HHS Public Access

Author manuscript

J Dev Behav Pediatr. Author manuscript; available in PMC 2023 January 01.

Published in final edited form as:

J Dev Behav Pediatr. 2022 ; 43(2): 104–110. doi:10.1097/DBP.0000000000000976.

Association of Age of Enrollment in Early Intervention with Emergent Literacy in Children who are Deaf or Hard of Hearing

Jareen Meinzen-Derr, PhD[a], **Mekibib Altaye, PhD**[a], **Wendy Grove, PhD**[b], **Alonzo T. Folger, PhD**[a], **Susan Wiley, MD**[c]

[a]Division of Biostatistics and Epidemiology, Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio

[b]Office of Early Learning and School Readiness, Ohio Department of Education, Columbus, Ohio

[c]Division of Developmental and Behavioral Pediatrics, Cincinnati Children's Hospital Medical Center, Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio

Abstract

Objective: Literacy skill development in deaf or hard of hearing (DHH) children is essential for success in school and beyond. Our objective was to evaluate the association between age of early intervention (EI) enrollment for DHH children and emergent literacy in preschool.

Methods: This was a population-based study leveraged state public health and education data on all children identified with hearing loss. Children born between 2008 and 2014 enrolled in EI for hearing loss who received preschool supports (years 2011–2014) through the Ohio Department of Education. The *Get it! Got it! Go!,* measuring emergent literacy domains of picture naming, rhyming and alliteration, was administered during preschool in fall and spring. Exposure was enrollment into EI before age 6 months (early) vs. at/after 6 months (later). Propensity score matching and mixed model analyses were used to examine associations between EI enrollment and outcomes over time. Model least square means with 95% confidence intervals (CI) were reported.

Results: One hundred two successful matches were made for 256 preschoolers. Children enrolled in EI early had significantly higher mean scores (mean, (95% CI)) over time for emerging literacy domains of picture naming (2.42, (0.47, 4.37)), rhyming (1.2, (0.35, 2.06)), and alliteration (0.61, (0.15, 1.07)) compared to later enrolled children. Children enrolled early had significantly higher emergent literacy scores at entry, though literacy development was similar between groups.

Conclusion: Children enrolled in EI before age 6 months had consistently higher scores in emergent literacy components over time compared to children enrolled at/after age 6 months.

Keywords

deaf or hard of hearing; early intervention; emergent literacy

Corresponding author: Jareen Meinzen-Derr, PhD, MPH, 3333 Burnet Ave MLC 5041, Cincinnati Children's Hospital Medical Center, Cincinnati, OH 45229, Phone: 513-636-7789, Fax: 513-636-7509, jareen.meinzen-derr@cchmc.org.

INTRODUCTION

To ensure all newborns receive hearing screening, follow-up diagnostic and early intervention (EI) services, Early Hearing Detection and Intervention (EHDI) programs have been established in all 50 states and U.S. territories. The national EHDI "benchmarks" are to screen infants for hearing loss by one month of age, diagnose hearing loss by age 3 months, and enroll infants with permanent hearing loss into EI by age 6 months (EHDI 1–3-6).[1] These benchmarks have been implemented due to the increased risk for language delays in children who are deaf or hard of hearing (DHH). These delays impact downstream development, placing DHH children at risk for social-emotional problems and academic underachievement. With 1–2 per 1000 infants identified with hearing loss at birth each year in the United States,[2] the overall impact is consequential.

Learning to read is a crucial academic achievement. Despite many years of UNHS implementation, many DHH children exhibit deficits in literacy skills.[3–5] Previous states' academic testing have found that high school DHH graduates were reading at the fourth grade level.[6,7] Emergent literacy is the knowledge of reading and writing that children acquire in natural settings (e.g., at home). This foundation is vital to literacy development (reading, writing) prior to formal reading instruction.[8] Evidence suggests that young DHH children struggle with emergent literacy skills compared to hearing peers.[9–12] Because emergent literacy difficulties may lead to difficulty with later reading skills, it is important to understand how to support these foundational skills at an early age.

