

## The Impact of the COVID-19 Pandemic on Newborn Hearing Screening Programs in Western States

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### Abstract

The primary objective of this study was to determine the impact of the COVID-19 pandemic on newborn hearing screening guideline adherence and the respective rates of screening, diagnosis, and intervention. This was a review of newborn hearing screening data compiled from the Departments of Health in six states for the time periods of March 2019–September 2019 and March 2020–September 2020. Endpoints included the numbers of live births as well as the numbers and timeframes of screening, diagnostic, and intervention events. Two-tailed paired *t*-tests were performed to determine statistical significance. Data included assessment of 181,662 births in six states. Compared to March 2019–September 2019, March 2020–September 2020 had a significantly lower mean rate of screening before 1 month of age (97.3% vs. 96.2%,  $p < 0.001$ ) and mean screen rate overall (98.9% vs. 98.0%,  $p < 0.001$ ). Additionally, the 2020 time period had a significantly higher mean rate of patients lost to follow up for referral to early intervention (14.7% vs. 28.9%,  $p = 0.005$ ). The COVID-19 pandemic has had a significant impact on the newborn hearing screening programs of several states in the Western United States. This information holds significant implications for the current evaluation of these newborn hearing screening programs.

**Keywords:** EHDI, COVID-19 pandemic, newborn hearing screening, early intervention, guideline adherence

**Acronyms:** CDC = Centers for Disease Control and Prevention; CI = Confidence Interval; EHDI = Early Hearing Detection and Intervention; EI = Early Intervention; JCIH = Joint Committee on Infant Hearing

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The detriments of permanent childhood hearing impairment are well known and include negative impacts on language, speech, and behavioral development, all of which may influence a child's social and academic outcomes (Pimperton & Kennedy, 2012; The Joint Committee on Infant Hearing, 2019). To combat this, all states, territories, and Washington D.C. have developed early hearing detection and intervention (EHDI) programs, which use audiological and medical practitioners to screen infants for hearing loss and provide patients and families with the appropriate treatments and guidance to minimize developmental impact. Following guidance from the Joint Committee on Infant Hearing (JCIH), these programs aim to provide hearing screening no later than one month

of age, comprehensive audiological evaluation no later than three months of age for those that do not pass their hearing screening, and appropriate intervention initiated no later than six months of age for infants with confirmed hearing loss (JCIH, 2019). Due to circumstances surrounding the global COVID-19 pandemic, these recommended timelines may not be achieved, and future patient outcomes could be affected.

Although the importance of EHDI guidelines is well-established and the impact of the COVID-19 pandemic has been widespread, there has been no previous study investigating the role of the current pandemic in delaying hearing screenings and interventions in infants. This study

seeks to determine the effect of the COVID-19 pandemic on EHDI program guideline adherence and screening rates in several rural Western states using a retrospective review of data from their respective State Departments of Health. This information holds significant implications for the current evaluation of the EHDI program in these states and provides insight that could be used to prepare for future, major disruptive events.

### Method

The Institutional Review Board at the University of South Dakota granted exemption to this project for purposes of program evaluation and improvement.

### Program Structure

EHDI programs consist of many essential team members, including the birth hospitals, primary health care providers, otolaryngologists, audiologists, and speech-language pathologists, among others. The birth hospital is essential for providing initial newborn hearing screening and ensuring that parents and other healthcare providers receive and understand the hearing screening results as well as follow-up instructions. Audiologists play a large role, contributing to the development, management, and coordination of hearing screening programs. Additionally, audiologists conduct the comprehensive diagnostic assessment that determines the presence of hearing loss or normal hearing. Specifically, pediatric audiologists are uniquely skilled to work with infants, children, and their families. The audiologist also refers the family to other services, including early intervention programs to support the infant and family through early childhood development or medical evaluation of the hearing loss to assist in determination of etiology of loss, receipt of medical clearance for amplification (if the family chooses to pursue that option), and building the support team that is necessary for the family.

