OUTCOMES AND CONSIDERATIONS FOR CHILDREN WHO ARE DEAF OR HARD OF HEARING: ASSESSMENT AND INTERVENTION FOR PRESCHOOL AND PRIMARY STUDENTS

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A dissertation submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Allied Health Sciences in the School of Medicine.

Chapel Hill
2018

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ABSTRACT

Thomas Adams Page: Outcomes and Considerations for Children who are Deaf or Hard of Hearing: Assessment and Intervention for Preschool and Primary Students
(Under the direction of Melody Harrison)

The purpose of these studies was to provide a depiction of academic performance for students who are deaf and hard of hearing and the related services they receive. The first study utilized statewide, longitudinal data to examine standardized public school testing results in reading. Furthermore, it estimated how hearing loss, the use of testing accommodations, and school membership impacts performance. Comparted to students who were typically developing, students who are deaf or hard of hearing demonstrated statistically significant poorer performance on end of grade reading tests administered annually between grades 3 and 8. Students who were deaf or hard of hearing who utilized testing accommodations performed significantly worse than students who did not use accommodations. The achievement gap between students who are deaf or hard of hearing and typically developing students was observed at grade 3 and persisted until 8th grade, the final grade of administration.

The second study focused on the preschool and school services received by students who are hard of hearing. In addition to a thorough account of the service characteristics and the professionals who provide them, this study analyzed differences in service setting, amount of family participation, and service provider confidence providing support to this unique population. A majority (81%) of preschool age CHH received services. Children were more likely to be in a preschool for children who are deaf or hard of hearing (CDHH) or exceptional children than a general education preschool. By elementary school, 70% received services, nearly all in general education settings. Sessions averaged twice a week for a total of approximately 90 minutes. Children who no longer received services performed significantly better on speech/language measures than those who received services, regardless of service setting. Professionals were primarily speech-language pathologists (SLPs) and teachers of CDHH. Speech-language pathologists reported significantly less comfort with skills involving auditory development and hearing technologies

Through an examination of historical and current literature, the final component of this dissertation employed an historical account with current evidence to guide clinicians in the evaluation of children who are hard of hearing during the preschool and early elementary school years.

ACKNOWLEDGEMENTS

"Education is not the filling of a pail, but the lighting of a fire."
-William Butler Yeats

My pursuit and completion of this doctoral degree would have not been possible, it may not have even been considered, if it were not for the guidance and motivation from my advisor and friend, Dr. Melody Harrison. Thank you for recognizing potential when I had yet not, and for creating opportunities that otherwise would not exist. I am truly fortunate to have you in my life. I feel I can say, literally, thank you *for everything*.

I am deeply grateful and indebted to my wife, Corrina, for her love, support, and consistently well-timed nudging. Thank you for recognizing the rigor the doctoral program demanded, but more importantly, for reminding me to pause and enjoy life and loved ones along the way. Additionally, I could not love nor be more proud of my two children, Cadence and Ethan. It's impossible to express how wonderful I feel to know that you return my love and are also proud of me. My family is more than I could have ever asked for. I love you.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
AVEd	Auditory-Verbal Educator
AVT	Auditory-Verbal Therapist
BEPTA	Better ear pure-tone average
CASL	Comprehensive Assessment of Spoken Language
CDHH	Children who are deaf or hard of hearing
CDI	MacArthur Bates Communicative Development Inventory
CELF	Clinical Evaluation of Language Fundamentals
CHH	Children who are hard of hearing
CNH	Children with normal hearing
DHH	Deaf or hard of hearing
DPI	Department of Public Instruction
EI	Early intervention
EOG	End of grade
FM	Frequency-modulated amplification system
GED	General Equivalency Diploma
GFTA	Goldman Fristoe Test of Articulation
HA	Hearing aid
HL	Hearing loss
HLM	Hierarchical linear model
ICC	Intraclass correlation coefficient
IDEA	Individuals with Disabilities Education Act

IEP	Individualized Education Plan
NC	North Carolina
NCLB	No Child Left Behind Act
NIDCD	National Institute on Deafness and Other Communication Disorders
O&C	Open & Closed Set Task
OCHL	Outcomes of Children with Hearing Loss
PPVT	Peabody Picture Vocabulary Test
SDHH	Students who are deaf or hard of hearing
SLP	Speech-language pathologist
SPQ	Service Provider Questionnaire
TDS	Typically developing students
TODHH	Teacher of students who are deaf or hard of hearing
UNHS	Universal newborn hearing screening
WASI	Wechsler Abbreviated Scale of Intelligence-II
WPPSI	Wechsler Preschool & Primary Scale of Intelligence-III

CHAPTER 1: INTRODUCTION

Historically, children who are deaf or hard of hearing are at higher risk for communication and academic delays regardless of their degree of hearing loss (HL; Davis, Shepard, Stelmachowicz & Gorga, 1981; Blair, Peterson, Viehweg, 1985; Davis, Elfenbein, Schum & Bentler, 1986). Although the evidence is increasingly optimistic, recent findings suggests that for many children these delays remain, even in the current era of universal newborn hearing screening, earlier intervention and fitting of advanced assistive technologies (Lederberg, Schick, & Spencer, 2013; Markman et al., 2011; Moeller, Tomblin, & OCHL Collaboration, 2015).

Hearing Loss and Development: The Inconsistent Access Hypothesis

The quantity and quality of language input is critical in shaping a child's language development. These two primary characteristics are associated with the amount and variety of words in the child's lexicon, the breadth and depth of semantic knowledge, and the rate at which language develops (Hart & Risely 1995, Huttenlocher et al., 1991, Hoff and Naigles, 2002). Moreover, a child's exposure to subtle acoustic features in varied language input supports the development of phonetic and grammatical repertoires (Maye et al., 2002; Richtsmeier et al. 2011).

To explain the communication and resulting academic delays commonly found in children with HL in the mild to severe range, Moeller and Tomblin (2015) posited the inconsistent access hypothesis that considered both the quantity and quality of linguistic input for children who are hard of hearing (CHH). The researchers hypothesized that CHH are vulnerable to disruptions in the frequency and integrity of language input due to their HL, resulting in a reduction and degradation of their cumulative linguistic experience, and thus putting them at greater risk for delay. Within a conceptual framework (Figure 1) aimed to identify factors that influenced linguistic input and the resulting cumulative linguistic experience, the authors postulated three primary factors that influence linguistic access for CHH: (1) audibility provided from the child's hearing aid (HA) (2) the duration and consistency of HA use, and (3) the amount and quality of linguistic input provided by caregivers. While this hypothesis was developed for CHH, the logic holds for children with profound HL and those who use hearing devices other than traditional HAs (e.g., cochlear implants, bone conduction HAs).

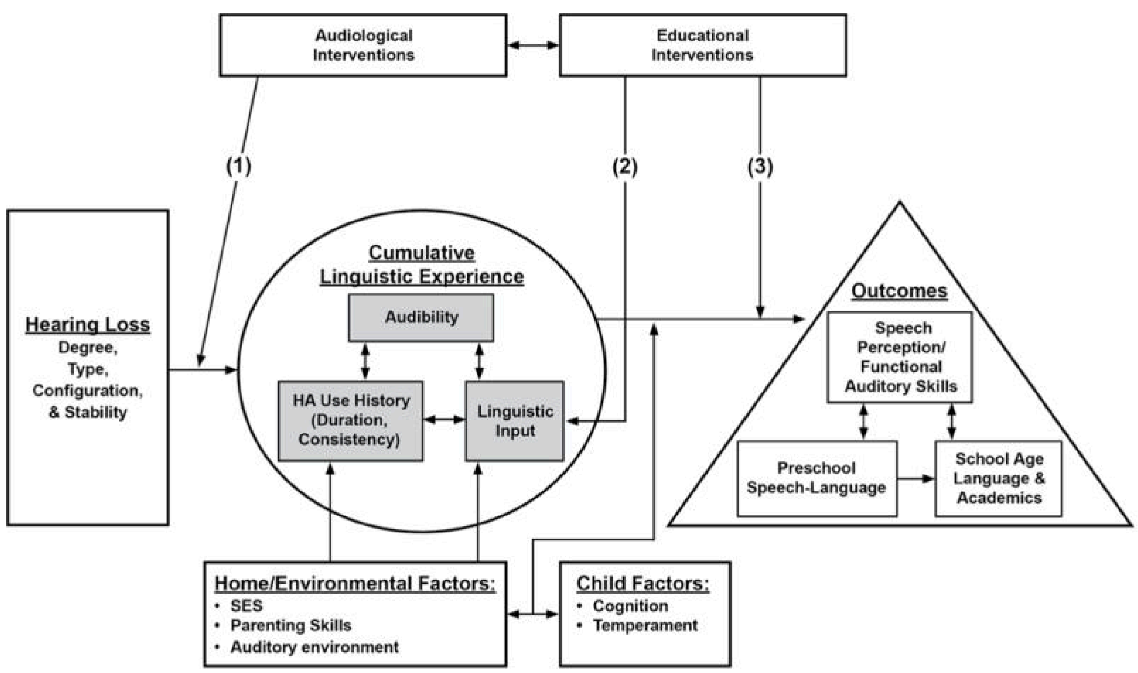

Figure 1.1 Model of Hypothesized Factors that may Influence the Relationship Between Childhood Hearing Loss and Developmental Outcomes. HA = hearing aid; SES = socioeconomic status. Reprinted from "An Introduction to the Outcomes of Children with Hearing Loss Study," by Moeller and Tomblin, 2015, *Ear & Hearing*, *36*, p. 7S.

The inconsistent access hypothesis was developed and utilized in the Outcomes of Children with Hearing Loss (OCHL) study (Moeller & Tomblin, 2015). This longitudinal, multi-site research collaboration applied this framework to investigate a range of communication and academic outcomes for CHH and identify factors that mitigate them. The OCHL study is one of a few longitudinal research efforts to highlight the critical role that early language plays upon the developmental trajectory in later language and pre-academic abilities of children with hearing loss (Catts et al., 2001; Lederberg, Schick, & Spencer, 2013; Markman et al., 2011; Moeller, Tomblin, & OCHL Collaboration, 2015). The first and second studies in this dissertation aim to provide a richer understanding of two domains potentially affected by inconsistent access: 1) school age academic outcomes and 2) preschool and school educational interventions. A third manuscript synthesizes OCHL findings to highlight early language domains of particular risk for CHH and to guide professionals in assessing language in CHH prior to elementary school in areas of vulnerability so that they can be addressed by teachers and clinicians.

Greater Inclusion for Children who are Deaf or Hard of Hearing

The adoption of The Education for All Handicapped Children Act of 1975 established a continuing trend towards greater inclusion of students with all disabilities among their typically developing (TD) classmates. As a result, a greater proportion of students who are deaf or hard of hearing (SDHH) are learning in general education settings than ever before (Gallaudet Research Institute, 2014). At the classroom level, the percentage of SDHH receiving greater than 60% of their instruction in self-contained classrooms has also been in decline (Mitchell, 2004). Findings from the 2014 Gallaudet Annual Survey reported that 51% percent of the 23,731 SDHH polled received educational instruction primarily in general education classrooms with TD classmates, 24% received some instruction in self-contained classrooms within general education settings, and the remainder of SDHH were educated solely in special schools. The Gallaudet surveys include children who are profoundly deaf, as well as those with multiple disabilities, which is likely to affect then overall distribution of educational placements. Blackorby and Knokey (2006) reported that almost 70% of students with mild to moderately-severe hearing loss were in general education classrooms (with support services for some) rather than a self-contained classroom or specialized school for SDHH.

Placement within general academic settings presents both opportunities and challenges for individual SDHH. Research has shown that SDHH educated in mainstream academic settings tend to have higher academic achievement on standardized tests than those in self-contained classrooms (Holt, 1994), even when controlling for factors including socio-economic status (SES) and ethnicity (Marschark, 2015). Unfortunately, when compared to their TD classmates, the academic achievement of SDHH fares less favorably (Davis, Shepard, Stelmachowicz, & Gorga, 1981; Blair, Peterson, Viehweg, 1985).

An achievement gap has long been documented and continues to persist. Early grade-matched studies of SDHH and TD students have demonstrated that SDHH, across all degrees of HL, perform significantly poorer than classmates in reading and math (Davis, Shepard, Stelmachowicz, & Gorga, 1981; Blair, Peterson, Viehweg, 1985). Recent evidence suggests that reading and math abilities of SDHH are improving, but the achievement gap between SDHH and their TD classmates persists (Antia, Jones, Reed, & Kreimeyer, 2009; Easterbrooks & Beal-Alvarez, 2012).

Standardized Testing in Public Schools

Since the No Child Left Behind Act (2001) was signed into law, large-scale, standardized testing has become a ubiquitous guidepost for schools in the United States. Currently, every state in the U.S. relies upon results from End of Grade (EOG) testing for a myriad of determinants, including student achievement and placement, teacher evaluation, and school ratings and funding.

No Child Left Behind mandated the inclusion of all students, including those with disabilities, in state assessment programs. As a result, SDHH in public schools continue to be required to participate in annual assessments of curricular knowledge in reading in grades 3-8 and are subject to the same level of accountability as their TD classmates based on their testing performance. Typically developing students comprise much of the current literature related to large-scale assessment administration and performance, and insufficient research exists that offers a comprehensive description of SDHH performance and the potentially unique factors that may influence their assessment outcomes. The intention of the first study in this dissertation is to compare the longitudinal performance and growth on statewide administered tests of reading between all students in North Carolina identified as deaf or hard or hearing (i.e., mild to profound degrees of hearing loss) and TD classmates, and to investigate potential factors that predict testing achievement.

Services: Supporting Access, Development and Achievement

The history of poorer achievement for SDHH may be explained, in part, by evidence that many of these students enter elementary school with significant delays in language (Singleton & Morgan, 2006; Tomblin et al., 2015). Mitchell and Karchmer (2006) reported that nearly 90% of SDHH who received at least part of their instruction in a general education classroom were receiving special education or related services. As increasing numbers of SDHH are placed in general education settings, many are likely to rely on special education services to participate and progress within the curriculum.

To ensure optimal academic achievement in vulnerable populations like SDHH, related services are often implemented to support access to the learning environment and curricular content. Service providers of SDHH should possess an understanding of their unique vulnerabilities across developmental domains, the importance of hearing technologies and functioning, and ultimately, the confidence in their knowledge and practice to implement the necessary support for their SDHH. Additionally, the assessments completed by service providers as children transition into school settings are critical in determining the language abilities and related goals that are to be addressed by the professionals serving them.

The OCHL study highlighted several primary factors shown to positively influence outcomes for children with mild to severe degrees of hearing loss (Moeller, Tomblin, & OCHL Collaboration, 2015). These include early and well-fit HAs that provide optimal speech audibility (McCreery et al., 2015), early and consistent use of HAs (Walker et al., 2015a), and supporting caregivers in providing a rich linguistic environment (Ambrose et al., 2015). These factors are congruent with the inconsistent access hypothesis and fortunately, are malleable. They can be targeted and supported through intervention provided by service providers, most often speech-language pathologists and teachers of children who are deaf or hard of hearing, in hopes of minimizing the severity and persistence of delays for burgeoning students.

Recognizing the influential factors found in the OCHL study, professionals must be knowledgeable about current hearing technology (e.g., digital HAs, cochlear implants, FM systems) and the critical role such technologies play in providing critical access to linguistically rich environments to optimize communication and language development (Houston & Perigoe, 2010). With substantial responsibility resting on the shoulders of service providers, there is an urgent need to examine professional characteristics and practice in the provision of assessment and intervention services for CHH. Although there remains a paucity of research concerning services specific to school age CHH, an emerging body of literature suggests that service providers may not feel adequately prepared nor confident in their abilities to support children with hearing loss (Richburg & Knickelbein, 2011; Marschark & Knoors, 2013, Harrison et al., 2016).

To better understand the services that CHH receive, the second study in this dissertation examines the preparation of preschool and school service providers and describes the services received by children with mild to severe hearing loss from the OCHL study. Additionally, it evaluates the relationships between provider characteristics and self-reported levels of comfort in the delivery of specific skills necessary to best support CHH. This study continues a line of research initiated by Harrison et al. (2016), which investigated the characteristics of early intervention services and related professionals for CHH three years of age and younger. The authors discovered that comfort levels differed significantly on an array of skills between the two primary professional disciplines, speech-language pathologists and teachers of children who are deaf and hard of hearing.