Within the United States, children identified with a hearing loss are federally mandated to be referred to Early Intervention (EI: Part C of Individuals with Disabilities Education Act), which has historically focused on children with or at risk for developmental delays.[13] The Part C EI program, for infants and toddlers birth to 3 years, includes a wide range of services (e.g., home visits, family training, counseling, special instruction and therapy). Variability exists across states and sometimes within states regarding access to specific services and availability of resources. Additionally, Part C programs are required to have a transition plan to provide on-going developmental support, as services most often cease when a child turns 36 months of age. The body of research on the effectiveness of EI services on language development in DHH children has grown.[14–16] DHH infants who receive EI before age 6 months have improved vocabulary and language development compared to those who receive EI at/after age 6 months. Persistent benefits of newborn screening and early identification on reading skills later in life (i.e. primary school age and teenage years) has been described.[17–19] The longer-term impact of EI on educational outcomes (e.g., emergent literacy in preschool) in DHH children identified through EHDI programs remains unclear.

In the state of Ohio, approximately 200 infants are identified with permanent hearing loss through the EHDI program annually; approximately 60% enroll into EI.[2] We have previously reported on the association between receiving EI services before age 6 months (an EHDI benchmark) with kindergarten or school readiness.[20] The purpose of this current study was to evaluate the relationship between EI enrollment age for DHH children and earlier outcomes of emergent literacy measured in preschool. We hypothesized that children

who enter EI early (before age 6 months) will have higher emergent literacy skills over time compared to children who enter EI later.

METHODS

We created a comprehensive longitudinal database linking hearing screening and diagnostic data, EI data, and educational records of infants identified with permanent hearing loss born January 1, 2008 through December 31, 2014. Details of the linkage methods are published elsewhere.[21] Screening and EI data systems, from the Ohio Departments of Health and Developmental Disabilities respectively, were linked using a deterministic, two-staged algorithm with information from both infants and mothers. Education data from the Ohio Department of Education were linked using an identifier assigned to children served in EI. This study was approved and granted a waiver of consent by the institutional review boards of Cincinnati Children's Hospital Medical Center with Memoranda of Understandings across all institutions/agencies involved.

Variables

Variables available for analysis included demographic fields (i.e., maternal age, race and ethnicity, education level of parents, and insurance status/payer). Variables that characterized the birth included gestational age, birthweight, Apgar score, hearing loss-specific risk indicators (e.g., family history, specific physical findings, neonatal intensive care stay) and pregnancy-related risk factors (e.g., in utero infections). Risk indicators were according to the Joint Committee of Infant Hearing Position Statement.[1] Hearing-specific information included age at screening and diagnosis, laterality of hearing loss (unilateral/bilateral), and degree of hearing loss (e.g., mild, moderate, moderate-severe, severe and profound). Early intervention data used in the current study included date of EI enrollment and documented developmental delays/disabilities. Presence of disabilities within the EI record was according to a form completed by medical professionals licensed to diagnose and treat mental and physical conditions believed to likely lead to developmental delays. Information on amplification was not available in the record.

Outcome measures

All academic outcomes were part of Ohio's assessment standards. Between 2011 and 2014, emergent literacy was measured during preschool using the *Get it! Got it! Go!* (GGG) assessment.[22] The GGG is composed of three individual indicators in children's language and literacy development: Picture Naming (measuring expressive language development), Rhyming, and Alliteration (measures of phonological awareness associated with early literacy development).[23] Each task is individually administered and timed. Picture naming (one minute) requires the child to quickly name pictures of familiar objects found in home, classroom, or community settings. Rhyming (one minute) requires the child to point to one of three pictures that rhymes with a target picture, after all pictures are named by the examiner. Alliteration (two minutes) requires the child to identify one of three pictures that starts with the same sound as the target picture. GGG scores reflect the number of items answered correctly in the time limit; no maximum or standard score exists. These three indicators have good test-retest reliability (from r=0.67 to 0.89), significantly correlated

with other language standardized measures that are a correlate of literacy, are sensitive to change,[23] and have been used in previous emergent literacy research.[24] The GGG was administered in the Fall and Spring of each school year. The number of available assessments varied (918 observations total). Fifty children had one GGG assessment date, 65 had two assessments and the remainder had three or more (range 1–10; mean 3.3).

Exposure variable

The initial Individualized Family Service Plan date was used as the EI enrollment date. Early intervention exposure was defined using the national EHDI benchmark of enrollment into EI before age 6 months. Children were classified as entering EI early if they enrolled before age 6 months and as entering EI later if they enrolled at/after age 6 months.