The EHDI programs in the states included in this study exist within their respective State Departments of Health (Nebraska DHHS, n.d.; North Dakota Center for Persons with Disabilities, n.d.; Idaho Department of Health and Welfare, n.d.; South Dakota Department of Health, n.d.; Kansas Department of Health and Environment, n.d.; Utah Department of Health, n.d.). In North Dakota and South Dakota, these programs collaborate with Minot State University and the University of South Dakota, respectively, for purposes of program assessment and improvement.

EHDI programs throughout the nation report data to the Centers for Disease Control and Prevention (CDC) on a yearly basis via the Hearing Screening and Follow-up Survey (CDC, 2017). This reporting, although voluntary, is usually completed by nearly all EHDI programs and allows for CDC collaboration and assistance with program improvement (Alam et al., 2016).

### Study Population and Outcome Variables

This study evaluated EHDI program data acquired from the Departments of Health of six Western states: South

Dakota, North Dakota, Utah, Kansas, Nebraska, and Idaho. These states were chosen due to their unique rural setting, their varying levels of pandemic-related restrictions and mandates, and their readily available 2020 EHDI data due mostly to their smaller populations.

All the residents of these states born between March 1 and September 30 of 2019 and 2020 were included in the study population (Figure 1). The data collected included the number of births, infant deaths, and parental refusals of screening services. The number and timing of screening, diagnostic, and early intervention (EI) events and referrals were also obtained. From these measures, several outcome variables were calculated (Table 1). These outcome variables included screen rate by one month, screen rate overall, diagnosis rate by three months, lost to follow up rate for diagnostic evaluation, and lost to follow up rate for referral to EI services. Children were considered lost to follow up for diagnostic evaluation if they did not pass the initial hearing screening and subsequent attempts to contact their parents to schedule a diagnostic evaluation resulted in failure to make contact or lack of response from the parents; this category also included children who were lost to follow up for unknown reasons. Children were considered lost to follow up for referral to EI services if they were determined to be deaf or hard of hearing upon diagnostic evaluation and were not subsequently referred to EI services.

### Statistical Analysis

Comparisons of 2019 and 2020 outcome variables were statistically analyzed using two-tailed paired *t*-tests, and 95% confidence intervals were calculated. State results were analyzed in a blinded fashion and will be presented as such.

### Results

During the studied time periods, there were a total of 181,662 births across the six states included in this study.

