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Sociodemographic Factors Influencing Pandemic-Era EHDI Use and Access

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Abstract

Objective: The COVID-19 pandemic impact on Early Hearing Detection and Intervention (EHDI) programs is unknown. This research evaluated sociodemographic factors influencing adherence to EDHI diagnostic testing and the incidence of infant hearing loss during the pandemic.

Method: We evaluated EHDI adherence and incidence of hearing loss in Kentucky before and during the COVID-19 pandemic. Using univariate and multivariate analysis, we evaluated the association of these outcomes to sociodemographic variables.

Results: There were 71,206 births and 1,385 referred infant hearing screening tests during the study period. Infants during the pandemic had a 24% lower odds of hearing testing adherence (OR = 0.76, p = 0.05, 95%CI: 0.57–1). Hispanic infants have 45% lower odds of EHDI adherence (OR = 0.55, p = 0.03, 95%CI: 0.31–0.96) and infants of Swahili speaking families have 90% lower odds of EHDI adherence (OR = 0.10, p = 0.001, 95%CI: 0.02–0.42). Infants of mothers with a high school degree had a higher odds of adherence (OR = 1.50, p = 0.02, 95%CI: 1.06–2.17), presented earlier for testing (p = 0.003, 95%CI: -15.73– [-]3.32), and had a higher odds of normal hearing (OR = 1.63, p = 0.03, 95%CI: 1.06–2.51).

Conclusion: EHDI adherence is influenced by the COVID-19 pandemic and sociodemographic factors. EHDI programs are encouraged to use this data to promote timely and equitable access and use of diagnostic services.

Keywords: Infant hearing loss, Health disparities, COVID-19, EHDI, Access to care, Newborn hearing screening, Follow-up adherence

Acronyms: EHDI = Early Hearing Detection and Intervention; HA = hearing aid; UNHS = Universal Newborn Hearing Screening

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Hearing loss affects 2–3 of every 1,000 American newborns screened (Centers for Disease Control and Prevention [CDC], 2020a). Pediatric hearing loss can have a long-term impact on speech, language, and social development. For this reason, children with hearing loss require early intervention and multifaceted care. Children with congenital hearing loss who receive timely diagnosis and intervention have remarkably improved speech and language outcomes (CDC, 2019). Universal standard protocols of infant hearing screening and diagnostic testing have been developed by the CDC and are implemented by each state's Early Hearing Detection and Intervention (EHDI) program. These EHDI standards dictate that all newborns are to be screened at birth or no later than 1 month of age. An abnormal screening test should result in diagnostic testing at no later than 3 months of age. Babies with confirmed hearing loss should receive early intervention by 6 months of age (CDC, 2019).

Early detection of hearing loss initiates intervention earlier and improves overall outcomes. Universal Newborn Hearing Screening (UNHS) has been proven successful in identifying hearing loss at an earlier age leading to earlier intervention in several studies. A study disclosed that the median age at hearing aid (HA) fitting of the newborn hearing screened group was 3.9 months (IQR: 2.3-10.1) and the median age at HA fitting for the non-screened group was 17.3 months (IQR: 7.5-25.9; Ching & Leigh, 2020). Of those in the screening group, 72% received HA fitting no later than 6 months of age, comparatively, only 32% were fitted in the same time frame in the non-screened group (Ching & Leigh, 2020). The EHDI program has improved detection and early intervention; however, there has always been a long-standing problem with non-adherence to follow up for diagnostic testing after an abnormal hearing screening. This non-adherence leads to significant delays in diagnosis and may result in life-long negative consequences on language development. A number of factors may influence infants receiving timely hearing diagnostic testing. There is evidence that patients from low-income and rural backgrounds have lower rates of adherence. Parental education, insurance status, and proximity to hearing specialists may also influence access and use of infant hearing healthcare (Boss et al., 2011; Pynnonen et al., 2016). There is a paucity of research examining social and economic factors driving disparities that impact access to infant hearing healthcare. This gap is important to address as there is strong evidence that minority racial and ethnic groups have a higher incidence of infant hearing loss (Lantos et al., 2018). In addition to the existing factors of adherence, the COVID-19 pandemic resulted in additional factors influencing EHDI care and amplified healthcare disparities. However, the pandemic's impact on EHDI programs is unknown. Therefore, we hypothesized that: (a) Racial and ethnic minority infants have a higher rate of non-adherence to diagnostic testing after an abnormal infant hearing screening test, as compared to non-Hispanic Caucasian infants. (b) Infants undergoing a diagnostic hearing test during the COVID-19 pandemic (March 1, 2020–September 30, 2020) have a higher non-adherence rate as compared to those who underwent testing before the pandemic.

