Advancing Early Hearing Detection and Intervention in Kentucky: A Seven-Year Review of EHDI Benchmarks, Risk Factors, and Geographic Trends

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Introduction

Early Hearing Detection and Intervention (EHDI) programs are essential for identifying hearing loss in infants and young children and ensuring timely access to diagnostic and intervention services. Kentucky's EHDI program began implementing universal newborn hearing screening in 2001 and is now over two decades old, supporting early identification of hearing loss to promote optimal language, social, and cognitive development. National EHDI benchmarks recommend that all infants receive a hearing screening before 1 month of age, that infants who do not pass screening receive a diagnostic evaluation by 3 months of age, and that infants with confirmed permanent hearing loss are enrolled in early intervention services by 6 months of age. These 1-3-6 benchmarks provide measurable targets for public health performance and guide quality improvement efforts statewide. While newborn hearing screening identifies many children with hearing loss, some infants with permanent childhood hearing loss may not be detected through screening alone. **Incorporating risk factors as recommended by the Joint Committee on Infant Hearing (JCIH) into EHDI surveillance is therefore critical for identifying at-risk children and supporting timely diagnosis and intervention.**

Using aggregated statewide birth data from Kentucky from 2017 to 2023, this project examines hearing screening, diagnostic, and intervention outcomes alongside a comprehensive set of risk factors associated with permanent childhood hearing loss. By integrating risk factor and geographic data with traditional EHDI metrics, **this analysis highlights opportunities to strengthen early identification efforts, address disparities across Kentucky communities, and enhance the overall impact of the statewide EHDI program.**

Methods

Data Source:
Data was pulled from Kentucky's EHDI program, within the Office for Children with Special Health Care Needs (OCSHCN), an agency of the Department for Public Health (DPH) at the Commonwealth of Kentucky's Cabinet for Health and Family Services (CHFS). Screening and diagnosis data is to be reported to the Kentucky EHDI program and is organized for reporting to CDC on an annual basis.

Study Sample:
This study sample includes all children born as residents of Kentucky, with birth data that is provided for the Office of Vital Statistics in Kentucky. Data from 2017 to 2023 was available and deidentified prior to analysis.

Study Variables:
Risk factors for childhood hearing loss were collected at birth, as well as screening status, age at screening, diagnosis, and age at diagnosis as reported to EHDI program (Table 1). These PCHL risk factors were determined by the Joint Committee on Infant Hearing (JCIH) for all or part of the data collection period (2017-2023).
All missing or unknown data was kept in the sample.

Geographic Analysis:
For geographic factors, maternal residence was used to determine county of residence and area of birth. County of residence as well as 5-digit zip code was used to determine Appalachian status (according to the Appalachian Regional Commission). Maps were generated using R software.

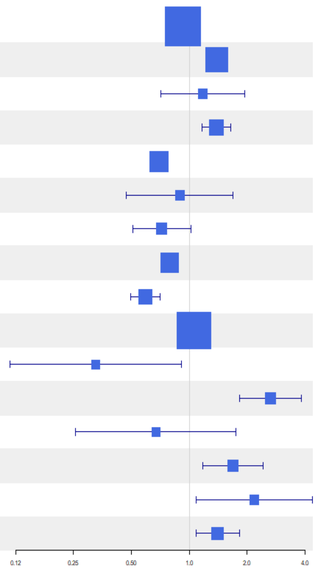
Statistical Analysis
Descriptive statistics were generated for all study variables. A complete list of perinatal characteristics considered risk factors for permanent childhood hearing loss (PCHL) is provided in Table 1.

Odds ratios were calculated via univariate logistic regression using the SAS procedure PROC LOGISTIC. All statistical analysis was performed using SAS 9.4 (Cary, NC).

Results

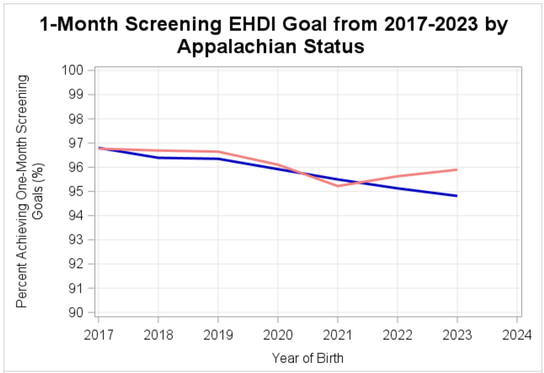
1-3-6 Goals and PCHL Risk Factors by Appalachian Status Aggregate from 2017-2023

