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Neonatal Abstinence Syndrome and Infant Hearing Assessment: A Kids' Inpatient Database Review

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Abstract

Objective: Neonatal abstinence syndrome (NAS) has become an epidemic. This study assesses documented rates of failed newborn hearing screening (NBHS) or hearing loss (HL) diagnosis in NAS infants, and sociodemographic factors associated with abnormal inpatient hearing results.

Method: The 2016 HCUP/KID national database was used to identify a weighted sample of infants with failed NBHS/HL during birth hospitalization. Independent variables included diagnoses of NAS/in-utero opioid exposure, HL risk factor presence, and sociodemographic data. Univariate analyses and multivariate logistic regression were used to determine associations between NAS and abnormal hearing assessment.

Results: NAS infants had lower odds ratio (OR) of documented failed NBHS (OR = 0.76, $p < 0.05$) than controls, but a higher rate of HL diagnosis (OR = 2.17, $p < 0.01$). Certain sociodemographic factors had higher OR of abnormal hearing results, including race ($p < 0.001$) (Black, OR = 1.48 and Native American, OR = 1.83), and Medicaid coverage (OR = 1.45, $p < 0.001$). A lower OR of HL diagnosis was observed in females (OR = 0.84, $p < 0.001$) and infants with higher household income (OR = 0.53, $p < 0.01$).

Conclusion: NAS children have lower rates of inpatient documented failed NBHS and higher rates of HL diagnosis. The complex medical care of these infants could complicate NBHS, documentation, and subsequent follow-up. Certain sociodemographic factors result in a higher risk of hearing loss.

Acronyms: EHDI = Early Hearing Detection and Intervention; HCUP = Healthcare Cost and Utilization Project; HL = hearing loss; NAS = neonatal abstinence syndrome; KID = Kids' Inpatient Database; NBHS = newborn hearing screening; OR = odds ratio

Keywords: Neonatal abstinence syndrome, hearing loss, newborn hearing screen

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Neonatal abstinence syndrome (NAS) is a condition of the newborn in which withdrawal signs and symptoms are displayed following exposure to an offending medication and/or drug of abuse (McQueen & Murphy-Oikonen, 2016). The vast majority of cases are due to *in-utero* exposure from maternal use of opioids during pregnancy, and like all problems stemming from the opioid epidemic, the incidence of NAS has increased (Patrick et al., 2015). This has placed strain on not only an increasing number of patients, families, and caretakers, but has also been responsible for a large economic burden within the healthcare system, estimated at $1.5 billion in 2012 (Patrick et al., 2015).

There has been little to no focus on this population within the otolaryngology literature. As such, the needs of an NAS patient within this specialty are not well defined. Prior studies have shown NAS patients to be at risk for poor use of prophylactic and specialty care (Fang et al., 2015; Gill et al., 2007; Kivisto et al., 2014; Payot & Berner, 2000). Poor healthcare utilization and being lost to follow-up is a concern for any condition, but this is especially true with newborn hearing loss. There have been no reports of

clinically significant teratogenic effects of opioids leading to hearing loss in a newborn, nor has the rate of hearing loss in the NAS population ever been specifically assessed. However, there have been reports in adults of opioid use causing sensorineural hearing loss (Friedman et al., 2000; Ho et al., 2007; Rigby & Parnes, 2008; Vorasubin et al., 2013). Infants with NAS are a significantly vulnerable population and deserve special attention as they may face barriers to hearing healthcare after birth.