Statistical Analysis

Statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC) software. Data distributions were assessed for normality. Socio-demographic and clinical variables were tested between EI early group and EI late group using Pearson chi-square or Student's *t* test as appropriate. In order to balance the characteristics of children who entered EI early vs. later, we employed a propensity score (PS) matching. PS is the probability of group assignment based on observed baseline characteristics and usually obtained using logistic regression where group label (EI early vs EI late) will be modeled as a function of baseline variables. Variables included in the logistic regression model are: gender, birth weight, gestational age, race, maternal education level, insurance status, degree of hearing loss, presence of risk indicator for hearing loss, and presence of disability. Once the PS was generated, we used nearest-neighbor matching approach in which each subject in the EI late group is sequentially matched with one or more (up to 5) subjects in the EI early group, with a caliper width of 0.25 of the logit of the propensity score (i.e. subjects are considered for matching if the difference in the log propensity score is <0.25).

The relationship of emergent literacy skills development (measured in preschool) over time (age of child) as a function EI enrollment (EI early vs EI later) was investigated using mixed effects models (PROC MIXED) with a random intercept to account for the matched design and a repeated statement with a compound symmetry covariance structure to account for potential correlation induced by repeated data measures. Three models were constructed for the GGG domains of picture naming, rhyming, and alliteration. Variables that remained significantly different between the EI enrollment group after matching were included in the model (high risk indicator of hearing loss, disability diagnosis, bilateral vs. unilateral hearing loss). A group by age interaction term was tested in each model to examine whether trajectories across time differed by group. Estimated trajectories (based on least square means) of emergent literacy outcomes derived from these models were graphically illustrated. Outcome trajectories of all Ohio preschoolers during the same time frame were illustrated as a reference. Because we did not have the same detailed data on all Ohio preschoolers, we did not statistically compare the trajectories of DHH children with all preschoolers.

Domain scores that were classified as “not reported” were coded missing (accounting for 6.8% picture naming, 12.1% rhyming, 10.6% alliteration). To reduce bias and maximize use of available information, we conducted a multiple imputation procedure to impute missing data along an estimate of uncertainty about the imputed data. We used a regression approach, including relevant covariates to impute missing data, creating a complete dataset. We repeated this process 20 times, generating 20 complete datasets. We then fit the mixed model described above and generated estimated parameter values for each dataset. We pooled the parameter estimates (including standard errors) from each dataset to obtain a combined estimate which were reported as results of the final model. Finally, we performed sensitivity analyses to understand potential biases in our estimates given missing outcome data. First, we rerun our models treating the not reported scores as “0”, (instead of setting them as missing) possibly biasing our estimated slopes towards zero. We also reran the models using only available data (without imputation).

RESULTS

Participants

Within the Ohio EHDI Data Linkage Project, 1262 born between 2008 and 2014 were enrolled into EI. The GGG was administered to 276 children enrolled in preschool during the school years 2011–2014. Thirteen additional children had been enrolled in preschool by 2014 but had no GGG assessment data available (10/13 were enrolled in 2014). Of the 276, 160 (58%) had been enrolled in EI before age 6 months. Propensity score matching resulted in 102 matches for 256 children. Twelve children had missing match data and eight children did not match at all. Of the 256 matched children, 154 (60.2%) had enrolled in EI before age 6 months.

Children included in the current analysis looked similar to all DHH children enrolled in EI (Table 1). Compared to children who entered late, those who entered early were more likely ($p<0.05$) to have had hearing loss confirmed early (median 2.9 months vs. 8.4 months), a risk indicator for hearing loss (56.5% vs 35.3%), a disability diagnosis reported in the EI system (44.8% vs 28.4%), and less likely to have bilateral hearing loss (82.5% vs. 93.1%) (Table 1).

Emergent Literacy

Model results indicated that the group by age interaction term was not statistically significant for all three models. DHH children who enrolled in EI early had significantly higher mean scores (mean, 95% CI) over time compared to children who enrolled later for the GGG domains of picture naming (2.42, (0.47, 4.37)), approximately 2.4-word difference), rhyming (1.2, (0.35, 2.06)), approximately 1-word difference) and alliteration (0.61, (0.15, 1.07)). (see Table 2 for unadjusted and adjusted model results). All models accounted for the pre-specified set of covariates listed earlier, including assessment age in years, presence of disability, presence of risk factor for hearing loss, and laterality (unilateral vs. bilateral). Figure 1a–c illustrates the trajectories for the GGG domains of picture naming, rhyming, and alliteration for DHH children and for Ohio preschoolers as a reference. DHH children had similar trajectories for picture naming as Ohio preschoolers. Ohio preschoolers

had steeper trajectories for rhyming and alliteration, indicating a faster pace of learning for these two domains. The sensitivity analyses resulted in consistent results with the final models (Supplemental Digital Content Tables 1 and 2).

