected each measure that was evaluated in this study because they represented several aspects of access to reproductive healthcare services and barriers to accessing these services and because these policy areas varied between states and changed in many states during the study period.

The reproductive healthcare policies included in this study were selected based on policy domains commonly examined in prior reproductive healthcare research. The diverse measures captured state-level differences in insurance coverage for reproductive healthcare services,

ultrasound requirements, counseling and waiting period requirements, and gestational and general limits on abortion services. These policy areas were selected because prior literature identifies them as important components of state reproductive healthcare policy environments and because policy analyses regularly document substantial differences in these policies between states (Chatterji et al., 2024; Guttmacher Institute, 2026a; Kaiser Family Foundation, 2026; Roth & Lee, 2023; Wängborg et al., 2025). They also provided meaningful longitudinal variation for these analyses because these policies were enacted, repealed, or modified in multiple states during the 2017–2024 study period. Together, these measures of reproductive healthcare policy allowed the reproductive healthcare policy measure to capture policy domains established in prior literature while also focusing on policies with sufficient between-state and within-state variation to evaluate their relationship with changes in audiologist supply over time.

In addition to analyses using the overall reproductive healthcare policy score, I conducted secondary analyses using selected individual reproductive healthcare policies as independent predictors. These analyses included the presence of a mandatory waiting period, a total abortion ban, and a gestational abortion ban occurring in or before the first trimester. I selected these policies a priori from the larger set of reproductive healthcare policies based on prior research suggesting that they represent particularly consequential restrictions on reproductive healthcare access and may be more likely to influence perceptions of a state's reproductive healthcare environment (Berglas et al., 2025; Cornell et al., 2026; Guttmacher Institute, 2016). Mandatory waiting periods can impose additional time and travel requirements on individuals seeking abortion care, while total abortion bans represent the most comprehensive restriction on the availability of abortion services. Gestational bans covering the first trimester can substantially restrict the period during which abortion care is legally available even when abortion is not

prohibited entirely. Examining these policies individually allowed me to evaluate whether specific reproductive healthcare restrictions were associated with audiologist movement or initial registration even if their associations were obscured when combined with less influential policies in the overall reproductive healthcare policy score.

LGBTQ+ Policy

I used a similar approach for the LGBTQ+ state policy data. I used the Movement Advancement Project, a policy analysis think tank focusing on LGBTQ+ and election policy, as the initial source for LGBTQ+ policy data (Movement Advancement Project, 2026c). I reviewed state-specific data, including the years each policy was created, repealed, or modified, using the primary regulatory documents from each state. I reviewed topics that encompassed school-based, healthcare, and nondiscrimination policies, including the availability of X gender markers on official documents; processes for changing gender markers on legal documents; nondiscrimination protections for foster or adoptive parents with LGBTQ+ identities; nondiscrimination in public places or housing based on LGBTQ+ identity; legal definitions of sex as an immutable binary; bathroom bans based on sex assigned at birth; religious exemptions for HCPs, businesses, and marriage services; prohibitions on teaching about LGBTQ+ topics in schools; bans on medical gender transition care; and restrictions on the participation of gender diverse youth in sports.

The LGBTQ+ policies included in this study were selected based on policy domains identified in prior literature. The selected measures captured policies related to identity documents and legal recognition, nondiscrimination protections, religious exemptions permitting discrimination, school-based restrictions, access to gender transition healthcare, bathroom access, and participation of gender diverse youth in sports. These policy areas were selected from

all possible LGBTQ+ policies because prior policy analyses regularly identify them as areas in which states differ substantially and because they represented policies that were enacted, repealed, modified, or affected by judicial decisions during the 2017–2024 study period (Garrison & Cunningham, 2024; Goldenberg, L. Reisner, et al., 2020; Goldenberg, Reisner, et al., 2020; Jackson et al., 2023; Lee et al., 2024). Including policy areas with both between-state differences and within-state changes over time allowed the policy score to characterize meaningful differences in state LGBTQ+ policy environments while also providing longitudinal variation to evaluate whether changes in policy were associated with subsequent changes in audiologist supply.

In addition to analyses using the overall LGBTQ+ policy score, I conducted secondary analyses using selected individual LGBTQ+ policies as independent predictors. These analyses included broad religious exemption laws, public accommodations nondiscrimination laws, and "Don't Say Gay" laws explicitly restricting educators from discussing LGBTQ+ people or issues in schools. I selected these policies from the larger set of LGBTQ+ policies assessed in this dissertation based on prior literature suggesting that they may be particularly impactful in interstate migration as a response to LGBTQ+ policy change (Baumle et al., 2023; Herry & Dyar, 2025; Last et al., 2026; Mann, 2024). Broad religious exemption laws can permit differential treatment of LGBTQ+ individuals across otherwise protected settings, and public accommodations nondiscrimination laws provide protections against discrimination in spaces and services used in everyday life. Laws restricting discussion of LGBTQ+ people or issues in schools may be particularly relevant to HCPs with children because they directly shape the educational and social environments available to their families. Examining these policies individually allowed me to evaluate whether specific dimensions of the LGBTQ+ policy context

were associated with audiologist movement or initial registration even if their associations were obscured when combined with less influential policies in the overall LGBTQ+ policy score.

Covariates

I retrieved audiology graduate training program data from American Speech-Language-Hearing Association (ASHA) EdFind, a database of all audiology graduate training programs in the United States certified by ASHA, the certifying body for this discipline's education programs (ASHA EdFind, n.d.). I created a dataset of all past and current audiology graduate programs, and I treated consortia where several schools partnered to train a single cohort of audiology graduate students as one program. This source also listed expected graduating class sizes for each program, and I added these values to the dataset. I accessed the years that each program was accredited and enrolling students from the ASHA Council on Academic Accreditation online data portal (American Speech-Language-Hearing Association Council on Academic Accreditation, 2024). I recorded the start date and, when applicable, the end date for each program.

To account for the influence of audiology graduate programs on the number of audiologists in a state, I evaluated the number of audiology programs and their average graduating class sizes. I calculated the number of active audiology graduate programs for each state-year by counting the programs in each state that operated during each year of the study period. I summed up the expected number of graduates across programs within each state-year to estimate the total number of audiologists expected to graduate by state in each year.

Most audiology graduate programs operated for the entire study period, with a small number opening or closing in certain years. The programs were distributed unevenly across states, with many states having none and some states having up to seven graduate programs.

Four consortium programs operated during the study period, where several universities participated in a single AuD (doctor of audiology) program with a graduating class size comparable to other single-school programs. All consortium partnerships only included universities in a single state, so I counted each consortium as one program in its state for these analyses.

The graduating class size reported to the program's accrediting body had a mean of 16 in each year of the study period, with a range of 2 to 29. Three programs did not report expected graduating class sizes and two programs reported a range of ± 2 graduates. For these programs, I left their expected graduating class size as missing and used the midpoint as the expected graduating class size, respectively. These uncertainties reduced the accuracy of the graduating-class variable in later analyses.

In models that included both the audiology program count and the expected number of graduates, the variance inflation factor (VIF) exceeded 11 for each of these variables, indicating substantial multicollinearity that could bias the LME results. To reduce multicollinearity and because some programs had missing or imprecise graduating-class data, I dropped the expected number of graduates from further analyses and used the number of audiology programs by state as a proxy for the number of graduating audiologists a state produced.

Other potential covariates such as rurality, socioeconomic status, or population size were not included in these analyses. The results from chapter 2 indicate that audiologists evaluate these factors at a community level, not at a state level, and that state-level context is not routinely evaluated in siting decisions among these HCPs. Given that rurality, SES, and population size and density vary a great deal within individual states and that state level factors are not routinely considered by EHC HCPs, these were not included as covariates in these analyses.

I did not include census tract- or county-level rurality and socioeconomic measures evaluated in Aim 2 as covariates in these analyses because the unit of analysis in this study was the state. Incorporating local community characteristics while preserving their local variation would require a multilevel analytic approach where community-level observations were nested within states, which was outside the scope of these state-level longitudinal analyses. Aggregating these characteristics to the state level, such as by including state median income or unemployment, would not provide an equivalent adjustment because statewide measures obscure within-state variation in the local socioeconomic and geographic environments in which audiologists actually live and practice. This decision was informed by the findings from Aim 1, where audiologists described local cost of living, housing, schools, employment opportunities for spouses, healthcare services, and other community characteristics as relevant to their geographic decisions. These findings suggest that the local context experienced by providers may be more relevant to siting than a statewide summary of socioeconomic conditions. Because of these methodological and theoretical reasons, I limited covariate adjustment in these analyses to variables that could be meaningfully operationalized at the state level and did not include state-level proxies for the more geographically specific community characteristics examined in Aim 2.

Statistical Analyses

I used R version 4.4.2 for statistical analyses, and primarily used the R package lme4 for model building and evaluation (Bates et al., 2026). Before model building, I calculated descriptive statistics, distributions of individual variables, and bivariate correlations between variables of interest.

In all models, I lagged covariates by one year so covariates from year Y predicted outcomes in year Y + 1. The final models that were assessed contained both reproductive

healthcare and LGBTQ+ policy scores to fully explore the influence of one after controlling for the other. I built models using a hierarchical forward fixed-effect procedure to create a sequence of nested models that culminated in a fully adjusted model containing all covariates. For each outcome, I limited the analytic dataset to observations with complete data on year, outcome, and all fixed-effect covariates. I made all modeling decisions (years included, filtering rules, and selection criteria) a priori.

I selected the model family based on the distribution of each dependent variable. For outcomes representing proportions of audiologists entering or leaving a given state, I estimated state-level longitudinal associations between each outcome and a prespecified set of state covariates using linear mixed-effects models (LMEs). Outcomes representing the raw number of audiologists who left a state, entered a state, or newly registered to practice in a state were nonnegative counts and were therefore analyzed using generalized linear mixed-effects models with a Poisson distribution and log link. These models included a state-specific random intercept to account for repeated observations within states across years and year fixed effects to account for temporal differences shared across states.

For the Poisson models, fixed-effect coefficients were estimated on the log scale and exponentiated to produce incidence rate ratios (IRRs) with 95% confidence intervals. I used IRRs for interpretation of the magnitude of associations with the count outcomes. An IRR above 1 indicates a higher expected count of audiologists associated with a one-unit increase in the predictor, while an IRR below 1 indicates a lower expected count, holding the other variables in the model constant. Statistical inference for fixed effects in these models was based on Wald tests rather than Satterthwaite-approximated degrees of freedom and F tests, which were used for the Gaussian linear mixed-effects models. This approach allowed the models for provider counts

to reflect the discrete distribution and range of those outcomes while retaining the longitudinal structure of repeated state observations.

Pretrend Analyses

I conducted additional analyses to evaluate whether changes in audiologist movement preceded changes in state policy environments, which could indicate that observed associations between policy and audiologist movement reflected preexisting relocation trends rather than changes occurring after the policy environment changed. Because the reproductive healthcare and LGBTQ+ policy measures were constructed as indices containing multiple policies that could change independently and by different magnitudes, I used a threshold change of at least 2 points in either direction representing a net change of at least two policies being enacted in a given year in each policy score to identify meaningful changes in the state policy environment and establish the timing of policy events for these analyses. For states with multiple years where the policy change crossed the threshold of 2 points, the largest difference was used, or the earliest if there were ties. This approach allowed states experiencing meaningful changes in their overall policy environments to be compared relative to the timing of those changes rather than treating every one-point fluctuation in a policy index as an equivalent event.

I evaluated pretrends using an event-study specification in which time was defined relative to the year of the identified policy change. The event-study used was:

$$Y_{st} = \alpha_s + \lambda_t + \sum_{k \neq -1} \beta_k (t - T_s = k) + \epsilon_{st}$$

where:

- Y_{st} is the audiologist movement outcome for state s in calendar year t,
- α_s is the state fixed effects, and

- λ_t is the year fixed effects.

Event time $t - T_s = k$ was measured in one-year increments because the underlying data were observed annually, so $k - 1$ represents one year before the policy-change year and served as the omitted reference period, $k = 0$ represents the policy-change year, and $k = 1$ represents one year after the policy-change year. The coefficients β_k estimate differences in the outcome at each available annual event time relative to the year immediately preceding the policy change.