The prevalence and the lifelong effects of unrecognized hearing impairment in a newborn have been the driving force to support universal newborn hearing screening. The Early Hearing Detection and Intervention (EHDI) guidelines state that children should undergo hearing screening by 1 month of age, receive audiologic testing and diagnosis by 3 months if testing indicates hearing impairment, and have an intervention as indicated by 6 months. These recommendations were made by the U.S. Preventive Task Force and Joint Committee on Infant Hearing (JCIH) Loss over a decade ago and have been underscored by studies demonstrating improved speech and language outcomes in children whose care benefitted from earlier detection as advised by EHDI guidelines (JCIH, 2007; Kennedy et al., 2006; U.S. Preventive Services Task Force, 2008; Yoshinaga-Itano, 2017). Recently JCIH updated their position statement, recommending that EHDI programs consider a new target where hearing screening would occur by 1 month of age, audiologic testing and diagnosis by 2 months of age, and intervention as indicated by 3 months (JCIH, 2019). Achieving this goal can prove difficult, especially in patient populations at risk for poor follow-up and healthcare use. Newborn hearing screening and subsequent follow-up testing can be complicated by many barriers, making it difficult for patients and families to navigate. Over 98% of children within the United States undergo NBHS (CDC, 2015); however, nearly 60% of infants fail to obtain a timely diagnosis after abnormal screening (CDC, n.d.). Certain sociodemographic factors, such as insurance status and parental education level, have been associated with decreased use of audiologic services following a failed newborn hearing screening (Folsom, 2000; Liu, 2008; Oghalai, 2002; Spivak, 2009). Communication of failed NBHS is important for continuity of care of timely diagnosis of infant hearing loss, however, many primary care providers and parents are either uninformed or misinformed about NBHS results (Bush, Alexander, et al., 2015, Bush, Hardin, et al., 2015). Birthing hospitals are mandated to report NBHS results to state Early Hearing Detection and Intervention (EHDI) agencies; however, the documentation and subsequent billing of abnormal NBHS on birth inpatient records on a local level is largely unknown. A disconnect between the NBHS results and inpatient records could influence continuity of care for the infant after hospital discharge. The relationship of NAS and infant hearing screening results and/or documented diagnosis of hearing loss has not been previously described. The primary aim of this study was to assess the documented rate of failed newborn hearing screenings and diagnoses of hearing loss in NAS patients during their birth hospitalizations. Furthermore, by using a large national inpatient admissions database, we aimed to assess the association of NBHS screening results and patient demographics and socioeconomic factors.

Materials and Method

The study uses publicly available data that is deemed by the Institutional Review Board (IRB) as not involving human subjects and not requiring IRB review and approval.

Study Sample

The study examines the association between NAS and NBHS screening results in 2016 using the Kids' Inpatient Database (KID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. The database includes relevant diagnostic and procedure codes, as well as demographic data, for a national sample of pediatric inpatient hospitalizations. Pediatric inpatient admissions were included in the study sample if the admission was associated with a hospital birth, where NBHS is expected to be performed and where NAS could be detected. Admissions associated with patients at risk for iatrogenic NAS were excluded using methods described in prior studies (Patrick et al., 2012). The study also excludes admissions with Medicare as primary payer and where data on demographic variables of interest were missing.

Measures

NAS was identified using the International Classification of Diseases, 10th ed. [ICD-10] code P96.1. The study uses two measures of potential hearing loss, a failed NBHS or a diagnosis of hearing loss during the inpatient birth admission. A failed NBHS was identified using ICD-10 codes R94.120, R94.8, and Z01.110. Diagnosed hearing loss was determined using ICD-10 codes H91.90, H90.3, H90.41, H90.42, H90.71, H90.72, H90.6, H90.2, H90.11, H90.12, H90.0, H90, H90.1, H90.4, H90.5, H90.7, H90.8, H90.A, H90.A1, H90.A11, H90.A12, H90.A2, H90.A21, H90.A22, H90.A3, H90.A31, H90.A32, H91, H91.0, H91.01, H91.02, H91.03, H91.09, H91.8, H91.8X, H91.8X1, H91.8X2, H91.8X3, H91.8X9, H91.9, H91.91, H91.92, H91.93, and H91.3.

To control for the potential effects of known risk factors for hearing loss on a failed NBHS or hearing loss diagnosis, a variable indicating the presence of any known risk factor was developed. This indicator variable denotes whether or not sepsis, bacterial meningitis, jaundice, cytomegalovirus, syphilis, rubella, herpes, craniofacial anomalies, or persistent pulmonary hypertension were present diagnoses in the birth admission. ICD-10 codes were used to identify these diagnoses and are available upon request. There are other risk factors, including family history of hearing loss, not used to construct these variables due to lack of a diagnostic code to identify that the risk factor was present. Additional demographic measures included in the study include payer type, race, gender, urban/rural residence, and median household income, all of which are available in the KID.

Statistical Approach

All statistical analyses were performed using Stata 15 (StataCorp LL, College Station, Texas). The construction

of the KID and its sampling approach are described on the HCUP website (https://www.hcup-us.ahrq.gov/tech_assist/sampledesign/508_compliance/index508_2018.jsp). Statistical analyses use sampling weights to account for the KID's complex design and to calculate accurate standard errors. We performed descriptive univariate analyses to summarize the characteristics of the study sample, using chi-square tests to assess differences in demographic variables for the groups with and without a failed NBHS. We used multivariate logistic regression to test for associations between NAS diagnosis and either a failed NBHS or hearing loss diagnosis, controlling for demographic characteristics and the presence of any risk factors for hearing loss. We further examined, again using logistic regression, the association between NAS and, separately, each measure of hearing loss: a failed NBHS and a diagnosis of hearing loss. We report odds ratios (OR) with 95% confidence interval (CI) and a level of significance at alpha = 0.05.