Method

Patients

This study was approved by the University of Kentucky Institutional Review Board before data analysis. A retrospective review of the EHDI program database of Kentucky newborns was performed. The database documents hearing screening within the birthing hospitals and reports follow-up documentation for infants born in the state of Kentucky. The database reported 75,132 infants born between April 1, 2019 and September 30, 2020. Inclusion criteria included documented hearing screening result and state of Kentucky residency. Out of state infants and infants with no hearing screening were removed. The demographic information for the 71,206 infants who met inclusion criteria can be found in Table 1.

Table 1

Demographic Data

Demographic Data	Number of Participants (%)
Gender	
Male	36,187 (51%)
Female	35,019 (49%)
Race	
White	57,733 (81%)
BIPOC*	13,475 (19%)
Ethnicity	
Non-Hispanic	66,137 (93%)
Hispanic	4,938 (7%)
Language	
English	68,464 (96%)
Non-English	2,744 (4%)
Maternal Education	
Less than High school	8,805 (12%)
High school or greater	62,036 (88%)
Location	
Urban Counties	84 (70%)
Rural Counties	36 (30%)
COVID-19	
Born prior to COVID-19 pandemic	43,843 (62%)
Born during the COVID-19 pandemic	27,365 (38%)
Insurance	
Private	12,121 (45%)
Medicaid	14,556 (55%)
Total Participants	**71,206**

Note. Numbers do not add up to 100% of total in each group due to incomplete reporting in some of the data fields. BIPOC = Black, Indigenous, and people of color.

Data Acquisition/Organization

The following variables were extracted from the database and coded to facilitate analyses: race/ethnicity, language preference, date of birth, ZIP code, maternal education, hearing screening outcomes and timing, diagnostic hearing testing (if attended) and timing, as well as insurance status. The categorical data were numerically coded to allow for statistical analyses. The coded data were analyzed both before **(**April 1, 2019–February 28, 2020) and during (March 1, 2020–September 30, 2020) the COVID-19 pandemic.

Data Analysis

Statistical analysis was done using SPSS 28.0. These analyses evaluated the impact of racial, ethnic, social, and linguistic factors on diagnostic testing adherence. Univariate and multivariate logistic regression were

calculated to generate odds ratios and 95% confidence intervals of diagnostic testing adherence. Receipt of infant diagnostic testing by 3 months and the timing of testing were analyzed as a dependent variable in the analyses and the independent variables are as follows: race, ethnicity, language, zip code, maternal education, and insurance status. A separate multivariate logistic regression analysis was conducted to assess the factors influencing the presence of hearing loss in infants. Multivariate linear regression was conducted to assess the relationship of timing (in days after birth) of diagnostic testing (dependent variable) with the above listed independent variables. A *p*-value equal to or less than 0.05 was considered statistically significant. Control variables were employed to enhance internal validity.