Models included state fixed effects to account for time-invariant differences between states that could be associated with both state policy environments and audiologist movement, such as geographic, cultural, or healthcare workforce characteristics. Models also included year fixed effects to account for temporal changes common across states, including national trends in the audiology workforce or other changes occurring during the study period. Although the primary analyses used mixed-effects models to estimate associations across states while accounting for repeated observations within states, the event-study analyses instead used state and year fixed effects. This was used because the purpose of the event-study analysis was to evaluate within-state changes in audiologist movement relative to the timing of meaningful policy changes, while controlling for time-invariant differences between states and common year-specific changes.

The year immediately preceding the policy change served as the reference period, and indicator variables represented the available years before and after the policy change. This specification allowed changes in audiologist movement before the policy event to be evaluated separately from changes occurring after the event rather than estimating a single association across the full study period. Estimates that differed significantly from the reference period before the policy change indicate that audiologist movement was already changing prior to the change

in policy environment, which would complicate interpretation of an association between movement and policy change. Alternately, pre-policy estimates that did not differ significantly from the reference period were interpreted as an absence of detected evidence of differential pre-policy trends rather than proof that no preexisting differences were present.

I conducted these analyses separately for reproductive healthcare and LGBTQ+ policy and for the audiologist movement outcomes evaluated in the primary analyses. For each available pre-policy event period, I report the event-study estimate and corresponding *p* value to characterize both the direction and statistical evidence for changes in audiologist movement relative to the reference period. Consistent with the approach used in prior state-policy analyses, these estimates were evaluated collectively to determine whether there was evidence that the outcome trajectory systematically changed before the identified policy event (Lipton et al., 2022).

Descriptive Movement Trends

To evaluate whether audiologists who relocated across state lines tended to move toward states with more or less supportive policy environments, I conducted supplementary directional interstate migration analyses. These analyses differed from the primary state-level longitudinal models by considering the origin and destination of each observed interstate move rather than separately modeling the number or proportion of audiologists entering or leaving each state. I created one observation for each audiologist who was registered in one state in year t and a different state in year $t + 1$. For each move, I identified the reproductive healthcare and LGBTQ+ policy index scores of the origin and destination states in year t, allowing the policy environments preceding the observed move to be compared.

For each policy index, I calculated the difference between the destination-state and origin-state policy scores. Because higher scores represented more supportive policy environments, a positive difference represented movement toward a more supportive policy environment, a negative difference represented movement toward a more restrictive policy environment, and a difference of zero represented movement between states with equivalent policy scores. I calculated the number and proportion of interstate moves occurring in each of these three directions separately for reproductive healthcare and LGBTQ+ policy. I also summarized the magnitude of policy differences between origin and destination states using the median, interquartile range, and range of destination-minus-origin policy-score differences. Among moves occurring between states with different policy scores, I used two-sided exact binomial tests to evaluate whether the proportion of moves toward more supportive policy environments differed from 0.50, representing an equal number of moves toward more supportive and more restrictive policy environments.

Finally, I descriptively evaluated the state-to-state pathways underlying these patterns. I identified the most frequent origin and destination states and the most common interstate migration pairs, and compared the reproductive healthcare and LGBTQ+ policy scores of the states within these migration pathways. These analyses were intended to provide additional context regarding whether states experiencing larger numbers of audiologists entering or leaving were contributing disproportionately to movement toward more supportive or restrictive policy environments.

Results

Descriptive Data

Descriptive statistics for this study are presented in Table 9. Each state had an average of over 300 audiologists with a wide range between the states with the most and least audiologists (Table 9). In each state, an average of fewer than 10 audiologists left or moved to the state each year. Each state lost and received a small percentage of that state's total supply of audiologists each year. About 22 newly graduating audiologists entered each state with more entering states with higher populations (data not shown).

Table 9, Descriptive Statistics by State for Dependent and Independent Variables in Longitudinal LME Models, 2017 – 2024

Variable	Mean	SD	Median	IQR	Range
Total Audiologists (*n*)	334.35	332.03	211.00	314.50	1358.00
Audiologists who Leave a Given State (*n*)	8.47	7.19	6.00	12.00	24.00
Audiologists who Leave a Given State (%)	3.10	2.36	2.77	2.50	11.11
Audiologists who Enter a Given State (*n*)	8.47	7.21	6.00	9.00	35.00
Audiologists who Enter a Given State (%)	3.55	3.02	2.70	2.83	16.28
Graduating Audiologists (*n*)	22.04	24.62	14.00	24.00	109.00
Graduating Audiologists (%)	1.96	2.19	1.25	2.14	9.70
Reproductive Healthcare Policy Score	-2.43	1.86	-2.00	3.00	6.00
LGBTQ+ Policy Score	1.92	2.16	1.00	4.00	8.00

Note: IQR = interquartile range.

Reproductive healthcare policy became more restrictive across the study period (Table 10). Mean reproductive healthcare policy score declined from -2.43 in 2017 to -3.06 in 2024, with state-year values ranging from -6 to 0. This shift was concentrated in Southern and Midwestern states (Figure 3).

Table 10, Descriptive Statistics by State for Reproductive Healthcare Policy Scores, 2017 - 2024

Year	Mean	SD	Median	IQR	Range
2017	-2.43	1.86	-2.00	3.00	6.00
2018	-2.47	1.87	-2.00	3.00	6.00
2019	-2.51	1.88	-3.00	3.00	6.00
2020	-2.65	2.01	-3.00	3.00	6.00
2021	-2.71	2.04	-3.00	4.00	6.00
2022	-2.80	2.14	-3.00	4.00	6.00
2023	-2.92	2.21	-3.00	4.00	6.00
2024	-3.06	2.29	-4.00	4.00	6.00

Note: IQR = interquartile range; SD = standard deviation.

LGBTQ+ policy scores were more variable than reproductive healthcare policy scores across the study period. The mean LGBTQ+ policy score increased from 1.92 in 2017 to 3.12 in 2020, then declined to 1.71 in 2024, with state-year values ranging from -6 to 7 (Table 11). The decline after 2020 generally reflected a shift toward more restrictive LGBTQ+ policies in Southern and Midwestern states, alongside less acute movement toward more permissive policy in New England and West Coast states (Figure 4).

Table 11, Descriptive Statistics by State for LGBTQ+ Policy Scores, 2017 - 2024

Year	Mean	SD	Median	IQR	Range
2017	1.92	2.16	1.00	4.00	8.00
2018	2.29	2.40	1.00	5.00	8.00
2019	2.65	2.67	2.00	5.00	8.00
2020	3.12	2.68	3.00	5.00	9.00
2021	3.02	2.97	3.00	6.00	9.00
2022	2.84	3.24	3.00	6.00	11.00
2023	2.10	3.91	2.00	7.50	11.00
2024	1.71	4.29	1.00	8.00	13.00

Note: IQR = interquartile range; SD = standard deviation.

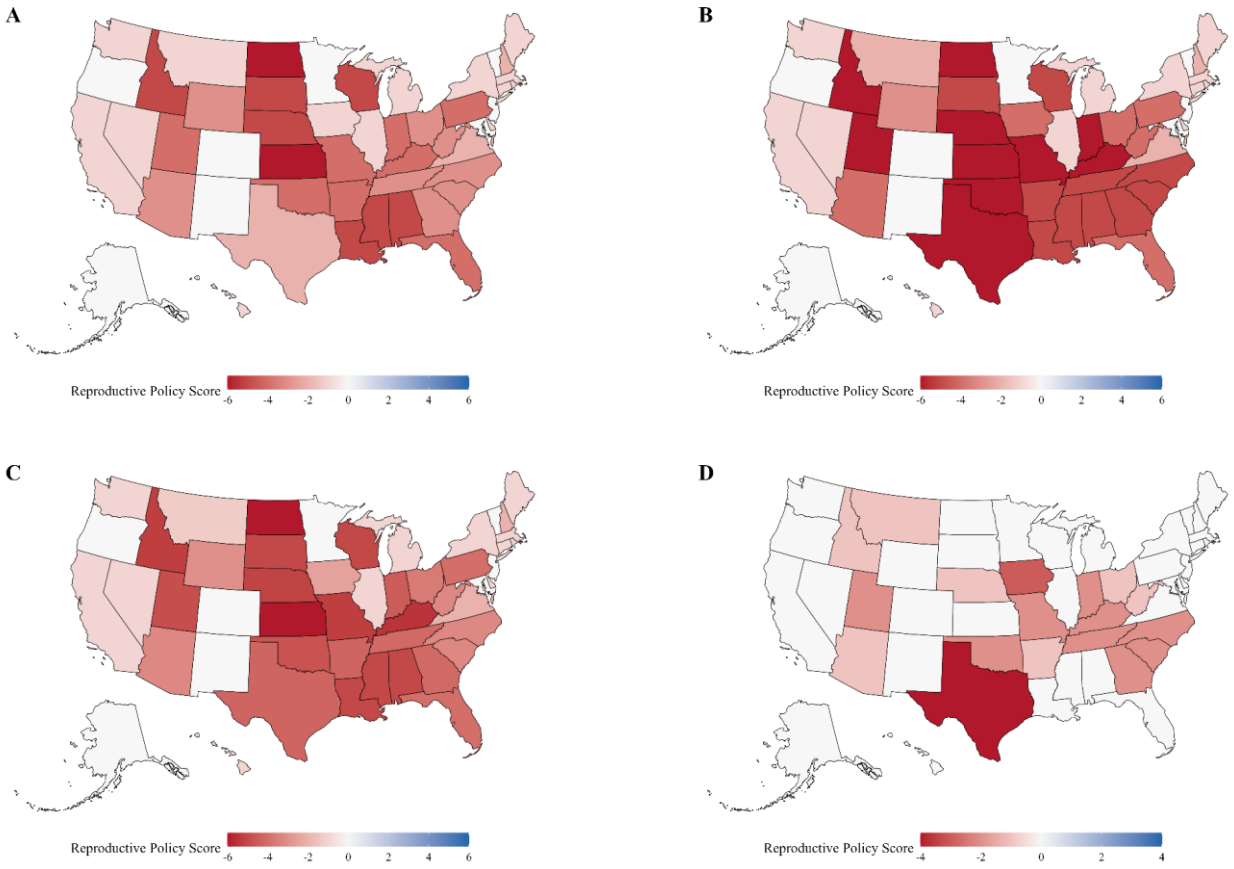

Figure 3, Reproductive Healthcare Policy Score. Panel A shows policy score in 2017. Panel B shows policy score in 2024. Panel C shows average score collapsed across years 2017 to 2024. Panel D shows change from 2017 to 2024.

