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Third Grade Reading Proficiency in Deaf or Hard of Hearing Children who Received Early Intervention

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Abstract

Background: Early enrollment in Part C Early Intervention (EI) before age 6 months is linked to improved language and kindergarten readiness in children who are deaf or hard of hearing (DHH), but the effect on later academic outcomes is unclear. This study examines whether earlier (< 6 months) versus later (> 6 months) enrollment of children who are DHH in early intervention programs influences third-grade reading proficiency.

Method: This study used data linked from three Ohio state agencies for infants identified with permanent hearing loss born 2008–2014 who received EI. The sample consisted of 412 children who were DHH and had scores on third grade standardized reading tests. Reading levels were categorized from limited to advanced. Logistic regression assessed the association between enrollment timing and reading proficiency, adjusting for potentially confounding variables.

Results: Children enrolled in EI programs before 6 months of age ($n = 231$; 56.1%) were more likely to achieve advanced reading levels (19.9% vs. 12.2%) and less likely to score at limited levels (27.7% vs. 36.5%) than those enrolled later. Earlier enrolled children had reading performance comparable to all Ohio third graders. Earlier enrollment was statistically significantly associated with proficient or better reading levels compared to later enrollment (OR 1.64 95% CI [1.06, 2.57]).

Conclusion: Benefits of earlier EI enrollment extend into elementary school, supporting healthy developmental trajectories and reducing risk for later academic challenges in children who are DHH.

Keywords

early intervention; reading; deaf or hard of hearing

Early Hearing Detection and Intervention (EHDI) programs are vital public health initiatives across all U.S. states and territories, aimed at early screening, identification, and intervention for children who are Deaf or Hard of Hearing (DHH; Joint Committee on Infant Hearing, 2019). Current EHDI guidelines, endorsed by the Joint Committee on Infant Hearing, recommend hearing screening before one month of age, a definitive diagnosis before three

months, and early intervention (EI) enrollment no later than six months (1-3-6 goals; Joint Committee on Infant Hearing, 2019). These guidelines aim to support language development for infants and toddlers who are DHH.

Many studies highlight the importance of EI enrollment by six months for improved vocabulary and language development (Grey et al., 2022; Meinzen-Derr et al., 2011; Moeller, 2000; Yoshinaga-Itano et al., 2017). Research is now exploring the long-term outcomes of early EI enrollment, such as early literacy and school readiness (Meinzen-Derr, Altaye, et al., 2022; Meinzen-Derr et al., 2020), but its sustained impact on educational outcomes remains unclear.

Reading is a fundamental skill for all children, and for most children, literacy development requires a strong foundation of language development (vocabulary, receptive and expressive language skills; Eadie et al., 2021; Hjetland et al., 2020). Additional factors are also known to be important among strong readers, such as phonological awareness, rapid naming, letter-sound correspondence, reading fluency, the use of prediction and context clues, and reading comprehension (Horowitz-Kraus et al., 2017). Children who are DHH are at risk for language delays, regardless of degree of hearing loss, which can lead to reading challenges (Moeller et al., 2007). For children who are DHH, literacy outcomes have often been described as below basic levels with significant gaps compared to hearing peers (Qi & Mitchell, 2012; Traxler, 2000), with a long-held belief of a “4th grade ceiling” for reading levels (Trybus & Karchmer, 1977). Advances over the past one to two decades in hearing technology (e.g., digital hearing aids, cochlear implants), early identification and intervention, and educational placement have helped children who are DHH make gains in reading (Easterbrooks & Beal-Alvarez, 2012; Lederberg et al., 2013), though great variation in reported outcomes exist (Antia et al., 2020; Easterbrooks & Beal-Alvarez, 2012; Yoshinaga-Itano et al., 2021).

EI programs play a crucial role in enhancing language and cognitive skills, which are foundational for literacy development. These programs often include activities that promote vocabulary growth, phonemic awareness, and early reading skills. Yet, the impact of EI on literacy for children who are DHH is not well understood. EI before 6 months of age is associated with higher emergent literacy among preschoolers who are DHH (Meinzen-Derr, Altaye, et al., 2022) and can impact kindergarten readiness, including early literacy (Meinzen-Derr et al., 2020). This study aimed to determine if earlier access to EI continues to influence third grade reading outcomes. We compared earlier EI enrollment (before 6 months) to later enrollment (> 6 months of age) on reading proficiency of students who are DHH in Ohio. We hypothesized that earlier EI enrollees would be more likely to achieve proficient reading levels in third grade compared to those who enrolled later. Third grade reading levels were selected due to a statewide initiative designed to ensure that all students are reading at grade level by the end of third grade.