Results

Database Characteristics

The EHDI database included 75,132 infants born in the state of Kentucky between April 1, 2019 and September 30, 2020. Of those, 3,926 infants were excluded because they were not Kentucky residents or they never received an infant hearing screening test, leaving 71,206 infants included in the study. The database included 36,187 (51%) males and 35,019 females (49%). Regarding race and ethnicity, 57,733 (81%) newborns were white and 13,475 (19%) were black, indigenous or persons of color (BIPOC). Most newborns were non-Hispanic, 66,137 (93%) infants identified in this category and 4,938 (7%) newborns were Hispanic. There were 43,843 (62%) infants born prior to the COVID-19 pandemic **(**April 1, 2019–February 28, 2020) and 27,365 (38%) infants born during the COVID-19 pandemic (March 1, 2020–September 30, 2020). There was a multitude of different languages spoken by the mothers of infants included in this study. Twenty-eight different languages were identified. However, 68,464 (96%) mothers spoke English, and 2,744 (4%) spoke a non-English language. The three most common non-English languages were Spanish (*n* = 1,988), Swahili (*n* = 186), and Arabic (*n* = 125). Maternal education was also available in the database. Maternal education data was not available on 365 dyads; however, of those with education data, mothers with an education level less than high school accounted for 8,805 (12%) participants and those with a high school degree or greater included 62,036 (88%) mothers. Seventy percent of the newborns lived in urban counties and thirty percent lived in rural counties. The demographics of the sample are included in more detail in Table 1.

Study Results

Overall, 1,385 infants had abnormal hearing screening tests in Kentucky during the study period (Tables 2 and 3). Overall, 82% of those infants received diagnostic testing within 3 months of age as recommended by the CDC. Conversely, 18% of the infants in our study failed to adhere to these guidelines. Of those infants, 5% received delayed diagnostic testing at nine to sixteen months of age. Infants born before the COVID-19 pandemic had an adherence rate of 84%. Adherence dropped to 80% percent during the pandemic. The multivariate logistic regression showed that infants during the COVID-19 pandemic had a 24% lower odds of hearing testing adherence (OR = 0.76, *p* = 0.05, 95%CI: 0.57–1) compared to those infants during the pre-pandemic period. Additionally, the logistic regression model found that infants who had mothers with a high school degree or higher had 1.50 times higher odds of EHDI adherence (OR = 1.50, *p* = 0.02, 95%CI: 1.06–2.17). Additionally, a multivariate linear regression showed that infants of mothers with a high school degree or greater presented on average 9.5 days earlier for testing (*p* = 0.003, 95%CI: -15.73– -3.32). Further details are included in Table 4. Separate multivariate logistic regression analyses were conducted to evaluate the factors on the presence of infant hearing (variables included COVID-19 era, gender of infant, insurance status, rural residence, race/ethnicity, and maternal education). Only maternal education was a significant variable. We found that infants who had mothers with at least a high school degree have a 1.63 times higher odds of having normal hearing on EHDI testing (OR = 1.63, *p* = 0.03, 95%CI: 1.06–2.51). We found that about 1% of those infants who received diagnostic hearing testing were diagnosed with a hearing loss. We observed a trend that male infants have 14.8% lower odds of hearing testing adherence and infants born in rural locations have 15.7% lower odds of hearing testing adherence; however, these trends were not statistically significant. We did not identify any significant association between hearing loss incidence and sociodemographics such as sex, insurance status, or race/ethnicity.

There was no evidence in the primary logistic regression analysis of differences in adherence based on race/ethnicity between pre- and post-pandemic time frames. We conducted separate multivariate logistic regression analyses to assess the association of Hispanic ethnicity, Swahili language status, and the COVID-19 era with diagnostic adherence as these are much small populations in the state of Kentucky and the relationship of these factors on diagnostic adherence may be overlooked in the larger logistic regression model. In the separate models, we identified that infant ethnicity is associated with EHDI adherence. The logistic regression found that Hispanic infants have 45% lower odds of EHDI adherence when compared to non-Hispanic infants (OR = 0.55, *p* = 0.03, 95%CI: 0.31–0.96; Table 5**)**. Using multivariate logistic regression, we also evaluated language impact on diagnostic testing adherence. Analyses showed infants of Swahili-speaking families (*n* = 9) have 90% lower odds of EHDI adherence (OR = 0.10, *p* = 0.001, 95%CI: 0.02–0.42; Table 5). This finding is important as Swahili was the 3rd most common language spoken by the mothers in this study.

