# Relationship Between Household Income and Loss to Follow Up for Neonatal Hearing Screenings in Washington State

**Anisha Upasani**

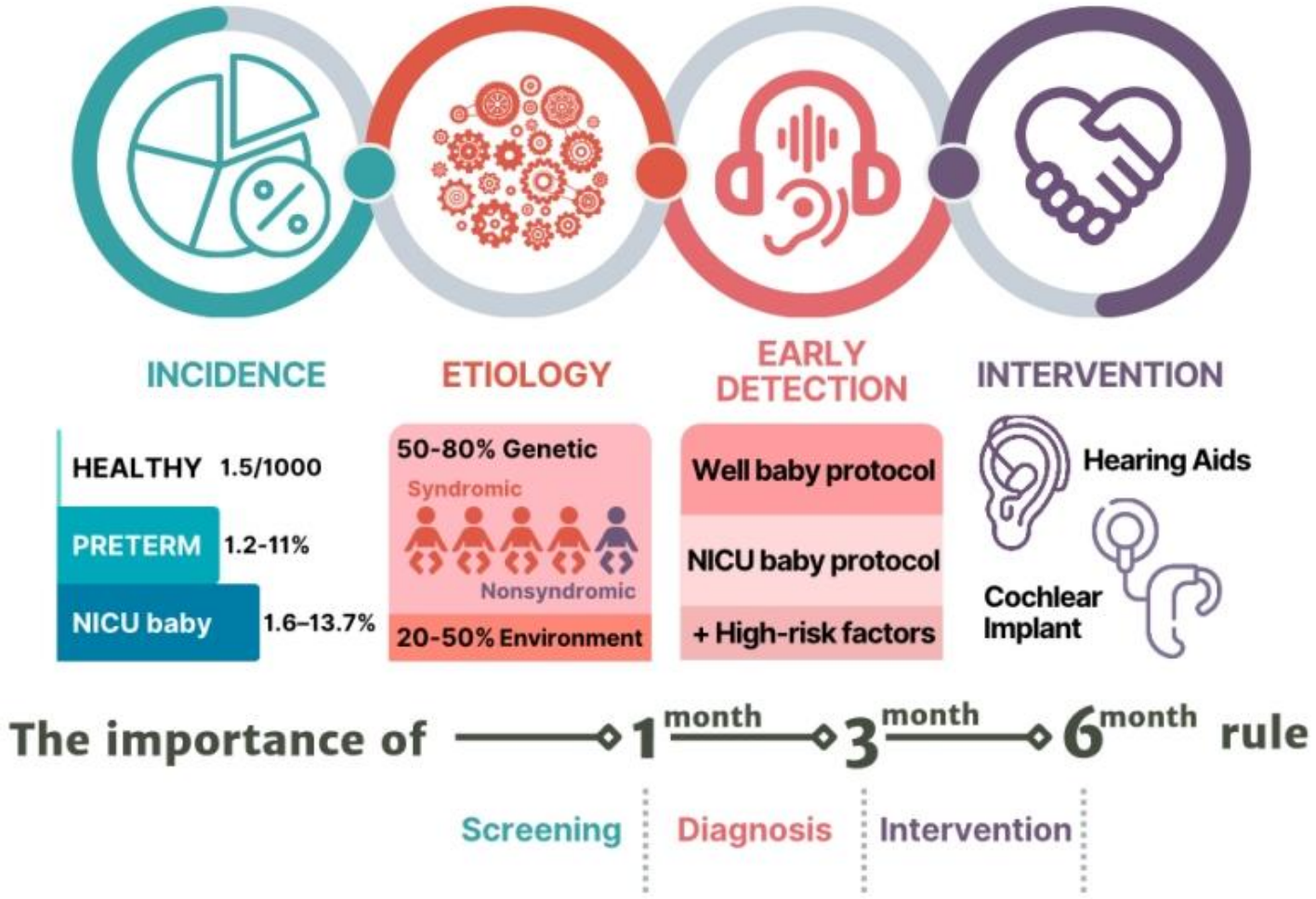
# Newborn Hearing Screening – Basic Facts

- Measures responses from your baby's auditory system when he or she hears sound
- Can be done using either auditory brainstem response (ABR) testing or otoacoustic emissions (OAE) testing
- Takes about 10-20 minutes
- Can be performed by nurses, technicians, midwives, audiologists (hearing specialists) and other trained professionals
- Cannot determine if your baby is deaf or hard of hearing, but can tell you if your baby needs more testing
- Cannot tell the difference between fluid in the ear and permanent hearing loss if a baby does not pass
- Babies who have never had a hearing screening or who did not pass one hearing screen should receive a hearing screen before 1 month of age
- Follow up is required only if potential hearing loss is detected in the infant

# Importance of Newborn Hearing Screening

- Each year, approximately 86,000 infants are born in Washington State, and approximately 233 babies are born deaf or hard of hearing (DHH)
- With an incidence of approximately 3 in 1,000 births, hearing loss is the most common birth defect
- The first two years of life are critical for learning speech and language, and unidentified hearing loss can significantly impact a child's ability to develop these skills
- Over 50% of babies born with hearing loss have no known risk factors and 90% of babies with hearing loss are born to parents with normal hearing
- Universal newborn hearing screening is essential to identify hearing loss early
- All birth hospitals in Washington state currently perform newborn hearing screening as the standard of care

# Steps for Congenital Hearing Loss




- Proper follow up is required for early detection and intervention
- Otherwise, the patient cannot receive the necessary care and may experience *permanent hearing loss*