Method

This cohort study used a comprehensive longitudinal database that included hearing screening, diagnostic data, early intervention data, and educational records of children born

between January 1, 2008 through December 31, 2014 in Ohio (Folger et al., 2019; Meinzen-Derr et al., 2020). Screening and EI data systems from the Ohio Department of Health and Developmental Disabilities 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 a special identifier assigned to children who were served in EI. This study was approved and granted a waiver of consent by the institutional review board of Cincinnati Children's Hospital Medical Center with Memoranda of Understanding across all institutions/agencies involved.

Covariates

Family demographic variables available for analysis included maternal age, race and ethnicity, parental education level, and insurance status/payer at the time. Variables that characterized the infant at birth included gestational age, birth weight, pregnancy-related risk factors (e.g., in-utero infections), and hearing loss-specific risk indicators specified by the Joint Committee on Infant Hearing Position Statement (e.g. family history, specific physical findings, and neonatal intensive care stay; American Academy of Pediatrics, 2007). Hearing-specific information included ages at screening and diagnosis, hearing loss laterality (unilateral/bilateral), and degree of hearing thresholds (mild, moderate, moderate-severe, severe, and profound). EI data included date of EI enrollment, services received and documented developmental delays/disabilities. The presence of disabilities (documentation on a specific eligibility form) was determined by a professional medical diagnosis, which is used to ensure children with specific conditions at risk for developmental delays are served within the EI system. Information on amplification with hearing aids or the use of cochlear implants was not available in the database.

Outcome Measure

As part of statewide accountability measures, Ohio administers the Ohio State Test in English Language Arts (ELA) to all public school students in grades 3 through 8. The Grade 3 ELA assessment is designed to measure knowledge and skills outlined in Ohio's learning standards, which emphasize that, by the end of third grade, students are able to "read and comprehend literature, including stories, dramas, and poetry, at the high end of the grades 2–3 text complexity band independently and proficiently" (Ohio Department of Education, 2017). The assessment evaluates four core content areas: Reading Literary Text, Reading Informational Text, Writing, and Language Conventions (including grammar, sentence formation, spelling, and punctuation). Students with disabilities may be offered an alternative assessment based on their individualized needs as guided by their individualized education program (IEP). Students may have had testing accommodations such as extended time, use of an interpreter, and/or use of a dictionary. Students received a scaled score, which was classified into one of five performance standards: Limited, Basic, Proficient, Accomplished, or Advanced. For state accountability purposes, scores at Proficient level or higher (Proficient, Accomplished, or Advanced) are considered meeting grade-level expectations. Third grade reading assessment performance standard data were available for the school years 2017–2021.

Exposure Variable

EI exposure was defined using the national EHDI benchmark of enrollment into EI before age 6 months. Children were classified as earlier EI enrollment if they enrolled before age 6 months and as later EI enrollment if they enrolled at 6 months of age or later.

Statistical Analysis

Statistical analyses were conducted using SAS version 9.4 software (SAS Institute Inc, Cary, NC). Characteristics of the sample were described according to enrollment age (earlier vs. later) and presented as frequencies with percentages and as medians with interquartile ranges. Sociodemographic and clinical variables were tested between EI groups using Pearson χ^2 or Student's t test as appropriate. Students who are DHH who enrolled earlier were compared with those who enrolled later regarding the percentage of students who had reading skills that were proficient or better. Multiple logistic regression was used to evaluate the independent association between earlier versus later EI enrollment and reading proficiency. Covariates and known or suspected confounders from the literature or statistically associated with the outcome included hearing levels and laterality, age of identification, presence of diagnosed disability reported while the child was in EI, insurance status, and maternal education level. These variables were tested in the model and remained if $p < 0.05$. To adjust for potential differences in the outcome that are specific to each school year, year was included as a strata variable in the regression model.

To reduce bias and maximize use of available information, we conducted a multiple imputation procedure to impute missing data. We generated 10 complete datasets using the relevant variables to predict the missing values. We then fit a logistic regression 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 was reported as results of the final model. Because reading skills of children who required an alternative assessment may be different, we also reran the model including only individuals who did not take an alternative assessment. Model results were reported as odds ratios (OR) with 95% confidence intervals (CI).