### Outcome Variables

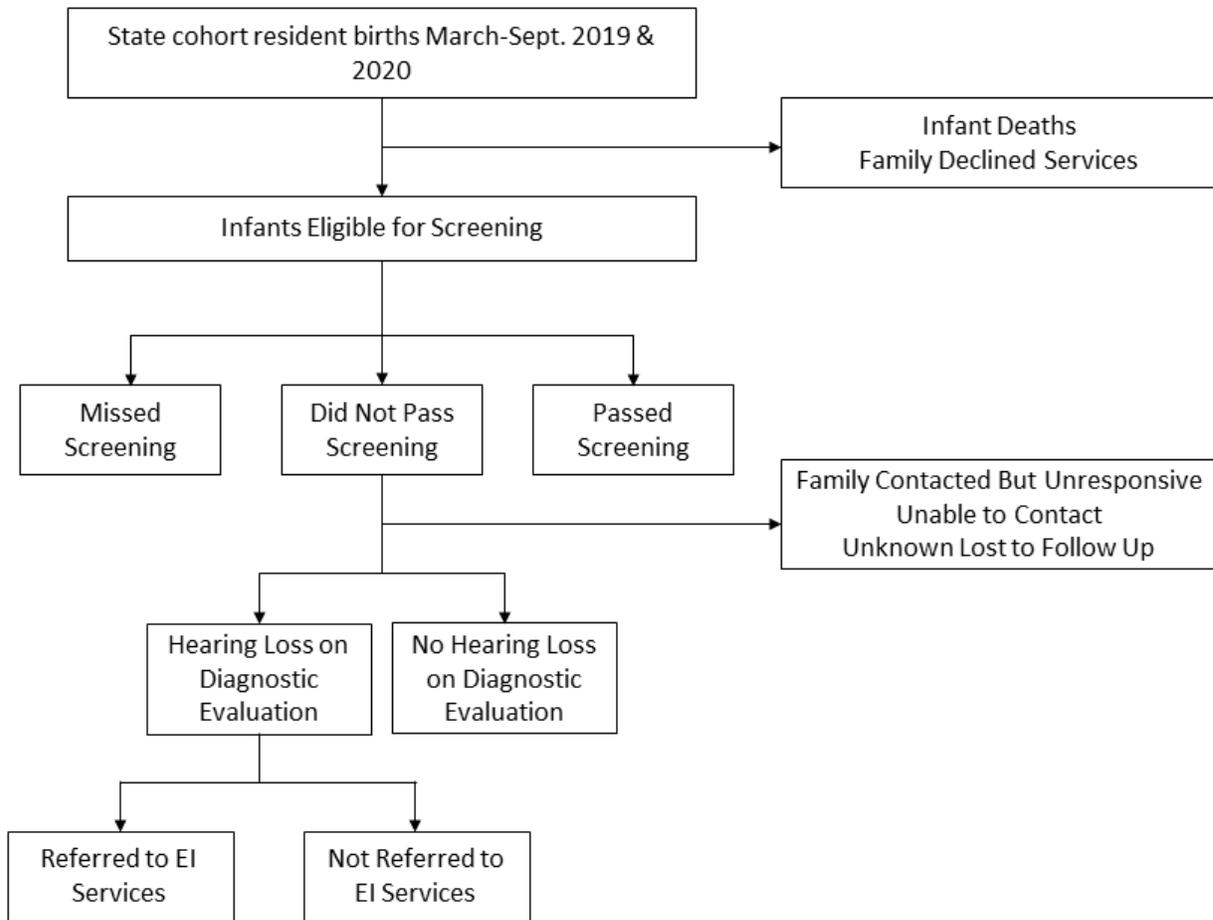
#### *Screen Rate Overall*

Overall screen rates were near 100% in most of the studied states during the designated time period in 2019, with an overall mean of 98.5% (Figure 2A; Table 2). In the 2020 time period, three states recorded significantly decreased overall screen rates of 93.3% ( $p = 0.001$ ), 99.8% ( $p = 0.04$ ), and 99.1% ( $p = 0.03$ ), respectively. Overall, the 2020 mean screen rate was 98.0%, demonstrating a significant decrease compared to the same time period in 2019 ( $p < 0.001$ ).

#### *Screen Rate by One Month*

The rate of screening by one month of age averaged 97.3% across all the studied states in the 2019 period (Figure 2B; Table 2). During March 2019–September 2020, all the studied states recorded decreased rates of screening by one month of age, with three states demonstrating a significant decrease ( $p = 0.004$ ,  $p = 0.005$ ,  $p = 0.01$ , respectively). Altogether, the average rate of screening by one month of age decreased during the 2020 time period to an average of 96.2% ( $p < 0.001$ ).