# What is Loss to Follow-Up

- In the context of infant hearing loss, **"loss to follow-up" (LTF)** refers to cases where infants who fail a newborn hearing screening (NBHS) but do not receive the necessary follow-up testing or intervention to confirm or address the hearing loss
- This can lead to:
  - **Delayed Diagnosis and Intervention:** Missing the critical window for early treatment (before 6 months of age) can lead to speech, language, cognitive, and social development delays
  - **Reduced Access to Hearing Support:** Infants who do not receive timely follow-up may miss out on hearing aids, cochlear implants, and speech therapy, causing many potential long-term impacts

# Problems with Untreated Hearing Loss

- Difficulty understanding speech/communicating with others
- Delayed speech and language development
- Poor academic performance
- Difficulty forging social connections and making friends
- Limited career opportunities in adulthood

All problems listed above are avoidable with proper follow-up after a failed hearing loss test. Patients lost to follow up do not receive the necessary, ***timely*** treatment for hearing loss. It is often too late to reverse the damage later in life.

# Project Overview

## Project Focus

- Analysis of the relationship between poverty and infants lost to follow up after a failed hearing screening
- Understand regional disparities across Washington State
- Explore inequity and systemic barriers to follow-up care

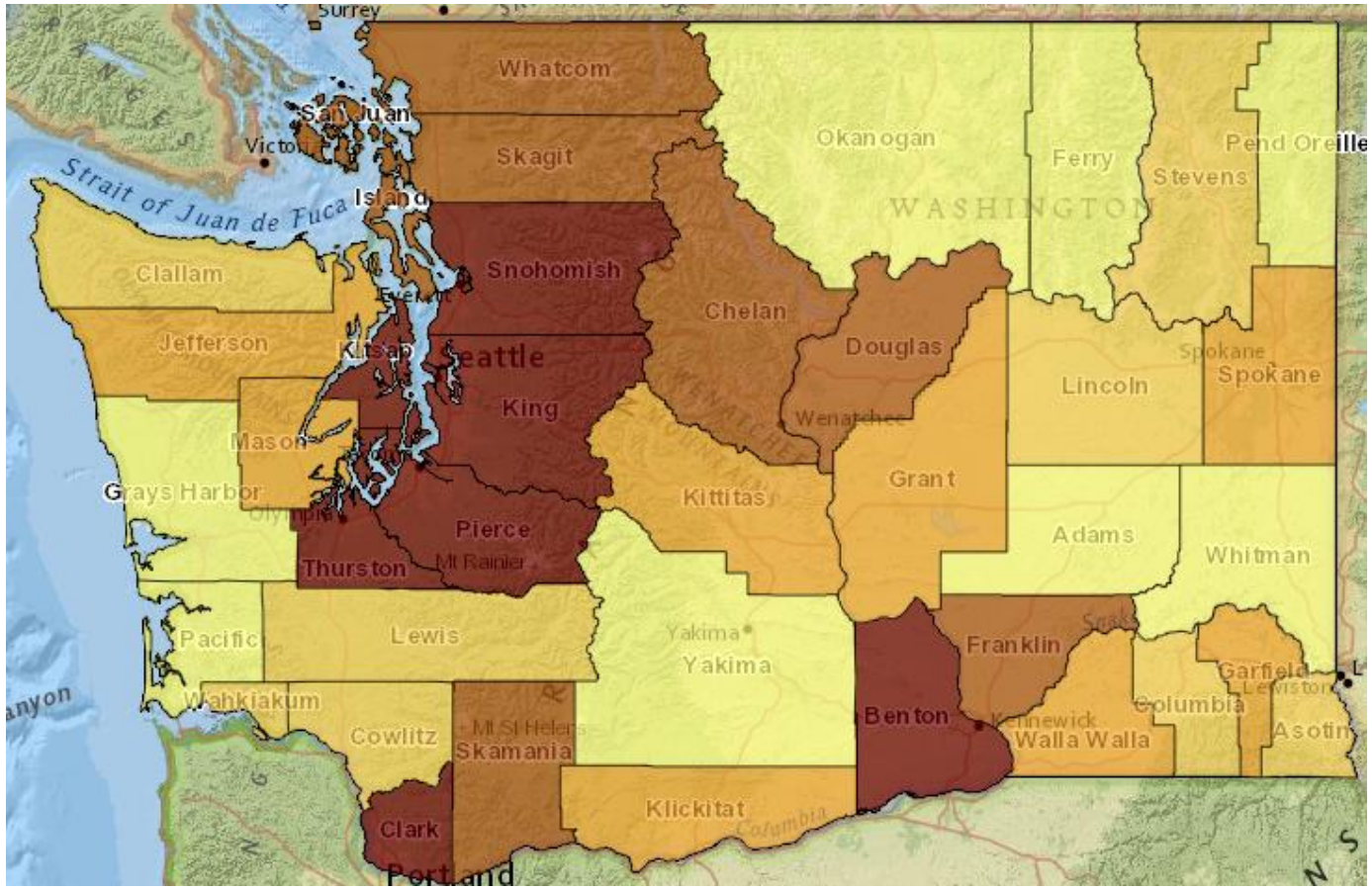
## Project Goals

- Explore the topics of health equity and early intervention
- Raise awareness about chronic poverty and lack of healthcare access for lower-class individuals
- Emphasize the importance of access in early childhood screening outcomes

# My Process

| | |
|---|---|
| **Research** | Acquired WTN data with a focus on household income levels and follow up rates after initial hearing screenings.<br>Supplemented my research with published papers and studies on loss to follow up patients. |
| **Analysis** | Cross-compared county LTF rates with median household income.<br>Identified patterns present and researched possible reasons for the correlations. |
| **Conclusion/Thesis** | Condensed my research and analysis into a single, cohesive conclusion.<br>Ensured the focus of my project remained on the inequity in healthcare access and infant hearing screening processes. |