Evidence-based Guidance for Service Providers

Tomblin et al. (2015) reported that approximately half of the OCHL cohort of CHH lagged at least one standard deviation behind their SES-, age-matched peers in language ability at 6 years of age. Additionally, a significant negative relationship existed between age and language delay; younger children were more likely to exhibit greater delay. This poses a particular concern regarding the readiness of CHH as they enter kindergarten. There exists little guidance for service providers who are tasked with identifying and targeting early communication delays prevalent in CHH. The final chapter of this dissertation synthesizes emerging OCHL evidence and highlights measures and techniques from the study to support professionals in early and effective assessment of at-risk communication abilities in children with mild to severe hearing loss as they approach kindergarten.

REFERENCES

Ambrose, S. E., Walker, E. A., Unflat-Berry, L. M., Oleson, J. J., & Moeller, M. P. (2015). Quantity and quality of caregivers' linguistic input to 18-month and 3-year-old children who are hard of hearing. *Ear and Hearing*, *36*, 48S–59S. http://doi.org/10.1097/AUD.0000000000000209

Antia, S. D., Jones, P. B., Reed, S., & Kreimeyer, K. H. (2009). Academic status and progress of deaf and hard-of-hearing students in general education classrooms. *Journal of Deaf Studies and Deaf Education*, *14*(3), 293–311. http://doi.org/10.1093/deafed/enp009

Blackorby, J., & Knokey, A. M. (2006). *A national profile of students with hearing impairments in elementary and middle school: A special topic report from the special education elementary longitudinal study*. Menlo Park, CA. Retrieved from /www.seels.net/designdocs/HI_SPEC_TOPIC_ 112906_ww.pdf

Blair, J. C., Peterson, M., & Viehweg, S. (1985). The effects of mild sensorineural hearing loss on academic performance of young school-age children. *Volta Review, 87*(2), 87–93.

Catts, H. W., Fey, M. E., Zhang, X., & Tomblin, J. B. (2001). Estimating the risk of future reading difficulties in kindergarten children: A research-based model and its clinical implementation. *Language, Speech, and Hearing Services in Schools, 32*(1), 38–50. http://doi.org/10.1044/0161-1461(2001/004)

Davis, J. M., Shepard, N. T., Stelmachowicz, P. G., & Gorga, M. P. (1981). Characteristics of hearing-impaired children in the public schools: Part II--psychoeducational data. *The Journal of Speech and Hearing Disorders*, *46*(2), 130–7.

Davis, J. M., Elfenbein, J., Schum, R., & Bentler, R. A. (1986). Effects of mild and moderate hearing impairments on language, educational, and psychosocial behavior of children. *Journal of Speech and Hearing Disorders*, *51*, 53–62.

Easterbrooks, S. R., & Beal-Alvarez, J. S. (2012). States' reading outcomes of students who are d/Deaf and hard of hearing. *American Annals of the Deaf, 157*(1), 27–40. http://doi.org/10.1353/aad.2012.1611

Harrison, M., Page, T. A., Oleson, J., Spratford, M., Unflat Berry, L., Peterson, B., Arenas, R. M., Moeller, M. P. (2016). Factors affecting early services for children who are hard of hearing. *Language, Speech, and Hearing Services in Schools, 47*(1), 16–30. http://doi.org/10.1044/2015_LSHSS-14-0078

Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experiences of young American children*. Baltimore, MD: Paul H Brookes Publishing.

Hoff, E., & Naigles, L. (2002). How children use input to acquire a lexicon. *Child Development*, *73*(2), 418–433. http://doi.org/10.1111/1467-8624.00415

Holt, J. (1994). Classroom attributes and achievement test scores for deaf and hard of hearing students. *American Annals of the Deaf, 139*(4), 430–437.

Houston, K. T., & Perigoe, C. B. (2010). Speech-language pathologists : Vital listening and spoken language professionals. *The Volta Review*, *110*, 219–230.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & et al. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology*, *27*(2), 236–248. http://doi.org/10.1037/0012-1649.27.2.236

Lederberg, A. R., Schick, B., & Spencer, P. E. (2013). Language and literacy development of deaf and hard-of-hearing children: Successes and challenges. *Developmental Psychology*, *49*(1), 15–30. http://doi.org/10.1037/a0029558

Markman, T. M., Quittner, A. L., Eisenberg, L. S., Tobey, E. A., Thal, D., Niparko, J. K., & Wang, N. Y. (2011). Language development after cochlear implantation: An epigenetic model. *Journal of Neurodevelopmental Disorders, 3*(4), 388-404.

Marschark, M., & Knoors, H. (2015). Predicting the academic achievement of deaf and hard-of-hearing students from individual, household, communication, and educational factors. *Exceptional Children*, *81*(3), 350–369. http://doi.org/10.1177/0014402914563700

Marschark, M., & Knoors, H. (2013). Educating deaf children: Language, cognition, and learning. *Deafness & Education International*, *14*(3), 136-160. DOI: 10.1179/1557069X12Y.0000000010

Maye, J., Werker, J. F., & Gerken, L. A. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, *82*(3), B101-B111. http://doi.org/10.1016/S0010-0277(01)00157-3

McCreery, R. W., Walker, E. A., Spratford, M., Bentler, R., Holte, L., Roush, P., … Moeller, M. P. (2015). Longitudinal predictors of aided speech audibility in infants and children. *Ear and Hearing*, *36*(Suppl. 1), 24S–37S. http://doi.org/10.1097/AUD.0000000000000211

Mitchell, R. E. (2004). National profile of deaf and hard of hearing students in special education from weighted survey results. *American Annals of the Deaf*, *149*(4), 336–349.

Moeller, M. P., & Tomblin, J. B. (2015). An Introduction to the outcomes of children with hearing loss study. *Ear and Hearing*, *36*(Suppl. 1), 4S–13S. http://doi.org/10.1097/AUD.0000000000000210

Moeller, M. P., Tomblin, J. B., & Collaboration, O. (2015). Epilogue: Conclusions and implications for research and practice. *Ear and Hearing*, *36*(Suppl. 1), 92S–98S. http://doi.org/10.1097/AUD.0000000000000214

No Child Left Behind Act of 2001, Pub. L. No. 1425 (2002). 115.

Richburg, C. M., & Knickelbein, B. A. (2011). Educational audiologists: Their access, benefit, and collaborative assistance to speech-language pathologists in schools. *Language, Speech & Hearing Services in Schools*, *42*(4), 444–460. http://doi.org/10.1044/0161-1461(2011/10-0011)

Richtsmeier, P., Gerken, L., & Ohala, D. (2011). Contributions of phonetic token variability and word-type frequency to phonological representations. *Journal of Child Language*, *38*(5), 951–978. http://doi.org/10.1017/S0305000910000371

Singleton, J. L., & Morgan, D. D. (2010). Natural signed language acquisition within the social context of the classroom. In *Advances in the Sign-Language Development of Deaf Children*. New York, NY: Oxford University Press. http://doi.org/10.1093/acprof:oso/9780195180947.003.0014

Tomblin, J. B. Harrison, M., Ambrose, S. E., Walker, E. W., Oleson, J. J., & Moeller, M. P. (2015b). Language outcomes in young children with mild to severe hearing loss. *Ear and Hearing, 36* (Suppl. 1), 76S–91S. doi:10.1097/AUD.0000000000000219

Walker, E. A., McCreery, R. W., Spratford, M., Oleson, J. J., Van Buren, J., Bentler, R., Roush, P., Moeller, M. P. (2015). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear and Hearing, 36* (Suppl. 1), 38S–47S.

Chapter 2: Statewide, Longitudinal Reading Achievement for Students Who Are Deaf or Hard of Hearing

Introduction

At no time in our educational history has reliance on results from school-administered standardized-tests been so great. Decisions for curricular support, student retention or matriculation, and the receipt of educational or related-service support are but a few of the ramifications that are influenced by current standardized, "high-stakes" accountability testing. The recent passage of the Every Student Succeeds Act of 2015 extends these policies, suggesting that the administration of and reliance upon standardized testing is likely to remain a high-priority policy initiative.

The Rise of Large-Scale Testing in Schools

In a review of trends, theory, and research surrounding large-scale testing and accountability, Supovitz (2009) noted that the nation and developed world have shifted how they measure educational outcomes. From the 1980s through the early 1990s, educational outcomes were based upon the collection of educational characteristics such as class size, attendance, per-pupil expenditures, and teacher salaries. Public school testing lacked uniformity, and existed primarily to determine subject knowledge and for evaluation of individual concerns such as learning disabilities or giftedness. As such, the relevance of student achievement data rarely extended beyond its limited sphere of administration.

Beginning with the passage of the Individuals with Disabilities Education Act (IDEA, 1990), reform initiatives called for increased achievement testing and reporting across states, and for greater participation from exceptional populations. Much like IDEA, the No Child Left Behind Act (NCLB; 2002) sought to improve public education for all students including a targeted reduction of academic inequalities for under-served and under-resourced populations.

The widespread adoption of test-based measurement stemmed from NCLB's mandate that states utilize test-based systems to measure annual grade-level content in reading, mathematics, and as of 2008, science. Further, it ushered in systematic procedures for collecting and reporting results of student performance across the nation. This increased uniformity allowed for schools to be "graded" and held accountable based on educational improvement, or lack thereof. As both testing standards and data organization became increasingly uniform under federal guidelines, greater reliance could be placed on standardized achievement testing, and as a result, student performance became a primary measure of educational outcomes and accountability.

For the first time in federal legislation, all students were to be tested annually under NCLB, including students with disabilities, and as a result, they became accountable for their performance alongside their typically-developing classmates. Test-based accountability attaches incentives to results for the purpose of improving student performance. Supovitz (2009) acknowledged that current large-scale testing holds two primary parties accountable: students and schools. Incentives can be positive or negative, and have differing implications for students (e.g., matriculation vs retention, individual educational guidance) than for institutions (e.g., assess teacher quality, measure school progress, or highlight system weaknesses).

Well over a decade since the adoption of NCLB, a substantial literature now documents large-scale, standardized testing in schools. The majority of this research centers on typically-developing students (TDS). While evidence addressing more vulnerable populations does exist, there are often methodological drawbacks that make the generalization of results difficult. Findings are commonly reported for exceptional students across needs or diagnoses (Katisyannis, Zhang, Ryan, & Jones, 2007; Thurlow & Johnson, 2000; Ysseldyke & Nelson, 2004). Additionally Wei, Blackorby and Schiller (2011) acknowledged many lack a representative sample of students with disabilities, a typically developing comparison group, and current large-scale measures of achievement. Research centered on specific exceptionalities remains sparse, and literature detailing large-scale standardized testing for students who are deaf or hard of hearing (SDHH) is no exception.

Students who are deaf or hard of hearing

Children who are deaf or hard of hearing continue to be at higher risks for communication and academic delays (Catts, Fey, Zhang, & Tomblin, 2001; Markman et al., 2011; Moeller, Tomblin, Yoshinaga-Itano, Connor, & Jerger, 2007; Tomblin et al., 2015) and in comparison to TDS are more likely to rely upon communication modalities (e.g., American Sign Language, total communication) other than solely English. Thus, SDHH are more likely learning content that is not at the grade-level for which they are tested, may have more difficulty processing content that is at their grade-level, and depending on the degree of inclusion, would have unequal access to content taught in the general classroom (Qi & Mitchell, 2012). Reduced linguistic, acoustic, and physical access threatens consistent and equal exposure to content that SDHH are held accountable for in end of grade (EOG) testing.

Historically, evidence has shown that SDHH are likely to struggle on standardized achievement examinations. Trybus & Karchmer (1977) reported the average 20 year old deaf or hard of hearing adult read at between a fourth and fifth grade level. Subsequent studies upheld these findings, documenting significantly depressed literacy abilities in SDHH (Wolk & Allen, 1984). Recent literature paints a more promising picture, suggesting that overall literacy abilities of SDHH are improving although they continue to demonstrate performance levels poorer than TDS (Antia, Jones, Reed, & Kreimeyer, 2009). In a summary of SDHH achievement testing across several states, Easterbrooks and Beal-Alvarez (2012) found that results varied widely by state, with 35%-65% of students meeting proficiency requirements for elementary and secondary reading. Although the evidence is limited and variable across recent studies, performance of SDHH on statewide achievement testing appears to be improving. It remains unclear if this progress is adequate to ultimately close the achievement gap between their classmates who are typically-developing.

The implementation of standardized testing with any exceptional population raises numerous issues; the overarching concern is the validity of the results, and therefore a potential equivocation as to how results can or should be interpreted and utilized (Phillips, 1994). The use of testing accommodations to more accurately assess student knowledge and achievement has been used in an attempt to improve test validity. Through the use of a national survey regarding accommodations and alternative assessments for SDHH, Cawthon (2006) reported that extended time, the use of an interpreter for instructions, and separate testing rooms were accommodations most commonly provided. Additionally, accommodations were primarily used in mainstream settings, while those students in schools for the deaf or district-wide programs had a higher likelihood of receiving an alternate assessment. Although a small body of literature exists regarding the prevalence of accommodation use by SDHH, little is understood regarding the impact on testing performance. To date there have been no studies that have simultaneously investigated the prevalence of testing accommodations for SDHH and the effect of accommodations on testing performance for SDHH.

Research Questions

The overarching rationale for this study is to provide a foundational understanding of longitudinal SDHH reading achievement in a state-wide assessment program. This investigation will 1) describe and estimate longitudinal EOG reading achievement for SDHH to a comparison sample of TDS, analyze whether 2) testing accommodation use and 3) the student's school influence actual and estimated achievement from grades three through eight. The following research questions are addressed:

1. How do reading growth trajectories differ between SDHH and TDS?
2. How do reading growth trajectories differ for SDHH who utilize reading test accommodations from students who do not?
3. How much variation in student reading performance is attributed to the student's school?

Methods

Instrumentation

With over 10 million residents, North Carolina (NC) is the ninth most populous state in the US with 66.1% of residents inhabiting urban areas, comparable to the US mean of 62.7% (U.S. Census Bereau, 2010b, 2015). Additionally, the state's population statistics represent an ethnic and economical diversity similar to US averages in racial makeup, attained educational levels, and household income (U.S. Census Bereau, 2010a).

Beginning with the 2000-2001 school year, NC policy has required the inclusion of students with disabilities in annual, statewide testing administration (North Carolina Testing Program, 2015). In-line with the objectives of NCLB, the primary aims of the NC Testing Program are:

(i) "To assure that all high school graduates possess those minimum skills and that knowledge thought necessary to function as a member of society;

(ii) To provide a means of identifying strengths and weaknesses in the education process in order to improve instructional delivery; and

(iii) To establish additional means for making the education system at the state, local, and school levels accountable to the public for results." (Purposes of the statewide testing program, 2009)

The State Board of Education offers 3 broad formats to assess EOG knowledge in reading comprehension for grades 3-8: (1) the general multiple-choice assessment under standard conditions, (2) the general multiple-choice assessment with testing accommodations, and (3) the state-designed NCEXTEND1 Alternate Assessment (North Carolina Testing Program, 2015). The accommodations and alternative assessment formats are administered only to those students who possess an individualized education plan (IEP) or Section 504 Plan and have the corresponding format identified in their plan (Responsibilities of Agencies, 2009). Furthermore, NCEXTEND1 is designated only for students identified as having a severe cognitive disability, demonstrating "…severe and pervasive delays in ALL areas of conceptual, linguistic, and academic development and also in adaptive behavior areas." (North Carolina Testing Program, 2013, p. 1). If the IEP team determines that the alternate assessment is to be used, NCEXTEND1 must be administered for all content areas assessed at that grade level.

Sample

Extant North Carolina Department of Public Instruction (DPI) data were obtained from the NC Education Research Data Center at Duke University. This database retains longitudinal testing results and demographic information for each student in NC public schools. This information includes average EOG test scores for grades 3 through 8, student demographic information, student school, and exceptionality status. This data structure is well-suited for detailing the extent to which individual and external variables influence performance as well as changes in individual, school, and state-wide performance on EOG tests.