DISCUSSION

Our findings demonstrate the benefits of EI enrollment prior to age 6 months on emergent literacy outcomes for DHH preschool children. Children who entered EI before age 6 months had higher emergent literacy skills of picture naming, rhyming, and alliteration compared to children who entered at/after age 6 months. This relationship held after controlling for factors that have been associated with emergent literacy in previous studies,[25–27] such as presence of a disability diagnosis, more severe hearing loss, laterality, and maternal education level. Although the rate of change (trajectory) was no different between groups, early EI children entered preschool with higher skills, supporting the sustained benefits of enrollment into EI at earlier ages. Our study advances our understanding of potential benefits of early EI enrollment on important early academic outcomes occurring after the EI period of birth to 36 month in a population of DHH children.

Impact of early intervention programs for DHH

For DHH infants and toddlers, Part C EI initially serves as a proactive approach supporting language development in a population that is considered high risk for language delays. There is considerable evidence supporting the impact of UNHS and EI on decreasing ages of identification and improving language and vocabulary development in DHH children.[1,4,14,15] Early ages of EI enrollment have provided stronger evidence towards improved language outcomes for this population. Although earlier hearing loss confirmation has been associated with better reading abilities at primary school age,[19] little is known regarding how early enrollment into EI may impact reading abilities. It is encouraging that findings from the current study indicate that the benefit of early EI enrollment (prior to age 6 months) can be seen with emergent literacy measured in preschool.

In Ohio, DHH infants and toddlers with their families receive specialized EI services focused on goals that support the needs specific to DHH educational practice. Earlier enrollment into EI services allows for a longer period of time within EI (longer exposure time). Early EI enrollment may have provided more opportunities for EI providers to develop an effective relationship with families and coach families on early language stimulation. Transitioning from EI to academic settings shifts from a high level of direct family coaching and language focus to the structured setting focusing on academic and social performance. EI and academic systems are not always congruent, with distinct oversight agencies in some circumstances, differing funding sources, and disparate data systems in which information regarding an individual child are tracked. Our study had the benefit of strong agency partnerships and the foundation of a robust data linkage study.

Emergent Literacy in DHH

Emergent literacy skills provide the foundation for later reading and academic development in all children[28] including in DHH children.[12] Reading comprehension in DHH children remains below that of hearing peers despite technological advances (e.g., cochlear implants) which have facilitated improvements in speech perception and production abilities. Many DHH children enter kindergarten behind their peers regarding literacy and this gap persists into school age; a high proportion of students have consistently had reading skills below age-appropriate or grade-level.[3,6,29] Previous emergent literacy studies in DHH children have not evaluated the impact of EI exposure in the first 36 months of life on these outcomes. Our study provides a different approach to understanding emergent literacy by emphasizing the importance of the early receipt of EI on these later outcomes. Children who received EI before age 6 months had consistently higher emergent literacy outcomes in picture naming, rhyming, and alliteration than children who received EI at/after age 6 months. A striking finding was the inability for the later EI group to close the gap over time; they entered preschool with gaps in emergent literacy skills compared to early EI children and these gaps remained over time. We believe it is possible that providing children with a strong foundation for language development as early as possible (prior to 6 months in this case) indirectly provides them with necessary tools for emergent literacy.

It is important to note that DHH children did not always appear to enter preschool with emergent literacy scores lower than the Ohio preschool reference group. Because our data were limited regarding the reference group, we were unable to determine levels of ability for this group. It is likely that some preschoolers could have language or cognitive disabilities that would affect their academic progress. We were unable to control for such factors in the broader population as compared to the models for DHH children. Although our primary goal was to compare the EI early vs. EI later groups of DHH children, and not directly compare DHH children to children with hearing, the difference in trajectories for rhyming and alliteration warrant further investigation. The persistent lower scores on the GGG domains for DHH preschoolers who enrolled into EI later (at/after age 6 months) emphasize the potential need for additional support early on regarding emergent literacy. The differences in scores between early and later EI groups on these limited timed assessments were not only statistically significant, but also academically meaningful. It has been shown that it is difficult for children to “catch up” to their peers in formal academic settings when they start with fewer skills, even if the skill gap is narrow.[30] Due to the greater risks for language-based skill delays, seemingly small differences in pre-literacy skills during preschool for DHH children allow for early recognition of needs for targeted intervention. Our findings support a positive association with early EI enrollment on continued development of these emergent literacy skills. Emergent literacy warrants further attention for DHH preschoolers.