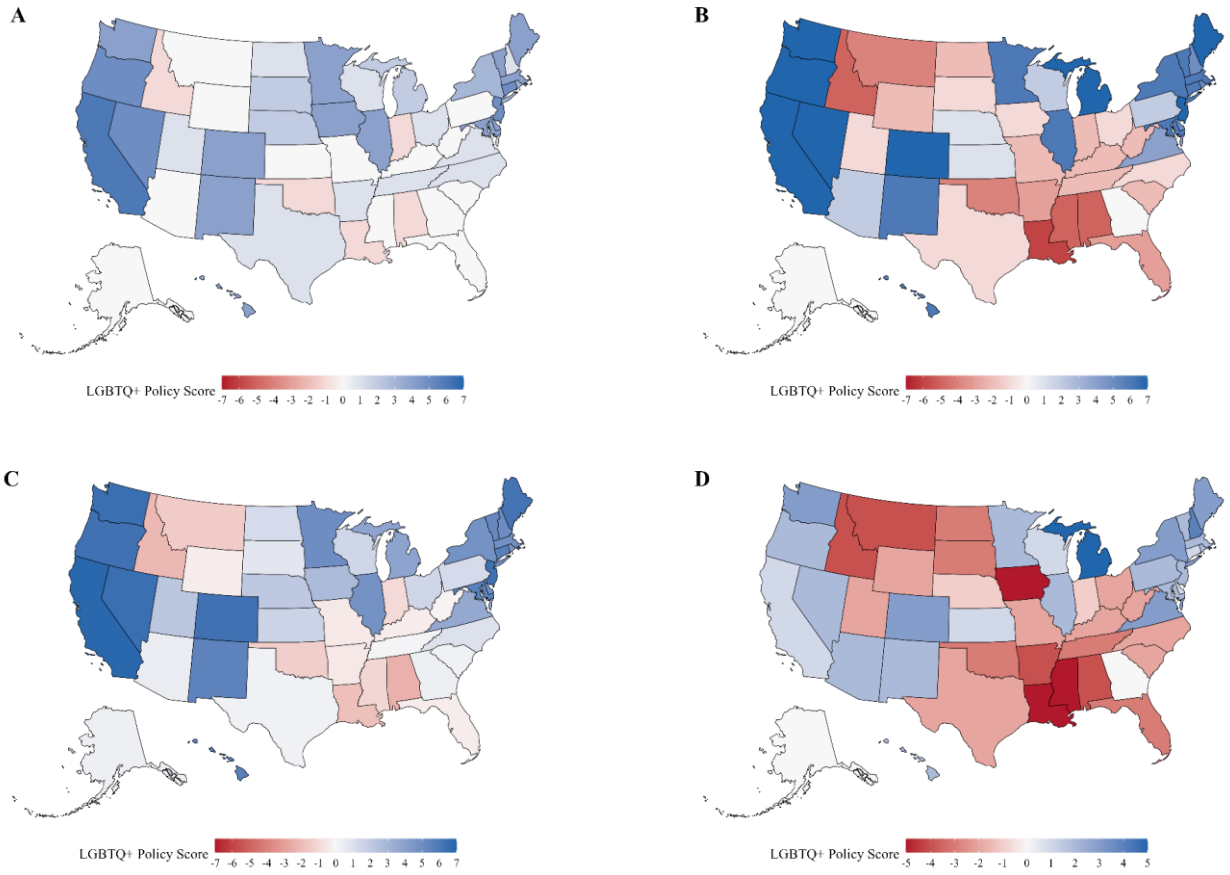

Figure 4, LGBTQ+ Policy Score. Panel A shows policy score in 2017. Panel B shows policy score in 2024. Panel C shows average score collapsed across years 2017 to 2024. Panel D shows change from 2017 to 2024.

Research Question 3.1: Reproductive Healthcare Policy Results

Hypothesis 3.1a: Leaving Restrictive States

Presented in Tables 12 and 13 are tests of the hypothesis (Hypothesis 3.1a) that audiologists move away from states with restrictive reproductive healthcare policies within 1 year of their adoption. The results did not support this hypothesis. In the fully adjusted model, a one-point increase in the reproductive healthcare policy score was not statistically significantly associated with the proportion of audiologists leaving a state in the following year ($b = 0.00$, $p = .989$; Table 12, Model 1). Similarly, reproductive healthcare policy was not statistically significantly associated with the number of audiologists leaving a state in the following year (IRR = 1.02, 95% CI [0.95, 1.09], $p = .589$; Table 13, Model 4).

Table 12, Fully Adjusted LME Models Estimating Audiologist Movement and Initial Registration State the Following Year after Policy Change, 2017-2024

Model	Intercept			Reproductive Healthcare Policy			LGBTQ+ Policy		
	b	**SE**	***P*-value**	***b***	**SE**	***P*-value**	***b***	**SE**	***P*-value**
Model 1, Audiologists who Leave a Given State (%)	0.01	0.01	.038	0.00	0.00	.989	0.00	0.00	.406
Model 2, Audiologists who Enter a Given State (%)	0.01	0.00	.009	0.00	0.00	.874	0.00	0.00	.528
Model 3, Graduating Audiologists (%)	0.01	0.00	.002	0.00	0.00	.072	0.00	0.00	.426

Note: SE = standard error. Audiology training program supply was controlled for.

Table 13, Fully Adjusted Poisson Generalized Linear Mixed-Effects Models Estimating Audiologist Movement and Initial Registration State the Following Year After Policy Change, 2017–2024

Model	Intercept			Reproductive Healthcare Policy			LGBTQ+ Policy		
	IRR	**95% CI**	***P*-value**	***IRR***	**95% CI**	***P*-value**	***IRR***	**95% CI**	***P*-value**
Model 4, Audiologists who Leave a Given State (*n*)	4.15	[3.03, 5.69]	< .001	1.02	[0.95, 1.09]	.589	1.01	[0.97, 1.05]	.696
Model 5, Audiologists who Enter a Given State (*n*)	4.00	[2.93, 5.45]	< .001	0.99	[0.93, 1.06]	.825	1.03	[0.99, 1.07]	.205
Model 6, Graduating Audiologists (*n*)	10.68	[7.55, 15.11]	< .001	1.04	[0.99, 1.09]	.123	1.00	[0.97, 1.02]	.837

Note: IRR = incidence rate ratio, CI = confidence interval. Audiology training program supply was controlled for.

Hypothesis 3.1b: Entering Permissive States

Presented in Tables 12 and 13 are tests of the hypothesis (Hypothesis 3.1b) that audiologists move into states with permissive reproductive healthcare policies within 1 year of their adoption. The results did not support this hypothesis. In the fully adjusted model, reproductive healthcare policy was not statistically significantly associated with the proportion of audiologists entering a state in the following year (b = 0.00, p = .874; Table 12, Model 2). Similarly, reproductive healthcare policy was not statistically significantly associated with the number of audiologists entering a state in the following year (IRR = 0.99, 95% CI [0.93, 1.06], p = .825; Table 13, Model 5).

Hypothesis 3.1c: Graduates Registering in Permissive States

Presented in Tables 12 and 13 are tests of the hypothesis (Hypothesis 3.1c) that newly graduating audiologists register to work in states with permissive reproductive healthcare policies. The results did not support this hypothesis. In the fully adjusted model assessing the proportion of all graduating audiologists that registered to work in a given state, reproductive healthcare policy was not statistically significantly associated with newly graduated audiologist siting in the following year (b = 0.00, p = .072; Table 12, Model 3). Similarly, reproductive healthcare policy was not statistically significantly associated with the number of newly graduating audiologists registering in a given state in the following year (IRR = 1.04, 95% CI [0.99, 1.09], p = .123; Table 13, Model 6). Taken together, these findings indicate that reproductive healthcare policy was not statistically significantly associated with the proportion or number of newly graduating audiologists entering a state in the following year.

Research Question 3.2: LGBTQ+ Policy Results

Hypothesis 3.2a: Leaving Restrictive States

Presented in Tables 12 and 13 are tests of the hypothesis (Hypothesis 3.2a) that audiologists move away from states with restrictive LGBTQ+ policies within 1 year of their adoption. The results did not support this hypothesis. In the fully adjusted model, LGBTQ+ policy was not statistically significantly associated with the proportion of audiologists leaving a state in the following year (b = 0.00, p = .406; Table 12, Model 1). Similarly, LGBTQ+ policy was not statistically significantly associated with the number of audiologists leaving a state in the following year (IRR = 1.01, 95% CI [0.97, 1.05], p = .696; Table 13, Model 4).

Hypothesis 3.2b: Entering Permissive States

Presented in Tables 12 and 13 are tests of the hypothesis (Hypothesis 3.2b) that audiologists move into states with permissive LGBTQ+ policies within 1 year of their adoption. The results did not support this hypothesis. In the fully adjusted model, LGBTQ+ policy was not statistically significantly associated with the proportion of audiologists entering a state in the following year (b = 0.00, p = .528; Table 12, Model 2). Similarly, LGBTQ+ policy was not statistically significantly associated with the number of audiologists entering a state in the following year (IRR = 1.03, 95% CI [0.99, 1.07], p = .205; Table 13, Model 5).

Hypothesis 3.2c: Graduates Registering in Permissive States

Presented in Tables 12 and 13 are tests of the hypothesis (Hypothesis 3.2c) that newly graduating audiologists register to work in states with permissive LGBTQ+ policies. The results did not support this hypothesis. In the fully adjusted model assessing the proportion of all graduating audiologists that registered to work in a given state, LGBTQ+ policy was not statistically significantly associated with newly graduating audiologist siting in the following

year (b = 0.00, p = .426; Table 12, Model 3). Similarly, LGBTQ+ policy was not statistically significantly associated with the number of newly graduating audiologists registering in a given state in the following year (IRR = 1.00, 95% CI [0.97, 1.02], p = .837; Table 13, Model 6). Taken together, these findings indicate that LGBTQ+ policy was not statistically significantly associated with the proportion or number of newly graduating audiologists entering a state in the following year.

Other Analyses

Individual Policy Analyses

Individual reproductive healthcare and LGBTQ+ policies were evaluated to determine whether associations with specific policies were obscured when policies were combined into the composite policy scores used in the primary analyses. The individual-policy models included mandatory waiting periods, total abortion bans, gestational abortion bans occurring in or before the first trimester, public accommodations nondiscrimination laws, broad religious exemption laws, and "Don't Say Gay" laws explicitly restricting educators from discussing LGBTQ+ people or issues in schools. All six policies were included simultaneously in each model.

None of the three individual reproductive healthcare policies were statistically significantly associated with the proportion of audiologists leaving a state, entering a state, or initially registering in a state after graduating (Table 14). The count models similarly did not identify statistically significant associations between total abortion bans or gestational abortion bans occurring in or before the first trimester and any of the three outcomes (Table 15). However, states with mandatory waiting periods had 39% more audiologists entering the state in the following year compared with states without mandatory waiting periods (IRR = 1.39, 95% CI [1.04, 1.87], p = .025; Table 15, Model 5). The reader should note, however, that this result

became non-significant after applying a Bonferroni alpha level adjustment (p = .175). Mandatory waiting periods were not statistically significantly associated with the number of audiologists leaving a state or initially registering in a state after graduating (Table 15).

Among the LGBTQ+ policies, public accommodations nondiscrimination laws were statistically significantly associated with the proportion of newly graduating audiologists initially registering in a state, although this association was borderline statistically significant (b = 0.003, SE = 0.002, p = .050; Table 14, Model 3). Like mandatory waiting periods in Model 5, this became nonsignificant after Bonferroni alpha level adjustment (p = .350). The coefficient corresponds to an approximately 0.3 percentage point higher proportion of newly graduating audiologists initially registering in states with public accommodations nondiscrimination laws compared with states without these laws. Public accommodations nondiscrimination laws were not statistically significantly associated with the proportion or number of audiologists leaving or entering states, or with the number of newly graduating audiologists initially registering in a state (Tables 14 and 15).

"Don't Say Gay" laws explicitly restricting educators from discussing LGBTQ+ people or issues in schools were associated with the number of audiologists entering a state in the following year, with states having these laws experiencing 63% more audiologists entering compared with states without these laws (IRR = 1.63, 95% CI [1.16, 2.28], p = .005; Table 15, Model 5). This remained statistically significant after applying a Bonferroni alpha level adjustment (p = .035). These laws were not statistically significantly associated with the proportion of audiologists entering states or with the proportion or number of audiologists leaving or newly graduating audiologists initially registering in states (Tables 14 and 15). Broad

religious exemption laws were not statistically significantly associated with any of the six audiologist movement or initial registration outcomes (Tables 14 and 15).

Overall, the individual-policy analyses identified few statistically significant associations across the six policies and six outcomes evaluated. The significant associations also did not show a consistent pattern in which policies categorized as more supportive were associated with greater audiologist entry or policies categorized as more restrictive were associated with greater audiologist departure from a given state. The individual-policy results provide limited evidence that a single policy included within the broader reproductive healthcare or LGBTQ+ policy indices consistently accounted for audiologist movement or initial registration patterns.