To adequately address the research questions, the raw dataset underwent several waves of data reduction mostly due to exclusionary criteria. Students with missing data regarding their unique identifier, school, type of test administered, grade, or year of assessment were removed for that particular grade. Students who attended a school for less than 90 days were not included in analysis. If a student was represented more than once in a given school year or grade, likely due to transferring schools or grade retention, only one score per grade was included in analyses. For students with more than one school in a given year, the school with a reported reading score was chosen, as long as he or she had spent at least 90 days in that school. If a student had repeated a grade level in the same school, the observation with the higher reading score was chosen. Observations based upon alternative testing (e.g., NCEXTEND1) were removed, likely resulting in a reduced representation of SDHH with concomitant cognitive disabilities. Lastly, a minimum of at least two years of testing results were required for a student's scores to be included in analysis. These methods resulted with an investigated sample of 1,305,502 unique students consisting of 1,303,508 TDS and 1,994 SDHH from 2,180 schools within NC. Numerous SDHH characteristics within the DPI dataset are not identified or defined such as: communication mode, degree/type of hearing loss, or assistive technology use/or. Thus, the present study includes a highly heterogeneous population of SDHH with mild to profound degrees of HL, who employ a variety of communication modes and may or may not wear hearing devices.

Variables

Annual NC EOG tests in reading comprehension from grades 3 through 8 served as the dependent variable. North Carolina EOG test scores are vertically scaled across as grade level, meaning the expected score for a particular grade level is higher than for the previous grade level. Essentially, scores represent a continuous variable that spans grades 3-8, and thus are appropriate for longitudinal growth analysis.

The independent variables in this study are exceptionality status and testing accommodation use. Exceptionality status is a categorical variable coded as TDS or SDHH. Within the state dataset, exceptionality status is identified by the IEP for a particular grade and therefore it can change. For example, a particular SDHH could have had an IEP between grades 3 and 5. If that student is dismissed from IEP services at the end of grade 5, they would be labeled as TDS for grade 6 within the state dataset. For the current investigation, students were coded as SDHH if at *any time* in the data they had an eligibility code of deaf or hard of hearing. This allows for SDHH who no longer have an active IEP, and therefore lack an exceptionality code of deaf or hard of hearing, to be included in the analysis as SDHH. This allows for a more accurate representation of the SDHH population within public schools.

The second independent variable, testing accommodation use, is a categorical variable that includes three student groups: TDS, SDHHno, and SDHHyes. The TDS did not receive testing accommodations, nor did the subset of SDHH students identified as SDHHno. Those SDHH who did have testing accommodations were labeled as SDHHyes. Since testing accommodation use contained the same participants as exceptionality status, but separated into three groups, the two independent variables were analyzed separately as predictors of reading achievement.

Study Analysis

Student reading growth was modeled using a three-level hierarchical linear model (HLM) with repeated measures (Raudenbush & Bryk, 2002). Multilevel models consider the hierarchical nature of data. In this case, individual EOG performance (level 1) is nested within each student (level 2), which are in turn nested within a contextual variable, their particular school (level 3). This structure supports the rationale that a given student's performance is not simply influenced by individual characteristics, such as hearing status, but also by related factors within the academic environment in which they learn. Level 1 represents the within-student model, which predicts reading scores from variables that change over time as in the use of testing accommodations. Level 2 is the between-student model, which estimates the differences in EOG level and growth in relation to variables that typically do not change over time (i.e., hearing status). At Level 3, the student's school is incorporated into the model to assess variance in student scores between schools.

Grade, hearing status, and testing accommodations were modeled as fixed effects, while the intercept represented a random effect. Grade was centered by its mean, grade 5.5, to make interpretation of model estimates more natural. Therefore, estimated reading achievement scores are for students midway through grade 5. If grade was not mean centered, estimates would be based on scores at grade zero, and thus more challenging to interpret. Maximum likelihood estimation was employed with an unstructured covariance structure using the *lme* function from the *nlme* package (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2017) in the statistical programming language R, version 3.3.3 (R Core Team, 2017).

Predictors were entered sequentially into models. Model 1 is an unconditional three-level HLM model with student school at Level 3, hearing status as a predictor at Level 2 using TDS as the reference group and includes the longitudinal component of grade level at Level 1. In Model 2, student school remains at Level 3, testing accommodation use is included as a categorical predictor with TDS as the reference (no accommodations for TDS), SDHH who did not use testing accommodations (“SDHHno”), and SDDH who did use testing accommodations (“SDHHyes”) to Level 1.

Results

Descriptive Statistics

Table 2.1 displays the sample’s demographic proportions for gender, ethnicity, and economic status for the two primary participant groups, TDS and SDHH. The accompanied means of reading achievement are not grade centered, but represent the average score across grades 3-8 for each demographic designation. Demographic distributions of gender and ethnicity are similar for TDS and SDHH, but a larger proportion of SDHH are classified as being economically disadvantaged. Group means of reading achievement are lower in SDHH than TDS across all of the demographic designations.

Table 2.1 Study Sample Demographic Makeup with Group Means of Reading Achievement

	TDS			**SDHH**		
	%	***M* Read**	***SD* Read**	**%**	***M* Read**	***SD* Read**
Gender						
Female	51.6	453.01	11.203	48.5	444.66	12.440
Male	48.4	452.15	10.976	51.5	444.04	12.649
Ethnicity						
American Indian	1.3	449.29	10.804	1.3	438.33	10.988
Asian	3.0	455.42	11.645	2.6	447.33	12.391
Black	24.7	448.60	10.628	24.4	441.26	11.872
Hispanic	14.4	448.16	11.178	16.7	439.34	11.491
Multi-racial	3.8	452.76	10.625	3.8	442.06	12.167
Hawaiian/Pacific Islander	0.1	451.36	11.292	0.1	432.57	9.343
White	52.7	455.58	10.247	51.2	447.64	12.251
Economically Disadvantaged						
No	49.5	456.27	10.179	41.9	449.11	12.328
Yes	50.5	448.99	10.765	58.1	440.90	11.537

Note. SDHH = student who is deaf or hard of hearing; TDS = typically developing student. Group means are averaged across grades.

Table 2.2 shows descriptive statistics for the measured EOG reading achievement scores by grade, including the average score change from the prior grade for TDS and SDHH. The mean scores for both TDS and SDHH increased with increasing grade levels, demonstrating positive growth for both student groups. However, reading scores, on average, for SDHH begin 9.5 points lower than TDS at grade 3, and remain between 7.8 to 8.6 points (*M* = 8.25) lower through grade 8 testing. Visually, as seen in Figure 2.1, this reading achievement gap persists from grades 3-8, following a similar pattern of growth for TDS and SDHH.

Table 2.2 Reading Performance by Participant Group (grand *M* = 452.58, *SD* = 11.101)

Student group	**Grade**	***N***	***M* read**	***SD* read**	***M* change by grade**
TDS	3 - 8	3883047	452.59	11.094	3.75
	3	644516	441.97	9.849	-
	4	639938	447.73	8.914	5.76
	5	643452	452.11	8.580	4.39
	6	644676	454.86	9.154	2.74
	7	654267	457.88	9.239	3.03
	8	656198	460.72	9.107	2.83
SDHH	3 - 8	5426	444.34	12.545	4.01
	3	903	432.48	10.907	-
	4	882	439.14	10.311	6.66
	5	897	444.35	9.910	5.21
	6	906	447.03	10.450	2.67
	7	901	450.10	10.959	3.07
	8	937	452.52	10.741	2.42

Note. SDHH = student who is deaf or hard of hearing; TDS = typically developing student

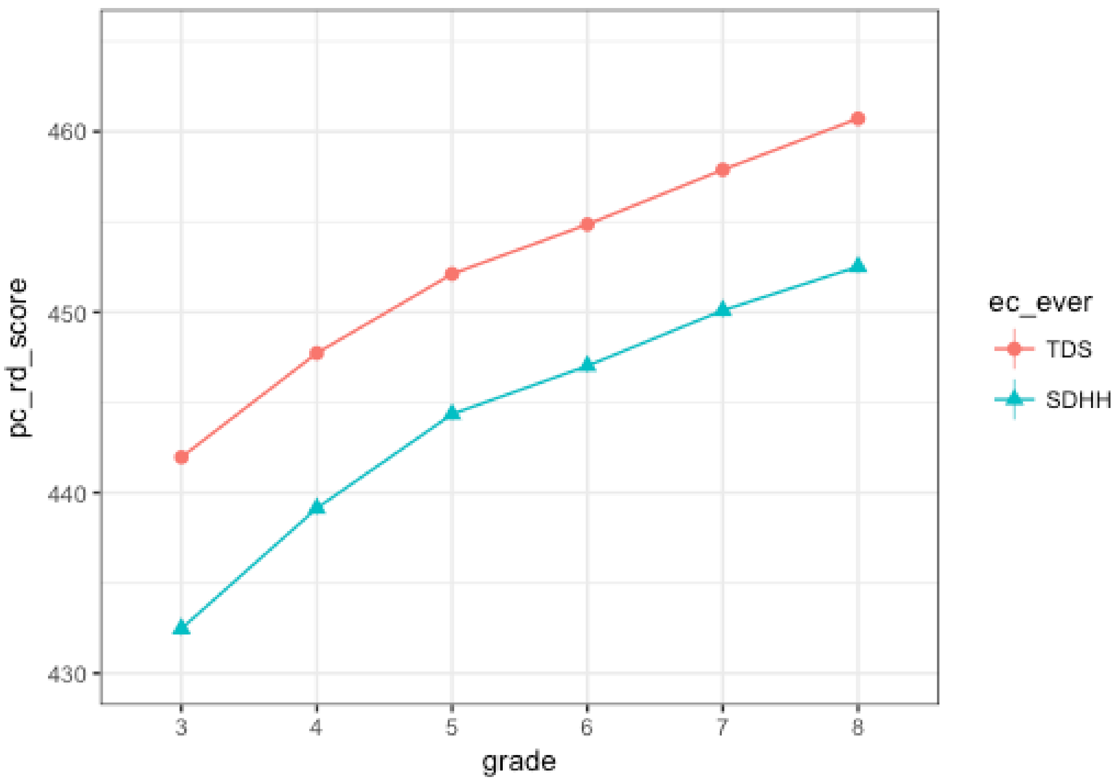

Figure 2.1 Measured Growth Trajectories in Reading Achievement for Typically Developing Students and for Students who are Deaf and Hard of Hearing. pc_rd_score = reading achievement score; SDHH = students who are deaf of hard of hearing; TDS = typically developing students.

Table 2.3 displays reading scores by grade level but with subgrouping of SDHH by testing accommodation use. Measured reading achievement growth rate trajectories for all three groups are shown in Figure 2. While both groups demonstrated annual reading growth, the SDHHno, who did not utilize accommodations, demonstrated better reading scores across all grade levels than SDHHyes who had accommodations during testing (*M* difference of 9.34, range 7.35 – 9.69). Thus, the difference in reading scores between SDHHno and TDS is less than that seen in a comparison of all SDHH and TDS. The SDHHyes and TDS achievement divide is noticeably larger with an average difference of 11.50 points, approximately one standard deviation, with a range of 10.34 to 12.15 points across grades. Visual inspection of growth trajectories in Figure 2.2 highlights the differences between the three groups. Again, the achievement gap between TDS and SDHH groups persists throughout elementary and middle school. However, there appears to be more variability in the slopes for SDHH when they are subdivided by accommodation use. The growth trajectories suggest a potential widening of the achievement gap for SDHH who use testing accommodations in later grades.

Table 2.3 Measured Reading Achievement Scores for Students with and without Testing Accommodations

SDHH w/ Accommodations?	**Grade**	***N***	***M* read**	***SD* read**	***M* change by grade**
SDHHno	3 - 8	1888	450.43	11.954	4.15
	3	285	437.51	9.878	-
	4	270	445.08	9.874	7.57
	5	282	449.98	9.490	4.89
	6	325	452.11	9.839	2.14
	7	344	455.42	10.534	3.31
	8	382	458.26	9.267	2.83
SDHHyes	3 - 8	3538	441.09	11.610	3.68
	3	618	430.16	10.580	-
	4	612	436.52	9.376	6.36
	5	615	441.77	8.995	5.25
	6	581	444.18	9.681	2.41
	7	557	446.81	9.878	2.63
	8	555	448.57	9.876	1.76

Note. SDHH = student who is deaf or hard of hearing; SDHHno = SDHH who did not use reading test accommodations; SDHHyes = SDHH who used reading test accommodations.

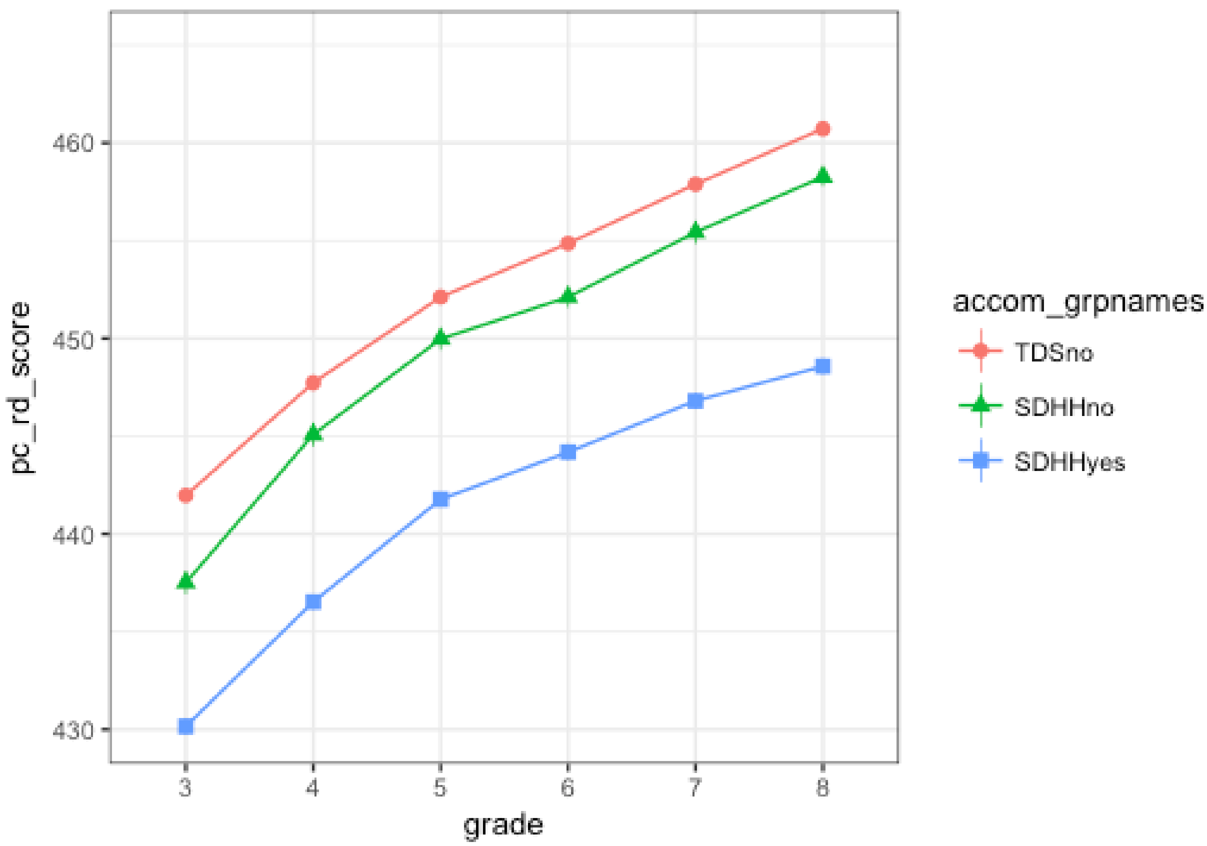

Figure 2.2 Measured Growth Trajectories in Reading Achievement for Typically Developing Students and for Students who are Deaf and Hard of Hearing with and without Reading Test Accommodations. pc_rd_score = reading achievement score; SDHH = students who are deaf of hard of hearing; SDHHno = SDHH who did not use reading test accommodations; SDHHyes = SDHH who used reading test accommodations; TDS = typically developing students.

Estimated Differences in Reading Achievement

Model 1 sought to *estimate* differences in longitudinal reading achievement for TDS and SDHH accounting for their school of attendance. Overall, reading scores estimates showed significant, positive growth over time for all students, b = 3.685 (95% *CI*: 3.679, 3.691), $t(1,886,751) = 1250.31$, $p < .001$. Reading scores were predicted to increase 3.7 points with an increase of one grade level. The intraclass correlation coefficient (ICC) equaled 0.756, indicating that 76% of the variance in reading scores could be explained by the differences among students.