Strengths and Limitations

Study strengths include a large representative sample size of young Ohio -born children identified with hearing loss, and repeated outcome measures. Data were collected in the same way for all children and were linked across different state agencies providing a unique opportunity to understand outcomes occurring beyond the EI period. This has allowed us to evaluate a large longitudinal cohort from birth into school ages. We acknowledge limitations

of this research. Data were collected through public health and education agencies. Although the potential for unmeasured confounding exists, we conducted a matched analysis to minimize potential bias and confounding that may exist between the groups. Although there was imbalance with regard to a few of the variables (disability, risk indicator, laterality), these factors were more prevalent among children who enrolled into EI early. These factors also did not appear to confound the relationship between EI enrollment and outcome, according to the regression models. We did not have current language skills for preschoolers, which could help elucidate emerging literacy levels. This study was not designed to understand the mechanisms of skill development, but to assess the association of EI with later skills. Audiologic data was only available at EI enrollment; we were unable to account for current hearing levels. Reliance on specific technology (i.e. hearing aids, cochlear implants) and aided responses were not reported. Although device information may be important for understanding factors associated with outcomes, we do not believe that it would impact the relationship between age of EI (early vs. later) and outcomes. We included data on whether a child had a diagnosed disability that may be related to high risk for developmental delays, though we had no specific information on cognitive development. At the time of this study, the EI record only included whether a developmental assessment was scored below 2 standard deviations of the population for any developmental domain. Since no actual score was provided, and the record had no indication of when scores were above the cutoff of 2 standard deviations, we were not confident in using this variable to indicate cognitive development. The inclusion of the variable indicating the presence of disability appeared to be a robust predictor of outcomes. Future research should include more specific information on cognitive development. Education data from the state department include children on Individualized Education Programs (IEP), regardless of setting. A child in a private educational setting without an IEP would not have available data. Finally, the assessments available did not provide standard scores. The GGG is a standardized evaluation that targets key early literacy components to allow educational systems to track a child's trajectory over time. Since rhyming and alliteration have been noted to be areas of challenge for DHH children,[31] the GGG allowed us to assess these areas in the context of EI exposure. We were able to compare GGG data of DHH children with all Ohio preschoolers, allowing for a reference comparison.

Conclusion

The current findings extend previous research demonstrating the continued benefits of receiving early intervention before age 6 months, an important EHDI benchmark. While much research has focused on EI benefits on language outcomes during the first 36 months of life (the EI period), we focused on novel outcomes of preschool emergent literacy skills, which require a language foundation. Child outcomes beyond the early intervention period are important to track and understand. Understanding the association between these early childhood investments and the later developmental needs that occur during early school ages help provide further evidence of the long term importance of EI. By evaluating components of emergent literacy, we not only see that children who are enrolled in EI before 6 months of age have consistently higher scores in the areas of picture naming, rhyming, and alliteration over time compared to children enrolled at/after 6 months of age, it appeared that children enrolled early did as well as the preschool reference group at preschool enrollment and

with picture naming over time. These findings are important because they highlight an area in which EI interventionists can help facilitate improved outcomes in the preschool/kindergarten transition. Although there have been interventions to improve reading in DHH children,[32] research is needed to understand intervention strategies in first 36 months of life designed to enhance later reading abilities during for DHH children. Though not a current focus in EI, considerations for emergent literacy should be discussed, particularly for DHH children. Early EI enrollment should be a high priority for children who are identified with a hearing loss.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Role of the Funder/Sponsor:

The funder had no role in the design and conduct of the study: collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication. Contents are solely the responsibility of the authors and do not necessarily represent the official views of the granting agencies.

Conflict of Interest of Source of Funding:

All authors declare they have no conflicts of interest to report. This study was funded by the Disability Research and Dissemination Center (DRDC) through its Cooperative Agreement from the Centers for Disease Control and Prevention (U01DD001007 and U19DD001218) (Meinzen-Derr, PI).