Because we were working with public health and state education data, we did not have information about the child's language level or IQ. Results were reported as adjusted odds ratios (OR) with 95% confidence intervals (CI). Outcome results for all Ohio third graders during the same time were illustrated as a reference. We did not have the same detailed data on all Ohio third graders. Since reading skills for children receiving an IEP-based alternative assessment might be disproportionately lower than those receiving the standard assessment, a variable for this was also tested in the model. We then reran the model after excluding children with IEP-based alternative assessments.

Results

Participants

Among DHH infants born between 2008 and 2014, 1,262 were enrolled in EI. Of these, 412 children had completed third grade and had available assessment data from 2017 to 2021;

231 (56.1%) were enrolled in EI earlier and 181 (43.9%) were enrolled later. Children not included in the analysis due to missing third grade data were divided as follows: 339 had not yet reached third grade, 164 lacked identifiers linking them to education records, 27 had only fourth or fifth grade assessments, with no third grade data available, and 320 children may not have been served in Ohio public schools or were enrolled in private schools without an IEP. Characteristic differences between children with and without third grade data are presented in Table 1.

Among the 412 third grade students who were DHH, earlier EI enrollment, compared to later enrollment, was associated with having a risk indicator for hearing loss (45.9% vs. 33.2%), disability diagnosis (35.5% vs. 18.2%), higher maternal education (some college; 66.6% vs. 54.7%), and private insurance (61.0% vs. 47.5%; Table 2). There were no statistically significant differences between earlier and later enrollment regarding race, gender, prematurity, or hearing thresholds.

Of the 412 third graders who were DHH, 56 (13.6%) took an IEP-based alternative assessment; 35 (15.2%) children who were earlier enrolled and 21 (11.6%) children who were later enrolled ($p = 0.30$). As a reference, 1.3% of Ohio third graders required alternative assessments.

Reading Proficiency

Among third graders who were DHH, reading levels were categorized as Limited in 31.6% ($n = 130$), Basic in 17.2% ($n = 71$), Proficient in 17.0% ($n = 70$), Accomplished in 17.7% ($n = 73$), and Advanced in 16.5% ($n = 68$). There were statistically significant differences in the reading categories by enrollment age ($p = 0.038$). Children who enrolled earlier were more likely to have advanced reading skills (19.9% vs. 12.2%) and less likely to have limited reading levels (27.7% vs. 36.5%) compared to children who enrolled later (Figure 1). A greater proportion of children who enrolled earlier (55.8%, $n = 129$) were rated as Proficient, Accomplished, or Advanced in reading skills, compared to 45.3% ($n = 82$) of children who enrolled later. As a reference, 58.9% of all Ohio third graders had reading levels categorized as Proficient, Accomplished, or Advanced.

Table 3 includes the results of the logistic regression model for higher reading categories. Model results indicated that, after controlling for previous disability diagnosis (maternal education level [some college or higher, less than college, or unknown], insurance status, and severity of hearing thresholds), children with earlier EI enrollment had statistically significantly higher odds of having Proficient or better third grade reading levels compared to children enrolled later (OR 1.64, 95% CI [1.06, 2.57]). Factors not statistically significant in the final model included laterality of reduced hearing (bilateral vs. unilateral; $p > 0.3$), age of hearing confirmation, prematurity, and taking an IEP-based alternative assessment ($p > 0.8$). Because reading skills could be disproportionately lower among those taking an alternative assessment, we reran our models excluding alternative assessments (Table 3). Results are consistent with the original findings that children with earlier enrollment had higher odds of proficient reading than those with later enrollment (OR 1.98, 95%CI [1.22, 3.21]).