Results

The weighted study sample included 1,113,150 observations, of which 0.67% (n = 21,888) had a diagnosis of NAS. Approximately 0.71% (n = 23,185) of all infants had ICD-10 codes indicating either abnormal NBHS or diagnosis of hearing loss on inpatient birth records. Among those infants with NAS, 117 had a failed NBHS and 15 had a HL diagnosis; none had both. The incidence of documented failed NBHS/hearing loss diagnosis in the NAS cohort was 0.6% (n = 133), and not statistically different, compared to 0.7% (n = 23,051) in the unexposed cohort (p = 0.23). This is summarized in Table 1 along with other patient-specific factors including race and sex. Higher rates of documentation of failed NBHS were seen in males ($p < 0.001$) and Black and Native American infants ($p < 0.001$). When assessing for an association between documented inpatient failed NBHS or hearing loss diagnosis and socioeconomic factors, statistically significant differences were seen based on patient insurance status, primary place of residence, and familial income levels. These findings are shown in Table 2.

Table 1

Diagnosis of NAS and Patient Demographics and Association with Failed Newborn Hearing Screen or Hearing Loss Diagnosis During Birth Hospitalization (Weighted Estimates)

		Abnormal Auditory Function Diagnosis or Hearing Loss Diagnosis				
		No		Yes		
		n	%	*n*	%	*p*-value
NAS	No	3,234,872	99.3%	23,051	0.7%	0.2329
	Yes	21,754	99.4%	133	0.6%	
Risk †	No	3,214,278	99.3%	22,943	0.7%	< 0.05
	Yes	42,348	99.4%	241	0.6%	
Sex	Male	1,665,967	99.2%	12,857	0.8%	< 0.001
	Female	1,590,659	99.4%	10,328	0.6%	
Race	White	1,693,045	99.4%	10,916	0.6%	< 0.001
	Black	466,282	99.1%	4,410	0.9%	
	Hispanic	655,020	99.2%	4,968	0.8%	
	Asian or Pacific Islander	201,572	99.5%	1,044	0.5%	
	Native American	22,442	98.7%	291	1.3%	
	Other	218,262	99.3%	1,553	0.7%	

Note. NAS = neonatal abstinence syndrome.
†Risk=Presence of known medical risk factor for hearing loss

Multivariate logistic regression analyses reveal several findings. When a failed NBHS and hearing loss diagnosis are combined as the outcome variable, we identify no statistically significant association between NAS and hearing loss (OR = 0.82, p = 0.11, data not shown). This analysis includes a weighted sample of 22,327 infants with a failed NBHS, 844 with a HL diagnosis, and 12 with both.

However, when separate regressions are performed for each measure, this study reveals more meaningful associations. Patient demographics and socioeconomic factors and odds of a failed NBHS (i.e. abnormal auditory function diagnosis) or hearing loss diagnosis are summarized in Tables 3 & 4, respectively. When controlling for confounding variables, infants with NAS had a lower odds ratio of documentation of abnormal NBHS (OR = 0.76, $p < 0.05$) compared with non-NAS infants. There is also a statistically significant difference in the odds of

Table 2

Socioeconomic Characteristics and Association with Failed Newborn Hearing Screen or Hearing Loss Diagnosis During Birth Hospitalization (Weighted Estimates)

		Abnormal Auditory Function Diagnosis or Hearing Loss Diagnosis				
		No		Yes		
		n	%	*n*	%	*p*-value
Payer Type	Medicaid	1,518,324	99.2%	12,204	0.8%	< 0.001
	Private Insurance	1,499,297	99.4%	9,325	0.6%	
	Self-Pay	146,617	99.3%	1,083	0.7%	
	No Charge	1,590	98.6%	23	1.4%	
	Other	90,796	99.4%	548	0.6%	
Patient Geography †	Central metro	1,123,029	99.4%	7,017	0.6%	< 0.001
	Fringe metro	781,982	99.4%	5,110	0.6%	
	Mid-metro	643,885	99.2%	5,149	0.8%	
	Small metro	270,852	99.2%	2,274	0.8%	
	Micropolitan	262,985	99.1%	2,273	0.9%	
	Not metro- or micropolitan	173,890	99.2%	1,359	0.8%	
Income Quartile	1st (< $25,000)	953,931	99.2%	7,640	0.8%	< 0.001
	2nd ($25,000–$34,999)	803,257	99.3%	5,958	0.7%	
	3rd ($35,000–$44,999)	797,211	99.3%	5,719	0.7%	
	4th (> $44,999)	702,226	99.5%	3,866	0.5%	