Table 14, Fully Adjusted LME Models Estimating Individual Policy Associations with Audiologist Movement and Initial Registration, 2017–2024

	Model 1, Audiologists who Leave a Given State (%)			Model 2, Audiologists who Enter a Given State (%)			Model 3, Graduating Audiologists (%)		
Variable	***b***	**SE**	***P*-value**	***b***	**SE**	***P*-value**	***b***	**SE**	***P*-value**
Intercept	0.04	0.01	< .001	0.04	0.005	< .001	0.01	0.003	.002
Mandatory Waiting Period	-0.002	0.01	.772	0.005	0.005	.327	-0.001	0.003	.586
Total Abortion Ban	0.005	0.01	.653	0.01	0.01	.587	0.0003	0.003	.919
Gestational Ban in First Trimester	-0.001	0.01	.937	-0.003	0.01	.726	-0.002	0.003	.573
Public Accommodations Nondiscrimination Laws	0.004	0.005	.409	0.01	0.004	.103	0.003	0.002	.050 *
Broad Religious Exemption Laws	-0.001	0.004	.857	0.0000	0.004	.995	0.002	0.002	.272
"Don't Say Gay" Laws	0.01	0.01	.432	0.01	0.01	.207	-0.002	0.002	.258

*Note: IRR = incidence rate ratio. * = p under .05.*

Table 15, Fully Adjusted Poisson GLMMs Estimating Individual Policy Associations with Audiologist Movement and Initial Registration, 2017–2024

	Model 4, Audiologists who Leave a Given State (*n*)			Model 5, Audiologists who Enter a Given State (*n*)			Model 6, Graduating Audiologists (*n*)		
Variable	**IRR**	**95% CI**	***P*-value**	**IRR**	**95% CI**	***P*-value**	**IRR**	**95% CI**	***P*-value**
Intercept	3.94	[2.93, 5.31]	< .001	3.91	[2.93, 5.22]	< .001	10.06	[7.19, 14.08]	< .001
Mandatory Waiting Period	1.00	[0.74, 1.36]	.995	1.39	[1.04, 1.87]	.025 *	0.90	[0.68, 1.20]	.485
Total Abortion Ban	0.95	[0.66, 1.38]	.803	0.80	[0.55, 1.17]	.255	1.03	[0.80, 1.32]	.814
Gestational Ban in First Trimester	1.04	[0.75, 1.45]	.813	1.08	[0.76, 1.51]	.677	0.93	[0.74, 1.16]	.518
Public Accommodations Nondiscrimination Laws	1.08	[0.91, 1.28]	.374	1.02	[0.86, 1.22]	.780	1.12	[0.99, 1.27]	.080
Broad Religious Exemption Laws	1.00	[0.77, 1.30]	.992	1.16	[0.90, 1.49]	.263	1.11	[0.91, 1.37]	.300
"Don't Say Gay" Laws	1.26	[0.92, 1.74]	.150	1.63	[1.16, 2.28]	.005 **	0.93	[0.79, 1.09]	.343

*Note: * = p under .05, ** = p under .01.*

Descriptive Movement Trends

Across the study period, 3,005 interstate audiologist moves were identified. There was no clear overall pattern of audiologists moving toward more supportive reproductive healthcare or LGBTQ+ policy environments (Table 16). For reproductive healthcare policy, 1,121 (37.3%) moves were toward states with more supportive policy environments, 688 (22.9%) were between states with the same policy score, and 1,196 (39.8%) were toward states with more restrictive policy environments (Table 16). Among the 2,317 moves between states with different reproductive healthcare policy scores, 48.4% were toward the more supportive state (95% CI, 46.3% – 50.4%; Table 16). The proportion of moves toward more supportive reproductive healthcare policy environments did not differ significantly from an equal distribution of moves toward more supportive and more restrictive environments ($p = .124$; Table 16).

Table 16, Direction of Interstate Audiologist Movement Relative to State Policy Environments, 2017–2024

Policy domain	More supportive, *n* (%)	Same score, *n* (%)	More restrictive, *n* (%)	More supportive among different policy score moves, % (95% CI)	*P-value*
Reproductive Healthcare Policy	1,121 (37.3)	688 (22.9)	1,196 (39.8)	48.4 (46.3–50.4)	.124
LGBTQ+ Policy	1,256 (41.8)	477 (15.9)	1,272 (42.3)	49.7 (47.7–51.7)	.765

Note: CI = confidence interval.

A similar pattern was observed for LGBTQ+ policy. Of the 3,005 interstate moves, 1,256 (41.8%) were toward states with more supportive LGBTQ+ policy environments, 477 (15.9%) were between states with the same policy score, and 1,272 (42.3%) were toward states with more restrictive policy environments (Table 16). Among the 2,528 moves between states with different LGBTQ+ policy scores, 49.7% were toward the more supportive state (95% CI, 47.7% – 51.7%),

which did not differ significantly from an equal distribution of moves toward more supportive and more restrictive environments (p = .765; Table 16). Taken together, these findings indicate that audiologists who moved between states did not disproportionately relocate toward states with more supportive reproductive healthcare or LGBTQ+ policy environments.

The magnitude of differences between origin and destination policy environments was also generally balanced around no change. For reproductive healthcare policy, the median destination-minus-origin policy score difference was 0 (IQR = 2; range = −6 to 6), with the middle 50% of moves involving differences ranging from −1 to 1. Of all interstate moves, 688 (22.9%) occurred between states with equivalent reproductive healthcare policy scores, while 487 (16.2%) represented a one-point change toward a more restrictive environment and 450 (15.0%) represented a one-point change toward a more supportive environment. Larger differences were similarly distributed, with 709 (23.6%) moves toward states at least two points more restrictive and 671 (22.3%) toward states at least two points more supportive. For LGBTQ+ policy, the median destination-minus-origin policy score difference was also 0, although there was greater variability in the policy environments between origin and destination states (IQR = 4; range = −10 to 11), with the middle 50% of moves involving differences ranging from −2 to 2. Although differences between origin and destination states were centered on no directional policy change for both policy domains, interstate moves occurred across a wider range of differences in LGBTQ+ policy environments than reproductive healthcare policy environments, likely because the greater number of policy items in the LGBTQ+ policy index created a broader range of possible state-level values.

Directional movement varied somewhat across years, although the annual trends did not indicate a sustained pattern of movement toward more supportive policy environments (Figure

5). For example, reproductive healthcare movement was slightly more likely to be toward restrictive environments in 2021, when 471 (38.7%) moves were toward more restrictive states compared with 437 (35.9%) toward more supportive states. In 2022 through 2024, these percentages were more similar: 38.4% versus 35.4% in 2022, 38.5% versus 36.5% in 2023, and 38.7% versus 36.8% in 2024 for moves toward more supportive and more restrictive reproductive healthcare policy environments, respectively. The annual LGBTQ+ trends similarly varied over the study period rather than showing a consistent directional preference.

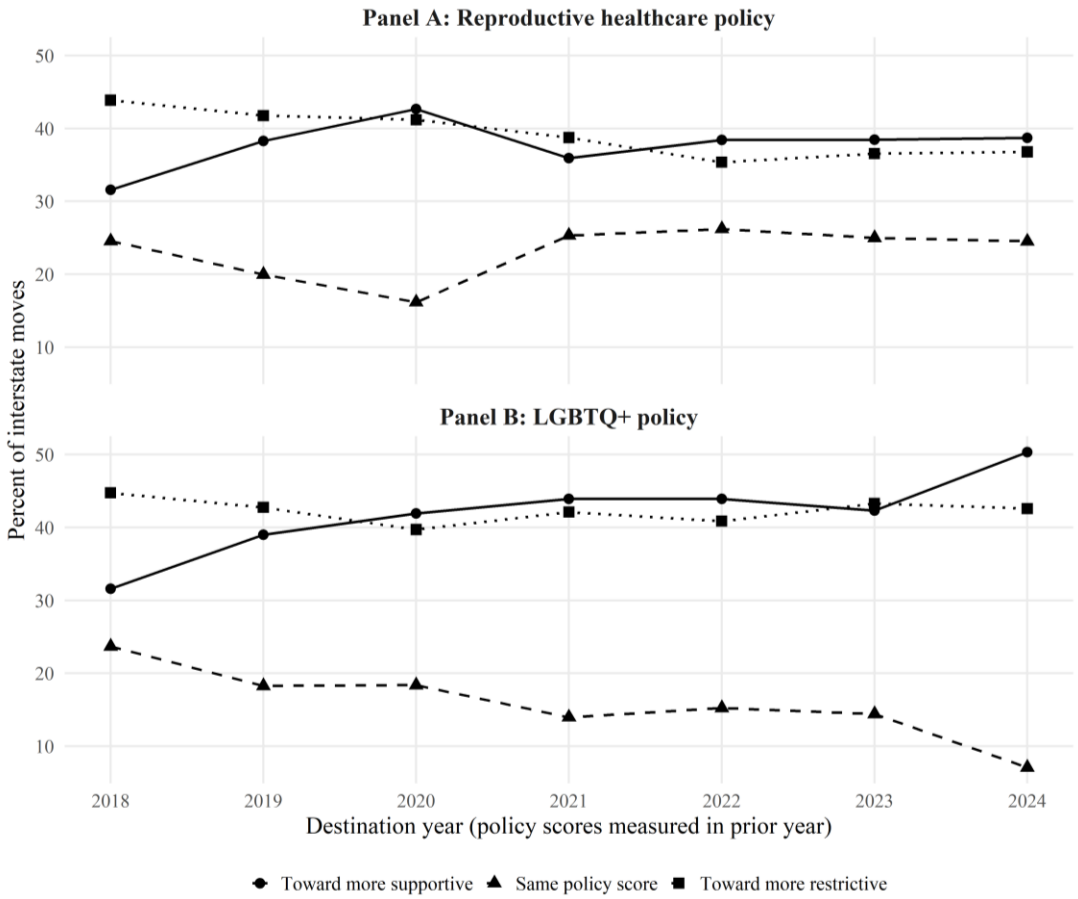

Figure 5, Annual Direction of Interstate Audiologist Movement Relative to State Reproductive Healthcare and LGBTQ+ Policy Environments, 2018–2024

The most frequent state-to-state migration pathways did not uniformly represent movement toward more supportive policy environments (Table 17). The most frequent pathway was from Missouri to Kansas, with 46 observed moves from 2018 through 2024. The median reproductive healthcare policy score was the same in the two states for these moves, while the median LGBTQ+ policy difference favored the destination. The second most frequent pathway was from New Jersey to New York, with 44 moves; this pathway was associated with median destination-minus-origin differences of −1 for both reproductive healthcare and LGBTQ+ policy, indicating movement toward somewhat more restrictive policy environments on both indices. Overall, the state-to-state pathways with the largest number of movements show that interstate audiologist movement occurred in both directions relative to policy environment rather than being concentrated in moves from restrictive to supportive states.

Table 17, Annual Direction of Interstate Audiologist Movement Relative to State Reproductive Healthcare and LGBTQ+ Policy Environments for States with the 10 Largest Numbers of Moves, 2018–2024

Commented [SK1]: Complete

Origin state	Destination state	Moves, *n*	Median reproductive policy difference	Median LGBTQ+ policy difference
Missouri	Kansas	46	0	3
New Jersey	New York	44	-1	-1
New York	New Jersey	41	1	2
Pennsylvania	New Jersey	41	4	5
Kansas	Missouri	40	0	-3
New Jersey	Pennsylvania	32	-4	-4
North Carolina	South Carolina	29	0	0
South Carolina	North Carolina	27	0	1
Georgia	Florida	19	0	0
New York	Pennsylvania	19	-3	-3

Movement Pretrends

Event-study analyses were conducted to evaluate whether differences in audiologist movement were present before changes in state reproductive healthcare and LGBTQ+ policy

environments. Meaningful policy changes were defined as annual changes of at least 2 points in the respective policy score, representing changes in at least two policies during the same year. Both increases and decreases in score, a change in score of ± 2 units. There were no increases of at least 2 points in reproductive healthcare policy scores during the study period, so pretrends for increases in reproductive healthcare policy scores could not be evaluated. F-tests of joint significance on the available pre-policy event-time estimates were used to evaluate whether audiologist movement differed during the period preceding the remaining meaningful policy changes (Table 18). The number of available pre-policy periods varied according to the timing of qualifying policy changes within the 2017 – 2024 study period so joint tests included event times −7 to −2 when available and −6 to −2 when the timing of observed policy changes provided one fewer pre-policy period.