As such, the dispersion of scores is primarily a function of the student when accounting for grade level and student group (TDS or SDHH) in the linear model. There was significant variance among all students, *SD* = 7.514 (7.506, 7.523), within individual performance, *SD* = 4.260 (4.256, 4.4264) and across schools, *SD* = 3.792 (3.718, 3.868). These findings suggest that the school a student attends has an influence on his or her reading score. The SDHH showed significantly lower reading scores *t*(1,999,730) = -55.65, p <.001. This model predicted that SDHH on average score 8.5 points lower, approximately ¾ of a standard deviation. Figure 2.3 graphs measured and estimated reading scores from Model 1.

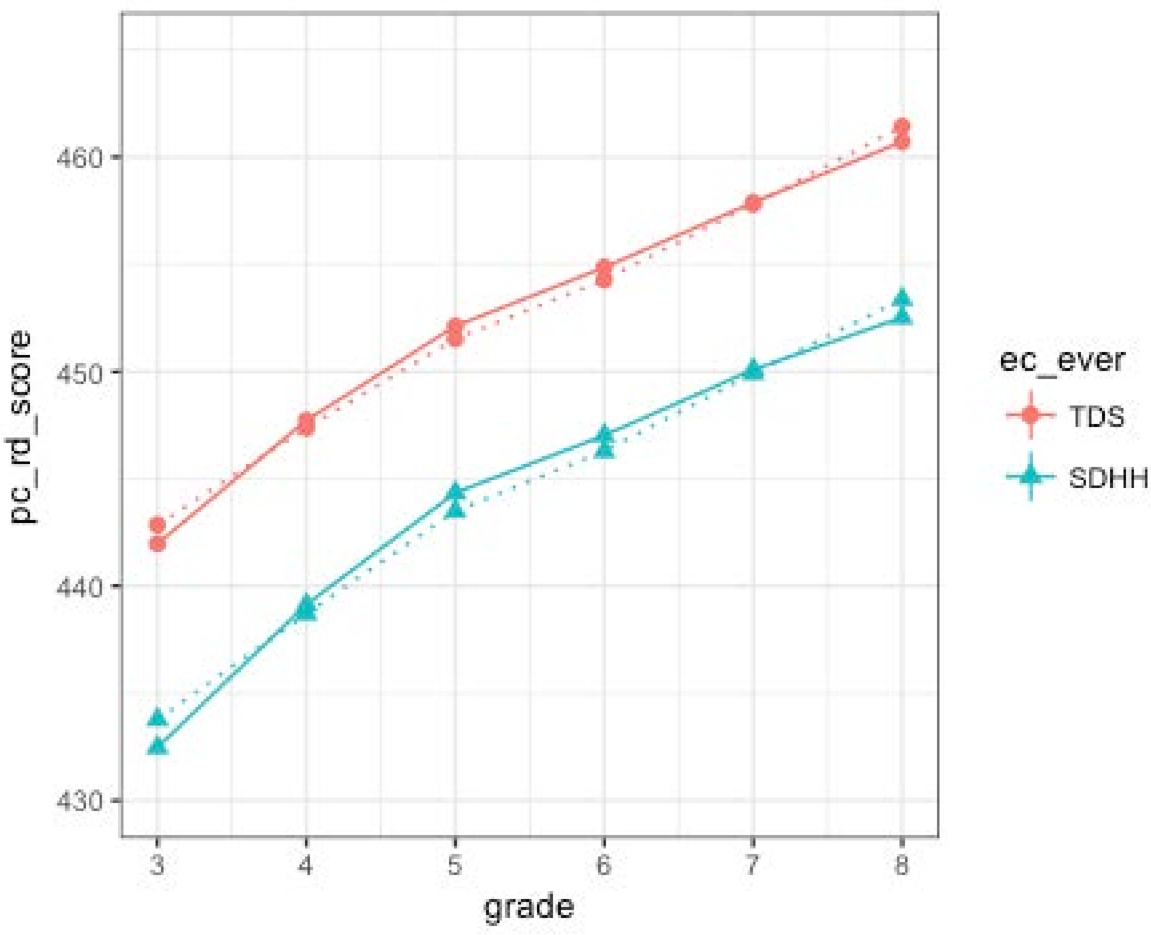

Figure 2.3 Model 1 Predicted and Measured Reading Score Trajectories in Reading Achievement for Typically Developing Students and for Students who are Deaf and Hard of Hearing. pc_rd_score = reading achievement score; SDHH = students who are deaf of hard of hearing. TDS = typically developing students. Dashed lines represent predicted reading scores from Model 1, and solid lines indicated actual testing scores**.**

Testing Accommodations and Estimated Reading Performance

For Model 2, students were separated into three groups based on their use of reading testing accommodations. Two groups of students did not use accommodations including all of the TDS from the sample and SDHH ("SDHHno") where accommodations are not specified on their IEP or Section 504 Plan. The third group ("SDHHyes") included SDHH who did use testing accommodations. As similarly specified in Model 1, the same positive effect of grade level on reading score performance is seen in TDS, who serve as the reference group in all models. Additionally, the large amount of variance (ICC = .756) in reading scores explained by differences among students is the same in Model 2. Essentially, this model allows a more detailed examination of the SDHH performance between those who utilize testing accommodations and those who do not. SDHHno were predicted to perform significantly poorer with reading scores 6.5 points below than their typically developing peers, $t(1,886,569) = -31.41$, $p < .001$. SDHHyes were predicted to have even larger deficits in reading performance, 9.5 points less, or nearly one standard deviation, than TDS, $t(1,886,569) = -56.87$, $p < .001$. The reading scores for SDHHno and SDHHyes were compared using the Tukey HSD test yielded a significant difference in scores by testing accommodation use, $t(1,886,569) = 14.88$, $p < .001$. As in Model 1, a similar significant variation existed in reading scores across schools, SD = 3.790 (3.653, 3.931).

Model 2 results suggest that SDHH who use testing accommodations are predicted to have poorer reading scores than TDS and SDHH who do not, similar to measured reading achievement seen in Figure 2.4. These findings imply that SDHH who utilize testing accommodations have greater reading delays than their classmates, and thus rely on these accommodations to better access the assessment instructions and/or content. Table 2.4 summarizes the two multilevel models for estimating growth curves in achievement on reading tests between grades 3 and 8.

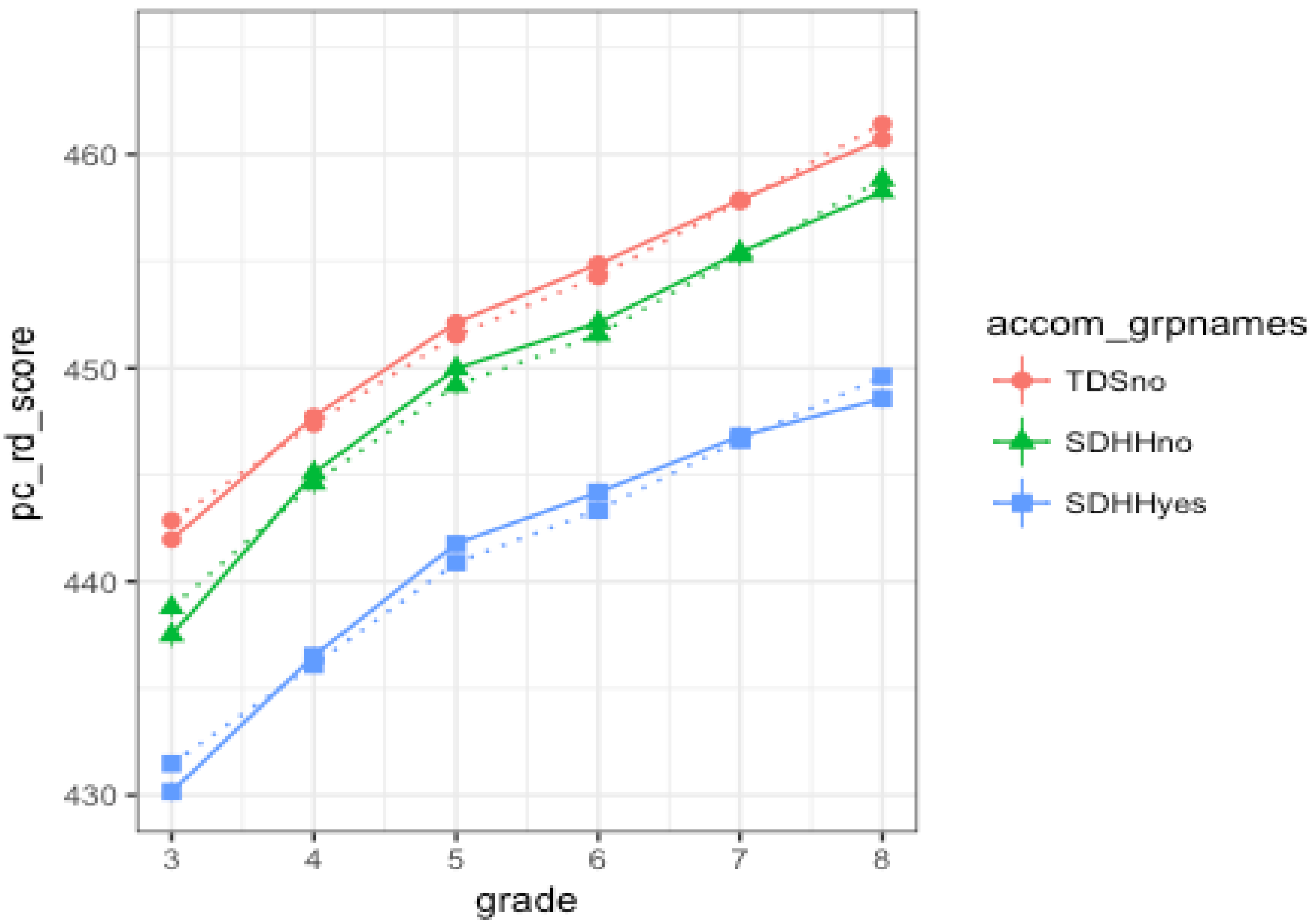

Figure 2.4 Model 2 Predicted and Measured Growth Trajectories in Reading Achievement for Typically Developing Students and for Students who are Deaf and Hard of Hearing with and without Reading Test Accommodations. pc_rd_score = reading achievement score; SDHH = students who are deaf of hard of hearing; SDHHno = SDHH who did not use reading test accommodations; SDHHyes = SDHH who used reading test accommodations; TDS = typically developing students. Dashed lines represent predicted reading scores from Model 2, and solid lines indicated actual testing scores**.**

Table 2.4 HLM Models of Reading Achievement Growth Trajectories for Grades 3-8

	Model 1		**Model 2**	
Model Parameter	**Level**	**Slope**	**Level**	**Slope**
Fixed Effect				
Intercept	451.78**	3.69**	451.78**	3.69**
Hearing Status				
SDHH	-8.50**			
SDHHno			-6.45**	
SDHHyes			-9.52**	
Random Effect				
School Variance Component	14.382		14.361	
Student Variance Component	56.465		56.451	
Residual	18.145		18.148	

Note. Typically developing students are the reference group. Grade is centered at mean of 5.5. HLM = Hierarchical Linear Model; SDHH = students who are deaf or hard of hearing; SDHHno = SDHH who did not use testing accommodations; SDHHyes = SDHH who did use testing accommodations. **$p < .001$

Discussion

This study investigated reading achievement growth in students who are deaf or hard of hearing compared to typically-developing peers. This work addressed methodological shortcomings noted by Wei, Blackorby, and Schiller (2011) that are often found in the literature by incorporating current, representative longitudinal data from a statewide public school population. Overall, findings suggest that a substantial achievement gap continues to exist between SDHH and TDS, and that significant variability in reading achievement exists across schools. Reading achievement scores of SDHH were nearly ¾ of a standard deviation behind TDS. Measured and estimated reading achievement scores were similar, less than a one point difference across grades. While variation in growth for the individual student groups was not estimated in the present study, similar differences in reading achievement across all grade levels further suggest that, on average, SDHH do not close, nor do they diminish, the achievement gap. Similar to studies of students with other disabilities, the persistent achievement gap for SDHH can be best defined by a deficit model, where initial differences remain, rather than a lag model where initial differences lessen over time (Morgan, Farkas, & Wu, 2011; Wei, Blackorby, & Schiller, 2011).

Classifying Exceptionality

A practical, but unique component of this study involved the classification and analysis of SDHH by an *active or prior* exceptionality designation as deaf or hard of hearing, rather than only considering a student as deaf or hard of hearing if that exceptionality status was labeled on an IEP at the time of testing. Students identified as being deaf or hard of hearing within the educational system must have permanent hearing loss or a fluctuating hearing loss significant enough to warrant support from an IEP or 504 Plan. Theoretically, SDHH who have been dismissed from IEP-based services no longer require additional educational support and therefore could be expected to perform better than peers who continue to rely upon specially designed instruction to address significant delays and to access the educational curriculum. Exclusion of these higher achieving students could lead to an even more pessimistic picture of the overall achievement and abilities of SDHH. It was beyond the scope of the present investigation to determine whether significant differences in achievement status and growth exist between SDHH with and without a current IEP or 504 Plan. Future cross-sectional and longitudinal research with large, representative samples should investigate whether differences in testing outcomes exist depending on whether or not students have a current IEP at the time of testing. Even if future research determines that differences are minimal or non-existent, it is likely more representative to recognize a student as deaf or hard of hearing by their actual hearing status, rather than a classification from his or her IEP at a given point in time.

Accommodations

The decision to include testing accommodations as a predictor variable allowed for a separation of the SDHH group for further comparison on reading achievement. With population-level research or studies that rely on extant data, valuable predictive information may not be available. For example, in the present study's existing dataset, information was not available regarding factors known to be associated with individual differences in language and pre-literacy skills among SDHH, including age of identification, age of device fitting, degree of hearing loss and hearing assistive technology use (Tomblin et al., 2015; Walker et al., 2015). While less specific than established, discrete predictors, the separation of SDHH by testing accommodation provided a method to identify more precise differences *within* this population in addition to TDS.

Poorer performance for SDHH with testing accommodations should not imply that accommodations negatively influence achievement assessment. Rather, the differences in achievement with or without testing accommodation suggest that there remain a portion of SDHH who require accommodations to access testing, and possibly the curriculum that it aims to assess. More research is warranted in the realm of testing accommodation implementation, variance, and effectiveness when tailored to areas of vulnerability common in SDHH.

Addressing a Deficit Model of Achievement

The findings presented here suggest that for many SDHH significant delays in reading achievement are likely to be present at third grade, when federally mandated testing begins, and are likely to remain through, at least, middle school for many of these students. This persistent achievement gap calls for novel research, policy and interventions to minimize initial literacy delays, and when they exist, implement targeted intervention and educational strategies to turn deficit into achievement.

There is general consensus that children with poor language skills are at increased risk for later reading problems. Longitudinal studies of children who are deaf or hard of hearing have highlighted the critical role that early language plays upon developmental trajectory in later language and pre-academic abilities (Catts et al., 2001; Lederberg, Schick, & Spencer, 2013; Markman et al., 2011; Moeller, Tomblin, & OCHL Collaboration, 2015). As children who are deaf and hard of hearing are at higher risk for early communication delays, effective early identification and intervention to minimize deficits are critical to best prepare them both academically and socially. Consistent access to high-quality linguistic input, be it through audition (auditory), visual-spatial, or a combination of modes is required to develop optimal language. For children who are deaf or hard of hearing who rely on auditory input to develop spoken language, early support of well-fitted, consistently worn hearing devices can support higher language skills at entrance to elementary school than children with less or compromised auditory, and therefore, linguistic input (Tomblin et al., 2015). Unfortunately, research has reported that many early intervention professionals lack experience and comfort with skills that support consistent access to language in young children who are deaf or hard of hearing (Harrison et al., 2016; Marschark & Knoors, 2012; Richburg & Knickelbein, 2011). Targeted policy and programs to provide greater preparation and opportunities for pre- and post-graduate training of early service providers could be have widespread implications for supporting early development of language in this population and ultimately the reading ability and academic achievement of school age children.