Discussion

Our findings demonstrate that EI enrollment before age 6 months significantly benefits reading outcomes in young students who are DHH. Those with earlier EI enrollment were more likely to demonstrate proficient or better reading skills in third grade compared to children who enrolled later (after age 6 months). This aligns with our previous work on EI enrollment age and its impact on emergent literacy (Meinzen-Derr, Altaye, et al., 2022) and kindergarten readiness (Meinzen-Derr et al., 2020). The proportion of earlier-enrolled children with proficient or better reading skills was comparable to all Ohio third graders (55.8% and 58.9% respectively). Additionally, the proportion of students who were DHH with advanced reading levels (the highest skill category) was similar to all Ohio students (19.9% and 21.5%). However, children with later enrollment had a higher rate of limited proficiency reading skills (36.5%) and lower rate of advanced reading skills (12.2%) compared to their earlier-enrolled peers. Other factors associated with poorer reading outcomes included the presence of a disability diagnosis and more severe hearing thresholds. These findings indicate that EI enrollment before 6 months of age provides sustained benefits for children in third grade who are DHH, advancing our understanding of the long-term academic benefits of early intervention.

Reading and Early Intervention for Students who are DHH

Learning to read is a crucial academic achievement, especially by third grade, as it forms the basis for acquiring knowledge for subsequent academic achievement. This is particularly important for DHH students, who often face unique challenges such as limited access to incidental learning opportunities, reduced exposure to rich language environments, and potential delays in language acquisition. These challenges can exacerbate academic disadvantages and make it even harder for DHH students to catch up to their peers. Several studies have observed that while early reading achievement among DHH students may be within the expected range, the literacy gap can widen at later grades due to the advanced language and reading comprehension skills required for grade-level material (Antia et al., 2020; Dillon et al., 2012; Harris et al., 2017; Hrastinski & Wilbur, 2016; Luft, 2018; Marschark et al., 2007).

Reports on the reading levels of students who are DHH have varied, and it is no longer appropriate to reference the older benchmarks of fourth-grade reading levels for this population (Geers & Hayes, 2011; Hrastinski & Wilbur, 2016; Qi & Mitchell, 2012; Traxler, 2000). Reading outcomes have improved due to the widespread implementation of universal newborn hearing screening (UNHS) and advances in hearing technology. For instance, Mayer and colleagues (2021) reported that deaf students in grades 4–12 surpassed the fourth-grade reading achievement ceiling, obtaining reading scores classified at or above the low average range. Easterbrooks and Lederberg (2021) found that over 50% of second graders who were DHH were reading fluently at or above grade level, with this percentage increasing with grade level and varying according to communication modality (sign, speech, bimodal). However, research has also shown that many children who are DHH acquire simple reading skills but may hit a barrier as reading becomes more complex (Antia et al., 2020; Easterbrooks & Lederberg, 2021; Kyle & Harris, 2006). For example, Antia and

colleagues (2020) reported a widening gap from kindergarten to second grade in reading scores between students who are DHH and their normative sample; only 25% of second graders who are DHH scored within the average range for reading comprehension. Our results indicated that approximately 50% of students who were DHH achieved proficient or higher reading levels on state tests, but over 30% of third graders who were DHH still had limited reading skills, a higher percentage than their peers in Ohio. This highlights the need for ongoing efforts to ensure that children who are DHH read proficiently as they progress through grade levels.

Impact of Early Intervention on Reading

In the United States, infants and toddlers identified as DHH must be referred to Part C Early Intervention under federal law. Part C of the Individuals with Disabilities Education Act (IDEA) aims to provide services that optimize child growth and development from birth to age three, preparing them for successful school entry (United States Department of Education, 2018). These services often focus on motor, social, and cognitive skills and language development. Considerable evidence supports EI's positive impact on language and vocabulary growth in young children who are DHH (Meinzen-Derr et al., 2011; Moeller, 2000; Vohr et al., 2011; Walker et al., 2022; Yoshinaga-Itano et al., 2020). The National Early Literacy Panel concluded that foundational early literacy skills developed before elementary school are crucial for positive reading outcomes (National Early Literacy Panel, 2008, 2010).

Early identification of hearing loss has been linked to improved reading skills in elementary school (McCann et al., 2009). However, the impact of EI on later reading abilities is less clear, as most research has focused on early literacy interventions rather than specific effects of Part C EI (National Early Literacy Panel, 2008, 2010). Few studies have reviewed the impact of Part C EI on literacy outcomes. Geers and colleagues (2019) found that early intervention intensity, defined as the number of hours of attendance before age 36 months in a listening and spoken language center, predicted better reading comprehension at age 10, with 76% of children achieving average reading scores. Yoshinaga-Itano and colleagues (2021) observed notable increases in the percentage of students who were DHH identified with proficient or higher reading scores following the introduction of UNHS and EHDI programs. However, they were unable to individually link children to UNHS results or EI enrollment data, limiting their ability to assess the impact of these programs.