# Median Household Income by County



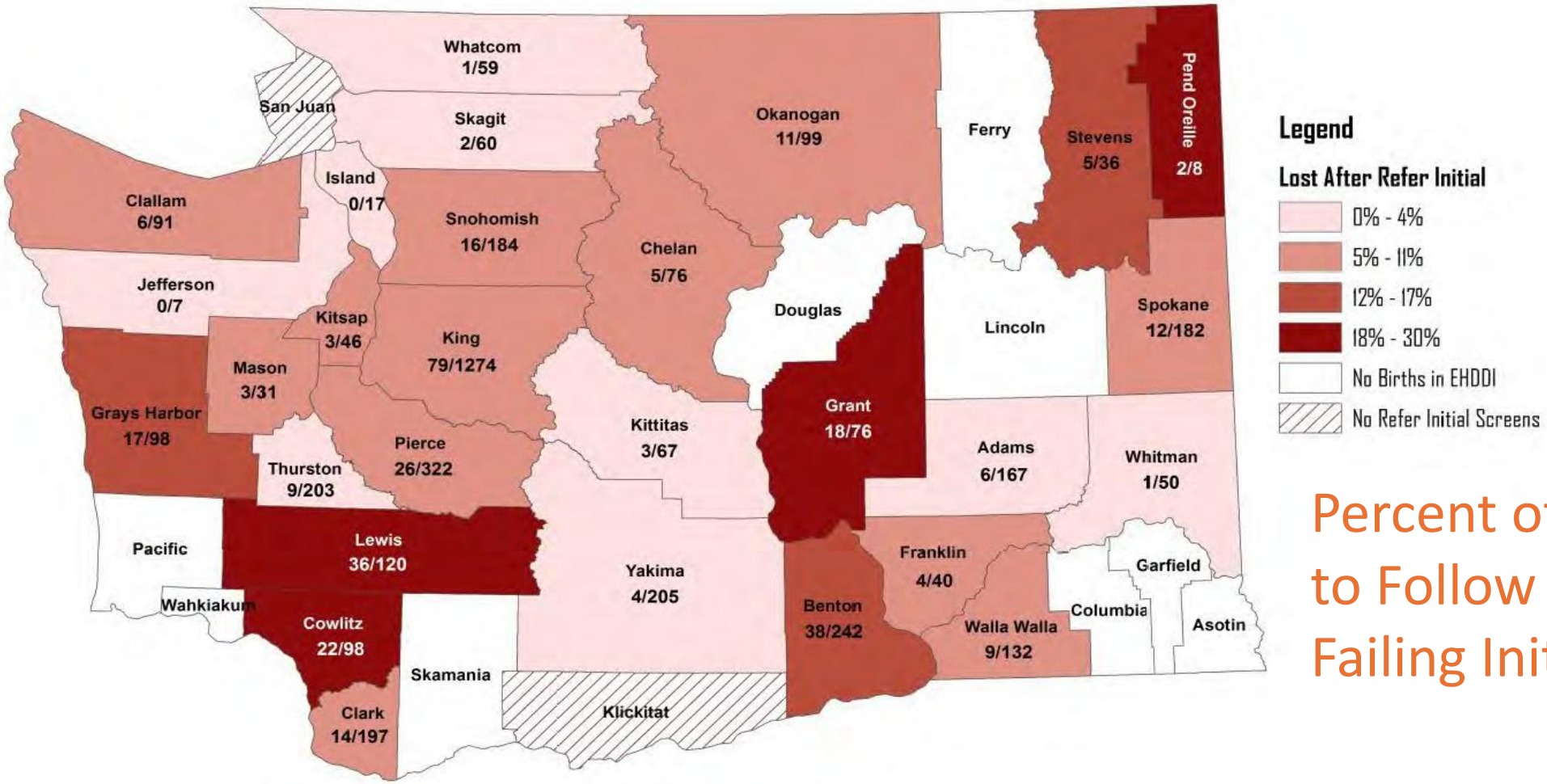

**Legend (Measure 1)**

Median Household Income

- 41939 - < 51775
- 51775 - < 55127
- 55127 - < 58795
- 58795 - < 69023
- 69023 - 94974