**Figure 1**  
Study Population and Program Flow

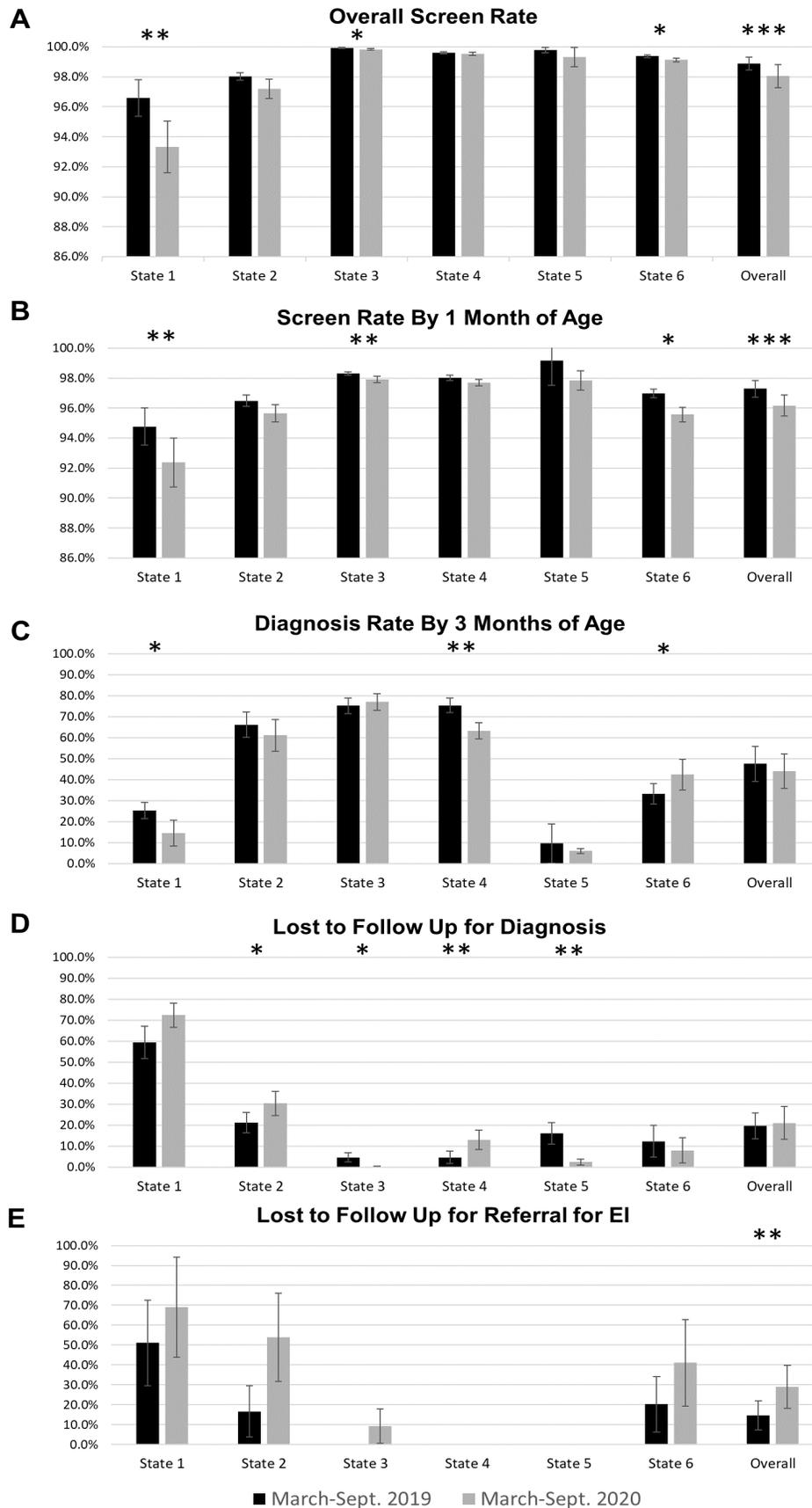


**Table 1**  
Outcome Variables Definitions

Outcome Variable	Description	Operational Definition
Screen Rate Overall	Percentage of infants screened at any age	$\frac{\text{Total screened } (n)}{\text{Eligible for screening } (n)}$
Screen Rate By 1 Month of Age	Percentage of infants screened before 1 month of age	$\frac{\text{Screened before 1 month of age } (n)}{\text{Eligible for screening } (n)}$
Diagnosis Rate By 3 Months of Age	Percentage of infants completing diagnostic testing by 3 months of age	$\frac{\text{Diagnosed by 3 months of age } (n)}{\text{Failed screening } (n)}$
Lost to Follow Up for Diagnosis	Percentage of infants who referred on the initial hearing screening and did not receive diagnostic evaluation	$\frac{\text{Family contacted but unresponsive } (n) + \text{Unable to contact } (n) + \text{Unknown lost to follow up } (n)}{\text{Failed screening } (n)}$
Lost to Follow Up for Referral for EI	Percentage of infants who were diagnosed with hearing loss but did not receive referrals to EI	$\frac{\text{Not referred to EI } (n)}{\text{Diagnosed with hearing loss } (n)}$

Note. EI = Early Intervention.

**Figure 2**  
Outcome Variables Compared Between States And Years



*Note.* A comparison of (A) overall screening rate, (B) screening rate by 1 month of age, (C) diagnosis rate by 3 months of age, (D) the proportion of children lost to follow up for diagnosis, and (E) the proportion of children lost to follow up for referral to early identification (EI). All data displayed as means +/- 95% CI. Statistical significance determined via two-tailed paired *t*-test. \**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.

**Table 2***Outcome Variables Differences Between Years*

<b>Measure</b>	<b>March 2019–Sept. 2019</b>		<b>March 2020–Sept. 2020</b>		<b>p value</b>
		<b>95% CI</b>		<b>95% CI</b>	
Total Births (n)	94,039	-	91,555	-	-
Screen Rate (%)	98.9	98.5–99.3	98.0	97.2–98.8	< 0.001
Screen Rate Before 1 Month of Age (%)	97.3	96.7–97.9	96.2	95.5–96.9	< 0.001
Diagnosis Rate by 3 Months of Age (%)	47.5	39.2–55.8	44.1	35.8–52.4	0.06
Lost to Follow Up Rate for Diagnosis (%)	19.8	13.6–26.0	21.1	13.2–29.0	0.54
Lost to Follow Up Rate for Referral to EI (%)	14.7	7.3–22.1	28.9	18.1–39.7	0.005

Note. EI = Early Intervention; CI = Confidence Interval.