Our study benefited from strong agency partnerships, allowing us to link birth and EHDI data, EI data, and education data to investigate the impact of EI enrollment age on distal academic outcomes, such as reading proficiency. This provided a unique opportunity to disentangle factors associated with better reading skills for children who are DHH served by our EHDI system, further supporting the importance of EI for this population. Meinzen-Derr and colleagues previously evaluated the impact of receiving EI before age 6 months on emergent literacy skills among preschoolers who were DHH (Meinzen-Derr, Altaye, et al., 2022). They found that earlier EI enrollment was associated with better emergent literacy skills of picture naming, rhyming, and alliteration. However, the development of rhyming and alliteration over time was slower compared to all preschoolers. In a related study,

EI enrollment by age 6 months was associated with kindergarten readiness and a higher likelihood of being on track for language and literacy (Meinzen-Derr et al., 2020).

In our current study, EI enrollment before 6 months of age was associated with higher likelihood of third grade reading proficiency for students who were DHH. Specifically, 56% of earlier enrolled students had proficient or better reading skills compared to 45% of later enrolled students. Encouragingly, earlier enrolled students who are DHH were similar to all Ohio students, with nearly 58% being proficient in reading. This is higher than Yoshinaga-Itano and colleagues' (2021) report of approximately one-third of students who were DHH reading at proficient levels. Future research could further examine aspects of EI, such as service types, frequency, and duration, that may be most impactful on later outcomes. This direction could help systems better target their approach to optimize development for children who are DHH.

EI plays a crucial role in supporting literacy development, targeting key areas that impact literacy, such as language and communication skills, phonological awareness, and print knowledge. Earlier EI enrollment also provides more opportunities for EI providers to develop effective relationships with families, coach families on early language stimulation, and allow for longer exposure to systems that support development. Establishing foundational literacy skills when the brain is most adaptable is essential (Hutton et al., 2020; Klass et al., 2020). Our study helps fill the research gap on EI's impact on later academic outcomes for children who are DHH.

Limitations

This study had several limitations. Our sample included children who were DHH served in publicly-funded educational settings, including public schools and charter programs, or those with an IEP adhering to state education standards. Thus, we did not have education data on children in other settings. We were unable to evaluate the impact of communication modalities, such as the use of American Sign Language, or hearing technology like cochlear implants and hearing aids on literacy skills, as this information was not in the education data we obtained. The state reading assessment targeted multiple reading components and created a compound assessment of general reading proficiency which included a variety of factors. Thus, we were unable to address separate components of reading, such as reading comprehension and fluency, phonological awareness, or orthographic skills, nor did we have information on the educational curricula, limiting in-depth understanding of how best to support the reading development of students who are DHH. We also did not have the language level of the student nor the performance IQ which could help understand factors associated with reading performance. We were able to evaluate the impact of some factors, such as presence of a disability, hearing loss severity, and other demographic characteristics that may impact outcomes. Although we had information on service intensity and types, the focus of this analysis was on the age of EI enrollment. Our previous research indicated that intensity and types of service may be associated with enrollment age and duration in EI (Meinzen-Derr, Tabangin, et al., 2022). Finally, because we used public health and education data, we were unable to understand the role of parental involvement regarding either EI or support at home that could contribute to children's reading skills.

Conclusion

This study makes a significant contribution to the field by demonstrating that early enrollment in EI has a measurable impact on later academic success, specifically third-grade reading proficiency for children who are DHH. By linking data across three state agencies, this research provides robust, longitudinal evidence of the long-term benefits of EI for children who are DHH. Importantly, it challenges outdated assumptions about the academic potential of children who are DHH, such as the fourth-grade ceiling, and shows that enrolling in EI by age 6 months can help children who are DHH achieve reading outcomes comparable to their hearing peers. For those entering EI after age 6 months, a stronger emphasis on language and literacy development is essential for academic success. The EHDI program and EI are vital public health initiatives that ensure timely support for children who are DHH. This research underscores the critical role of timely EI services in shaping developmental trajectories and call for continued investment in and refinement of EHDI and EI systems, ensuring long-term success for children who are DHH.