The presence of statistically significant differential pre-policy trends for several outcomes complicates interpretation of the null findings from the primary analyses. These preexisting differences make it difficult to distinguish a lack of association with policy change from outcome trajectories that were already changing differently before the policy change occurred. The null estimates for outcomes with evidence of differential pre-policy trends should be interpreted cautiously.

Table 18, Joint Tests of Audiologist Movement Pretrends Before Meaningful Changes in State Reproductive Healthcare and LGBTQ+ Policy Environments, 2017–2024

Outcome	Policy Environment	Direction of Policy Change	Treated States, *n*	Pre-Policy Periods Tested	*F*	df	*P*-value
Audiologists who Leave a Given State (%)	Reproductive Healthcare	Decrease (more restrictive)	5	-7 to -2	55.54	(6, 50)	< .001 ***
Audiologists who Enter a Given State (%)	Reproductive Healthcare	Decrease (more restrictive)	5	-7 to -2	237.60	(6, 50)	< .001 ***
Graduating Audiologists (%)	Reproductive Healthcare	Decrease (more restrictive)	5	-7 to -2	16.73	(6, 50)	< .001 ***
Audiologists who Leave a Given State (*n*)	Reproductive Healthcare	Decrease (more restrictive)	5	-7 to -2	67.36	(6, 50)	< .001 ***
Audiologists who Enter a Given State (*n*)	Reproductive Healthcare	Decrease (more restrictive)	5	-7 to -2	1248.17	(6, 50)	< .001 ***
Graduating Audiologists (*n*)	Reproductive Healthcare	Decrease (more restrictive)	5	-7 to -2	146.41	(6, 50)	< .001 ***
Audiologists who Leave a Given State (%)	LGBTQ+	Increase (more supportive)	9	-6 to -2	3.23	(5, 31)	.018 *
Audiologists who Enter a Given State (%)	LGBTQ+	Increase (more supportive)	9	-6 to -2	85.44	(5, 31)	< .001 ***
Graduating Audiologists (%)	LGBTQ+	Increase (more supportive)	9	-6 to -2	13.46	(5, 31)	< .001 ***
Audiologists who Leave a Given State (*n*)	LGBTQ+	Increase (more supportive)	9	-6 to -2	12.66	(5, 31)	< .001 ***
Audiologists who Enter a Given State (*n*)	LGBTQ+	Increase (more supportive)	9	-6 to -2	33.30	(5, 31)	< .001 ***
Graduating Audiologists (*n*)	LGBTQ+	Increase (more supportive)	9	-6 to -2	50.14	(5, 31)	< .001 ***
Audiologists who Leave a Given State (%)	LGBTQ+	Decrease (more restrictive)	19	-7 to -2	1.68	(6, 41)	.151
Audiologists who Enter a Given State (%)	LGBTQ+	Decrease (more restrictive)	19	-7 to -2	1.31	(6, 41)	.275

Graduating Audiologists (%)	LGBTQ+	Decrease (more restrictive)	19	-7 to -2	2.64	(6, 41)	.029 *
Audiologists who Leave a Given State (*n*)	LGBTQ+	Decrease (more restrictive)	19	-7 to -2	1.92	(6, 41)	.100
Audiologists who Enter a Given State (*n*)	LGBTQ+	Decrease (more restrictive)	19	-7 to -2	1.54	(6, 41)	.191
Graduating Audiologists (*n*)	LGBTQ+	Decrease (more restrictive)	19	-7 to -2	1.89	(6, 41)	.105

*Note: df = degrees of freedom. * = p under .05, *** = p under .001. No states had a 2 unit increase in reproductive healthcare policy score, preventing evaluation in these analyses.*

For reproductive healthcare policy, five states experienced decreases of at least 2 points in their policy scores. Joint tests identified statistically significant pre-policy differences for the proportion of audiologists leaving a state ($F(6, 50) = 55.54$, $p < .001$), entering a state ($F(6, 50) = 237.60$, $p < .001$), and newly graduating audiologists registering in a state ($F(6, 50) = 16.73$, $p < .001$; Table X). Statistically significant pre-policy differences were also identified for the corresponding numbers of audiologists leaving ($F(6, 50) = 67.36$, $p < .001$), entering ($F(6, 50) = 1248.17$, $p < .001$), and newly graduating audiologists registering in a state ($F(6, 50) = 146.41$, $p < .001$; Table 18). The pre-policy event-time estimates were not jointly equal to zero for any of the six outcomes preceding meaningful decreases in reproductive healthcare policy scores.

For LGBTQ+ policy, nine states experienced increases of at least 2 points toward more supportive policy environments. Joint tests identified statistically significant pre-policy differences for the proportion of audiologists leaving a state ($F(5, 31) = 3.23$, $p = .018$), entering a state ($F(5, 31) = 85.44$, $p < .001$), and newly graduating audiologists registering in a state ($F(5, 31) = 13.46$, $p < .001$; Table 18). Statistically significant pre-policy differences were also identified for the corresponding numbers of audiologists leaving ($F(5, 31) = 12.66$, $p < .001$), entering ($F(5, 31) = 33.30$, $p < .001$), and newly graduating audiologists registering in a state ($F(5, 31) = 50.14$, $p < .001$; Table 18). The pre-policy event-time estimates were not jointly equal to zero for any of the six outcomes preceding meaningful increases in LGBTQ+ policy scores.

Nineteen states experienced decreases of at least 2 points toward more restrictive LGBTQ+ policy environments. Joint tests did not identify statistically significant pre-policy differences in the proportion or number of audiologists leaving a state (proportion: $F(6, 41) = 1.68$, $p = .151$; number: $F(6, 41) = 1.92$, $p = .100$; Table 18) or entering a state (proportion: $F(6, 41) = 1.31$, $p = .275$; number: $F(6, 41) = 1.54$, $p = .191$; Table 18). The proportion of newly

graduating audiologists registering in a state was significantly different during the pre-policy period ($F(6, 41) = 2.64$, $p = .029$), while the corresponding number of newly graduating audiologists did not ($F(6, 41) = 1.89$, $p = .105$; Table 18).

Overall, the pretrend analyses identified statistically significant pre-policy differences across all six movement outcomes preceding meaningful decreases in reproductive healthcare policy scores and meaningful increases in LGBTQ+ policy scores. In contrast, five of the six joint tests preceding meaningful decreases in LGBTQ+ policy scores were not statistically significant, with the proportion of newly graduating audiologists registering in a state as the exception. The significant joint tests indicate that the corresponding pre-policy event-time estimates were not jointly equal to zero and suggest that differences in audiologist movement were already present before some changes in state policy environments. Findings associated with these policy changes should not be interpreted as differences in movement that clearly emerged only after the policy changes. For the five nonsignificant joint tests preceding decreases in LGBTQ+ policy scores, I was unable to reject the null hypothesis of similar pre-policy trends. However, these findings do not establish that the parallel-trends assumption held, because whether trends would have remained parallel in the absence of the policy change is inherently counterfactual and cannot be directly observed. None of the primary associations between the reproductive healthcare or LGBTQ+ policy scores and the six audiologist movement outcomes were statistically significant. There were no statistically significant primary estimates for which the pretrend analyses altered interpretation of an observed association. The few statistically significant associations identified in the individual-policy analyses were supplemental analyses of specific policies and were not the policy-score changes evaluated in these pretrend analyses.

Discussion

The purpose of this study is to evaluate if state-level reproductive healthcare or LGBTQ+ policies influence the spatial accessibility of audiologists in the US. There are six key findings from this study, three each for research question 3.1 and 3.2 which evaluated if restrictive state-level reproductive healthcare policies and LGBTQ+ policies respectively reduce the local supply of audiologists in its respective state. Overall, the primary analyses did not identify statistically significant associations between either composite policy score and the proportion or number of audiologists leaving a state, entering a state, or newly graduating audiologists initially registering in a state in the following year.

First, with respect to patterns of reproductive healthcare policies influencing audiologist out-migration from states with reproductive healthcare policy restrictions, audiologists do not appear to leave states with more restrictive reproductive healthcare policies, showing no support for hypothesis 3.1a which proposed that audiologists move away from states with restrictive reproductive healthcare policies within 1 year of their adoption. Second, with respect to patterns of reproductive healthcare policies influencing audiologist in-migration to states with fewer reproductive healthcare policy restrictions, audiologists do not appear to move to states with less restrictive reproductive healthcare policies, again showing no support for hypothesis 3.1b which proposed that audiologists move to states with fewer restrictive reproductive healthcare policies within 1 year of their adoption. Third, with respect to patterns of reproductive healthcare policies influencing newly graduating audiologist registration in states with fewer reproductive healthcare policy restrictions, reproductive healthcare policy was not significantly associated with the proportion or number of newly graduating audiologists initially registering in a state in the following year. This finding shows no support for hypothesis 3.1c, which proposed that

graduating audiologists entering the profession register to work in states with fewer reproductive healthcare policy restrictions more often than states with greater reproductive healthcare policy restrictions.

Fourth, with respect to patterns of LGBTQ+ policies influencing audiologist out-migration from states with LGBTQ+ policy restrictions, audiologists do not appear to leave states with more restrictive LGBTQ+ policies, showing no support for hypothesis 3.2a which proposed that audiologists move away from states with restrictive LGBTQ+ policies within 1 year of their adoption. Fifth, with respect to patterns of LGBTQ+ policies influencing audiologist in-migration to states with fewer LGBTQ+ policy restrictions, audiologists do not appear to move to states with less restrictive LGBTQ+ policies, again showing no support for hypothesis 3.2b which proposed that audiologists move to states with fewer restrictive LGBTQ+ policies within 1 year of their adoption. Finally, with respect to patterns of LGBTQ+ policies influencing newly graduating audiologist registration in states with fewer LGBTQ+ policy restrictions, graduating audiologists do not appear to selectively register to work in states with less restrictive LGBTQ+ policies, showing no support for hypothesis 3.2c which proposed that graduating audiologists entering the profession register to work in states with fewer restrictive LGBTQ+ policies more often than states with greater LGBTQ+ policy restrictions.

The additional analyses provide additional context that assists in contextualizing the primary analyses. Descriptive analyses of individual interstate moves did not identify a tendency for audiologists to move toward states with more supportive reproductive healthcare or LGBTQ+ policy environments. Individual-policy analyses identified few statistically significant associations, and those associations did not show a consistent pattern in which more supportive policies were associated with greater audiologist entry or more restrictive policies were

associated with greater audiologist departure. These results suggest that the lack of consistent associations in the primary composite policy analyses is not attributable to combining multiple policies into summary indices.

The pretrend analyses likewise do not suggest that audiologists are moving between states in response to reproductive healthcare or LGBTQ+ policy. Statistically significant pre-policy differences were identified across all six movement outcomes preceding meaningful decreases in reproductive healthcare policy scores and meaningful increases in LGBTQ+ policy scores, indicating that differences in audiologist movement were already present before some of the meaningful policy changes evaluated in this study. There was less evidence of statistically significant pre-policy differences preceding meaningful decreases in LGBTQ+ policy scores, though nonsignificant joint tests do not show that preexisting differences were not present for these scores. These findings provide no evidence that changes in state reproductive healthcare or LGBTQ+ policy independently caused changes in audiologist movement. Future research could use approaches such as synthetic control methods that more explicitly account for differences in pre-policy outcome trajectories to evaluate the effects of policy changes with greater certainty.

Taken together, these findings suggest that state reproductive healthcare and LGBTQ+ policy environments did not consistently influence audiologist movement or the initial registration locations of newly graduating audiologists during the study period. This does not necessarily mean that these policies are irrelevant to where audiologists prefer to live or work. State policy represents one potential influence on siting within a broader set of occupational, interpersonal, community, and policy considerations. This interpretation is consistent with the social ecological framing of this dissertation and with the findings from Aim 1, where audiologists described reproductive healthcare and LGBTQ+ policy as relevant to the desirability

of some locations but generally described family location, spouse employment, compensation, children's needs, and other considerations as more influential in their actual relocation decisions.