Discussion

Bilateral hearing loss is the most common congenital disorder seen in the United States, occurring in 2 to 3 per 1000 newborns (CDC, 2020a). Untreated hearing loss can lead to delayed language, psychosocial, and academic development. Early detection of hearing loss initiates intervention earlier and improves overall outcomes. Studies have shown that newborn hearing screening is more reliable than detection by clinician and caregiver. A

Table 2
EHDI Screening and Diagnostic Data 2019–2020

	Failed Hearing Screening*	Adherence YES	Adherence NO	Average Time to Diagnosis
Pre-COVID-19				
Infants born: (April 1, 2019–February 28, 2020)	*n* = 850 (1.93%)	*n* = 711 (83.65%)	*n* = 139 (16.35%)	61.4 days
COVID-19				
Infants born: (March 1, 2020–September 30, 2020)	*n* = 535 (1.96%)	*n* = 427 (79.81%)	*n* = 108 (20.19%)	58.4 days

Note. Includes inpatient hearing rescreen and outpatient hearing screening.

Table 3
Hearing Loss Incidence in Kentucky

	No Hearing Loss	Unilateral Hearing Loss	Bilateral Hearing Loss
Pre-COVID-19			
Infants born: (April 1, 2019–February 28, 2020)	*n* = 43,410 (99.01%)	*n* = 277 (0.63%)	*n* = 156 (0.36%)
COVID-19			
Infants born: (March 1, 2020–September 30, 2020)	*n* = 27,032 (98.78%)	*n* = 199 (0.73%)	*n* = 134 (0.49%)

Table 4
*Multivariate Linear Regression on the Impact of Maternal Education on Timing of Adherence (*n *= 1,134).*

	Co-efficient	*p* value	95% Confidence Interval
Maternal Education of at least a High School Degree	**-9.53**	**0.003**	**-15.73– -3.32**
Presence of infant hearing loss	-7.23	0.06	-14.78–0.31
COVID-19 era	-1.63	0.56	-7.14–3.87
Gender of infant (male)	0.65	0.81	-4.79–6.08
Rural residence	0.65	0.83	-5.11–6.43
Black, Indigenous, or persons of color	-12.37	0.72	-80.00–55.24
Hispanic ethnicity	-4.37	0.38	-14.06–5.31

Note. Bolded factor is statistically significant at $p \leq 0.05$.

Table 5

Multivariate Linear Regression on the Impact of Maternal Education on Timing of Adherence

COVID-19 and Sociodemographic Factors Impact on Diagnostic Adherence

Multivariate logistic regression *n* = 1,378	***p* value**	**Odds ratio of Diagnostic Testing Adherence**	**95% Confidence Interval**
COVID-19 era	0.05*	0.76	0.57–1
Gender of infant (male)	0.26	0.85	0.64–1.12
Rural residence	0.24	0.83	0.62–1.12
Maternal age	0.27	0.98	0.96–1.01
Maternal education of at least a high school degree	0.02*	1.5	1.06–2.17
Presence of infant hearing loss	0.42	1.20	0.76–1.88
Black, Indigenous, or persons of color	0.19	0.81	0.59–1.10

**Statistically significant $p \leq 0.05$*

Ethnicity Impact on Diagnostic Testing Adherence

Multivariate logistic regression *n* = 1,375	***p* value**	**Odds ratio of Diagnostic Testing Adherence**	**95% Confidence Interval**
Hispanic ethnicity	0.04*	0.55	0.31–0.96
COVID-19 era	0.07	0.77	0.58–1.02

Ethnicity Impact on Diagnostic Testing Adherence

Multivariate logistic regression *n* = 1,362	***p* value**	**Odds ratio of Diagnostic Testing Adherence**	**95% Confidence Interval**
Swahili language	0.001*	0.10	0.02–0.42
COVID-19 era	0.07	0.77	0.58–1.02

controlled trial of 53,781 infants born in different hospitals was done to evaluate the efficacy of newborn hearing screening. In the study, newborns with hearing loss who received newborn hearing screening were more likely to be detected (OR = 5, 95% CI: 1–23) and receive treatment (OR = 8, 95%CI: 1.5–41) at an earlier age than those who did not receive screening ("Controlled Trial of Universal Neonatal Screening," 1998).