Risk Factor	Overall (n, %) 353100 (100%)	Non-Appalachian (n, %) 271896 (77%)	Appalachian (n, %) 81204 (23%)	Odds Ratio 95%CI Appalachian as Reference
Screened Within 1 Month of Age	339246(96.08)	261405 (96.14)	77841 (95.86)	0.93 [0.89, 0.97]
Diagnosed within 3 months*	5062 (30.29)	3628 (28.57)	1434 (35.72)	1.39 [1.29,1.50]
Enrolled in Early Intervention **	81 (8.19)	58 (7.87)	23 (9.13)	1.18[0.71,1.95]
PCHL Diagnosis	616 (0.17)	436 (0.16)	180 (0.22)	1.38 [1.16,1.65]
Family History of HL	2663 (0.75)	2205 (0.81)	458 (0.56)	0.69 [0.63,0.77]
NICU Stay > 5 days	12208 (3.46)	45 (0.02)	12 (0.01)	0.89 [0.47,1.69]
Low Birthweight < 25g	12208 (3.46)	9275 (3.41)	2933 (3.61)	0.72 [0.51,1.02]
Ototoxic medication	2113 (0.60)	1709 (0.63)	404 (0.50)	0.79 [0.71,0.88]
Craniofacial Abnormalities	972 (0.28)	826 (0.30)	146 (0.18)	0.59 [0.50,0.71]
Persistent Pulmonary Hypertension	215 (0.06)	177 (0.07)	38 (0.05)	1.06 [1.02,1.11]
Anoxia	45 (0.01)	41 (0.02)	4 (0.00)	0.33 [0.12,0.91]
Sepsis	113 (0.03)	63 (0.02)	50 (0.06)	2.66 [1.83, 3.85]
Meningitis	30 (0.01)	25 (0.01)	5 (0.01)	0.67 [0.26,1.75]
Cytomegalovirus	131 (0.04)	87 (0.03)	44 (0.05)	1.69 [1.18,2.43]
Maternal Rubella	33 (0.01)	20 (0.01)	13 (0.02)	2.18 [1.08,4.38]
Maternal Syphilis	274 (0.08)	193 (0.07)	81 (0.10)	1.41 [1.08,1.82]



*Among children who did not pass initial screening
**Among children who received a HL diagnosis

Figure 1. Overall Aggregated Characteristics of Kentucky Births by Appalachian Status and PCHL Risk Factors from 2017-2023



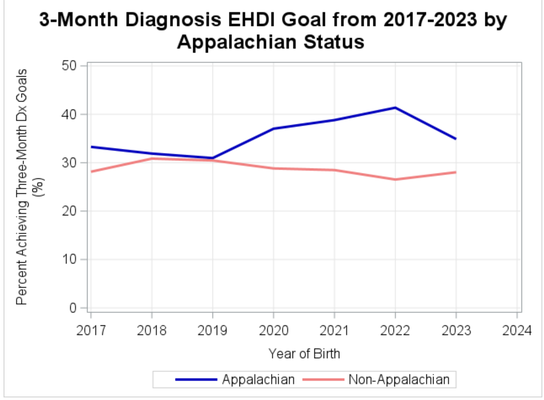


Figure 2. Series plot of 1-3 goals by Appalachian status from 2017-2023

1-3 Goals by Kentucky County

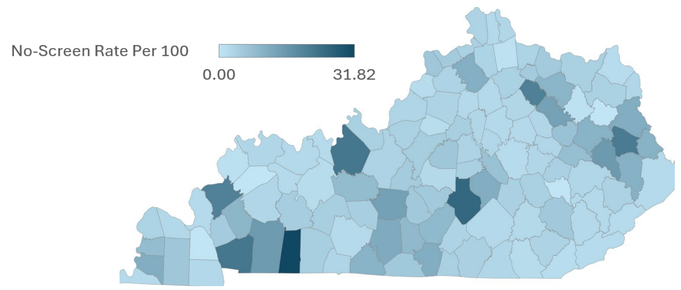


Figure 3. 2023 No-screen Rate Per 100 Infants Per County

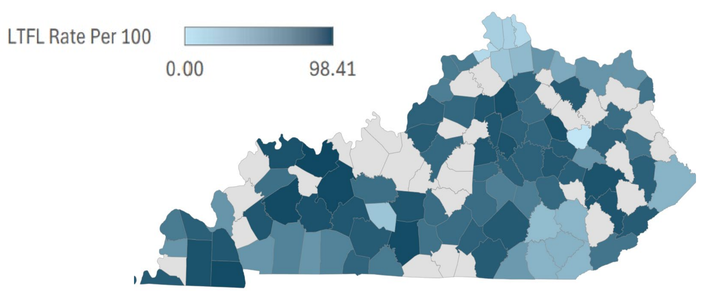


Figure 4. 2023 Loss to Follow-up Rate Per 100 Infants Per County
Grey counties indicate unstable rate calculations due to low failed screening rates (count < 5).

Discussion

We assessed the distribution of 1-3-6 goals and PCHL diagnosis between Appalachian and Non-Appalachian Kentucky counties (Figure 1) and found that while there was no difference in meeting the screening goal within 1 month of age, **children diagnosed within three months had 39% higher odds of being from an Appalachian county** vs a Non-Appalachian county. **Permanent childhood hearing loss diagnoses were 38% more likely to be from an Appalachian county**.

The distribution of risk factors for PCHL differed between Appalachian and non-Appalachian Kentucky counties, particularly for maternal infections. Children with sepsis were more likely to be Appalachian (OR: 2.66, 95% CI: 1.83, 3.85), maternal rubella (OR: 2.18, 95% CI: 1.08, 4.38), CMV (OR: 1.69, 95% CI: 1.18, 2.43), and maternal syphilis (OR: 1.41, 95% CI: 1.08, 1.82) were also more common in Appalachian children.

When looking at the Kentucky heat maps for lack of screening (Figure 3) and lack of follow-up for diagnosis after failed screening (Figure 4), **Appalachian counties appear to be similarly affected as a part of the rural areas also indicated in Western parts of the state**. These findings align with known disparities in access to audiology services in rural regions. Further geospatial analyses incorporating provider availability and travel burden may help clarify access-related barriers.

Despite higher PCHL incidence in Appalachian counties, disparities in screening and diagnostic follow-up were smaller than hypothesized (Figure 2). Continued investigation is needed to identify underlying contributors to the elevated PCHL burden in Appalachian regions. In the interim, Kentucky's EHDI program will expand educational outreach to parents and providers to reinforce the importance of timely hearing screening, diagnostic follow-up, and prevention of maternal infections that may cause PCHL.