Reproductive Healthcare Policy and Audiologist Distribution

The results of this study differ from prior work, which has found that states with restrictions on reproductive healthcare services can have a negative impact on HCP supply in that state, though this pattern does not appear equally strong for all HCPs. Healthcare workforce research has increasingly examined whether and when reproductive healthcare policy influences the number of HCPs in a region, particularly since the 2022 US Supreme Court ruling in *Dobbs v. Jackson Women's Health Organization* reduced access to reproductive healthcare services by allowing individual states to enact restrictions and bans (Zhu et al., 2024). A growing body of literature has found that states with restrictive reproductive healthcare policies have had fewer residency applications among medical students across disciplines, though specialties providing reproductive healthcare are affected by reproductive healthcare policy more strongly (Chatterji et al., 2024; Ganguly et al., 2026; Hammoud et al., 2024; Orgera & Grover, 2024; Peters et al., 2023). In contrast, reproductive healthcare policy was not significantly associated with established audiologists leaving or entering states or with where newly graduating audiologists initially registered to work in this study.

The lack of a significant association among newly graduating audiologists is somewhat surprising, as prior evidence suggested that early career HCPs who are may be less constrained by established employment and community ties may be influenced by reproductive healthcare policy (Ganguly et al., 2026). One potential explanation is that reproductive healthcare policy has different relevance across healthcare disciplines. Abortion restrictions can affect not only where HCPs who provide reproductive healthcare and their families can access reproductive

healthcare, but also their clinical training and future practice. Audiologists may consider reproductive healthcare access for themselves and their families, but reproductive healthcare restrictions do not directly affect audiologists' clinical training or scope of practice. Reproductive healthcare policy may represent both a personal and professional consideration for HCPs who provide abortion-related care while only functioning as a personal consideration for audiologists. This difference may reduce the relative importance of reproductive healthcare policy compared with other factors influencing where newly graduating audiologists initially practice. Alternately, newly graduating audiologists may have a large degree of choice in where they initially practice because the number of available audiology positions exceeds the number of audiologists graduating each year (Garuccio et al., 2025; Windmill & Freeman, 2013). This labor market shortage may allow new graduates to be relatively selective among employment opportunities and provide greater flexibility to consider geographic preferences when choosing where to practice. Despite this degree of choice, reproductive healthcare policy was not significantly associated with where newly graduating audiologists initially registered to work. Even when graduates have multiple employment opportunities, reproductive healthcare policy may remain one consideration, though not the most salient consideration among compensation, family location, spouse employment, community characteristics, and other factors that influence where they ultimately choose to practice.

Differences in how reproductive healthcare policy was operationalized could also contribute to differences between the findings from this study and prior research. The primary analyses in this study used a composite policy score intended to represent the broader reproductive healthcare policy environment within each state, while other research has used indices with different policies, sets of individual policies, or other approaches. Combining

multiple policies into a composite score could obscure associations if specific reproductive healthcare policies are more influential for HCP geographic decisions than others. To evaluate the influence of combining policies into indices in this study, individual-policy analyses evaluated mandatory waiting periods, total abortion bans, and gestational abortion bans occurring in or before the first trimester. These analyses provided limited evidence that the lack of an association in the primary models was attributable to combining reproductive healthcare policies into an index. None of the three individual reproductive healthcare policies were significantly associated with the proportion of audiologists leaving, entering, or newly graduating audiologists initially registering in a state. Among the count outcomes, mandatory waiting periods were associated with a greater number of audiologists entering a state, but total abortion bans and gestational abortion bans were not significantly associated with any of the three outcomes. The individual-policy analyses did not identify a consistent pattern in which more restrictive reproductive healthcare policies were associated with audiologists leaving states or avoiding them when selecting a location to practice.

Other differences between audiologists and the HCPs evaluated in prior work may help explain these findings. Audiologists do not have a residency program, and evidence on how reproductive healthcare policies shape the movement of established HCPs remains more limited than evidence examining medical students and residents. HCPs already working in their discipline have also appeared less likely to relocate than residents, possibly because residents and newly graduating clinicians face lower relocation costs and are less established in a region (Chatterji et al., 2024). This dynamic may help explain why significant relationships between reproductive healthcare policy scores and relocation among established audiologists were not present in this study. In other words, relocation costs and other established ties in a community

may outweigh the benefits of living in a preferred policy context. However, the absence of a significant association among newly graduating audiologists suggests that established ties alone do not explain the difference between the audiology findings and prior evidence among medical trainees.

The findings from Aim 1 provide additional context for a lack of association between reproductive healthcare policy and audiologist siting. Audiologists described reproductive healthcare policy as potentially important to the desirability of some locations, but siting decisions generally reflected multiple considerations, including employment opportunities, compensation, family location, spouse employment, children's needs, and other considerations. This pattern is consistent with the social ecological model used throughout this dissertation, which positions policy as one component of a broader environment that shapes where HCPs are willing and able to practice rather than an influence that operates independently. For audiologists, reproductive healthcare policy may contribute to the desirability of a state without being sufficiently influential to outweigh occupational, interpersonal, organizational, and community-level considerations. Prior research suggests that the relative importance of policy-level conditions may depend on characteristics of the healthcare profession and whether the policy environment also directly affects clinical training and practice (Ganguly et al., 2026).

LGBTQ+ Policy and Audiologist Distribution

The lack of a significant association between LGBTQ+ policy and audiologist movement or newly graduating audiologist registration differs from some limited prior evidence suggesting that LGBTQ+ policy can influence where individuals prefer to live and work. Prior research has found that LGBTQ+ people generally prefer to live in areas with more supportive LGBTQ+ policies and social environments, and these preferences may also extend to people who do not

identify as LGBTQ+ but value LGBTQ+ protections (Grant et al., 2018; Suen, 2021). The primary analyses did not identify significant associations between the LGBTQ+ policy score and the proportion or number of audiologists leaving a state, entering a state, or newly graduating audiologists initially registering in a state in the following year.

Audiologists who moved between states did not disproportionately move toward states with more supportive LGBTQ+ policy environments, and the most common state-to-state movement pathways included moves toward both more supportive and more restrictive policy environments. These patterns suggest that although LGBTQ+ policy may contribute to the desirability of a location for some audiologists, it was not consistently reflected in where audiologists actually moved during the study period.

The individual-policy analyses also provided limited evidence that specific LGBTQ+ policies consistently influenced audiologist movement. Public accommodations nondiscrimination laws were associated with a higher proportion of newly graduating audiologists initially registering in a state, though this association was borderline statistically significant. “Don’t Say Gay” laws were associated with a greater number of audiologists entering a state in the following year. These associations were not consistent across the corresponding proportion and count outcomes, and broad religious exemption laws were not significantly associated with any of the movement outcomes. The direction of these findings did not show a consistent pattern where policies categorized as more supportive were associated with greater audiologist entry or policies categorized as more restrictive were associated with greater audiologist departure. The individual-policy findings do not suggest that the lack of associations with the composite LGBTQ+ policy score was attributable to combining policies with different effects into a single index.

The pretrend analyses also provide context for interpreting LGBTQ+ policy and audiologist movement. Pre-policy differences were identified across all six outcomes preceding meaningful increases toward more supportive LGBTQ+ policy environments, indicating that differences in audiologist movement were already present before these policy changes. In contrast, there was less evidence of pre-policy differences preceding meaningful decreases toward more restrictive LGBTQ+ policy environments, with five of the six joint tests not statistically significant. The nonsignificant tests do not show that preexisting differences were absent, and the overall pattern provides little evidence that changes toward more restrictive LGBTQ+ policy environments were followed by movement of audiologists away from those states.

The lack of a consistent relationship between LGBTQ+ policy and audiologist movement may reflect the relative importance of other factors in siting decisions. State LGBTQ+ policy may be important to some audiologists without being sufficiently important to outweigh employment opportunities, compensation, spouse employment, proximity to family, children's needs, cost of living, or other characteristics of potential locations. This interpretation is consistent with the findings from Aim 1, where state policy was discussed as one consideration in relocation decisions but generally did not outweigh family and occupational considerations. LGBTQ+ policy may influence how some audiologists perceive the desirability of a state without producing measurable changes in the overall distribution of the audiology workforce.

Theoretical Implications

The results of this study contribute to the social ecological model (SEM) of HCP siting used throughout this dissertation. SEMs conceptualize individuals as embedded within interacting environments, and that influences within and across individual, interpersonal,

organizational, community, and policy levels influence outcomes together (Bronfenbrenner, 1994; Eriksson et al., 2025; Golden & Earp, 2012; Stokols, 1996). Applied to HCP siting, this framework conceptualizes spatial accessibility as a downstream outcome of the interacting conditions that shape where HCPs are willing and able to live and practice.

The findings from this study are consistent with the importance of considering policy as one ecological influence without assuming that policy independently determines HCP siting. State reproductive healthcare and LGBTQ+ policy environments varied substantially during the study period, but neither composite policy score consistently predicted audiologist movement or where newly graduating audiologists initially registered to work. Descriptive movement analyses did not identify a consistent tendency for audiologists to move toward states with more supportive policy environments, and the individual-policy analyses identified few significant associations without a consistent pattern across policies or outcomes. These findings do not necessarily show that policy is irrelevant to audiologist siting; they suggest that policy context may operate alongside individual and occupational priorities, interpersonal relationships and family needs, employment opportunities, and broader community conditions when HCPs choose where to live and work (Chatterji et al., 2024; Goddard et al., 2010; Levy et al., 2025).

These results complement findings from the other aims of this dissertation. Aim 1 identified interacting occupational, interpersonal, community, and policy considerations that audiologists described when making geographic decisions and Aim 2 demonstrated that community characteristics were associated with EHC HCP spatial accessibility and that these relationships differed between audiologists and HISs. Together with the findings from this study, these results support conceptualizing EHC HCP siting as a multilevel process in which the

importance of a particular level of influence depends on the other conditions surrounding a HCP and the characteristics of the profession being considered.

Policy Implications

The results of this study have several implications for policy in the state and university contexts. The lack of consistent associations between state reproductive healthcare or LGBTQ+ policy and audiologist movement suggests that changing any one aspect of a state policy environment is unlikely to substantially change the distribution of audiologists. These findings are consistent with the SEM used throughout this dissertation, where HCP siting is conceptualized as the result of interacting individual, interpersonal, organizational, community, and policy influences rather than any one factor operating independently (Bronfenbrenner, 1994; Eriksson et al., 2025; Golden & Earp, 2012). State policy is one component of the broader environment that can make a location more or less desirable, but occupational opportunities, family needs, characteristics of communities, and other conditions may reinforce or outweigh policy preferences when audiologists decide where to live and work (Chatterji et al., 2024; Goddard et al., 2010; Levy et al., 2025).

For state policymakers, these findings suggest that policies intended to improve the local supply of audiologists should consider multiple conditions that make a state feasible and desirable for HCPs rather than focusing on a single policy domain. Though no high-quality estimates exist for how many audiologists in a state or local area is adequate, researchers and leaders in the profession of audiology have suggested that there are not enough audiologists now and the growth rate of audiologists is inadequate to meet future need (Bray & Amlani, 2024; Windmill & Freeman, 2013). State reproductive healthcare and LGBTQ+ policies did not consistently predict audiologist movement in this study, but this does not mean that the broader

state policy environment is irrelevant to recruitment and retention. State-level occupational licensing requirements can create financial and administrative barriers to interstate practice, while reproductive healthcare and LGBTQ+ policies may affect whether some HCPs view a state as desirable for themselves and their families. These policy-level contexts exist alongside employment opportunities and community resources and may become more or less influential depending on the circumstances of an individual HCP.

Universities and audiology training programs may also influence the geographic distribution of the future audiology workforce. Training programs represent an organizational context where soon to graduate audiologists develop professional relationships and transition into the workforce. State and community characteristics surrounding training programs may interact with employment opportunities and individual or family preferences when graduates choose their initial practice locations. Policies designed to improve audiologist supply should consequently consider the location and capacity of audiology training programs as one part of a broader workforce environment rather than assuming that state social policy alone will determine where graduates enter practice.