Median Household Income
Washington Tracking Network (WTN) – Map View

# Percent of Infants Lost to Follow-Up by County




Percent of Patients Lost to Follow Up After Failing Initial Screening

Washington Department of Health (WADOH) – Map View

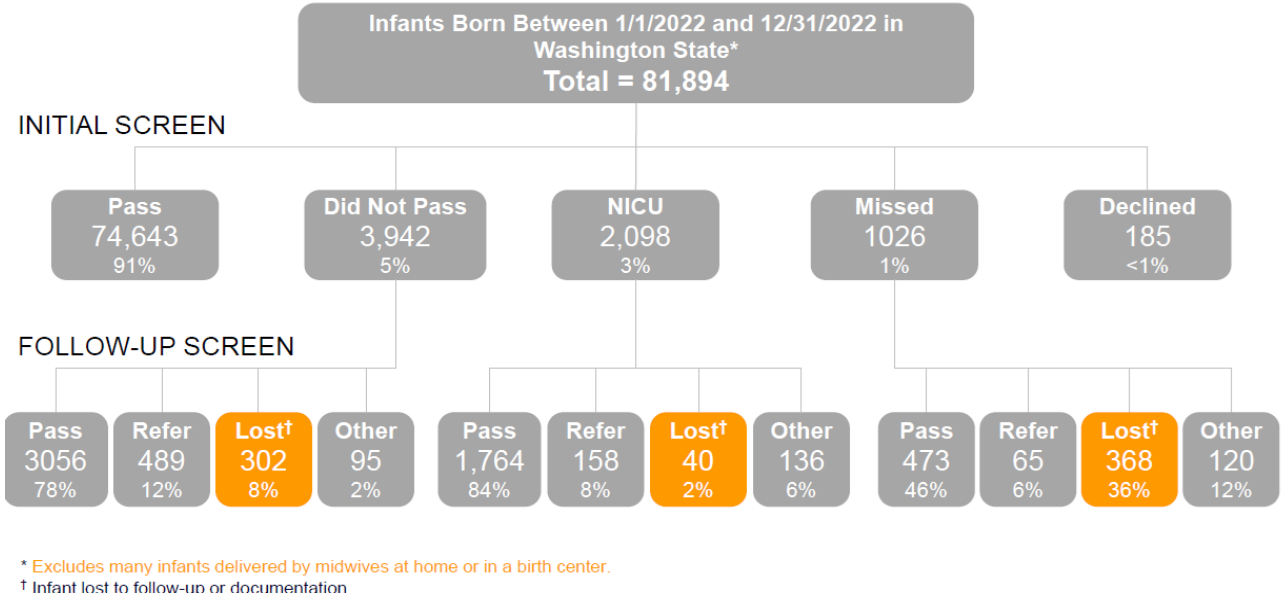
# What Does This Comparison Show?

- The counties with lower median household income are Lewis, Yakima, Cowlitz, Okanogan, Gray's Harbor, and Pend Oreille.
- The counties with the highest loss to follow up rates are Lewis, Cowlitz, Grant, Gray's Harbor, and Pend Oreille.
- Trend: Poorer counties are more likely to have higher loss to follow-up rates after hearing screening. This is an example of an inverse correlation: As poverty rates increase, follow-up rates on failed hearing screenings decrease.
- There are some outliers present such as Okanogan and Yakima counties. However, outliers are present in almost all data analysis, and the correlation seen here is too strong to disregard.

# Analysis on Loss to Follow-up Rates

- This image presents data on newborn hearing screenings in Washington State for infants born in 2022 and highlights key issues related to loss to follow-up (LTF)
- Among infants who did not pass the initial screening:
  - 8% (302 infants) were lost to follow-up
- Among infants in the NICU requiring follow-up:
  - 2% (40 infants) were lost to follow-up
- Among infants who missed the initial screening:
  - 36% (368 infants) were lost to follow-up, the highest among all groups

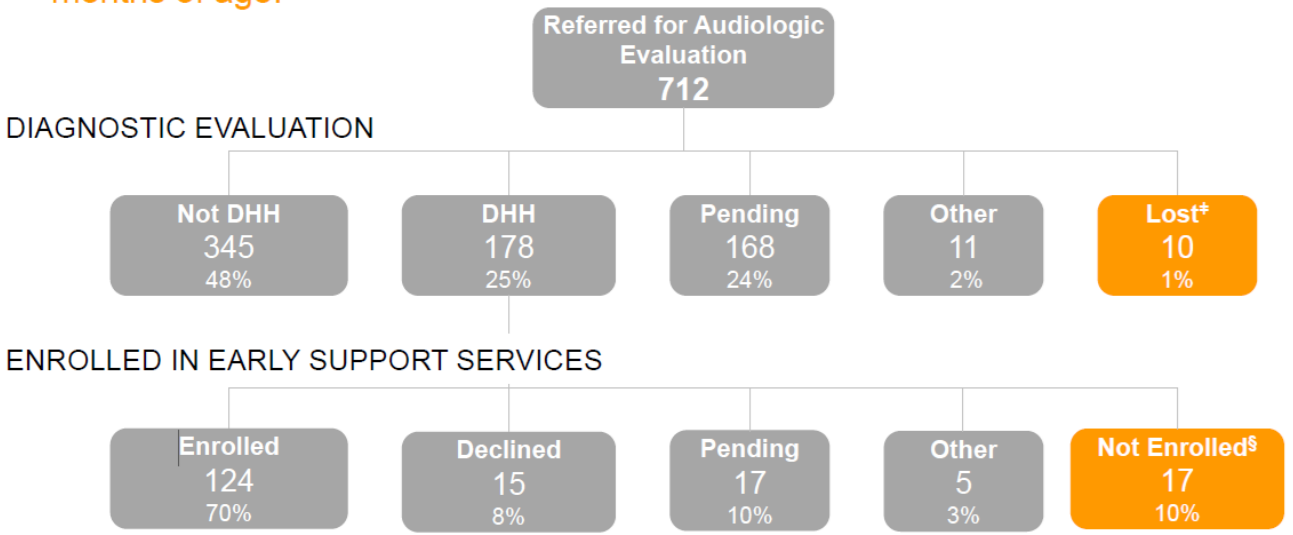
- Many infants born out-of-hospital did not get hearing screens.
- 710 infants did not get needed follow-up screens.