### **Diagnosis Rate by Three Months**

The rate of diagnosis by three months of age varied from 25.4% to 74.4% during the 2019 period, with an overall mean of 60.6% (Figure 2C, Table 2). During the 2020 period, four of the six studied states reported decreases in their rate of diagnosis by three months of age, two of which were statistically significant ( $p = 0.04$ ,  $p = 0.006$ , respectively). Interestingly, two of the six states reported increases in their mean rate of diagnosis by three months of age, one significantly so ( $p = 0.03$ ). Overall, the mean rate of diagnosis by three months of age decreased in the 2020 period to 54.0%, although this difference was not statistically significant ( $p = 0.07$ ).

### **Lost to Follow Up for Diagnosis**

The proportion of infants who were lost to follow up for diagnostic evaluation varied in 2019 from 4.7% to 59.5% with an overall mean of 19.8% (Figure 2D; Table 2). In March 2020–September 2020, three of the studied states reported increases in their mean proportion of infants lost to follow up for diagnosis, with two of those states reporting significant increases ( $p = 0.04$ ,  $p = 0.004$ , respectively). Conversely, three of the studied states demonstrated a decrease in the proportion of infants lost to follow up for diagnosis, with two of those states reporting significant decreases ( $p = 0.01$ ,  $p = 0.004$ , respectively). As a whole, the mean percentage of infants lost to follow up for diagnosis during the 2020 period increased to 21.1% in the studied group of states, but this difference was not statistically significant ( $p = 0.54$ ).

### **Lost to Follow Up for Referral to Early Intervention (EI)**

The percentage of infants lost to follow up for referral to EI averaged 14.7% in the studied states during March 2019–September 2019 (Figure 2E; Table 2). Three of the studied states reported a rate of 0% for this outcome variable during this time period. In the 2020 time period, four of the studied states reported increases in this metric, but none were statistically significant. Two states again reported rates of 0% lost to follow up for referral to EI during the

2020 period. Overall, the mean proportion of infants lost to follow up for referral to EI averaged 28.9% in March 2020–September 2020, demonstrating a significant increase compared to the prior year ( $p = 0.005$ ).