Taken together, the policy implications of this study are less that one specific reproductive healthcare or LGBTQ+ policy may increase or decrease audiologist supply and more that HCP workforce policy should account for the multiple ecological conditions that make locations feasible for providers. Spatial accessibility to EHC HCPs is a downstream outcome of where providers are willing and able to live and practice. Improving the distribution of audiologists may require coordinated approaches across ecological levels, including state policies that reduce barriers to practice, organizational conditions that make employment attractive, and community conditions that support the needs of HCPs and their households.

Policies addressing only one of these conditions may have limited effects when other conditions constrain where audiologists are able or willing to locate.

Future Research

Several questions remain after the findings from the research presented here. Neither reproductive healthcare or LGBTQ+ policy was consistently associated with established audiologist movement or where newly graduating audiologists initially registered to work. These findings suggest that future research should evaluate how policy-level conditions interact with other individual, interpersonal, organizational, and community-level factors that may influence HCP siting. In particular, longitudinal research that includes employment opportunities, compensation, family ties, spouse employment, and other factors identified in Aim 1 may clarify if and when state policy becomes sufficiently important to influence where HCPs ultimately choose to live and work.

Future research should also continue to evaluate whether the relationship between reproductive healthcare policy and HCP siting differs across healthcare disciplines. Prior research showing stronger relationships between reproductive healthcare policy and geographic preferences among HCPs whose training or clinical practice is directly affected by abortion restrictions suggests that the professional relevance of a policy may influence its importance to siting decisions. Reproductive healthcare policy may represent a personal consideration for audiologists while affecting both personal and professional considerations for HCPs who provide reproductive healthcare. Comparing audiologists with HCPs whose scope of practice is more directly affected by reproductive healthcare restrictions may help clarify whether policy-level influences on HCP siting differ according to professional context.

Differences in audiologist movement were already detectable before some meaningful changes in state reproductive healthcare and LGBTQ+ policy environments, limiting the ability to distinguish movement associated with policy change from patterns that were already occurring. Future studies using longer panels would allow evaluation of more pre- and post-policy periods and provide greater ability to characterize movement trajectories surrounding policy changes. Longer follow-up periods may also be important because relocating across states can require more than one year, particularly among established HCPs with employment, family, housing, and other ties to their current location.

Future work should also investigate whether reproductive healthcare and LGBTQ+ policy have different relationships with siting among audiologists who view these policies as personally salient. The population-level administrative data used in this study does not include information about audiologists' gender identity, sexual orientation, reproductive healthcare needs, family members, or other characteristics that could modify the importance of state policy for a HCP. An association among a subgroup of audiologists could be obscured when evaluating the workforce as a whole. Combining longitudinal workforce data with individual-level survey or qualitative data could help identify which HCPs consider state policy when making geographic decisions and when those preferences result in observed movement.

Finally, future research should evaluate whether similar patterns are present among other allied HCPs and among HISs. The results across this dissertation suggest that ecological influences on HCP siting may differ according to professional characteristics, including education, scope of practice, employment opportunities, and the populations or services provided by each profession. Evaluating state policy alongside these professional characteristics across multiple HCP groups would help determine whether the limited relationships identified among

audiologists are specific to this profession or reflect broader patterns among HCPs whose clinical practice is not directly affected by reproductive healthcare or LGBTQ+ policy.

Limitations and Strengths

This study has several strengths. The longitudinal design allowed audiologists to be followed across states over time and changes in state reproductive healthcare and LGBTQ+ policy environments to be evaluated over several years. The use of national NPPES data allowed these relationships to be evaluated across the US rather than within a single state or region. Evaluating both established audiologists who moved between states and newly graduating audiologists initially registering to work in a state also allowed policy relationships to be examined at different stages of audiologists' careers. Descriptive movement analyses evaluated where audiologists actually moved, individual-policy analyses evaluated selected components of the broader policy indices, and pretrend analyses evaluated whether differences in audiologist movement were already present before meaningful changes in state policy environments. Together, these analyses provide multiple approaches for evaluating whether state policy context was associated with audiologist siting rather than relying on a single operationalization of policy or movement.

Several limitations should shape interpretation of the findings. First, this study relied on administrative NPPES data. The NPPES data used in this study has limited validation, resulting in inaccurate and out-of-date records for an unknown number of the HCPs evaluated in this study (Bindman, 2013; Levinson, 2013). Though HCPs are legally required to provide accurate information and update it within 30 days of a change of address or other information, NPPES information may be inaccurate, outdated, and include individuals who register for an NPI but do not provide full time direct patient care, such as this author (Bindman, 2013). Despite these

limitations with the data used in this study, the NPPES remains one of the most reliable, preferred data sources for HCP workforce research (Levinson, 2013). NPPES data also do not include individual characteristics that may influence the importance of reproductive healthcare or LGBTQ+ policy to geographic decisions, including sexual orientation, gender identity, reproductive healthcare needs, or family members. Associations among policies and audiologists who consider these policies particularly salient to their unique context may be obscured when evaluating the audiology workforce as a whole.

Second, the primary analyses used summary reproductive healthcare and LGBTQ+ policy indices to characterize the broader state policy environment. Equal weighting allowed policy environments to be measured consistently across states and years, but assumes that each policy contributes equally to the broader policy environment and may obscure relationships with individual policies that are particularly important to geographic decisions. The individual-policy analyses partly addressed this limitation by separately evaluating selected reproductive healthcare and LGBTQ+ policies, but these analyses were limited to policies selected a priori and do not establish that other individual policies or combinations of policies were unrelated to audiologist siting.

Third, the pretrend analyses identified statistically significant pre-policy differences for several of the policy changes and outcomes evaluated. Differences in audiologist movement were already detectable across all six outcomes before decreases in reproductive healthcare policy scores and increases in LGBTQ+ policy scores. These findings limit the ability to interpret differences surrounding these policy changes as a response to the policy changes because some differences were already present beforehand. There was less evidence of statistically significant pre-policy differences preceding decreases in LGBTQ+ policy scores, but

nonsignificant joint tests do not establish that preexisting differences were absent. The relatively short study period limited by data availability also limited the number of available pre-policy event periods and the ability to statistically characterize longer-term movement trajectories surrounding policy changes.

Fourth, the primary analyses evaluated audiologist movement in the year following state policy exposure. Interstate relocation may take longer than one year to enact, particularly among established audiologists with employment, family, housing, licensure, and other ties to their current state. The one-year lag may not capture delayed movement associated with changes in policy environments. However, the observational design cannot establish that a policy change caused subsequent movement even when policy exposure preceded a change in location. State policy environments may change alongside other economic, political, occupational, or community conditions that also influence where audiologists choose to practice.

Finally, the study evaluated state-level policy environments and interstate movement. This approach was appropriate for reproductive healthcare and LGBTQ+ policies enacted at the state level but does not capture variation in the desirability or feasibility of locations within states. Audiologists may make geographic decisions based on specific communities, employment opportunities, family locations, or other local characteristics that are not represented by a statewide policy score. The findings describe relationships between state policy environments and interstate audiologist siting and should not be interpreted as showing that policy was unimportant to individual audiologists or that policy preferences did not influence choices among locations within the same state.

Conclusion

This study evaluated whether state reproductive healthcare and LGBTQ+ policy contexts were associated with the spatial distribution of audiologists in the US. Neither reproductive healthcare or LGBTQ+ policy was significantly associated with the proportion or number of established audiologists leaving or entering states or newly graduating audiologists initially registering in states in the following year. Descriptive movement analyses did not identify a consistent tendency for audiologists to move toward states with more supportive policy environments, and individual-policy analyses identified few significant associations and no consistent pattern across policies or outcomes. Together, these findings provide limited evidence that state reproductive healthcare or LGBTQ+ policy environments independently influenced the geographic distribution of audiologists during the study period.

These findings do not necessarily show that reproductive healthcare or LGBTQ+ policies are unimportant to individual audiologists when considering where to live and work. Consistent with the SEM used throughout this dissertation, policy represents one influence in a broader set of individual, interpersonal, organizational, and community conditions that shape where HCPs are willing and able to practice. Understanding and improving equitable access to the audiology workforce requires consideration of the multiple interacting contexts that make locations desirable for HCPs rather than assuming that any single aspect of the policy environment independently determines where audiologists practice.

CHAPTER 5: Summary and Conclusions

Introduction

This dissertation investigated whether ear and hearing care (EHC) healthcare providers (HCPs) are inequitably distributed across the US and, if so, what factors help explain these patterns. To address this question, I used qualitative and quantitative approaches to examine how provider preferences, community characteristics, and state policy context shape the spatial accessibility of EHC HCPs. Aim 1 qualitatively examined the individual, interpersonal, organizational, community, and policy factors audiologists considered when making geographic decisions. Aim 2 evaluated how community-level rurality and socioeconomic characteristics were associated with spatial accessibility to audiologists and hearing instrument specialists (HISs). Aim 3 evaluated whether state-level reproductive healthcare and LGBTQ+ policy environments were associated with audiologist movement and where newly graduating audiologists initially registered to work. Together, these studies provide a multi-level view of the factors shaping EHC HCP siting and show that spatial accessibility is a downstream outcome of interacting conditions that influence where HCPs are willing and able to practice.

Chapter 2 (Aim 1)

Chapter 2 (Aim 1) aimed to understand how and why audiologists, the most common EHC HCPs in the US, choose where geographically to live and provide their healthcare services. The research question guiding Chapter 2 was: What factors influence where geographically EHC HCPs choose to live and work among audiologists who relocate during their career? The findings from this chapter highlight three key themes that shape the communities audiologists choose to practice in: (1) occupational considerations, including compensation, financial incentives, and career opportunities; (2) local social and economic environments, including employment

opportunities and resources needed by spouses, children, and aging parents; and (3) state-level policies that did not directly influence participants' choice of where to practice, though participants acknowledged that state social and healthcare policies may influence the siting choices of some audiologists. Gender influenced all three themes rather than emerging as a separate siting factor. Participants described employment decisions as household decisions involving spouse employment, parenting, caregiving responsibilities, and the availability of community resources, which influenced which locations were feasible. Among all the considerations raised, family, typically spouses, children, and aging parents, was among the most important for audiologist siting. Taken together, the results of this chapter show that audiologists consider interacting occupational, interpersonal, community, and policy factors when choosing geographic regions to provide patient care. These results support the SEM of HCP siting used throughout this dissertation by showing that factors across ecological levels can reinforce or compete with one another when HCPs make geographic decisions, potentially contributing to downstream differences in the spatial accessibility of EHC HCPs.

Chapter 3 (Aim 2)

Chapter 3 (Aim 2) aimed to evaluate whether census tract level rurality or socioeconomic characteristics are associated with spatial accessibility to EHC HCPs in the contiguous United States from 2017–2023, and whether siting patterns differ between different classifications of EHC HCPs. The research question guiding this Chapter was: How does the spatial accessibility of different classes of EHC HCPs vary across community-level rurality and socioeconomic characteristics in the contiguous United States? Results from Aim 2 indicated that spatial accessibility was lower in more rural areas, with a stronger effect of rurality for audiologist siting than for HISs. Socioeconomic patterns were more mixed, with audiologist accessibility generally

greater in communities with higher educational attainment and income. HIS accessibility showed a more complex pattern, including relatively greater representation in lower-SES communities depending on how SES was operationalized. These findings suggest that rurality and community socioeconomic characteristics are associated with spatial accessibility to hearing healthcare services, and that audiologists are found in more affluent and urban regions while HISs are relatively more likely to be in rural and poorer regions than audiologists. The different patterns between audiologists and HISs further suggest that community-level influences on EHC HCP siting may operate differently based on characteristics of the profession.