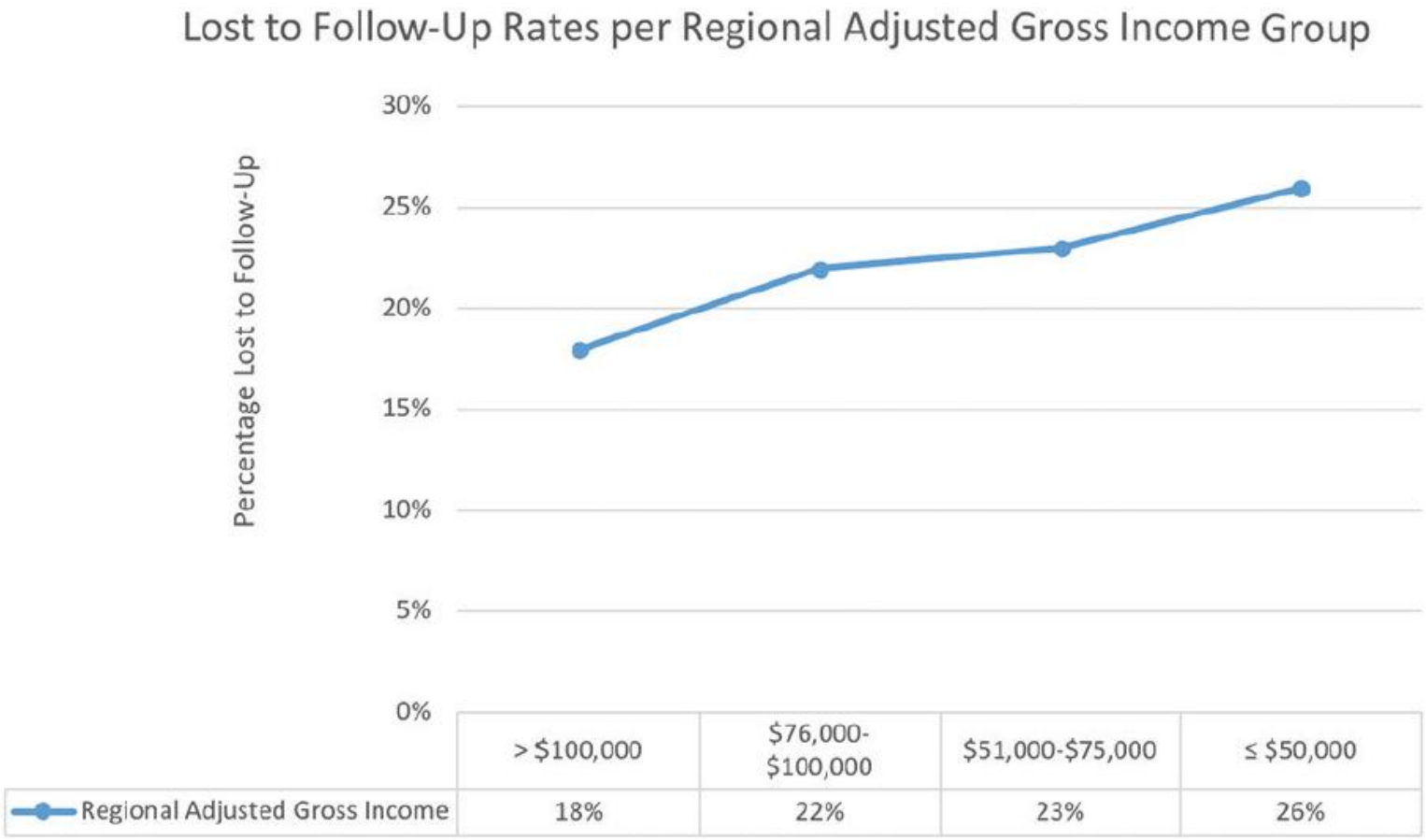
# Early Detection and Support Rates

- This image presents data on diagnostic evaluations and early support enrollment for infants referred for audiologic evaluation in Washington
- A significant portion of infants (40%) were not identified early enough, and half of Deaf & Hard of Hearing (DHH) infants did not receive early support services by 6 months

- Only 60% of infants were identified before 3 months of age.
- Just 50% of infants identified as DHH were enrolled in early support services by 6 months of age.