Limitations of the present study

Multilevel model estimations with random intercepts were used for analysis of the data presented in this study, allowing for valid estimates of achievement differences over time between SDHH and TDS. Random intercept models alone cannot estimate differences in the rate or shape of achievement between the groups. A random slope model would allow for a further estimation of individual growth variance across students. Random slope models require greater amounts of estimation and statistical processing. While attempts were made to model random slopes, the processing needed for this large, state population sample did not allow convergence, or completion, of random slope estimates. An interaction of exceptionality status and grade was analyzed in both Models 1 and 2 to test whether the achievement gap (i.e., reading score difference) changed significantly by grade, providing an estimation whether growth trajectories between TDS and SDHH were predicted to stay the same, converge, or diverge by eighth grade. Because the models including the interaction term were of poorer overall fit in estimating reading achievement growth and yielded predictions of limited clinical significance, they were not included in the results. As a follow-up investigation, smaller representative samples of this larger data set will be used to further estimate individual growth differences in reading achievement. In order to first describe broad differences between SDHH and TDS, other potential salient variables such as socioeconomic status, maternal education level, ethnicity, and gender were not included in the present study. Subsequent research considering exceptionality status and demographic characteristics from the population are to be conducted. By utilizing a statewide, longitudinal sample the present study provides a comprehensive estimate of reading achievement within one state. Similar investigations of state-administered assessments are needed to frame longitudinal SDHH reading achievement on a national scale.

Conclusion

In the state of North Carolina, SDHH are, on average, lagging behind TDS in their reading achievement scores measured annually between 3rd and 8th grade on EOG Tests. Despite the fact that SDHH receive or have received educational and speech-language services to address this deficit, this achievement gap, overall, does not close, but more positively it does not widen over time. This study identified a subset of SDHH who never or no longer received testing accommodation support. Although these students do not, on average, attain reading scores that are equivalent to TDS, their scores are significantly higher than those of SDHH with accommodations. These findings raise additional questions for future research including: 1) What are the child, family, or educational characteristics that are associated with SDHH who no longer utilize testing accommodations? and 2) Are any of these characteristics malleable factors? Essentially, can any of those factors be manipulated, prior to the initiation of EOG testing, to improve reading abilities, and related academic achievement, at grade 3 and beyond?

REFERENCES

Antia, S. D., Jones, P. B., Reed, S., & Kreimeyer, K. H. (2009). Academic status and progress of deaf and hard-of-hearing students in general education classrooms. *Journal of Deaf Studies and Deaf Education*, *14*(3), 293–311. http://doi.org/10.1093/deafed/enp009

Catts, H. W., Fey, M. E., Zhang, X., & Tomblin, J. B. (2001). Estimating the risk of future reading difficulties in kindergarten children: A research-based model and its clinical implementation. *Language, Speech, and Hearing Services in Schools*, *32*(1), 38–50. http://doi.org/10.1044/0161-1461(2001/004)

Cawthon, S. W. (2006). National survey of accommodations and alternate assessments for students who are deaf or hard of hearing in the United States. *Journal of Deaf Studies and Deaf Education*, *11*(3), 337–59. http://doi.org/10.1093/deafed/enj040

Easterbrooks, S. R., & Beal-Alvarez, J. S. (2012). States' reading outcomes of students who are d/Deaf and hard of hearing. *American Annals of the Deaf*, *157*(1), 27–40. http://doi.org/10.1353/aad.2012.1611

Every Student Succeeds Act, Pub. L. No. 114-95 (2015).

Harrison, M., Page, T. A., Oleson, J., Spratford, M., Unflat Berry, L., Peterson, B., Arenas, R. M., Moeller, M. P. (2016). Factors affecting early services for children who are hard of hearing. *Language, Speech, and Hearing Services in Schools*, *47*(1), 16–30. http://doi.org/10.1044/2015_LSHSS-14-0078

Individuals with Disabilities Education Act (IDEA), Pub. L. No. 94-142 (1990). U.S.C.

Katisyannis, A., Zhang, D., Ryan, J. B., & Jones, J. (2007). High-stakes testing and students with disabilities. *Journal of Disability Policy Studies*, *18*(3), 160-167. http://doi.org/10.1177/10442073070180030701

Lederberg, A. R., Schick, B., & Spencer, P. E. (2013). Language and literacy development of deaf and hard-of-hearing children: Successes and challenges. *Developmental Psychology*, *49*(1), 15–30. http://doi.org/10.1037/a0029558

Markman, T. M., Quittner, A. L., Eisenberg, L. S., Tobey, E. A., Thal, D., Niparko, J. K., & Wang, N. Y. (2011). Language development after cochlear implantation: An epigenetic model. *Journal of Neurodevelopmental Disorders, 3*(4), 388-404.

Marschark, M. (2015). Predicting the academic achievement of deaf and hard-of-hearing students from individual, household, communication, and educational factors. *Exceptional Children*, *81*(3), 350–369. http://doi.org/10.1177/0014402914563700

Moeller, M. P., Tomblin, J. B., & OCHL Collaboration. (2015). Epilogue: Conclusions and implications for research and practice. *Ear and Hearing*, *36* (Suppl. 1), 92S–98S.

http://doi.org/10.1097/AUD.0000000000000214

Moeller, M. P., Tomblin, J. B., Yoshinaga-Itano, C., Connor, C. M., & Jerger, S. (2007). Current state of knowledge: Language and literacy of children with hearing impairment. *Ear and Hearing*, *28*(6), 740–753. http://doi.org/10.1097/AUD.0b013e318157f07f

Morgan, P. L., Farkas, G., & Wu, Q. (2015). Kindergarten children's growth trajectories in reading and mathematics: Who falls increasingly behind? *Journal of Learning Disabilities*, *44*(5), 472–488. http://doi.org/10.1177/0022219411414010.Kindergarten

No Child Left Behind Act, Pub. L. No. 1425 (2002).

North Carolina Testing Program. (2015). *Testing students with disabilities*. Retrieved from http://www.ncpublicschools.org/accountability/policies/tswd/

North Carolina Testing Program. (2013). *North Carolina alternate assessment system - Eligibility criteria*. Retrieved from http://www.ncpublicschools.org/accountability/policies/tswd/

North Carolina Testing Program. (2009). *Purposes of the statewide testing program,* Pub. L. No. G.S. §115C-174.10.

Phillips, S. E. (1994). High-stakes testing accommodations: Validity versus disabled rights. *Applied Measurement in Education*, *7*(2), 93–120.

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., and R Core Team (2017). _nlme: Linear and nonlinear mixed effects models. R package version 3.1-131. Retrieved from https://CRAN.R-project.org/package=nlme>

Qi, S., & Mitchell, R. E. (2012). Large-scale academic achievement testing of deaf and hard-of-hearing students: Past, present, and future. *Journal of Deaf Studies and Deaf Education*, *17*(1), 1–18. http://doi.org/10.1093/deafed/enr028

R Core Team (2017). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from https://www.R-project.org/

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Responsibilities of Agencies, Pub. L. No. G.S. §115C-174.12 (2009).

Richburg, C. M., & Knickelbein, B. A. (2011). Educational audiologists: Their access, benefit, and collaborative assistance to speech-language pathologists in schools. *Language, Speech & Hearing Services in Schools, 42*(4), 444–460. DOI: 10.1044/0161-1461(2011/10-0011)

Supovitz, J. (2009). Can high stakes testing leverage educational improvement? Prospects from the last decade of testing and accountability reform. *Journal of Educational Change, 10*(2–3), 211–227. http://doi.org/10.1007/s10833-009-9105-2

Thurlow, M. L., & Johnson, D. R. (2000). High-stakes testing of students with disabilities. *Journal of Teacher Education, 51*(4), 305–314.

Tomblin, J. B., Harrison, M., Ambrose, S. E., Walker, E. A., Oleson, J. J., & Moeller, M. P. (2015). Language outcomes in young children with mild to severe hearing loss. *Ear and Hearing, 36*(Suppl. 1), 76S–91S. http://doi.org/10.1097/AUD.0000000000000219

Trybus, R., & Karchmer, M. (1977). School achievement scores of hearing impaired children: National data on achievement status and growth patterns. *American Annals of the Deaf, 122*(2), 62–69.

U.S. Census Bereau. (2010a). *Census of population and housing*. Retrieved from https://www.census.gov/prod/www/decennial.html

U.S. Census Bereau. (2010b). *Census urban and rural classification*. Retrieved from http://www2.census.gov/geo/docs/reference/ua/PctUrbanRural_State.xls

U.S. Census Bereau. (2015). *Release number: CB15-215*. Retrieved from https://www.census.gov/newsroom/press-releases/2015/cb15-215.html

Walker, E. A., McCreery, R. W., Spratford, M., Oleson, J. J., Van Buren, J., Bentler, R., … Moeller, M. P. (2015). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear and Hearing, 36*(Suppl. 1), 38S–47S. DOI:10.1097/AUD.0000000000000208

Wei, X., Blackorby, J., & Schiller, E. (2011). Growth in reading achievement of students with disabilities, ages 7 to 17. *Exceptional Children, 78*(1), 89–106.

Wolk, S., & Allen, T. E. (1984). A 5-year follow-up of reading comprehension achievement of hearing-impaired students in special education programs. *Journal of Special Education, 18*(2), 161–176.

Ysseldyke, J., & Nelson, J. R. (2004). What we know and need to know about the consequences of high-stakes testing for students with disabilities. *Exceptional Children, 71*(1), 75–95.

CHAPTER 3: Characteristics of Preschool and Elementary School Services for Children Who are Hard of Hearing

Introduction

In the past quarter century, a radical shift has occurred in educational philosophy and ideology regarding children who are deaf and hard-of-hearing (CDHH). The Education for All Handicapped Children Act of 1975 and subsequent legislation have resulted in a flow of students away from isolated residential, educational facilities staffed with personnel specially trained to serve the needs of students with hearing loss (HL). The Annual Survey Report, released by the Gallaudet Research Institute (2014), described educational placements for 23,731 students who are DHH, allowing respondents to select more than one setting per student when children were in multiple placements. Fifty-one percent were placed in general education classrooms with hearing students, 30% were educated in special schools and 24% received instruction in self-contained classrooms within general education settings. The shift to more inclusive settings has not been restricted to residential schools. The percentage of students who are DHH who received more than 60% of their instruction in self-contained classrooms has also been in decline (Mitchell & Karchmer, 2006). In 2004, 87% of CDHH and who were receiving special education or related services spent at least part of their instructional day in regular education classrooms. This represents an increase of 10% over 1989 when 77% of CDHH spent part of their day in a regular education classroom. Children who received no services at all are not included in the report (Mitchell & Karchmer, 2011).

Among the demographic variables that may influence educational setting, the child's degree of hearing loss is significant. In the elementary and middle school years approximately 80% of the children who attend specialized schools for children with HL have severe-to-profound HL. Among those whose education is delivered in a self-contained classroom, approximately 60% have a severe-to-profound HL and when the setting is a regular education classroom, including resource rooms, only about 30% of the students have HL in that range (Blackorby & Knokey, 2006). Children who are hard of hearing (CHH), those with mild to severe hearing loss, and particularly those with no other educational challenges and who are English speakers are more likely to be educated in regular classrooms. The likelihood of full inclusion in a regular education classroom increases as degree of hearing loss decreases.

Malleable Factors in Child Outcomes

Recent investigations of outcomes and predictors of success provide evidence that success can be enhanced by several malleable factors. These include early and well-fit hearing aids (HAs) that provide optimal speech audibility (McCreery et al., 2015), early and consistent use of HAs (Walker et al., 2015a), and supporting parents in providing a rich linguistic environment (Ambrose et al., 2015). Walker and colleagues (2015b) have shown that even among children with mild hearing loss, well-fit and consistently worn HAs positively influence child speech and language outcomes.

Achieving consistent device use and providing an enriched language environment involve both the child's family and the professionals who coach and support the family as they work to achieve and maintain these goals. Investigators have reported the positive effects of family and professional collaboration (Moeller, 2000; Sarant, Holt, Dowell, Rickards, & Blamey, 2009; Spencer, 2004). A compelling finding regarding the critical role of family involvement was reported by Watkin et al., in 2007. These investigators determined that teacher ratings of parents' level of involvement and the language outcomes of their children were strongly correlated. In a comparison of two groups of children with later-confirmed hearing losses, those with highly involved families had higher speech and language scores than those with families who were less involved, indicating that high family involvement can mitigate the some of the consequences of later identification.

Professionals' Knowledge and Skills

In order for most families to become proficient at employing the factors that have been identified as supporting positive outcomes, a knowledgeable professional is an essential partner. Following HA fitting, that professional is most likely to be a speech-language pathologist (SLP) or a teacher of children who are deaf or hard-of-hearing (TODHH). However, as early as 1987, Woodford reported that among 102 SLPs who participated in a written and practical evaluation of their knowledge and skills regarding HA management, a majority of the sample lacked the basic skills required to check hearing aid function. Moseley, Mashie, Brandt and Fleming (1994) conducted a survey of 1,459 professionals working in educational programs for children with HL to describe the demographic characteristics of those providing speech-language services to the children and their perceived adequacy of pre-professionals training. Of the 487 professionals who returned the survey, 65.5% were SLPs, 17.2% were TODHH and 10.1% were audiologists. The SLPs reported themselves to be better prepared in normal speech and language processes, but among the three professional groups they were the least prepared in audiology, clinical procedures, including interpretation of auditory measures or providing parent support on issues related to deafness. The SLPs also indicated a need for more preparation in evaluation of speech and language skills of children with hearing loss and the use of HAs and cochlear implants.

More recently, Nelson, Poole and Munoz (2013) used a cross-sectional survey method to investigate the use of sound field amplification and FM systems in preschool classrooms for CDHH, and the teachers' perceptions of the advantages and disadvantages of the technologies. Although over three-quarters of respondents had an audiologist available for technical support, they still desired more training specific to troubleshooting assistive hearing technologies. Almost half (47%) wanted information regarding the benefits of these assistive devices for the children. All of these studies indicate the need for more preparation in the essential factors than can substantively moderate the effects of limited decreased auditory access on child outcomes. In order to be effective in supporting intervention and education of CDHH, professionals must be knowledgeable about recent technological breakthroughs in advanced hearing technology (e.g., digital hearing aids, cochlear implants, FM systems) and the potential impact such technologies have on providing access to a linguistically rich auditory signal through which developmentally appropriate language can develop (Houston & Perigoe, 2010).

Ironically, one of the challenges faced by those providing services to CDHH is the setting in which services are delivered. As noted by Blackorby & Knokey, (2006), children with HL in the mild-to-severe range are much more likely to be in general education classrooms than those with profound HL. When infants and toddlers have benefited from newborn hearing screening and early HA fitting, their speech and language skills are more likely to be within normal limits (Tomblin et al., 2015b), thus enhancing the possibility of placement in a regular education class. Although the environment provided in those classrooms is a goal many families have for their children, the challenge of providing consistent auditory access does not end at the classroom door.

Harrison et al. (2016) investigated factors affecting early intervention (EI) for CHH. They reported significant relationships between the percent of CDHH on a professional's caseload and self-reported levels of comfort with skills identified as fundamental for effective service provision. Specifically, eight skills had significant positive correlations with caseload composition, six of which related to hearing aid use and management and promoting listening skills. Essentially, professionals with caseloads that included a greater proportion of CDHH felt more competent with hearing technologies and supporting listening development than professionals who served smaller percentages of these children. Another finding was that across the birth-to-three years the proportion of families receiving EI services *outside* the home increased each year. When services were not provided at home, parent participation was significantly lower. As a result, opportunities for the family and professional to work together to promote and support consistent device use and provide enriched language environments for the child were reduced.

As children age out of EI services at three years of age, those who are placed in regular education preschool and elementary classrooms may be the only child in the class, and sometimes the entire school, with HL (Mitchell & Karchmer, 2006). Thus, the professionals who serve them may be less confident and experienced in providing services to CDHH. To compound these potential challenges, the level of family participation and collaboration with the child's teachers and other professionals is at risk as children enter preschool and elementary school.

Research Questions

This study examines current service provision patterns and factors that may affect the speech-language and educational services provided to CHH in their preschool and school age years. The following research questions are addressed in the current study:

1a. Where are speech-language and educational services for CHH delivered in the preschool and school age years?

1b. Are there differences in CHH outcomes across settings?