The delivery of timely diagnostic testing after failed screenings is essential for EHDI programs. There are many factors that may influence adherence after a failed screening test. Although EHDI programs seek to improve their programs to promote timely access and use, there continues to be barriers to services that perpetuate disparities. To ensure that infants are meeting EHDI guidelines equitably, health disparities need to be addressed. Health disparities are preventable health differences associated with economic, social, or environmental factors (CDC, 2020b). Contributing factors to health disparities include race, ethnicity, religion, socioeconomic-status, gender, and geographic location (U.S. Department of Health and Human Services, n.d.b).

A study in rural Kentucky identified that 25% of Appalachian children that fail UNHS are lost to follow up (Bush, Bianchi, et al., 2014). Appalachian infants are 1.5 times more likely to be lost to follow-up when compared to non-Appalachian children given the unique challenges facing these rural communities (Bush, Bianchi et al., 2014). Distance to hearing healthcare providers and the socioeconomic status are pervasive issues facing pediatric hearing healthcare (Noblitt et al., 2018; Bush et al., 2013; Bush, Osetinsky, et al., 2014; Bush et al., 2015; Elpers et al., 2016). The socioeconomic depression within this rural region has been a pervasive problem. The per-capita income for residents in rural Kentucky is $39,917 and the poverty rate is 19.2% compared with $52,445 per-capita income and poverty rate of 12.0% in urban areas of the state (Economic Research Service, n.d.). Additionally, the

unemployment rate in rural Kentucky is 5.1% compared to 4.4% in urban Kentucky (Economic Research Service, n.d.). In our study, adherence to diagnostic testing did not differ between rural and urban Kentucky counties nor did the incidence of hearing loss.

Research also shows that racial and ethnic minority groups experience more challenges to receiving quality healthcare and overall have worse health outcomes. According to data reported by the United States Census Bureau, in 2020, 24.9% of Hispanics did not have health insurance. Comparatively, 7.7% of Caucasian Americans did not have insurance. Additionally, 75% of Caucasian Americans have private health insurance, compared to only 50% of Hispanics (Keisler-Starkey & Bunch, 2021). In our study, Hispanic infants were less likely to meet EHDI guidelines than non-Hispanic infants. Additionally, infants of Swahili-speaking families had lower odds of EHDI adherence when compared with English-speaking families. There is evidence that the prevalence of infant hearing loss is disproportionately higher in infants from minority races and ethnicities and infants from lower socioeconomic backgrounds (Lantos et al., 2018). Non-white infants had a 2.45 higher odds of hearing loss and infants born and living in urban low-income neighborhoods also had a higher prevalence of hearing loss (Lantos et al., 2018), however we did not see this in our study.

The mechanisms underlying these disparities are unclear. Additional research on the type, degree, and impact of health disparities related to EHDI services needs to be conducted to create equitable access and use of hearing healthcare for all infants regardless of race, ethnicity or socioeconomic status. Providing adequate follow-up instructions prior to discharge from the hospital may improve adherence to diagnostic testing (American Speech-Language-Hearing Association, n.d.). Moreover, instructions should be provided in a family's native language and at an appropriate reading level. Providing accurate and accessible information may also improve patient-provider communication and promote the notion of patient-centered care. A patient-centric environment has also been shown to improve patient adherence to follow-up and treatment (Roumie et al., 2011). Simple institutional changes are attainable and could potentially make immediate impact and ameliorate disparity. Additionally, increasing access to hearing healthcare services will increase equity of care. There is a longstanding challenge with access to hearing specialists in underserved and rural communities. Federal and state leaders need to work together to improve transportation, physician shortage, and affordability of care, especially within the specialty of hearing. Community and institutional interventions such as these have not been assessed as they relate to the pandemic, but would be worth further study.