†Patient Geography: Central metro = county population > 1 million; Fringe metro = co. pop. > 1 million; Mid-metro = co. pop. 250,000–999,999; Small-metro = co. pop. 50,000–249,999; Micropolitan = co. pop. 49,999–10,000; Not metro- or micropolitan = co. pop. < 10,000.

diagnosed hearing loss between NAS infants and non-NAS infants (OR = 2.17, $p < 0.01$). Sociodemographic factors with higher odds of abnormal NBHS results included Medicaid insurance status (OR = 1.27, $p < 0.001$), Black race (OR = 1.48, $p < 0.001$), Native American race (OR = 1.83, $p < 0.01$), and smaller metropolitan residence (OR = 1.33–1.44, $p < 0.05$). Factors with lower odds ratio of abnormal NBHS results included female gender (OR = 0.85, $p < 0.001$) and presence of a medical risk factor for hearing loss (OR = 0.69, $p < 0.001$). There are no observed associations between family income and an abnormal NBHS. Sociodemographic factors with higher odds ratio of diagnosis of hearing loss during birth admission records included Medicaid as the primary payer (OR = 1.45, $p < 0.001$) and presence of a medical risk factor for hearing loss (OR = 3.02, $p < 0.001$). Other factors with lower odds ratio of diagnosis of hearing loss were female gender (OR = 0.84, $p < 0.001$) and family income over $45,000 (OR = 0.53, $p < 0.01$).

Discussion

The most recently available data from the Centers for Disease Control and Prevention estimates a rate of failed newborn hearing screen at 1.7% with the prevalence of newborn hearing loss at 1.7 per 1,000 infants screened (CDC, 2018b). These data are reported to the CDC from each state EHDI program as collected from birthing hospitals. These data are collected from hospitals outside the medical record through reporting systems that are distinct from hospital records and billing. From an epidemiological standpoint, it is valuable to have data on the incidence and prevalence of infant hearing loss on a national level; however, these data are detached from the medical record of infants, which may limit progress in large scale research regarding other medical or sociodemographic factors associated with abnormal NBHS and infant hearing loss, when those factors are not captured in the EHDI program. With current EHDI data, it is impossible to investigate for links between medical conditions such as NAS and infant hearing loss, thus, other research tools and databases must be used. Unlike hospital EHDI data, there is no mandate or requirement of reporting abnormal NBHS results or hearing loss diagnosis in administrative records and it is possible that diagnoses related to abnormal NBHS and infant hearing loss may be underreported or may go unreported.

Table 3

Logistic Regression Analysis: Likelihood an Infant Failed Their Hearing Screen or was Given a Diagnosis of Hearing Loss Based on Patient-Specific Factors

Logistic Regression Analysis, Likelihood of Abnormal Hearing Assessment			
		Abnormal Auditory Function	**Hearing Loss Diagnosis**
		Odds Ratio (95% CI, *p*)	**Odds Ratio (95% CI, *p*)**
	NAS	0.76 (0.58–0.98, < 0.05)	2.17 (1.23–3.85, < 0.01)
	Risk†	0.69 (0.58–0.82, < 0.001)	3.02 (1.85–4.95, < 0.001)
	Female	0.84 (0.79–0.90, < 0.001)	0.84 (0.73–0.96, 0.01)
Race	White	1.00	1.00
	Black	1.48 (1.30–1.69, < 0.001)	0.77 (0.48–1.24, 0.29)
	Hispanic	1.18 (0.99–1.41, 0.06)	1.14 (0.73–1.79, 0.56)
	Asian or Pacific Islander	0.90 (0.74–1.10, 0.31)	0.98 (0.70–1.39, 0.92)
	Native American	1.83 (1.19–2.81, < 0.01)	1.94 (0.93–4.03, 0.08)
	Other	1.19 (0.94–1.49, 0.138)	0.68 (0.36–1.26, 0.22)

Note. NAS = neonatal abstinence syndrome. N = 951,437
Risk = Presence of known medical risk factor for hearing loss.