### **Discussion**

Prior to the widespread implementation of EHDI programs, children with severe-to-profound hearing loss, on average, completed their education at age 18 with reading and language levels equivalent to that of a 10-year-old child with normal hearing (Traxler, 2000). Due to the lack of widespread screening programs, these children were typically not identified and diagnosed until two to three years of age (Hoffman & Beauchaine, 2007). Conversely, the widespread adoption of EHDI programs has resulted in the average age of confirmed hearing loss decreasing to two to three months of age (Harrison et al., 2003). Children with hearing loss who receive appropriate diagnosis and intervention within the first six months of life achieve improvements in receptive and expressive language, vocabulary development, and educational attainment (Pimperton & Kennedy, 2012; Yoshinaga-Itano et al., 2017, 2018). Additionally, some studies have shown that early intervention may enable children who are deaf or hard of hearing to achieve normal levels of language development by five years of age (Calderon et al., 1998; Kennedy et al., 2005). Due to the demonstrable benefits of EHDI programs, all 50 states and many countries around the world continually work to implement and improve their infant hearing screening programs (Grosse et al., 2018; Moodley & Storbeck, 2015; White, 2003; Wroblewska-Seniuk et al., 2017).

The impact of the COVID-19 pandemic on early childhood health screening programs has not been previously reported. However, examples of delayed childhood screening as a result of major disruptive events do exist, including the influx of Syrian refugees to European and Asian nations due to the Syrian civil war, which began in 2011. This mass movement of refugees and collapse of the Syrian healthcare system resulted in large populations

of children who did not receive timely health screenings for a variety of conditions including congenital hypothyroidism, inborn metabolic diseases, and cleft lip and palate (Boynuyogun et al., 2020; Saoud et al., 2019; Schiergens et al., 2018). These gaps in healthcare led to severe, preventable sequelae including neurological dysfunction, delayed neuropsychomotor development, growth failure, and worsened surgical outcomes (Boynuyogun et al., 2020; Saoud et al., 2019; Schiergens et al., 2018). This major event also impacted newborn hearing screening. Studies performed at sites in Turkey reported many Syrian refugee children had not previously passed through hearing screening programs, and the rates of hearing loss were significantly higher in Syrian children compared to their Turkish counterparts (Çıkrıkçı et al., 2020; Kaplama & Ak, 2020; Yücel et al., 2019). Major events may contribute to delayed childhood health screening by disrupting both the program itself and the ability of individuals to pass through the given program.

Due to business restrictions as well as many patients choosing to defer and delay non-COVID-19-related healthcare, many healthcare practices saw reduced patient loads and clinic visits, with some data reporting reductions in outpatient visits by 60% (Commonwealth Fund, n.d.). Despite these restrictions and the shifting healthcare landscape, the American Academy of Pediatrics has strongly recommended that states continue to adhere to the established 1-3-6 EHDI guidelines (American Academy of Pediatrics, n.d.).

Our study demonstrates that the COVID-19 pandemic has significantly affected several aspects of newborn hearing screening programs in South Dakota, North Dakota, Nebraska, Idaho, Kansas, and Utah. With regards to screening, these states reported lower rates of screening overall and by one month of age. Both findings may be partially explained by the changing labor and delivery unit policies during the COVID-19 pandemic, including shortened post-partum hospital stays for mothers and newborns. Some reports describe the rate of newborns who were discharged after one night in the hospital increasing by roughly 25% (Greene et al., 2020). These shortened stays provide less opportunity for initial hearing screening to take place.