Hypothesis: We predict that children with greater degrees of HL and lower language levels will receive specialized services within general education settings. Children receiving no services will have language scores within or above the average range and better hearing thresholds compared to children receiving services.

2. What is the effect of service setting on family participation?

Hypothesis: We predict that most CHH will be placed in general education settings with less parent participation than reported for birth to three CHH (Harrison et al., 2016).

3a. What is the professional preparation and experience of individuals providing services to CHH?

3b. Does pre-professional preparation, experience or caseload composition relate to self-confidence in the delivery of specific professional skills?

Hypothesis: We predict that CHH will be served by professionals in a variety of fields and that a majority will be TODHH or SLPs. Due to education and training specific to pediatric hearing loss, TODHH will report more comfort in providing services to CHH than their intraprofessional colleagues.

Methods

Participants

Participants in the current study are 1) preschool and school age CHH and their parents, and 2) the professionals providing speech-language and educational services to them. Both groups of participants were initially recruited to participate in the Outcomes of Children with

Hearing Loss (OCHL) longitudinal study (Moeller & Tomblin, 2015). Children with a confirmed sensorineural, mixed, or permanent conductive bilateral hearing loss between 25 and 75 dB HL were included in the OCHL study. The preschool children (*n* = 174) averaged 50.5 months of age (*SD* = 7.9), and the 155 school age participants had a mean age of 81.2 months (*SD* = 13.8). Seventy-eight CHH transitioned from preschool to elementary school during the course of the study. Because the two age groups were analyzed separately, these 78 participants are represented in both groups, and thus the total number of unique CHH participants is 251.

Children with mild to severe degrees of HL were enrolled in the OCHL study. The majority of CHH had better-ear pure tone averages (BEPTAs) between 45 and 65 dB HL (*M* = 48.4, *SD* = 14.8). Seventy-one percent of the CHH were identified by newborn hearing screen establishing confirmation of HL at 7.4 months and HA fitting at 11.8 months on average. Later identified participants (29%) had hearing loss confirmed on average at 31.7 months with HA fitting at 32.6 months.

To describe the families who participated in the OCHL study in comparison to the population of the United States, participants provided demographic information including their educational background and annual income. In the present study, 53.6% of the mothers of the preschool and school age children enrolled in the study had earned a college, graduate, or professional degree. In contrast, only 33.4% of women 25 years or older in the U.S. have a college degree or higher (U.S. Census Bureau, 2013). Similarly, participating families reported higher levels of median household income (*mdn* range = $60,000 to $70,000) than the median U.S. household of $51,371 (U.S. Census Bureau, 2013). On average, the families enrolled in this study were more educated and had higher incomes than the larger population, typical for research involving volunteers (Holden, Rosenburg, Barker, Tuhrim, & Brenner, 1993).

Demographic descriptions of the child and family participants for both age groups are shown in Table 3.1.

Table 3.1 Description of Participating CHH and Their Households

Demographic and background characteristics	**Pre-K (*n* = 174)**		**School Age (*n* = 155)**	
	n	**%**	***n***	**%**
Highest educational level completed				
Some high school or less	2	1.2	1	0.7
Completed high school or equivalent	22	12.6	23	14.8
Post-secondary education	59	33.8	42	27.1
College graduate	41	23.6	43	27.7
Post-graduate work	49	28.2	44	28.4
Undisclosed	1	0.6	2	1.3
Household income level				
<$20,000	14	8.1	10	6.5
$20,001-$40,000	21	12.1	16	10.3
$40,001-$60,000	34	19.5	35	22.6
$60,001-$80,000	32	18.4	28	18.1
$80,001-$100,000	24	13.8	22	14.2
>$100,001	31	17.8	34	21.8
Undisclosed	18	10.3	10	6.5
CHH gender				
Male	96	55.2	81	52.3
Female	78	44.8	74	47.7
CHH ethnicity				
African American	13	7.5	9	5.8
Asian-Pacific	4	2.3	4	2.6
Hispanic or Latino	5	2.9	8	5.2
Multi-racial	8	4.6	9	5.8
White	140	80.3	120	77.4
Other	2	1.2	4	2.6
Undisclosed	2	1.2	1	0.6
Timing of identification				
HL identified at newborn screen	134	77.0	102	65.8
HL identified later	40	23.0	53	34.2
Service enrollment at last interview				
CHH receiving services	141	81.0	109	70.3
CHH not receiving services	33	19.0	46	29.7

Note. CHH = children who are hard of hearing; GED = general educational development; HL = hearing loss.

All participating families had at least one parent or primary caregiver who spoke English in the home. Children with developmental disabilities in addition to hearing loss were not included. Families were recruited from three study sites and surrounding states: University of Iowa, Iowa City, Iowa, Boys Town National Research Hospital Omaha, Nebraska and University of North Carolina, Chapel Hill, North Carolina. Approval was obtained from the Institutional Review Board at each research center.

The professionals (preschool *n* = 133; school age *n* = 104) who provided services to these children completed an online questionnaire each year a child was enrolled in the study. Among this group of professionals, 19 professionals provided services to children in both age groups. These professionals are represented in both the preschool and school age analyses and results.

Measures

Family Interview. In addition to standardized assessments, members of the OCHL research team developed two questionnaires. *The Family Interview* was designed to elicit information in seven categories, (a) household characteristics, (b) current child services, (c) parent/caregiver impressions of services, (d) additional services, (e) child-care, (f) child's disposition, and (g) sources of parent support. Three versions of the *Family Interview* were designed to best describe information relevant to three age groups, birth-to-three, preschool and school age. Data from the preschool and school age versions were used in this study. The National Early Intervention Longitudinal Study Interview (SRI, 2000) was the model for all the versions of this instrument; however, extensive modifications were made to adapt it specifically for families of CHH. An experienced research assistant, who is a parent of adult children who are deaf, completed the annual interview via telephone approximately 6 months after their study visit.

Service Provider Questionnaire. Three versions (birth-to-three, preschool and school age) of a *Service Provider Questionnaire (SPQ)* were also developed. This instrument was designed to elicit information from professionals who provided speech, language or educational services to the OCHL children. The *SPQ* consisted of six sections (a) characteristics of services provided to a family (e.g., type, frequency, setting, and family participation), (b) caseload characteristics, (c) provider preparation, (d) professional experience and comfort in providing services in specific skill areas, (e) family-centered practices, and (f) hearing aid and FM use. The sections regarding characteristics of services, caseload characteristics, provider preparation and professional experience, and confidence in skills were the sources of information reported here. The skills were identified by a group of professionals with experience providing speech and language services to CDHH. In response to each item professionals rated their comfort level on a four point Likert scale ranging from "Expert" to "None."

Parents provided contact information for the professionals and as well as a release of information form during their annual study visits. Service providers were mailed or emailed a link to the instrument and received a $15.00 gift card when it was completed. The *SPQ* and *Family Interview* are available to view at www.ochlstudy.org.

The preschool children enrolled in the OCHL study received services from 133 professionals. At school age 104 professionals provided those services. Fifty-five individuals completed both a preschool and school age *SPQ* during the course of the study. Their responses are included in both age groups of children in order to fully describe each cohort of professionals.

Audiological measures. Child participants completed a hearing evaluation that included otoscopy, pure tone audiometry, and tympanometry at each study visit. Hearing thresholds were obtained using insert earphones, supra-aural headphones, insert earphones with the child's earmolds, or via sound field, if ear-specific thresholds could not be measured. A four frequency BEPTA was calculated at 0.5, 1, 2, and 4 kHz. The most recent clinical audiogram was used when thresholds could not be completed at the study visit.

Speech and language measures. To compare the communication outcomes off CHH across a variety of service settings, speech and language testing results from the larger OCHL study were used. During selection of the tests used in this study, an emphasis was placed upon clinical and educational relevance, and thus standardized measures chosen are frequently used to evaluate preschool and school age children. These included the Goldman-Fristoe Test of Articulation 2nd edition (GFTA-2) Sounds-in-Words subtest (Goldman, R., & Fristoe, M., 1999), the Word Structure subtest of the Clinical Evaluation of Language Fundamentals 4th Edition (CELF-4; Semel, E., Wiig, E., Secord, W., 2004), the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, E. (1999) Core and Syntax subtest scores, the Wechsler Preschool and Primary Scale of Intelligence III (WPPSI-III) Vocabulary subtest, (Wechsler, D., 2002) and the Wechsler Abbreviated Scale of Intelligence (WASI) Vocabulary subtest (Wechsler, D., & Hsiao-pin, C., 2011). The tests selected and the number of children receiving each test by age group are shown in Table 3.2.

Table 3.2 The Number of CHH Participants for Speech and Language Outcomes by Visit

	Preschool			School				
Measures	3 Years	4 Years	5 Years[a]	5 Years[a]	6 Years	7 Years	8 Years	9 Years
Articulation								
GFTA-2 Sounds-in-Words	27	-	23	32	-	31	-	14
Language								
CASL Core Composite	13	101	5	2	35	4	18	1
Syntax[a]	13	101	22	26	39	34	18	1
Definitional Vocabulary								
WPPSI-III Vocabulary	-	80	-	-	-	-	-	-
WASI Vocabulary	-	-	-	-	36	34	19	16

Note. CHH = children who are hard of hearing; CASL = Comprehensive Assessment of Spoken Language; CELF-4 = Clinical Evaluation of Language Fundamentals 4th Edition; GFTA-2 = Goldman-Fristoe Test of Articulation 2nd edition; WASI = Wechsler Abbreviated Scale of Intelligence; WPPSI-III = Wechsler Preschool and Primary Scale of Intelligence 3rd Edition.

[a]5 year-olds were assigned to the preschool- or school-age group based upon their educational placement.
[b]Syntax consists of either the CASL Syntax subtest or the CELF-4 Word Structure subtest. In the four instances where participants were administered both subtests in the same year, the higher of the two scores was used.

Results

Educational Settings and Associated Outcomes

Research questions 1a and 1b aimed to describe where services are provided for CHH during the preschool and early school age years, and to determine whether there are differences in student characteristics across service settings. Parents were asked to identify the setting where their child most frequently received speech-language and education services in the annual *Family Interview*. Reported settings included general education preschools/schools, preschools/schools for CDHH, preschools for children with exceptional needs, childcare centers, clinics or therapist's offices, and home.

Families of preschool aged children reported that 19% (33 of 174) did not receive intervention services related to their HL. Of the preschool CHH enrolled in services, the largest percentage of preschool settings were general education preschools (32.6%, n = 46) and preschools for CDHH (31.2%, n = 44). The remaining CHH received services in preschools for children with exceptionalities (17%, n = 24), clinics or therapist's offices (14.2%, n = 20), at childcare (2.9%, n = 4), or in the home (2.1%, n = 3).

At school age, parents reported that 30% (46 of 155) of the children were not receiving services. Among the children who did have services, most (83%, n = 91) were delivered in a general education setting, 10% in an office/clinic (n = 11), 6% in schools for CDHH (n = 6), and <1% at home (n = 1).

Audiological characteristics by service setting. To address research question 1b, we utilized analyses of variance (ANOVA) for both preschool and school age service settings to test for differences between mean BEPTA, mean age in months when hearing loss was identified, and mean age in months when hearing aids (HAs) were first fitted.

Preschool settings used in the analysis consisted of general education preschools (*n* = 46), preschools for CDHH (*n* = 44), preschools for children with exceptional needs (*n* = 24), clinic or therapist's offices (*n* = 20). Children who did not receive services during preschool were included as a *no services* (*n* = 33) group. Because few preschool children received services in childcare (*n* = 4) or at home (*n* = 3), they were not included in these analyses. There were no statistically significant mean differences between preschool service settings detected for BEPTA (*F* (4, 162) = 1.42, *p* = .23), age of hearing loss diagnosis (*F* (4, 160) = 0.83, *p* = .511), nor age of HA fit (*F* (4, 159) = 0.59, *p* = .672).

The school age settings included general education schools (*n* = 91), schools for CDHH (*n* = 6), clinic or therapist's offices (*n* = 11), and *no services* (*n* = 46). Among school age children, the mean BEPTA between service settings was statistically significant (*F* (3, 150) = 4.55, *p* = .004). *Post hoc* pairwise comparisons using Bonferroni adjustments were performed to determine which specific service settings were significantly different from one another. These tests, shown in Table 3.3, revealed that, on average, children who received services in general education school settings had significantly poorer hearing thresholds (*M* = 50.22, *SD* = 14.46) than children who were not in services (*M* = 41.91, *SD* = 12.61). No other pairwise comparisons yielded significantly different results. There were no statistically significant main effects yielded between school age service settings for age of hearing loss diagnosis (*F* (3, 149) = 1.5, *p* = .217) or age of HA fit (*F* (3, 142) = 1.79, *p* = .153).

Speech-language characteristics by service setting. Next, we utilized ANOVAs to assess differences in articulation, language, and definitional vocabulary abilities between service settings for the preschool and school age CHH. Significant differences between preschool service settings were found on the CASL Core composite (*F* (4, 114) = 6.82, *p* < .0001) and for syntax (*F* (4, 132) = 5.21, *p* < .001). Post hoc comparisons using a Bonferroni multiple comparisons adjustment showed significant differences in CASL composite scores between the no services group (*M* = 110.0, *SD* = 18.228) and three preschool settings including general education preschools (*M* = 90.6, *SD* = 18.243), preschools for CDHH (*M* = 87.6, *SD* = 16.741), and the preschools for exceptional children (*M* = 88.4, *SD* = 17.185). On the preschool syntax measures, significant differences existed between the no services group (*M* = 102.5, *SD* = 16.026) and the same three settings: general education preschools (*M* = 89.4, *SD* = 16.609), preschools for CDHH (*M* = 86.5, *SD* = 15.545), and the preschools for exceptional children (*M* = 84.4, *SD* = 15.632). Children in the no services group demonstrated consistently better outcomes (i.e., group means) than children who received services, regardless of setting. There were no significant differences in the performance of preschool CDHH receiving services in a clinic or therapist's office and any of the other preschool groups. Significant main effects were not detected for outcomes on the preschool GFTA2 Sounds-in-Words subtest (*F* (4, 45) = 1.62, *p* = .187) nor for WPPSI Vocabulary subtest (*F* (4, 75) = 1.52, *p* = .203).

Similarly, we utilized ANOVAs for the school age settings to assess differences in articulation, language, and definitional vocabulary abilities of CDHH. Again, the no services group consistently demonstrated the highest mean scores on all measures compared to school age students in any of the service settings. Statistically significant main effects were detected for the GFTA2 Sounds-in-Words subtest (Welch's *F* (3, 7) = 6.30, *p* = .020). Post hoc comparisons using a Bonferroni multiple comparisons adjustment showed significant differences in standard scores between the no services group (*M* = 105.2, *SD* = 8.648) and the general education setting (*M* = 93.2, *SD* = 12.648) and schools for CDHH (*M* = 83.7, *SD* = 29.670). CASL composite scores also returned a significant main effect (*F* (3, 56) = 3.88, p = .014), and *post hoc* comparisons revealed significant group differences between the no services group (*M* = 117.5, *SD* = 17.022) and schools for CDHH (*M* = 69.5, *SD* = 7.778). For school age syntactic abilities, a significant main effect (*F* (3, 116) = 11.71, p < .0001) was also calculated. Pairwise comparisons determined statistically significant differences between the no services group (*M* = 112.3, *SD* = 17.009) and three settings including general education settings (*M* = 93.1, *SD* = 17.543), schools for CDHH (*M* = 74.4, *SD* = 29.779), and therapist's office/clinic (*M* = 92.8, *SD* = 17.268). Definitional vocabulary abilities, as measured by the WASI Vocabulary subtest, yielded a statistically significant main effect between standard *t*-scores (*F* (3, 101) = 8.95, p < .0001). Bonferroni comparisons detected significant group differences between the no services group (*M* = 56.9, *SD* = 10.618), and general education settings (*M* = 47.6, *SD* = 9.468), schools for CDHH (*M* = 33.5, *SD* = 2.121), and therapist's office/clinic (*M* = 45.3, *SD* = 6.047).