Maternal education had a positive impact on adherence. In our study, infants' mothers with a higher level of education had increased odds of EHDI adherence and were more likely to have normal hearing. Additionally, these infants presented on average 9.5 days earlier to testing. Although we controlled for variables in our regression analysis, certain factors that are unknown to us can be a proxy for maternal education. The association between maternal education levels and infant health outcomes has been studied in the past and a causal link between the two has been established. It has been hypothesized that higher maternal education allows for more autonomy to navigate health institutions, act on health knowledge, manage fertility, and overall improve child health. Although this is most likely true, the effect is not nearly as strong as predicted (Mensch et al., 2019). Therefore, it is very likely that factors such as poverty play a more significant role in health outcomes, and this should be the focus of community interventions.

The COVID-19 pandemic also impacted access to and use of hearing healthcare services for infants and their families. At the onset of the pandemic, many audiology facilities and services were considered non-essential and suspended operations. This certainly played a role in the ability of patients to adhere to recommended diagnostic testing (Cunningham et al., 2021). Many hospitals and clinics put more precautions in place and created stringent protocols to limit the spread of the virus, thus creating barriers to receiving care. Although the incidence of hearing loss was similar before and during the COVID-19 pandemic, the adherence to diagnostic hearing testing was different between the time periods. Adherence to diagnostic testing before the COVID-19 pandemic was 83.6% compared to 79.8% during the pandemic. Infants born during the pandemic had a 24.3% lower odds of diagnostic hearing testing adherence. Our results were reflected in another study in which 100% of parents in the study felt that the COVID-19 pandemic impacted access to timely hearing healthcare services for their children (Ayas et al., 2020). Additional research would be required to evaluate the effects of COVID-19 on testing adherence beyond the peak of the pandemic. Many barriers that were present during the pandemic such as limited clinic hours, clinic closures, limited access to public transportation and overall fear of leaving home improved as the pandemic continued. Moving forward, it is important that audiology testing be established as an essential practice for newborns. If another shutdown were to take place in the future, newborns should not receive delayed diagnostic testing or treatment.

The purpose of this research was to evaluate sociodemographic factors influencing adherence to EDHI diagnostic testing and the incidence of infant hearing loss before and during the pandemic. Results from this study found evidence that COVID-19, maternal education, race, ethnicity, and language affected adherence to follow-up diagnostic testing. Similar research has shown there are other barriers to health equity in addition to those addressed in this study (U.S. Department of Health and Human Services, n.d.a). To address these disparities and promote equity, further research needs to be done to test and evaluate strategies or interventions related to EHDI services. Several immediate and attainable recommendations were also made in this paper and we encourage EHDI programs to use this research in programmatic planning and intervention work.

There were limitations to this research study. As with many retrospective studies, there is the possibility of missing data and inaccurate reporting. Secondly, patients were excluded if they were not residents of Kentucky, if they failed to receive a hearing screening test, or if the result was not reported. Therefore, results of the study may not be generalizable since only Kentucky residents were included. Moreover, the excluded infants who never received screening may represent an important group who were not captured in this particular study. It is possible that this group of infants may have missed screening due to the similar disparities analyzed in this study. Lastly, our study included infants born between April 1, 2019 and September 30, 2020. We chose that end date to facilitate analyses in a timely manner. March 1, 2020 was the start date for the COVID-19 pandemic group in our analyses due to cases rising in the United States at that time. As a result, the pre-COVID-19 group included infants born over an 11 month span, compared to 7 months for the COVID-19 group. This discrepancy in data collection periods exists in large part due to the natural history of the pandemic as it relates to the time of the study. Despite this discrepancy, both groups had adequate sample sizes to complete statistical analysis.

Conclusion

The COVID-19 pandemic negatively impacted adherence to EHDI diagnostic services in Kentucky. Race, ethnicity, and language impacted adherence to testing. Maternal education was also found to influence adherence and infant hearing outcomes. Additional research is needed to identify other differences in infant hearing healthcare among different patient populations to improve adherence to diagnostic testing. However, results from this research could be used in programmatic planning and intervention work to promote hearing healthcare among vulnerable populations. Furthermore, continued awareness of these health disparities is necessary to achieve equitable access and use of hearing healthcare and improve health outcomes for all.

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