Several states' data revealed an impact on the rate of diagnostic evaluation following an abnormal hearing screening. Some states reported significantly decreased rates of diagnosis by three months of age as well as significantly increased rates of children who were lost to follow up for diagnostic evaluation. These results may be due to an increased aversion for healthcare settings as a result of the COVID-19 pandemic, resulting in families choosing not to return to a pediatric audiologist for further diagnostic evaluation.

An analysis of the reported data also revealed an increase in the proportion of children who were lost to follow up for referral to EI. These were children who, upon being diagnosed with hearing loss, were not subsequently referred to EI services. Four states in the studied cohort

reported increased rates of loss to follow up for referral to EI, although none of the states' differences were found to be statistically significant alone. When all the states' data is compiled and analyzed as a whole, a significant increase in loss to follow up for referral to EI is revealed. Interestingly, several states reported rates of 0% for this outcome variable for both 2019 and 2020. These findings may be due to multiple important factors. The states included in this study differ in the mandates present for their newborn hearing screening programs. In some states, such as South Dakota, North Dakota, and Idaho, newborn hearing screening is not mandated by law, creating more difficulty for the state Department of Health to collect diagnostic and EI data (National Center for Hearing Assessment and Management, n.d.). This lack of a mandate may result in less funding and fewer positions dedicated to newborn hearing screening programs. These difficulties were likely compounded during the COVID-19 pandemic.

Results of this study may be influenced by several factors unique to the geographic region under research. Rurality is one factor that might influence states' outcome variables. The six states being studied have an average population density ranked lower than 80% of all states' population densities (USA.com, n.d.). This rurality, combined with long driving distances and detrimental weather conditions, creates physical barriers between patients and healthcare providers, including pediatric audiologists (Krumm et al., 2018). In addition to population density, poverty levels of each state were compared to the national average. According to the most recent data reported by the United States Census Bureau, all six states' poverty levels are below the national average (United States Census Bureau, n.d.). Finally, each states' COVID-19 data was analyzed. As of February 2, 2021, the total COVID-19 cases per 100,000 individuals in each state was higher than the national average (CDC, 2020). These factors may have had an impact on the states' newborn hearing screening programs both before and during the COVID-19 pandemic. Other factors, such as states' lockdown measures during the pandemic, might have also impacted outcome variables.

Although the COVID-19 pandemic continues to present new challenges, important lessons have been learned over the past year. One such lesson is the importance of remaining vigilant and taking a proactive stance during an international crisis. Though it is likely that certain healthcare protocols and procedures take less precedence, lack of adherence to these protocols may create unintended ramifications when the crisis subsides. More specifically, lack of adherence to the EHDI 1-3-6 guidelines has affected several states' screening, diagnostic, and EI enrollment rates.

The pandemic has also highlighted the importance of telehealth. Even before the pandemic, several of the states under study had barriers that separated patients from healthcare providers, possibly due to the states' rurality. Telehealth allows patients to circumvent barriers created by both pre-existing factors and the COVID-19 pandemic. The feasibility of using remote control options to connect

patients and providers has changed the healthcare landscape, and it has been advantageous to several healthcare fields during the pandemic.

Some limitations should be considered when reviewing the results of this study. First, the geographic region under research may prevent generalization of data to other states and/or countries beyond the United States. Factors unique to these six Western American states could have impacted outcome variables, and further research must be done to confirm or refute these trends in other geographic regions. In addition, important demographic and socioeconomic factors were not considered when comparing outcome variables across the six states. For example, it is possible that the impact of COVID-19 on the EHDI 1-3-6 benchmarks could have differed among minority communities in each state.

### Conclusion

The COVID-19 pandemic has had a significant impact on the newborn hearing screening programs of several Western states. Most notably, these states reported significantly decreased rates of screening by one month of age, screening overall, and referral to early intervention services. This data provides valuable information for the evaluation of these programs as well as insight for future major disruptive events. This disruption in early childhood hearing screening may have far-reaching consequences for future health outcomes, and further research will be needed to fully assess the scope and magnitude of these potential detriments.

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