Table 3.3 Statistically Significant ANOVAs and *Post Hoc t*-tests Comparing Service Location to Preschool and School Age Outcomes

	ANOVA main effects			*Post hoc* comparisons			
						95% Family-wise CI	
Source	***df***	***F***	***p***	***M* difference[a]**	***p* adjusted[b]**	**Lower bound**	**Upper bound**
Preschool							
Syntax[c]	4, 132	4.90	.001				
No services X general ed. preschool				13.180	.017	1.823	24.536
No services X preschool for CDHH				16.079	.002	4.600	27.558
No services X preschool for CE				18.117	.003	4.580	31.655
CASL Core Composite	4, 114	6.82	<.0001				
No services X general ed. preschool				19.400	.001	5.850	32.950
No services X preschool for CDHH				22.429	<.0001	9.306	35.552
No services X preschool for CE				21.611	.002	6.226	36.997
School							
BEPTA	3, 150	4.55	.004				
No services X general ed. school				-8.312	.012	-15.191	-1.434
GFTA2[d]	3, 7	6.30	.020				
No services X general ed. school				11.974	.002	3.656	20.292
No services X school for CDHH				21.507	.035	1.587	41.428
Syntax[c]	3, 116	11.71	<.0001				
No services X general ed. school				19.203	<.0001	9.285	29.121
No services X school for CDHH				37.913	<.001	15.417	60.408
No services X Office/clinic				19.513	.020	2.565	36.460
CASL Core Composite[d]	3, 56	3.88	.014				
No services X school for CDHH				48.000	.021	6.273	89.726
WASI Vocabulary	3, 101	8.95	<.0001				
No services X general ed. school				9.344	<.001	3.773	14.915
No services X school for CDHH				23.397	.007	5.073	41.720
No services X Office/clinic				11.611	.030	1.056	22.166

Note. BEPTA = better-ear pure tone average; CDHH = children who are deaf or hard of hearing; CE = children with exceptionalities; Ed = education; GFTA2 = Goldman-Fristoe Test of Articulation (2nd edition) Sounds-in-Words subtest; WASI = Wechsler Abbreviated Scale of Intelligence.
[a]*M* Difference = *M* (no services) – *M* (intervention setting). [b]Bonferroni adjustment for multiple comparisons. [c]Depending on age at testing, syntax was either assessed with the Comprehensive Assessment of Spoken Language Syntax subtest or the Clinical Evaluation of Language Fundamentals (4th edition) Word Structure subtest. [d]Welch's *F*-ratio was utilized to address heterogeneity of variance in GFTA2 scores.

Family Participation in Services

Research question 2 examines whether a relationship exists between service setting and family participation in intervention. Families were asked how frequently they were able to participate in the services their child received. Response choices included *Always, Most of the time, About half the time, Some of the time, Not very often* and *Never*. The number of responses in several of the response choices was low. To facilitate analysis, levels of participation were collapsed from six into three, *Always/Most of the time, About half /Some of the time,* and *Not very often/ Never.* Three families with preschoolers and four with school age children declined to report their level of participation in their child's services leaving a total of 138 preschool and 105 school age family reports. Initial review of the data revealed that families reported a low level of participation in childcare as well as all preschool settings, regardless of designation. Settings were also combined in regards to environments where services and academics were likely delivered amongst peers (i.e., general education preschools/schools, preschools/schools for CDHH, preschools for children with exceptionalities and childcare), labeled *Preschool* or delivered individually (i.e., therapist office or clinic and home), identified as *Other Than Preschool.*

In contrast to the birth-to-three years when the majority of the services were delivered in families' homes (Harrison et al., 2016), only 17% (n = 23) of the families with preschool children reported receiving services in their homes or in a therapist's office by their last preschool *Family Interview*. Among this group, approximately one-third (n = 7) of the families reported participating *Always/ Most of the time*. In the *Preschool* setting, 77.3% – 88.6% of families reported participation in their child's services as *Not very often/Never*. A Pearson's Chi-square test (p = .0001) indicated significantly more family participation when services were delivered in an "*Other than preschool*" versus "*Preschool*" setting. Service setting and the family level of participation in services by setting in the last year of preschool are shown in Table 3.4.

Among families with school age children, 90% (*n* =95) reported that their child received services at school. Family participation was very low in that setting with 86% (*n* = 90) reporting that they *Never/Not very often* participated in services delivered in a school setting. Only ten percent (*n* =10) of the children received services in a non-school location. Three of the families indicated participating *Most of the time/Always* in their child's services with the other seven families reporting lesser amounts of involvement.

Table 3.4 Family Participation by Age-group and Service Setting

		Participation (%)		
Setting	***n***	**Never or not very often**	**About half or some of the time**	**Most of the time or always**
Preschool age				
Preschool	115	84.4	13.9	1.7
Other than preschool	23	56.6	13.0	30.5
School age				
School	95	94.7	5.3	0.0
Other than school	10	50.0	20.0	30.0

Professionals Providing Services

Research question 3a focused upon understanding the preparation, experience, and caseloads of professionals working with preschool and school age CHH, while 3b aimed to determine whether these variables were related to professional comfort with specific intervention and assessment skills relevant to the unique needs of these children and their families, factors that could potentially impact CHH outcomes. The information presented in this section is based upon the last report of the preschool or school age *SPQ* completed by the professionals who provided services related to hearing loss and communication.

Degrees, certifications, and continuing education. Among the preschool professionals, 51% (*n* = 68) identified themselves as an SLP, and 44% (*n* = 58) as a TODHH. The seven remaining service providers were special educators (*n* = 5), one early childhood educator and one speech-language assistant. All of the SLPs had earned at least a master's degree; one had earned an educational specialist degree (Ed.S.), and another had a Ph.D. Among the TODHH, the majority (*n* = 43) had a master's degree and one also had an Ed.S. The remaining 14 had a bachelor's degree. Three of the six special educator/early childhood special educators had a master's degree. The SLP assistant held an associate's degree.

Professionals were also asked to indicate any certifications they had earned in addition to that associated with their primary degree. The results for the SLPs and TODHH were strikingly similar with 88% of both groups reporting no additional certifications. Four of the SLPs (5.9%) and three of the TODHH (5.2%) were certified as either an auditory verbal therapist (AVT) or auditory verbal educator (AVEd). Two (2.9%) who identified their profession as an SLP and two (3. 5%) who identified as a TODHH were certified as both SLPs/TODHH. One TODHH was a certified reading specialist and one had a certificate in administration. The professional with a degree in special education reported being a certified sign language interpreter.

These professionals were also asked to identify the continuing education they had that was specifically related to childhood hearing loss. Among the 68 SLPs, only five percent (*n* = 7) indicated they had no related continuing education. The remaining 95% reported continuing education experiences ranging from as little as a half-day workshop to as much as a semester-long course or more. Of the 58 TODHH, 40% (*n* = 23) reported that they did not have any continuing education related to childhood hearing loss. The other 60% had a range of experiences as shown in Table 3.5.

At school age, 104 professionals provided services to the children in the study. Fifty-three percent (*n* = 55) were SLPs, 45% (*n* = 47) identified themselves as a TODHH, one as a special educator and one as a speech-language assistant. As was the case among preschool professionals all of the SLPs had earned a master's degree. Among the TODHH, 64% (*n* = 30) had a master's degree, 35% reported having a bachelor's degree and one had a doctoral degree. The special educator reported having earned a master's degree. The SLP assistant had an Associate's degree.

In response to the question about additional certifications, 82% (*n* = 45) of the SLPs and 92% (*n* =4) of the TODHH reported having none. Four of the SLPs (7%) were also certified as an Auditory-Verbal Therapist (AVT) or Auditory-Verbal Educator (AVEd). Three SLPs (5%) and one TODHH (2%) were certified as both SLPs and TODHH. Other SLP certifications included one in each of the following areas, special education, early childhood special education and administration. One additional certification was reported by TODHH in each of the following areas, reading, sign language, and administration. As seen in Table 3.5 continuing education among the professionals providing services to school age children was very similar to that of the professionals serving pre-school children.

Table 3.5 Reported Continuing Education Regarding Childhood Hearing Loss

	Continuing education (%)			
Profession	**None**	**Day-long in-service**	**One to two week course**	**Semester-long course or more**
Preschool age				
SLP	7 (10.3)	10 (14.7)	4 (5.9)	47 (69.1)
TODHH	23 (39.6)	12 (20.7)	4 (6.9)	19 (32.8)
School age				
SLP	6 (10.9)	8 (14.6)	2 (3.6)	39 (70.9)
TODHH	19 (40.4)	4 (8.5)	8 (17.0)	16 (34.1)

Note. SLP = speech-language pathologist; TODHH = teacher of children who are deaf or hard of hearing.

Years of Experience and Caseloads. Almost half (43.6%, *n* = 58) of the professionals providing services to preschool children had five or fewer years of experience. Another 20.3% had worked with preschoolers for 6 to 10 years with the remaining 36% reporting years of experience of 11 years or more. In contrast, 26% (*n* = 27) of school professionals had five or fewer years of experience and 21. 2% had 6 - 10 years. Another 22.1% reported more than 20 years of experience. Regardless of the children's age group, a two-sample t-test with equal variances indicated that the number of years of experience of the SLPs (*M* = 11.47, *SD* = 8.55) and the TODHH (*M* = 15.80, *SD* = 10.29) was significantly different (*t* = 2.37, *df* = 100, *p* = .0197) with TODHH averaging about 4 more years of work experience

Professions other than SLP or TODHH accounted for only 3.8% (*n* = 9) of the 237 responses to the *SPQ,* thus they have been removed from the following descriptions. The pre-professional education and the professional scope of practice of SLPs and TODHH are quite different. To explore the effect of these factors on caseloads and comfort with skills identified as fundamental to providing services to CDHH, these two groups were analyzed separately. Caseload characteristics including the total size, range, mean and median were calculated separately for those working with preschoolers (*n* = 126) versus those working with school age children (*n* = 104). If a professional had completed more than one annual survey over the preschool or school years, an average of the surveys submitted was calculated for both total number of children and percent of CDHH on their caseload. One respondent who worked with preschool children declined to complete the question related to the percent of CDHH on her caseload. Thus, 125 service providers are represented in that summary. As shown in Table 3.6, at both preschool and school age the caseload ranges, means, and medians were much higher for SLPs than for TODHH. However, the percent of children who were DHH on those caseloads was considerably higher for TODHH in both age groups. The exception was SLPs who were dually certified as a SLP and a TODHH, or who had certification as an AVT or AVEd. Using Pearson correlation, more specialized preparation in the area of childhood HL was correlated (r = 0.382; p = .0040) with a higher percent of children with HL on those SLPs caseloads. Specialized preparation was not significantly correlated with caseload composition of TODHH (r = 0.121; p = .4162).

Table 3.6. **SLP and TODHH Caseloads**

		Total students on caseload			**% of caseload with HL**		
Setting	***n***	**Range**	***M (SD)***	**Median**	**Range**	***M (SD)***	**Median**
Preschool age							
SLP[a]	68	5 - 80	34.4 (15.85)	32.8	1.8 – 100.0	29.0 (0.36)	8.9
TODHH	58	4 - 50	14.7 (10.15)	11.5	11.4 – 100.0	94.0 (0.17)	100.0
School age							
SLP	55	5 – 87	40.7 (18.23)	40.0	1.1 - 100.0	21.5 (0.33)	7.1
TODHH	47	4 - 45	17.1 (9.87)	14.8	45.8 – 100.0	97.7 (0.08)	100.0

Note. HL = hearing loss; SLP = speech-language pathologist; TODHH = teacher of children who are deaf or hard of hearing.
[a]Of the 68 preschool SLPs, one provided the total caseload amount but did not report the caseload percentage of HL

Provider Self-Assessment of Comfort. Each respondent who provided services to children at the preschool or school age was asked to indicate their level of comfort in response to a list of skills associated with providing services to CHH. Once again, because of the very small number of individuals (*n* = 9) who were neither an SLP nor a TODHH, those individuals are excluded in the analysis of comfort scores. A Fisher's Exact test was used to compare the self-reported comfort level the SLPs and TODHHs reported for each skill. This method was used rather than a Pearson Chi-Square test of independence because many cells contained five or fewer responses.

Among the SLPs (*n* = 68), and TODHH (*n* = 58), who responded to the 19 skills on the preschool list, the greatest difference in scores was found among skills associated with hearing technologies and auditory development using those technologies. As seen in Table 3.7, TODHH reported significantly more comfort ($p = < .0001$) providing each of the six items in this skill area including, inserting earmolds, daily HA checks, using the Ling sounds, troubleshooting hearing devices, using FM systems and developing a child's ability to listen. A significant difference at this level was also found with promoting early literacy. Among the remaining twelve skills, TODHH reported more comfort with six of them: however, as shown in Table 3.7 the difference was not as robust. No difference in comfort was found between the two professions for four of the skills. The only skill in which the preschool SLPs reported being more comfortable than the TODHH was assessing speech ($p = .0045$).

Twenty-five skills were included in the list related to school age children. Results were similar to that of the preschool professionals with TODHH reporting more comfort with the six skills involving hearing technologies and auditory development than did SLPs ($p = < .0001$). The TODHH also reported being more comfortable with six other essential skills. However, SLPs working with school age children reported more comfort than did TODHH with all of the items related to speech, as well as carryover of language goals to the home. No difference was found between the two professional groups on the eight remaining skill items.

As noted earlier, a small number of SLPs serving children in preschool also held certification as a TODHH ($n = 2$) or an AVT or AVEd ($n = 4$). When the comfort levels of this small group of individuals were compared to the larger group of SLPs without additional certifications related to hearing, significant differences appeared among skills specific to device management and auditory development. The group with additional certification reported being more comfortable inserting earmolds ($p = .0307$), conducting daily listening checks ($p = .0301$), using Ling sounds ($p = .0067$), troubleshooting hearing devices ($p = .0265$) and developing listening skills ($p = .002$). Among the SLPs serving school age children three were also certified as a TODHH and four were certified AVTs or AVEds. These professionals reported being more comfortable with three skills necessary for device management such as inserting earmolds ($p = .003$), conducting daily hearing aid checks ($p = .0074$) and troubleshooting devices ($p = .0008$).

Table 3.7 Professional Differences in Self-reported Comfort Providing Essential Skills to Preschool and School CHH

	Preschool							School						
	SLP			TODHH				SLP			TODHH			
Skill area	*n*	*M*	*SD*	*n*	*M*	*SD*	*p*	*n*	*M*	*SD*	*n*	*M*	*SD*	*p*
Assessing speech	68	1.50	0.504	57	1.759	0.512	.0045*	54	1.283	0.455	44	2.20	0.797	<.0001*
Assessing communication approach	68	1.788	0.595	57	1.333	0.476	.0001*	-	-	-	-	-	-	-
Designing therapy goals	68	1.561	0.558	58	1.204	0.451	.0018*	54	1.463	0.499	47	1.396	0.486	.429
Developing sign language	67	1.561	0.585	58	1.315	0.543	.0001*	55	1.943	0.818	41	1.314	0.471	<.0001*
Promoting speech into routines	-	-	-	-	-	-	-	54	1.444	0.533	45	1.822	0.739	.0221*
Carryover of speech therapy to home	68	2.227	1.005	56	1.056	0.231	.6569	54	1.509	0.505	41	2.2	0.868	<.0001*
Carryover of speech therapy to class	-	-	-	-	-	-	-	54	1.509	0.505	41	2.029	0.822	.0005*
Building language through play	68	1.273	0.482	58	1.093	0.292	.0292*	-	-	-	-	-	-	-
Promoting language in routines	68	1.333	0.506	58	1.074	0.264	.0046*	54	1.434	0.537	47	1.829	0.747	.7682
Carryover of language therapy to home	68	2.439	1.242	57	1.111	0.372	.0542	53	1.491	0.505	46	1.8	0.797	.0172*
Promoting participation in discussions	-	-	-	-	-	-	-	54	1.434	0.537	47	1.829	0.747	.0297*
Promoting early literacy / literacy	68	2.197	0.932	58	1.093	0.293	<.0001*	53	1.793	0.600	47	1.486	0.702	.001*
Supporting academic development	-	-	-	-	-	-	-	55	1.679	0.510	47	1.343	0.482	.0005*
Promoting accommodations in school	-	-	-	-	-	-	-	54	2.321	1.034	47	1.086	0.284	<.0001*
Developing self-advocacy	-	-	-	-	-	-	-	53	1.717	0.568	47	1.314	0.530	.0002*
Developing listening skills	67	1.788	0.595	58	1.333	0.476	<.0001*	55	2.076	0.805	47	1.486	0.562	<.0001*
Using Ling sounds	68	2.136	0.875	56	1.278	0.492	<.0001*	55	2.453	1.249	46	1.086	0.374	<.0001*
Inserting earmolds	67	2.667	0.950	58	1.370	0.525	<.0001*	55	2.547	0.845	47	1.714	0.750	<.0001*
Daily hearing aid checks	68	2.152	0.846	58	1.222	0.420	<.0001*	55	2.283	1.099	46	1.057	0.236	<.0001*
Troubleshooting hearing devices	68	1.50	0.504	58	1.759	0.512	<.0001*	55	2.660	0.999	47	1.371	0.490	<.0001*
Using FM	67	1.485	0.533	58	1.259	0.483	<.0001*	55	1.981	0.796	47	1.229	0.426	<.0001*

Note. Participants rated their comfort on a 4-point scale with lower scores indicating more comfort with a particular skill. Dashes indicate a particular skill was not queried on either the preschool or school survey. CHH = children who are hard of hearing; FM = frequency-modulated amplification system; SLP = speech-language pathologist; TODHH = teacher of children who are deaf and hard of hearing. *indicates significant between group differences at the <.05 level

Discussion

Service Setting and Outcomes

Primary findings from the larger OCHL study emphasize the importance of early, foundational goals for CHH which target consistent device use and coaching families to provide quality linguistic interactions. These intervention-based variables predict later language abilities, but unfortunately, these goals are not attained by every family/professional team by the child's third birthday (Moeller et al., 2015). In fact, nearly half of the OCHL kindergartners were one or more standard deviations behind their peers with typical hearing in regards to their language abilities (Tomblin et al., 2015b). This suggests that many CHH and their families continue to need support into the preschool and elementary school years. While young CHH primarily receive EI services at home (Harrison et al., 2016), the present study suggests that the preschool years, from ages 3 to roughly 6 years represent an interim period, as children and families transition out of home-based Part C services into a diverse array of intervention settings, primarily within preschools for CDHH, children with exceptionalities or general education preschools, but also in clinics, private-pay, or childcare settings. As hypothesized, the majority of children who continue to require services by kindergarten are most likely to receive them in a general education school setting, consistent with the trend of greater inclusion for this population (Gallaudet Research Institute, 2014). The preschool and early school years provide a critical opportunity, especially for those children who are later identified, later fitted with HAs, and for those who have not experienced quality linguistic interactions and/or optimal HA use, to achieve a higher level of communicative and academic success.