Chapter 4 (Aim 3)

Chapter 4 (Aim 3) aimed to evaluate whether state reproductive healthcare or LGBTQ+ policy was associated with the supply and movement of audiologists in the US from 2017–2024. The research questions guiding Aim 3 were: Does reproductive healthcare policy influence the supply of audiologists in a state; and does LGBTQ+ policy influence the supply of audiologists in a state? Results from Aim 3 indicated that neither reproductive healthcare or LGBTQ+ policy were significantly associated with the proportion or number of established audiologists leaving or entering states or newly graduating audiologists initially registering in states in the following year. supplemental analyses did not identify a consistent pattern of audiologists moving toward states with more supportive reproductive healthcare or LGBTQ+ policy environments, and individual-policy analyses identified few significant associations without a consistent pattern across policies or outcomes. Taken together, the results of Aim 3 provide no consistent evidence that state reproductive healthcare or LGBTQ+ policy environments independently influence audiologist siting. These findings together with the results from Aim 1 suggest that policy is one

factor among the individual, interpersonal, organizational, and community factors that may influence where audiologists choose to live and work.

Overarching Patterns of Ear and Hearing Care Provider Location

Taken together, the findings of this dissertation suggest that the spatial accessibility of EHC HCPs in the United States is structured by place in systematic ways. Across the qualitative and quantitative analyses, EHC HCP distribution reflected the influence of rurality, community socioeconomic context, provider type, and broader factors at each level of the SEM. In general, spatial accessibility was lower in rural areas, audiologists were more concentrated in more urban and more affluent settings, and HISs appeared to partially fill gaps in more rural and lower-income communities. The findings also suggest that where EHC HCPs choose to live and work is shaped not only by local labor market conditions, but also by whether places are viewed as financially viable and containing healthcare, education, and other important amenities for audiologists' families. State reproductive healthcare and LGBTQ+ policy environments were not consistently associated with audiologist movement or where newly graduating audiologists initially registered to work, suggesting that policy context alone may not independently determine audiologist siting. Overall, this dissertation indicates that inequitable access to EHC services may be produced through the interaction of factors across ecological levels that shape where the EHC workforce is able and willing to locate.

The findings from these analyses extend the literature by moving the study of EHC access beyond the assumption that provider availability is fixed or aligns with physician and other medical specialty siting and instead showing that the spatial accessibility of EHC HCPs is shaped by unique, multi-level place-based influences. In doing so, this dissertation brings EHC HCPs more fully into healthcare workforce and health services research by examining a

discipline whose siting patterns have been comparatively understudied. In addition, by showing that provider type matters rather than treating the hearing workforce as a single category, this dissertation provides evidence that healthcare workforce research across medical and nonmedical healthcare disciplines should account for all HCPs providing services of interest, not merely focusing on physicians or a single discipline.

Implications for Research

The findings from this dissertation suggest several implications for future research. First, research on healthcare workforces should avoid treating a workforce as a single group and should examine each profession separately, because the Aim 1 and 2 results suggest that these provider types follow distinct siting patterns across contexts. Second, the mixed socioeconomic findings depending on how SES was operationalized show a need for additional work clarifying which dimensions of community advantage or disadvantage are most relevant to HCP spatial accessibility. Third, because HISs appeared to be more represented than audiologists in some rural and lower-income areas, future studies should examine how different provider types complement or substitute for one another across communities. Fourth, because reproductive healthcare and LGBTQ+ policy were not consistently associated with audiologist siting, future studies should examine whether these policies are more influential for HCPs for whom the policies have greater personal or professional relevance, such as HCPs directly affected by reproductive healthcare policy or HCPs with LGBTQ+ identities. Finally, these findings indicate a need for research examining how policy context interacts with individual, interpersonal, organizational, and community factors to shape HCP siting, rather than evaluating state policy as an independent determinant of workforce availability.

These results support the SEM of HCP siting developed throughout this dissertation by demonstrating the importance of considering factors across ecological levels and how those factors operate differently between professions. Aim 1 showed that audiologists consider multiple interacting occupational, interpersonal, community, and policy factors when making geographic decisions, and Aim 2 showed that community-level rurality and socioeconomic characteristics were associated with EHC HCP spatial accessibility and that these patterns differed between audiologists and HISs. Aim 3 provided limited evidence that reproductive healthcare or LGBTQ+ policy independently influenced audiologist siting, suggesting that policy context may be insufficient on its own to explain where HCPs locate. Taken together, these findings suggest that future healthcare workforce research should evaluate HCP siting as the downstream result of interacting conditions across ecological levels and account for how the importance of these conditions may differ based on characteristics of the profession being studied.

Implications for Policy

These findings have several important implications for understanding and planning future hearing healthcare delivery in the US. First, EHC services are less accessible in rural regions, particularly EHC services provided by audiologists. This agrees with other studies that have found higher travel times to audiologists for people living in rural communities (Planey, 2019, 2020; Planey et al., 2024; Pudrith et al., 2024). For models of all EHC HCPs, the negative relationship between rurality and spatial accessibility after controlling for other covariates was the second strongest predictor of hearing healthcare access, mirroring trends in other healthcare disciplines (Costa et al., 2024; Hou et al., 2016). The observed relatively greater presence of HISs in rural communities suggests that HISs' shorter training pathways and lack of a need for

several years of graduate training may allow HISs to enter markets that are less accessible or less desirable to audiologists.

The dearth of audiologist services in rural areas also suggests that financial incentive programs for HCPs working in underserved areas may expand EHC services in these communities if incentive programs are expanded to include audiologists or HISs. Financial incentives are generally effective in increasing the prevalence of HCPs in underserved areas where their services are needed (Bärnighausen & Bloom, 2009; Goodfellow et al., 2016). Many state and federal financial incentive programs that provide funding or loan repayment for HCPs working in underserved areas such as the National Health Service Corps and Pediatric Specialty Loan Repayment Program exclude audiologists (American Association of Medical Colleges, 2024; Health Resources & Services Administration, n.d.; U.S. Department of Health and Human Services, 2024). Though these and similar programs in the US regularly include allied HCPs with similar levels of education to audiologists, EHC HCPs are often omitted. Expanding financial incentive programs to audiologists and/or HISs may incentivize these HCPs to live and work in communities that otherwise would not be financially feasible.

The socioeconomic findings also have implications for policies intended to improve EHC spatial accessibility. Audiologists were generally more accessible in more affluent communities, while HISs showed a more complex relationship with community SES and were relatively more represented than audiologists in lower-SES communities. These differences suggest that policies intended to improve EHC spatial accessibility should account for differences between provider types rather than treating the EHC workforce as a single group. Expanding the HIS workforce may be one path to improving spatial accessibility in communities where audiologists are less

likely to practice, and financial incentives or other policies that make practice more feasible in underserved communities may be important for increasing audiologist availability.

Finally, the findings from Aim 3 suggest that state reproductive healthcare and LGBTQ+ policy should not be treated as independent policy influences that influence the geographic distribution of audiologists. Neither policy context was consistently associated with audiologist movement or where newly graduating audiologists initially registered to work, and the additional analyses did not identify a consistent pattern suggesting that audiologists preferentially moved toward more supportive policy environments. These findings do not suggest that state policy is unimportant to individual audiologists, but that changing a single aspect of the state policy environment may be insufficient to alter the distribution of the audiology workforce. Policies intended to improve EHC HCP availability may be most effective when they address multiple conditions that make locations feasible and desirable for HCPs, including financial viability, employment opportunities, community resources, and other influences identified across this dissertation. This approach is consistent with the SEM, where HCP siting is conceptualized as the result of interacting influences across ecological levels rather than any one factor operating independently.

Strengths and Limitations

This dissertation has several notable strengths that make the analyses presented here effective at showing what influences EHC HCP siting. By using both qualitative and quantitative methods, this dissertation deeply analyzed the preferences of EHC HCPs in their own words and complemented it with national-scale data to explore these issues from several directions. The qualitative perspectives from Aim 1, for example, provided context that helped explain findings in Aims 2 and 3.

At the same time, several limitations should shape interpretation of the findings. The qualitative data presented in Aim 1 reflects a specific moment in time and a specific subset of providers, because it includes only audiologists who had relocated across states and excludes HISs and audiologists who did not relocate during their career, and participant responses may also have been influenced by the interviewer's professional and social positionality as a fellow EHC HCP. The tract-level analysis in Aim 2 was limited by unavailable 2020 socioeconomic covariate data, an inability to include EHC population need in the analyses, and by computational and measurement constraints inherent to national-scale spatial accessibility modeling, though as access disparities are likely underestimated these results remain useful for answering the research question. The analyses in Aims 2 and 3 relied on administrative NPPES data with known limitations to its validation of HCP addresses. In Aim 3, only evaluating movement for one year after policy change occurs may miss interstate movement that takes longer than one year to enact in response to changes in policy environments. In addition, the pretrend analyses identified differences in audiologist movement that were already present before some meaningful changes in state policy environments, limiting the ability to interpret subsequent differences in movement as resulting from the policy changes themselves. Taken together, these limitations suggest that the findings are best understood as identifying broad patterns in EHC HCP distribution in a specific time period, not as truths that necessarily apply in other nations or time periods.

Conclusion

This dissertation shows that the spatial accessibility of EHC HCPs in the US is shaped by place. Across qualitative, geospatial, and policy analyses, the findings presented here indicate that provider distribution is not solely a reflection of patient need or workforce size, but of the

individual, interpersonal, organizational, community, and policy contexts that make some communities and states more or less feasible and desirable for EHC HCPs to live and practice. Spatial accessibility was lower in rural areas, audiologists were found in wealthier and more urban settings more often than HISs, and community socioeconomic characteristics were associated with EHC HCP spatial accessibility differently depending on provider type and the measure evaluated. Reproductive healthcare and LGBTQ+ policy environments were not consistently associated with audiologist movement or where newly graduating audiologists initially registered to work, suggesting that policy context alone may not independently determine audiologist siting.

Taken together, these findings suggest that spatial accessibility to EHC HCPs is a downstream result of interacting factors that influence where HCPs are willing and able to practice. Audiologists described balancing occupational opportunities with family needs and community characteristics when choosing where to live and work, while the quantitative findings showed systematic differences in EHC HCP spatial accessibility by rurality, socioeconomic context, and provider type. Improving equitable access to hearing healthcare requires a focus on not only hearing loss treatment or workforce size, but also to the conditions that make communities feasible and desirable places for EHC HCPs to practice. Understanding these conditions may help identify opportunities to improve EHC HCP availability in communities where spatial accessibility to hearing healthcare services remains limited.

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Appendix A, Chapter 2 Interview Guide

1. Moving as part of a major life transition
    a. What stage of life were you in when you moved?
    b. Can you tell me about the timeline of your move?
    c. What were your main goals for moving?
    d. Did your family influence when or where you moved?
        i. What was important to you in choosing where you moved to? Childcare, schooling, availability of extracurriculars, something else?
2. Prior experiences
    a. How was the place you moved to similar to or different from places you had lived in the past?
    b. Did places you had lived previously cause you to seek out, or avoid, certain types of communities?
    c. Was there a certain population or type of people you hoped to be closer to by moving?
    d. How was the place you moved from similar to and different to places you had lived before?
3. Desirability of locations
    a. If you could move anywhere to work, where would you choose?
    b. Was the cost of living in your origin or destination influential in choosing to move or where to move?
    c. Were you thinking about weather, climate, or natural disasters when choosing to move, or where to move?
4. State policy
    a. Were there any state policies or laws that would make you more or less likely to live and work in a state?
    b. Did state licensing fees and licensing requirements that differ between states play a role in choosing to move or which state to move to?
    c. How do you think that the interstate compact might affect the profession of audiology?
5. Socioeconomic influences
    a. Was pay or compensation involved in your decision to move?
    b. What type of compensation or benefits was most important to you when thinking about getting a new job after moving – salary, benefits, work-life balance, something else?
    c. Did student loan forgiveness programs influence your decision to move, or where to move?
    d. Was opening or owning your own practice something that influenced you relocating?
6. Access and utilization of care
    a. What do you think is the ideal type of community for an audiologist to move to to be successful?
    b. Does it depend on their specialty?
    c. Were the number of other audiologists in the area relevant in choosing to or where to move?

d. Were the number of PCPs and ENTs in the area who could potentially refer to or receive referrals from you relevant in choosing to or where to move?