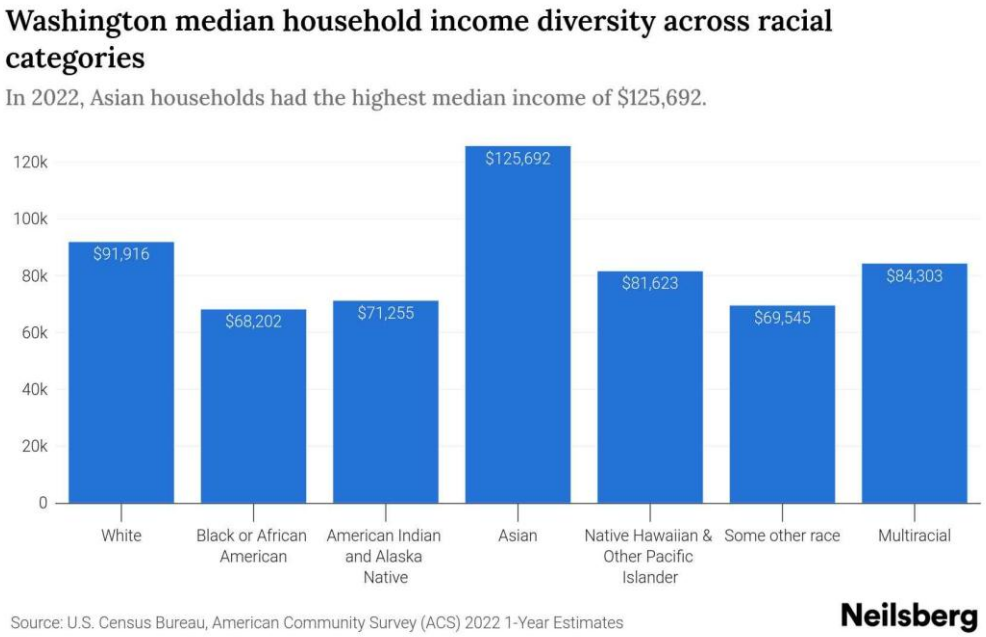


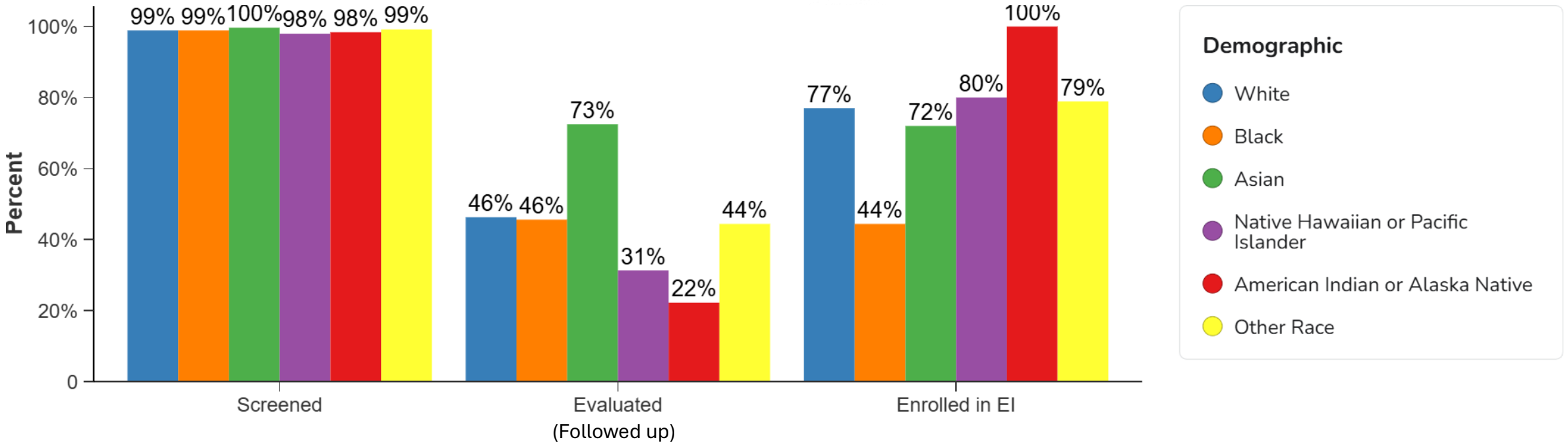
# Additional Research




- This graph depicts loss to follow up rates grouped by income classes
- People of the lowest income class in the study (<=$50,000), were observed to have the highest loss to follow-up rates at 26%
- Conversely, people of the highest income class (>$100,000), were seen to have the lowest loss to follow up rates at just 18%
- Evidently, there is a significant disparity in loss to follow up rates among people of different income classes
- People of higher income classes have higher follow-up rates, while people of lower income classes have lower follow-up rates

# Lost to Follow-up Rates vs. Race



# Loss to Follow-up Rates vs. Race continued…

- Lost to follow up rates disproportionately affect people based on race demographics.
- The races with the lowest median household income are American Indian and Alaska Native and Black.
- The second chart details the difference between the percent of people who receive their first screening, and the people who are further evaluated. The difference between the two is people who are lost to follow-up.
- The patients with the lowest follow-up rates are ‘American Indian & Alaska Native’, ‘Native Hawaiian & Pacific Islander’, and ‘Black’. These races also have the lowest median household income rates, further showing the disparity between income levels and loss to follow up rates.

# Effect of Poor Screening Quality on LTF

- Counties with the highest loss to follow-up rates (18%–30%) are linked to hospitals with:
  - High percentages of infants who do not pass their initial hearing screening
  - Lack of access to outpatient rescreening at the same facility
- Key examples include:
  - **St. John Medical Center (Cowlitz County):** Does initial screening but does not offer rescreens; community providers handle follow-ups
  - **Providence Centralia Hospital (Lewis County):** Has a 19% initial screening failure **rate** and does not conduct rescreens
  - **Coulee Medical Center (Grant County):** Fails 27% of infants on the initial screen; 11 out of 18 infants who needed a second screen did not receive it
- These cases highlight how poor-quality initial screenings and limited access to rescreening contribute to higher loss to follow-up rates
- These factors are directly related to poverty, and further highlight the challenges disadvantaged individuals face when attempting to rescreen/follow-up on an infant who failed the initial hearing screening.

# Causes of Loss to Follow-Up

## Maternal Factors:

- Low maternal education is linked to lower health literacy, reducing awareness of the importance of early hearing loss diagnosis
- Younger and unmarried mothers may struggle with follow-up due to limited social support and competing responsibilities (e.g., work, childcare)

## Geographic Barriers:

- Rural residents face longer travel distances and limited public transportation, making follow-up appointments more challenging
- Fewer healthcare providers and facilities equipped for newborn hearing screening (NBHS) and follow-up exist in rural areas

## Financial & Insurance Barriers:

- Insurance coverage varies by region; lower-income families are more likely to be uninsured or rely on public insurance
- *While most U.S. insurance plans cover initial NBHS, follow-up visits often require copayments, creating financial burdens*
- Families facing financial hardship may avoid screening, additional testing, and potential treatment due to cost concerns