Table 4

Logistic Regression Analysis: Likelihood an Infant Failed Their Hearing Screen or was Given a Diagnosis of Hearing Loss Based on Socioeconomic Characteristics

Logistic Regression Analysis, Likelihood of Abnormal Hearing Assessment			
		Abnormal Auditory Function	**Hearing Loss Diagnosis**
		Odds Ratio (95% CI, *p*)	**Odds Ratio (95% CI, *p*)**
Payer Type	Private	1.00	1.00
	Medicaid	1.13 (1.02–1.25, < 0.05)	1.45 (1.19–1.77, < 0.001)
	Self-Pay	1.10 (0.91–1.33, 0.34)	1.21 (0.80–1.81, 0.36)
	No Charge	2.24 (0.72–6.85, 0.16)	n/a‡
	Other	0.87 (0.66–1.16, 0.35)	1.41 (0.66–3.01, 0.37)
Patient Geography†	Central metro	1.00	1.00
	Fringe metro	1.10 (0.89–1.35, 0.37)	1.59 (0.87–2.93, 0.14)
	Metro of 250,000–999,999	1.33 (1.03–1.71, < 0.05)	0.58 (0.32–1.07, 0.08)
	Metro of 50,000–249,999	1.39 (1.04–1.86, < 0.05)	0.93 (0.40–2.15, 0.87)
	Micropolitan	1.44 (1.08–1.93, < 0.05)	0.79 (0.40–1.58, 0.51)
	Not metro- or micropolitan	1.26 (0.95–1.68, 0.11)	1.53 (0.59–4.0, 0.385)
Income Quartile	1st (< $25,000)	1.00	1.00
	2nd ($25,000–$34,999)	1.0 (0.88–1.13, 0.95)	0.83 (0.56–1.25, 0.38)
	3rd ($35,000–$44,999)	1.03 (0.90–1.18, 0.68)	0.96 (0.72–1.29, 0.0.80)
	4th ($45,000 and above)	0.89 (0.75–1.04, 0.15)	0.53 (0.34–0.81, < 0.01)

Note. N = 951,437. †Patient Geography: Central metro = county population > 1 million; Fringe metro = co. pop. > 1 million; Mid-metro = co. pop. 250,000–999,999; Small-metro = co. pop. 50,000–249,999; Micropolitan = co. pop. 10,000–49,999; Not metro- or micropolitan = co. pop. < 10,000.
‡Excluded from analysis due to small sample size and perfect failure prediction.

Our data are discordant with CDC findings, yielding a lower overall rate of failed hearing screen or hearing loss diagnosis of 0.71% in this inpatient sample of birth hospitalizations. This study found, using uni- and multivariate analysis, that infants with NAS have a lower odds ratio of reported abnormal NBHS results on inpatient discharge records than non-NAS infants. These findings could be due, simply, to an actually lower incidence of abnormal NBHS in NAS infants. There is no other evidence that would suggest that neonatal substance exposure is protective against hearing loss.

Conversely, we hypothesize that abnormal NBHS is underreported in the inpatient records and hospital billing of NAS infants which could account for the lower odds ratio found in this data. The complexity of medical care and multi-disciplinary discharge follow-up of NAS infants could influence the reporting of abnormal NBHS on inpatient hospital records. If proven true, this hypothesis is significant as it indicates that complex medical conditions in infants, such as NAS, could negatively influence the reporting of NBHS results. This could lead to delays in the diagnosis and treatment of hearing loss within the local medical community if NAS is indeed a risk factor for hearing loss. This hypothesis is further supported by this data which found a significantly lower odds ratio of documented abnormal NBHS in infants with known risk factors for hearing loss. These factors include complex medical conditions such as perinatal maternal infections, craniofacial abnormalities, ototoxic drug exposure, NICU admission, prematurity, and hyperbilirubinemia. These complex medical conditions along with other conditions in the infant would be prioritized in the inpatient and early outpatient care of infants which could influence the reporting of NBHS results, along with other relevant clinical findings. This study also finds a difference in the actual diagnosis of hearing loss of NAS-infants and non-NAS infants based on inpatient data. Although the overwhelming majority of infants who are diagnosed with hearing loss receive that diagnosis after multiple audiological evaluations on an outpatient basis, this study suggests that infants with NAS and congenital hearing loss may receive definitive audiological evaluation in addition to NBHS due to their prolonged inpatient stays in the hospital. Although this study does not test for the causal relationship between NAS and hearing loss diagnosis, it is the first to identify a relationship between the two in an infant population.