References

1. Joint Committee on Infant Hearing [JCIH], American Academy of Pediatrics. Year 2007 position statement: Principles and guidelines for early hearing detection and intervention programs. Pediatrics. Oct 2007;120(4):898–921. [PubMed: 17908777]
2. Summary of 2016 National Centers for Disease Control and Prevention [CDC] Early Hearing Detection and Intervention [EHDI] Data: 2016 CDC EHDI Hearing Screening and Follow-up Survey. 2016. www.cdc.gov/ncbddd/hearingloss/ehdi-data.html.
3. Lederberg AR, Schick B, Spencer PE. Language and literacy development of deaf and hard-of-hearing children: successes and challenges. Dev Psychol. Jan 2013;49(1):15–30. [PubMed: 22845829]
4. Moeller MP, Tomblin JB, Yoshinaga-Itano C, et al. Current state of knowledge: language and literacy of children with hearing impairment. Ear Hear. Dec 2007;28(6):740–753. [PubMed: 17982362]
5. Easterbrooks SR, Lederberg AR. Reading Fluency in Young Elementary School Age Deaf and Hard-of-Hearing Children. J Deaf Stud Deaf Educ. Sep 9 2020.
6. Traxler CB. The Stanford Achievement Test, 9th Edition: National Norming and Performance Standards for Deaf and Hard-of-Hearing Students. J Deaf Stud Deaf Educ. Autumn 2000;5(4):337–348. [PubMed: 15454499]
7. Qi S, Mitchell RE. Large-scale academic achievement testing of deaf and hard-of-hearing students: past, present, and future. J Deaf Stud Deaf Educ. Winter 2012;17(1):1–18. [PubMed: 21712463]
8. Roth FP, Paul DR, Pierotti AM. Emergent Literacy: Early Reading and Writing Development. Let's Talk 2006 2006; https://www.asha.org/public/speech/emergent-literacy. Accessed June 2019, 2019.
9. Werfel KL. Emergent Literacy Skills in Preschool Children With Hearing Loss Who Use Spoken Language: Initial Findings From the Early Language and Literacy Acquisition (ELLA) Study. Lang Speech Hear Serv Sch. Oct 5 2017;48(4):249–259. [PubMed: 28973172]

10. Kyle FE, Harris M. Longitudinal patterns of emerging literacy in beginning deaf and hearing readers. J Deaf Stud Deaf Educ. Summer 2011;16(3):289–304. [PubMed: 21307357]
11. Nittrouer S, Caldwell A, Lowenstein JH, et al. Emergent literacy in kindergartners with cochlear implants. Ear Hear. Nov-Dec 2012;33(6):683–697. [PubMed: 22572795]
12. Easterbrooks SR, Lederberg AR, Miller AM, et al. Emergent literacy skills during early childhood in children with hearing loss: strengths and weaknesses. The Volta Review. 2008;108(2):91–114.
13. Individuals with Disabilities Education Improvement Act of 2004, Pub L No. 108–446, 118 Stat 2467. In: United States Department of Education, ed2004.
14. Nelson HD, Bougatsos C, Nygren P, et al. Universal newborn hearing screening: systematic review to update the 2001 US Preventive Services Task Force Recommendation. Pediatrics. Jul 2008;122(1):e266–276. [PubMed: 18595973]
15. Vohr B, Jodoin-Krauzyk J, Tucker R, et al. Early language outcomes of early-identified infants with permanent hearing loss at 12 to 16 months of age. Pediatrics. Sep 2008;122(3):535–544. [PubMed: 18762523]
16. Yoshinaga-Itano C, Sedey AL, Wiggin M, et al. Early Hearing Detection and Vocabulary of Children With Hearing Loss. Pediatrics. Aug 2017;140(2).
17. Calderon R. Further Support for the Benefits of Early Identification and Intervention for Children with Hearing Loss. Volta Review. 11 1998;100(5):53.
18. Pimperton H, Blythe H, Kreppner J, et al. The impact of universal newborn hearing screening on long-term literacy outcomes: a prospective cohort study. Arch Dis Child. Jan 2016;101(1):9–15. [PubMed: 25425604]
19. McCann DC, Worsfold S, Law CM, et al. Reading and communication skills after universal newborn screening for permanent childhood hearing impairment. Arch Dis Child. Apr 2009;94(4):293–297. [PubMed: 19015215]
20. Meinzen-Derr J, Wiley S, Grove W, et al. Kindergarten Readiness in Children Who Are Deaf or Hard of Hearing Who Received Early Intervention. Pediatrics. Oct 2020;146(4): e20200557. [PubMed: 32989084]
21. Folger AT, Wiley SE, VanHorn A, et al. Development of a State-Wide Database of Early Intervention and Educational Outcomes for Children who are Deaf/Hard of Hearing Journal of Early Hearing Detection and Intervention. 2019;4(1):28–35.
22. McConnell S. Get it, Got it, Go!. Minneapolis, MN: Institute on Community Integration, University of Minnesota;2003.Available from: http://ggg.umn.edu
23. Missall KN, McConnell SR. Psychometric characteristics of Individual growth and development indicators: picture naming, rhyming, and alliteration. University of Minnesota: University of MInnesota; April 2004
24. Bailet LL, Repper KK, Piasta SB, et al. Emergent literacy intervention for prekindergarteners at risk for reading failure. J Learn Disabil. Jul-Aug 2009;42(4):336–355. [PubMed: 19398614]
25. Cupples L, Ching TY, Crowe K, et al. Predictors of Early Reading Skill in 5-Year-Old Children With Hearing Loss Who Use Spoken Language. Read Res Q. Jan 2014;49(1):85–104. [PubMed: 24563553]
26. Geers AE. Predictors of reading skill development in children with early cochlear implantation. Ear Hear. Feb 2003;24(1 Suppl):59S–68S. [PubMed: 12612481]
27. Kyle FE, Harris M. Concurrent correlates and predictors of reading and spelling achievement in deaf and hearing school children. J Deaf Stud Deaf Educ. Summer 2006;11(3):273–288. [PubMed: 16556897]
28. Whitehurst GJ, Lonigan CJ. Child development and emergent literacy. Child Dev Jun 1998;69(3):848–872. [PubMed: 9680688]
29. Spencer PE, Marschark M. Evidence-based practices in educating deaf and hard of hearing students. New York, NY: Oxford University Press; 2010.
30. Missall KN, McConnell SR, Cadigan K. Early Literacy Development: Skill Growth and Relations between Classroom Variables for Preschool Children. Journal of Early Intervention. 2006;29(1):1–21.