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Acronyms:

DHH	Deaf or Hard of Hearing
EHDI	Early Hearing Detection and Intervention (EHDI)
EI	Early Intervention
ELA	English Language Arts
IEP	Individualized Education Program

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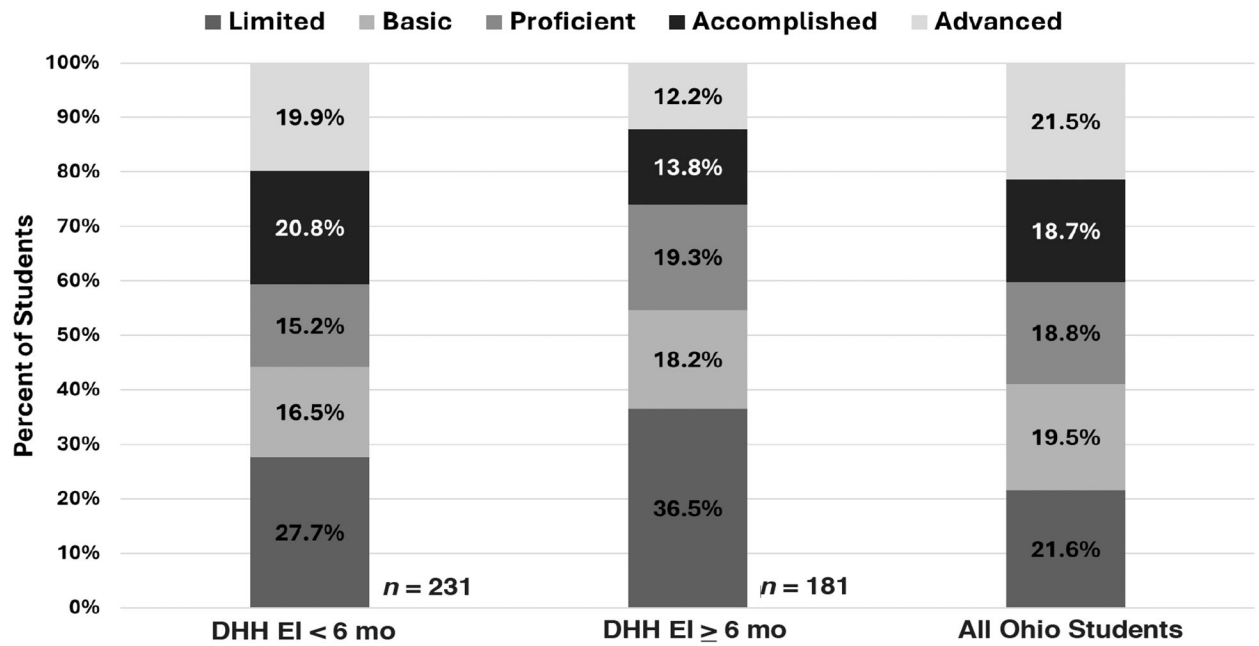


Figure 1.
Reading Proficiency of Deaf and Hard of Hearing (DHH) Third Graders who Received Early Intervention and for all Ohio Students

Table 1
Characteristics of Deaf/Hard of Hearing Children With and Without 3rd Grade Assessment

Characteristic	No 3rd grade data <i>n</i> = 850	With 3rd grade data <i>n</i> = 412	<i>p</i> -value
Gender, Female <i>n</i> (%)	387 (45.5)	191 (46.4)	0.78
Race – <i>n</i> (%)			
Black/African American	102 (12)	54 (13.1)	0.0002 ^a
White	628 (73.9)	334 (81.1)	
Asian	19 (2.2)	6 (1.5)	
Unknown/Other unspecified	101 (11.9)	18 (4.4)	
Ethnicity, Hispanic - <i>n</i> (%)	49 (5.8)	7 (1.7)	0.0004 ^a
Unknown/not reported	91 (10.7)	10 (2.4)	
Premature birth - <i>n</i> (%)	189 (22.2)	81 (19.7)	0.14 ^a
Unknown	64 (7.5)	12 (2.9)	
Hearing confirmation age in months – median [IQR]	4.1 [2.1–10.1]	3.4 [1.6–7.5]	< 0.0001
Has risk indicator for reduced hearing - <i>n</i> (%)	341 (40.1)	166 (40.3)	0.95
Presence of disability diagnosis - <i>n</i> (%)	208 (24.5)	115 (27.9)	0.19
Educational level of mother - <i>n</i> (%)			0.002 ^a
< High school	102 (12.0)	45 (10.2)	
High school/Graduate education degree	181 (21.3)	90 (21.8)	
Some college	246 (28.9)	123 (29.9)	
College graduate	213 (25.1)	130 (31.6)	
Unknown	108 (12.7)	24 (5.8)	
Receives private insurance - <i>n</i> (%)	373 (43.9)	227 (55.1)	< 0.0001 ^a
Unknown/not reported	99 (11.7)	16 (3.9)	
Bilateral hearing loss - <i>n</i> (%)	642 (75.5)	312 (75.8)	0.94
Severe to profound hearing thresholds - <i>n</i> (%)	318 (37.4)	127 (30.8)	0.02