Although few cases have been reported in the adult literature of hearing loss from opioid use, there is not strong evidence to suggest ototoxicity with *in-utero* opiate exposure. Our findings, based on birth hospitalization data, found there was no significant difference in hearing loss incidence between the exposed and unexposed cohorts. More research is needed to assess the relationship between NAS and infant hearing loss as the complex care and increased length of stay required by these patients can make identification of hearing loss a difficult task. Subsequent work should be completed to follow these patients into childhood to ensure longevity of hearing health or recognize later needs, as well as improve detection of delayed onset or progressive hearing loss not observable in the birth admission. It is also important to stress the need for thorough discharge planning for these patients and confirmation of audiologic follow-up in the event of a failed NBHS given their risk of poor use of prophylactic and specialty healthcare services (Fang et al., 2015; Gill et al., 2007; Kivisto et al., 2014).

In this study, we also assessed patient and socioeconomic factors associated with documented abnormal NBHS/infant hearing loss. In doing so, increased rates of failed hearing screens and hearing loss diagnoses were noted in vulnerable patient populations. Medicaid insurance status had higher odds of abnormal hearing assessments and diagnoses compared to patients with private insurance. Place of residence was also associated with differences in hearing assessment. Patients from outside a central metropolitan area were at increased odds of failed NBHS. The greatest likelihood was seen in micropolitan (county population 10,000-49,999), OR = 1.44. Compared to the lowest earning families, patients whose family incomes were in the 4th quartile had decreased odds ratios of HL, OR = 0.53 ($p < 0.01$). By using data from the National Health Interview Survey, Boss et al., 2011 also described increased rates of hearing loss in children of lower socioeconomic status. Increased rates of failed NBHS or HL diagnoses from national inpatient data in children covered by Medicaid, and in those from smaller communities are novel findings not yet reported in the literature. The possibility of failed NBHS or HL diagnoses is concerning given these are populations already at-risk for worse audiologic follow-up or decreased access to care following a failed NBHS. Prior studies with small samples have shown that loss to follow up and decreased care access are common for children from rural areas or outside a central metropolitan area, who are uninsured or covered by public insurance, and come from families with lower incomes and lower parental education levels (Bush et al., 2014; Liu et al., 2008; Oghalai et al., 2002; Ravi et al., 2016; Zeitlin et al., 2017). Individuals who identified as Black, OR =1.48 ($p < 0.001$) or Native American, OR = 1.24 ($p = 0.02$), were more likely to have abnormal hearing assessments. Unfortunately, racial and ethnic minorities have been noted to be at higher risk for loss to follow-up after a failed NBHS (CDC, 2018a; Liu et al., 2008; Zeitlin et al., 2017). This again highlights patient populations not only at risk for increased rates of hearing loss but also worse use of subsequent care.

This study is limited most notably by its retrospective nature and reliance on administrative data, which may not document all clinically-relevant information. Although 98% of newborns received hearing screening in 2015 (CDC, 2015), it must be noted that differing techniques of screening and reporting mechanisms are used throughout the country. As EHDI and KID data rely on reporting from national samples, testing and diagnostic homogeneity cannot be assumed for this study. Likewise, NAS is a clinical diagnosis made based on a constellation of signs and symptoms, and there is no uniform evaluation

mechanism to make this diagnosis (McQueen & Oikonen, 2016). Finally, our study uses imprecise measures of the outcome of an abnormal NBHS. We rely on ICD-10 codes for "abnormal auditory function" that may not be consistently coded in billing programs when an infant fails their screen.

Conclusion

NAS children have a lower rate of inpatient documented failed NBHS and a higher odds of HL diagnosis during the birth admission. The complex medical care of these infants could complicate NBHS and subsequent follow-up. Certain sociodemographic factors including some racial and ethnic minorities, lower income level, residence outside a metropolitan center, and Medicaid insurance are associated with higher risk of hearing loss. Further research is needed to assess hearing screening and diagnoses of hearing loss in vulnerable populations such as NAS infants.

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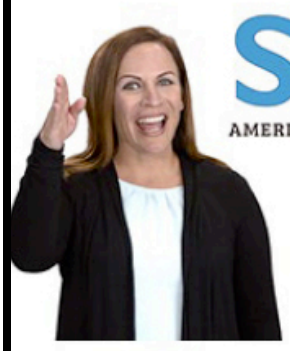
EHDInfo



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