# Causes of Loss to Follow-Up Continued…

- **Systemic Factors:**
  - **Increasing Out-of-Hospital Births in Washington:**
    - The number of out-of-hospital births in Washington has risen over the past decade
    - Washington ranks 4th in the U.S. for the highest percentage of out-of-hospital births (3.77% in 2017)
    - Nationally, home births increased by 77% (2004–2017), and birth center births more than doubled
  - **Effects of COVID-19 on Hearing Screenings:**
    - The pandemic led to decreased access to newborn hearing screenings, increasing numbers of infants not receiving hearing screenings or follow-up care in a timely manner
    - In 2020, 529 infants missed their hearing screening, compared to 350 in 2019
    - Only 55% of infants identified as deaf or hard of hearing in 2020 were found by three months of age, down from 67% in 2019
  - **Lack of Standardized Procedures:**
    - The increase in non-hospital births may lack standardized procedures for conducting hearing screenings, and even when screenings are performed, there may be no established process for reporting the results
    - Among the **83,945** infants tracked in 2012, **5% (4,187)** did not pass their initial hearing screening. Of these, **8% (352/4,187)** did not receive a necessary second screening. In **80% (251/352)** of these cases, the infant's primary care provider (PCP) informed the family of the need for rescreening, yet either the infant was not brought in, or the screening result was not reported

# Correlation vs. Causation

- Although there is a strong correlation present between poverty rates and loss to follow up rates, this does not directly indicate a causative relationship. Instead, there are many different factors *associated* with poverty, that can lead to this correlation.
- Some of these factors are:
  - Lack of transportation to healthcare facilities
  - Lack of a flexible work schedule for parents
  - Lack of health insurance
  - Limited access to nearby/local providers
  - Educational/health literacy barriers
- All the above problems are extremely prevalent among people of lower income classes. Their inability to access adequate healthcare is directly related to their income class but is not **caused** by their socioeconomic status.

# Equity:
# Economic disparities in follow-up after screening

- There are many barriers in place when it comes to receiving adequate healthcare. These barriers are only propagated by the cycle of poverty that may occur when children with untreated hearing loss do not have the skills nor the opportunities to escape the vicious cycle. Some specific challenges faced by people of lower socioeconomic class are:
- **Inability to afford secondary screenings:** As healthcare costs continue to rise, people of lower income classes have greater difficulty accessing adequate healthcare without going into debilitating debt. Oftentimes, a follow-up appointment is not deemed a necessity, and the hearing loss may go untreated.
- **Disparity in quality of healthcare:** Lower income areas are less likely to have adequate facilities for hearing loss screening. Additionally, hospitals in lower-income areas are unable to afford the necessary equipment and are forced to make use of subpar diagnostic tools. A lack of quality healthcare may mean that hospitals are not equipped to diagnose and treat hearing loss at an early enough time.

# Health and Social Significance

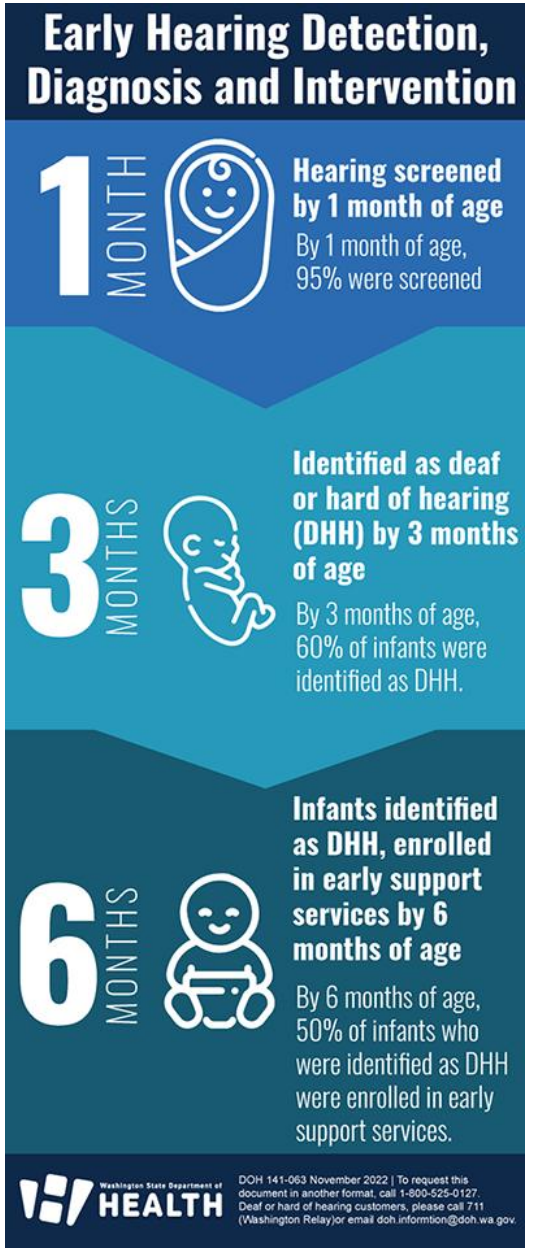
- Untreated hearing loss affects long-term educational outcomes
- Children with untreated hearing loss are likely to grow up feeling isolated and cut off from their peers due to major communication barriers.
- Social equity: children in low-income households already face educational and developmental disadvantages – hearing loss amplifies this.
- Early detection saves future costs and improves quality of life leading to a more equal and cohesive society.