^a Statistical testing includes unknown values as a category.

Characteristics of Deaf and Hard of Hearing Children Enrolled in Early Intervention by Enrollment Age

Table 2

Characteristic	Enrolled in EI < 6 months <i>n</i> = 231 (56.1%)	Enrolled in EI > 6 months <i>n</i> = 181 (43.9%)	<i>p</i> -value
Gender, Female <i>n</i> (%)	104 (45.0)	87 (48.1)	0.54
Race – <i>n</i> (%)			
Black/African American	25 (10.8)	29 (16.0)	0.07 ^b
White	196 (84.9)	138 (76.2)	
Asian	4 (1.7)	2 (1.1)	
Unknown/Other unspecified	6 (2.6)	12 (6.6)	
Ethnicity, Hispanic - <i>n</i> (%) ^a	3 (1.3)	4 (2.2)	0.43 ^b
Unknown/not reported	4 (1.7)	6 (3.3)	
Premature birth - <i>n</i> (%) ^a	45 (19.5)	36 (19.9)	0.90
Unknown	6 (3.3)	26 (2.6)	
Hearing confirmation age in months – median [IQR]	4.1 [2.1–10.1]	3.4 [1.6–7.5]	< 0.0001
Has risk indicator for reduced hearing - <i>n</i> (%)	106 (45.9)	60 (33.2)	0.009
Presence of disability diagnosis - <i>n</i> (%)	82 (35.5)	33 (18.2)	0.0001
Educational level of mother - <i>n</i> (%)			0.18
< High school	21 (9.1)	24 (13.3)	
High school/Graduate education degree	44 (19.1)	46 (25.4)	
Some college	74 (32.0)	49 (27.1)	
College graduate	80 (34.6)	50 (27.6)	
Unknown	12 (5.2)	12 (6.6)	
Receives private insurance - <i>n</i> (%) ^a	141 (61.0)	86 (47.5)	0.02
Unknown/not reported	9 (3.9)	7 (3.9)	
Bilateral hearing loss - <i>n</i> (%)	167 (72.3)	145 (80.1)	0.07
Severe to profound hearing thresholds - <i>n</i> (%)	78 (33.8)	49 (27.1)	0.14

^a Statistical testing includes unknown values as a category

^b Fisher's Exact test reported

Table 3
Factors Associated with Achieving 3rd Grade Reading Level Categorized as Proficient or Better among Deaf or Hard of Hearing Children who Received Early Intervention

Predictor	Imputed model			Among those with no alternative assessment		
	Adjusted Odds Ratio	95% Confidence Interval	p	Adjusted Odds Ratio	95% Confidence Interval	p
Early Intervention enrollment age						
< 6 months	1.64	[1.06, 2.57]	0.028	1.98	[1.22, 3.21]	0.006
≥ 6 months	Reference			Reference		
Presence of disability ^a						
Disability diagnosis	0.49	[0.30, 0.80]	0.004	0.42	[0.24, 0.74]	0.003
No disability diagnosis	Reference			Reference		
Mother education level						
Some college or higher	2.27	[1.40, 3.68]	0.0009	2.71	[1.59, 4.63]	0.0003
No college	Reference			Reference		
Health insurance coverage at birth						
Private insurance	1.86	[1.14, 3.02]	0.012	2.03	[1.19, 3.44]	0.009
Public or self-pay insurance	Reference			Reference		
Hearing threshold categories						
Severe or profound	0.49	[0.31, 0.79]	0.003	0.42	[0.25, 0.72]	0.002
Mild or moderate	Reference			Reference		

^aIdentified during Early Intervention.