31. James D, Rajput K, Brinton J, et al. Orthographic influences, vocabulary development, and phonological awareness in deaf children who use cochlear implants. Applied Psycholinguistics. 2009;30:659–684.

32. Lederberg AR, Miller EM, Easterbrooks SR, et al. Foundations for literacy: An early literacy intervention for deaf and hard-of-hearing children. J Deaf Stud Deaf Educ. Oct 2014;19(4):438–455. [PubMed: 25125456]

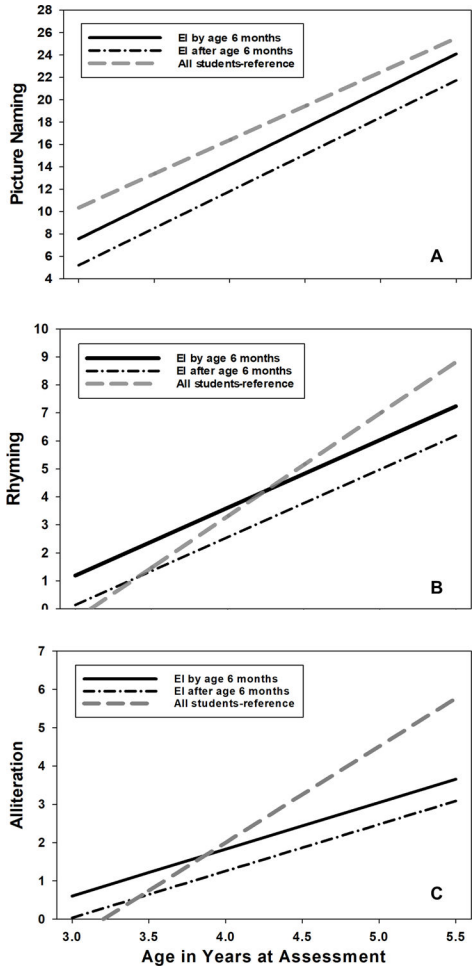

Figure 1.

Estimated trajectories (from the mixed models) for picture naming (Panel A), rhyming (Panel B) and alliteration (Panel C) for deaf or hard of hearing preschoolers served in EI by age of EI enrollment. X-axis illustrates the age of the child in years at time of the assessment. Y-axis illustrates the scores for each of the domains. Gray dash represents all Ohio preschoolers during the same years as a reference.

Table 1.

Distribution of characteristics of preschool children who were deaf or hard of hearing by age of early intervention enrollment