Effects of Untreated Hearing Loss
Social Rejection
Reduced Job Performance
Impaired Memory
Withdrawal From Loved Ones
Fatigue, Tension & Stress
Reduced Alertness
Irritability & Anger
Diminished overall health

# Early Hearing Detection, Diagnosis and Intervention

The Washington State Early Hearing Detection, Diagnosis and Intervention (EHDDI) Program follows the 1-3-6 goals, to ensure that infants in Washington are:

- **1** – Screened for hearing loss before hospital discharge or by **one** month of age
- **3** – Have a diagnostic hearing evaluation by an audiologist by **three** months of age (if the infant did not pass two screens)
- **6** – Enrolled in early intervention by **six** months of age (if a hearing loss was found)



# Collaborative Efforts Supporting Universal Newborn Hearing Screening in Washington

- ***American Academy of Pediatrics (AAP):***
  The AAP supports children's health and makes sure they get good care through their regular doctors. In Washington, the AAP works with the Department of Health to teach doctors about newborn hearing screening and available services for children with hearing loss
- ***Audiologists:***
  Audiologists are hearing specialists who help find out if a baby is deaf or hard of hearing. They conducting diagnostic evaluations for those who do not pass their first hearing screening. They also work with the Department of Health to make sure the right steps are followed and help report test results through a secure system
- ***Birthing hospitals:***
  Birthing hospitals run individual UNHS programs, with all Washington birthing hospitals having implemented them by the end of 2006. Hospital staff manage and maintain the screenings to make sure newborns get tested for hearing issues
- ***Center for Childhood Deafness and Hearing Loss (CDHL):***
  The CHDL works with schools and organizations across the state to support the education of children who are deaf, deaf-blind, or hard of hearing. They help coordinate services and ensure students have access to different ways of communicating
- ***Hands and Voices:***
  Hands and Voices  is a group that supports families of children who are deaf or hard of hearing. The Washington State Department of Health has worked with them to run the Guide By Your Side (GYBS) program, which connects families with trained parent guides. These guides help families find resources, understand the system, and speak up for their child’s needs in healthcare and school

# Collaborative Efforts Supporting Universal Newborn Hearing Screening in Washington

- **Seattle Children's Hospital:**
  Seattle Children's audiologists help hospitals with newborn hearing screening programs. They visit hospitals, train staff, and work with the Department of Health to create educational materials for parents and professionals
- **Washington Sensory Disabilities Services (WSDS):**
  WSDS helps families and teachers understand and support children with hearing or vision disabilities. They also train Head Start programs to improve hearing screenings for young children
- **Washington State Department of Early Learning (DEL):**
  DEL's Early Support for Infants and Toddlers program helps families with young children who have disabilities. Family resource coordinators in each county connect families with the services they need
- **Washington State Department of Social and Health Services (DSHS):**
  The Office of the Deaf and Hard of Hearing (ODHH) provides support for people who are deaf, hard of hearing, or deaf-blind. They run service centers across Washington that offer communication help, advocacy, interpreter information, workshops, and independent living support
- **Washington State Hospital Association (WSHA):**
  WSHA supports hospitals in Washington and encourages them to offer newborn hearing screening programs. They provide leadership and advocacy to help hospitals maintain these programs

# New Approaches: Advanced Technology as Part of Follow-up Care

- **Smartphone based screening**: This is a great, low-cost option for hearing screenings for lower-class individuals. It utilizes microphones and speakers on a smartphone, to potentially recognize and evaluate hearing loss in infants. However, they do have some limitations in accuracy and measuring bone conduction.
- **Automated Auditory Brainstem Response (AABR):** Measures how well a baby's hearing nerve and brain respond to sound. Efficient and accurate way to screen for hearing loss in infants.
- **Otoacoustic Emissions:** Checks if the inner ear is responding to sound by measuring an echo generated by the cochlea. One of two typical ways to screen for hearing loss in infants (second is AABR).

# American Sign Language (ASL) and Hearing Loss

- For families of children with hearing loss, ASL can be a valuable tool for communication and language development
- **American Sign Language (ASL)** is a fully developed, natural language with its own grammar and structure. It offers an accessible form of communication for deaf and hard-of-hearing individuals. It is the language of the Deaf community and the third most common language in the United States
- Engaging with early intervention services and introducing ASL from an early age can help prevent language delays

# Conclusion

- Loss to follow-up after a failed hearing screening test is one of the largest factors that result in lifelong hearing loss
- Poverty is directly tied to failure to follow up, due to multiple barriers faced by disadvantaged people
- Loss to follow-up rates have been declining in recent years, through efforts to establish low-cost accessible healthcare facilities for disadvantaged people
- The collaborative efforts for hearing screening in Washington State will allow everyone to receive the necessary treatment, bridging the gap between follow-up rates of different income classes and effectively giving many infants the healthcare they desperately need

# Reflection

Earlier this year, my classmate and I participated in the Congressional App Challenge, by developing an app to translate American Sign Language (ASL) into English text. Our goal was to help bridge the communication gap between the speech-impaired community and individuals unfamiliar with sign language. Developing this app opened my eyes to the broader challenges faced by individuals who are deaf or hard of hearing, especially in accessing timely and equitable communication support.

This experience inspired me to further explore a public health issue that often goes unnoticed: loss to follow-up (LTF) after newborn hearing screening. I dove into research on the WTN website and noticed that financially disadvantaged areas were experiencing the highest lost to follow-up rates. Through my research, I examined how sociodemographic, geographic, and systemic factors contribute to these missed opportunities for early intervention—opportunities that are critical for language development, cognitive growth, and overall well-being.

It was challenging to find accurate reliable sources that I could incorporate into my project. It took many weeks, and much painstaking labor and analysis to find sources that were both accurate and relevant to my topic. However, I believe that this process helped me improve both my research and critical thinking skills.

For the creation of this project, I stuck to the facts: I took existing data, analyzed it, and drew my interpretations and conclusions based off data from multiple sources with differing viewpoints. Throughout the course of this project, I gained many valuable skills including data analysis, reading charts and graphs, and drawing meaningful connections and conclusions between multiple sources of data. I also received support from my classmates, who proofread my project and pointed out confusing areas, or sections that did not have much relevance to my project topic.

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