Characteristic	All children enrolled in EI N=1262	EI before age 6 months n=154	EI at/after age 6 months n=102	p-value[a]
Age at EI enrollment, median [IQR], mos	5.3 [3.2–9.3]	3.4 [2.3–4.6]	9.8 [7.9–15.5]	NA
Gender – Male, No. (%)	684 (54.2)	86 (55.8)	54 (52.9)	0.64
Race, No. (%)				0.94[b]
White/Caucasian	952 (75.4)	129 (83.8)	88 (86.3)	
Black/African American	155 (12.3)	21 (13.6)	12 (11.8)	
Other	73 (5.8)	3 (2)	2 (2)	
Unknown	82 (6.5)	1 (0.7)		
Ethnicity – Hispanic, No. (%)	55 (4.4)	4 (2.6)	1 (1)	0.36[b]
Premature birth, No. (%)	270 (21.4)	41 (26.6)	21 (20.6)	0.27
Age hearing loss confirmed, median [IQR], mos	3.9 [1.9–9.0]	2.9 [1.6–6.5]	8.1 [4.5–16.7]	<0.0001
Has risk indicator for hearing loss, No. (%)	507 (40.2)	87 (56.5)	36 (35.3)	0.0009
Presence of disability diagnosis, No. (%)	323 (25.6)	69 (44.8)	29 (28.4)	0.008
Mother reported some college education, No. (%)	712 (56.4)	95 (61.7)	55 (53.9)	0.22
Receive private insurance, No. (%)	600 (47.5)	81 (52.6)	48 (47.1)	0.39
Bilateral hearing loss, No. (%)	954 (75.6)	127 (82.5)	95 (93.1)	0.01
Severe to profound hearing levels, No. (%)	445 (35.3)	55 (35.7)	30 (29.4)	0.29

Abbreviations: EI = Early Intervention, IQR=interquartile range

[a]Comparison made between EI before age 6 months and EI at/after age 6 months

[b]Fisher's Exact test used

J Dev Behav Pediatr. Author manuscript; available in PMC 2023 January 01.

Table 2.

Results from Mixed Models of *Get it, Got it, Go!* Domain Scores for DHH Preschoolers. Unadjusted and Adjusted Results from Imputed Models Reported

	Unadjusted		Adjusted	
Picture Naming	**Parameter estimate (95% CI)**	**p**	**Parameter estimate (95% CI)**	**p**
Age at assessment in years	6.27 (5.55, 6.98)	<0.0001	6.23 (5.51, 6.94)	<0.0001
Early EI enrollment (vs. Later EI enrollment)[a]	1.62 (0.37, 3.62)	0.11	2.42 (0.47, 4.37)	0.01
Presence of disability reported (vs. no disability reported)[b]	−5.85 (−7.80, −3.90)	<0.0001	−5.98 (−8.11, −3.85)	<0.0001
Bilateral (vs. unilateral) hearing loss	−1.82 (−4.75, 1.11)	0.22	−2.45 (−5.24, 0.33)	0.08
Had risk indicator for hearing loss at birth (vs. no indicator)	−3.11 (−5.10, −1.13)	0.002	−1.39 (−3.44, 0.67)	0.19
Rhyming	**Parameter estimate (95% CI)**	**p**	**Parameter estimate (95% CI)**	**p**
Age at assessment in years	2.36 (2.02, 2.70)	<0.0001	2.34 (2.00, 2.68)	<0.0001
Early EI enrollment (vs. Later EI enrollment)[a]	0.94 (0.10, 1.79)	0.028	1.20 (0.35, 2.06)	0.006
Presence of diagnosed disability (vs. no disability diagnosed)[b]	−1.44 (−2.29, −0.59)	0.0009	−1.62 (−2.54, −0.71)	0.0005
Bilateral (vs. unilateral) hearing loss	−0.16 (−1.41, 1.09)	0.80	−0.28 (−1.50, 0.95)	0.66
Had risk indicator for hearing loss at birth (vs. no indicator)	−0.49 (0.36, −1.34)	0.25	−0.13 (−1.04, 0.78)	0.78
Alliteration	**Parameter estimate (95% CI)**	**p**	**Parameter estimate (95% CI)**	**p**
Age at assessment in years	1.22 (0.99, 1.45)	<0.0001	1.20 (0.97, 1.43)	<0.0001
EI early enrollment (vs. EI later enrollment)[a]	0.52 (0.06, 0.98)	0.026	0.61 (0.15, 1.07)	0.009
Presence of disability reported (vs. no disability reported)[b]	−0.57 (−1.04, −0.10)	0.017	−0.67 (−1.17, −0.17)	0.009
Bilateral (vs. unilateral) hearing loss	−0.54 (−1.22, 0.14)	0.12	−0.58 (−1.26, 0.09)	0.09
Had risk indicator for hearing loss at birth (vs. no indicator)	−0.32 (−0.79, 0.15)	0.18	−0.22 (−0.72, 0.28)	0.38

Abbreviations: GGG=Get it, Got it, Go!; DHH=deaf or hard of hearing; CI=confidence interval; EI=early intervention

[a]Early EI defined as enrollment before 6 months of age. Later EI defined as enrollment at/after 6 months of age

[b]Reported on early intervention form