It is important to note that not all CHH continue to need, or qualify for speech and language services as they transition from EI to pre-K. Some of the children achieve consistent access to audition by their third birthday and have a family that is able to support language development at an age appropriate level. This study found a number of differences between CHH who were and were not receiving services. While there was not a statistically significant difference at preschool, CHH with milder degrees of hearing loss were less likely to receive services than children who have moderate to severe losses in elementary school. Regarding language, children receiving intervention services in a general education or specialized preschool had mean standard scores on syntax and global language measures between nearly 1 to 1.5 standard deviations behind children without services, suggesting that many children needing services were receiving them. Similar discrepancies in language existed for the school age setting comparisons. Contrary to our proposed hypotheses, CHH with greater degrees of HL and lower language levels primarily received services in general education environments rather than specialized education settings like schools for the DHH or children with exceptionalities.

The overall findings may be considered largely confirmatory: children no longer enrolled in intervention demonstrated higher proficiency in several domains of speech and language than children who continue to receive services in those areas. Nonetheless, these results underscore the continued need for speech and language intervention beyond the birth to three years for the majority of CHH, even in the age of newborn hearing screening and earlier intervention. Fortunately, our findings suggest that many CHH have access and continue to receive support services when individual delays persist, though neither the effectiveness nor the quality of their services were explicitly evaluated here.

Family Participation

In the U.S., when children with exceptionalities transition from EI (Part C) to preschool (Part B), there is a shift from a family-centered to a child- or school-centered model of service delivery (Individuals with Disabilities Education Act, 2004). For Part B services, home-based programs are rarely supported by the local school systems that provide and manage those services. As families transition into school or center-based services, the family-professional partnerships that may have been created over the course of EI, frequently come to an end. Simultaneously, families are asked to navigate new personnel, terminology, eligibility requirements, settings, and other novel factors. Notably, many parents experience a significant reduction in their role from an active leader and participant in their child's services (Fox, Dunlap, & Cushing, 2002). Our results confirm that family participation levels in preschool and school settings were low for the 70% of students who received services related to their HL in their elementary school years.

The present study does not assert that more parent participation in preschool- and school-based services leads to better communication outcomes for CHH. However, a conservative view could reason that higher levels of family participation would allow for more or richer opportunities for parent-professional collaboration, carryover of goals and related strategies outside of school, and the potential for families to be better informed regarding the dynamic abilities and needs of their children as they continue to develop within their educational setting.

Ambrose et al. (2015) provided evidence to support the need for prolonged involvement of some families of CHH. These investigators studied the quantity and quality of caregiver talk at eighteen months and three years of age. They reported that the quality of child language outcomes at three years was related to the quality, but not quantity, of caregiver input at 18 months. Furthermore, the quantity of directing utterances by the caregiver accounted for significant variance in child language outcomes with more directive caregiver input resulting in weaker child language outcomes at three years of age. Families with a pattern of directive input may well need continued professional support as they transition into a Part B service model to develop conversational rather than directive language interactions with their CHH.

The EI goals for most CHH should include achieving consistent device use and coaching families to provide quality linguistic interactions. The preschool and early school years can provide a critical opportunity, especially for those children who are later identified or later fitted with HAs and for those who have not experienced quality linguistic interactions, to achieve a higher level of success. With such low levels of parent participation where the majority of preschool and school age CHH receive services, the model currently in place is not optimally structured to assist families who need continued support to achieve consistent auditory access within a linguistically rich environment. Unfortunately, several factors that are likely to impede progress converge during the preschool and early school years. As noted, family participation, which is crucial for collaboration is minimal following transition from EI. It is also the case that preparation of approximately half of the professionals who serve CHH in preschools and schools is inadequate to provide them with some of the critical services and foundational skills required for success.

Factors Contributing to Professionals' Comfort

An essential component necessary to capitalize on opportunities post EI is the availability of professionals who are prepared to identify and provide the services needed to support development of language, speech and audition. As noted by Karchmer and Mitchell (2003, 2011) with the success of early identification and intervention, a significant demographic shift towards fuller inclusion in regular education classrooms, especially for those children with hearing losses in the mild to moderate range, has occurred. Although there are many positive aspects of this trend, the authors expressed concerns regarding the ability of teachers and other professionals in regular education classrooms to understand and address the developmental and educational challenges resulting from the children's restricted access to the auditory signal. Among the malleable strategies identified by the OCHL researchers, consistent HA use and coaching families in providing a linguistically rich environment are two that both SLPs and TODHH should be instrumental in supporting. Although the pre-professional education of SLPs prepares them to diagnose and provide intervention for a wide range of communication disorders across the lifespan, the certification requirement for knowledge and skills in the area of childhood hearing loss can be met by a few hours of supervised hearing screening and as little as one academic course.

In the current study, more than half of the professionals who provided language and speech services to preschool and school age CHH were SLPs. Yet, as a group the SLPs reported significantly less comfort than did TODHH with many of the skills necessary to support successful outcomes for the children. This was most clearly the case in regards to all of the skills associated with managing HAs and FM systems, the instruments that provide consistent auditory access and the bridge to language competency. The exceptions were those few SLPs who identified themselves as holding certifications that provided the skills and knowledge to manage HAs effectively. These included those who had earned a bachelor's degree as an educator of children with hearing loss, which made them eligible for that certification or who pursued AVT or AVEd certification after earning a master's degree in SLP. Although these data provide an indication that additional preparation makes a difference in comfort with these important skills, the number of individuals in this sample is small. What remains unclear is whether or not relatively brief, but well-designed modules could be used outside of an intensive certification process to increase comfort and competence in supporting auditory development and managing HAs to improve device use among SLPs.

Although some university programs do provide an option for specialized education in working with CDHH, preparation of every SLP to provide these services is not feasible. A strategy that has been employed by some local education agencies and state departments of public instruction is the placement of SLPs with expertise in childhood HL in consultative positions. These individuals provide technical support, coaching and professional education to SLPs who lack those skills and knowledge.

The devastating effects of inconsistent access to auditory input on language learning and school success have been well documented (Karchmer & Mitchell, 2003; White, 2006) and it is clear that SLPs need more preparation than is currently required for certification to comfortably and effectively support the management and use of hearing technology. Speech-language pathologists have the educational and clinical foundations upon which to build an understanding of the effects of HL on speech perception, language and learning. Combined with their extensive knowledge of a wide variety of other language and speech disorders, mentoring and technical support in regards to hearing devices and their effects upon auditory access would support SLPs in providing effective and comprehensive services to children with HL, including the large proportion who have additional language or other developmental challenges.

Limitations

The children enrolled in the OCHL study all had families with at least one parent who spoke English in the home and none of the children had co-occurring disabilities that significantly limited their cognitive or linguistic development. Children with unilateral or profound hearing loss and those with cochlear implants were also excluded from the study.

Although a broad range of maternal educational level and family income is represented in the sample, it is skewed in the direction of highly educated and resourced families. As has been noted, this is typical of families who are able to participate in longitudinal studies. However, this group of children is not representative of the entire population of CHH. As a result, these findings may portray a “better case scenario” than what is realized in the population of CHH, especially those with additional developmental or socioeconomic challenges.

While it is clear that levels of family participation are significantly lower when services are provided outside of the home, based on the data collected we cannot determine the degree to which families communicate with their child’s service providers through means other than by being present when services are delivered.

Implications for Professional Education

In the models of service delivery currently in place, families are at the center of service delivery until their children attain the age of three years at which time the model changes to one with much less focus on family involvement. However, some families and their children continue to warrant a higher level of family/professional interaction to achieve elusive intervention goals than is provided in most Part B programs. Consistent HA use, in particular, is essential to access the auditory information presented in preschools and schools that will support language development and academic success. Identifying children who have not achieved consistent device use around the period of transition from Part C to Part B services and providing enhanced support by a skilled SLP could provide an essential service component that is currently available in very few systems. A comprehensive approach, and one which builds competency within the system, would be to have an expert SLP work with classroom teachers and other SLPs in conjunction with the family. In this model, consistent HA use is a team goal with mutual support from multiple individuals. Because inconsistent HA use often results in compromised language development, this model could also be used to promote an enriched language environment in which parents and professionals strive to engage the child in linguistic interactions that are more conversational than directive. Another possibility might be to offer continuing education modules focused on specific critical skills. Regardless of the approach employed, there is evidence that skills managing hearing devices and developing auditory skills are lacking for the majority of the SLPs in preschools and schools of children enrolled in the OCHL study. Many CHH have the potential to be academically successful. Yet, if we are not prepared to support the professionals who provide services needed for academic success, we risk perpetuating underachievement and squandering the opportunities created by early identification and intervention.

REFERENCES

Ambrose, S. E., Walker, E. A., Unflat-Berry, L. M., Oleson, J. J., & Moeller, M. P. (2015). Quantity and quality of caregiver's input to 18–month-old and 3-year-old children who are hard of hearing. *Ear and Hearing, 36* (Suppl. 1), 48S – 59S.

Education for All Handicapped Children Act, 20 U.S.C.S. § 140 *et seq*. (1975).

Blackorby, J., & Knokey, A. M. (2006). *A national profile of students with hearing impairments in elementary and middle school: A special topic report from the Special Education Elementary Longitudinal Study.* Menlo Park CA: SRI International.

Carrow-Woolfolk, E. (1999). *Comprehensive Assessment of Spoken Language*. Circle Pines, MN: American Guidance Service.

Fox, L., Dunlap, G., & Cushing, L. (2002). Early intervention, positive behavior support, and transition to school. *Journal of Emotional and Behavioral Disorders*, *10*(3), 149-157. http://doi.org/10.1177/10634266020100030301

Gallaudet Research Institute (2014). *Annual survey of deaf and hard of hearing children and youth* (Summary Report of Data from 2013-2014). Washington, D.C.: GRI, Gallaudet University.

Goldman, R., & Fristoe, M. (1999). *Goldman-Fristoe Test of Articulation (2nd Ed.)*. Circle Pines, MN: American Guidance Service Inc.

Harrison, M., Page, T. A., Oleson, J. J., Spratford, M., Unflat Berry, L., Peterson, B., Welhaven, A., Arenas, R. M., Moeller, M. P. (2016). Factors affecting early services for children who are hard of hearing. *Language, Speech, and Hearing Services in Schools, 47*(1), 16-30. doi:10.1044/2015_LSHSS-14-0078

Holden, G., Rosenberg, G., Barker, K., Tuhrim, S., & Brenner, B. (1993). The recruitment of research participants: A review. *Social Work in Health Care*, *19*(2), 1-44. doi:10.1300/J010v19n02_01

Houston, K. T. & Perigoe, C. (2010). Speech-language pathologists: Vital listening and spoken language professionals. *The Volta Review, 110*(2), 219–230.

Individuals with Disabilities Education Improvement Act. H.R. 1350, 108th Congress (2004).

Karchmer, M. A., & Mitchell, R. E. (2003). Demographic and achievement characteristics of deaf and hard-of-hearing students. In M. Marschark & P. E. Spencer (Eds.) *Oxford handbook of deaf studies, language, and education* (pp. 21-37). New York, NY: Oxford University Press.

McCreery, R. W., Walker, E. A., Spratford, M., Bentler, R., Holte, L., Roush, P. Oleson, J. Van Buren, J., & Moeller, M.P. (2015). Longitudinal predictors of aided speech audibility in infants and children. *Ear and Hearing, 36* (Suppl. 1), 24S – 37S.

Mitchell, R. E., & Karchmer, M. A. (2006) Demographics of deaf education: More students in more places. *American Annals of the Deaf, 151*(2). 95–104.

Mitchell, R. E., & Karchmer, M. A. (2011). Demographic and achievement characteristics of deaf and hard-of-hearing students. In M. Marschark & P. E. Spencer (Eds.) *Oxford handbook of deaf studies, language, and education* (2nd ed., pp. 18-31). New York, NY: Oxford University Press.

Moeller, M. P. (2000). Early intervention and language development in children who are deaf and hard of hearing. *Pediatrics, 106*(3), E43. http://doi.org/10.1542/peds.106.3.e43

Moeller, M. P., & Tomblin, J. B. (2015). An Introduction to the outcomes of children with hearing loss study. *Ear and Hearing, 36*(Suppl. 1), 4S–13S. http://doi.org/10.1097/AUD.0000000000000210

Moseley, M. J., Mashie, J. J., Brandt, F. D., & Fleming L. F. (1994). A survey of professionals delivering speech-language services to children with hearing loss. *Language, Speech, and Hearing Services in the Schools, 25,* 100-104. doi:10.1044/0161-1461.2502.100

Nelson, L. H., Poole, B., & Muñoz, K. (2013). Preschool teachers’ perception and use of hearing assistive technology in educational settings. *Language, Speech, and Hearing Services in Schools, 44*(3), 239–251. http://doi.org/10.1044/0161-1461

Sarant, J. Z., Holt, C. M., Dowell, R. C., Rickards, F. W., & Blamey, P. J. (2009). Spoken language development in oral preschool children with permanent childhood deafness. *Journal of Deaf Studies and Deaf Education, 14*(2), 205-217. doi:10.1093/deafed/enh033

Semel, E., Wiig, E., & Secord, W. (2004). *Clinical Evaluation of Language Fundamentals-4*. San Antonio, TX: The Psychological Corp.

Spencer, P. E. (2004). Individual differences in language performance after cochlear implantation at one to three years of age: Child, family and linguistic factors. *Journal of Deaf Studies and Deaf Education, 9*(4), 395-412. doi:10.1093/deafed/enh033

SRI International (2000). *National Early Intervention Longitudinal Study (NEILS) telephone interviewer manual specifications* (revised). Menlo Park, CA.

Tomblin, J. B., Walker, E. W., McCreery, R., W., Arenas, R. M., Harrison, M., & Moeller, M. P. (2015a). Outcomes of children with hearing loss: Data collection and methods. *Ear and Hearing, 36* (Suppl. 1), 14S – 23S. doi:10.1097/AUD.0000000000000212

Tomblin, J. B. Harrison, M., Ambrose, S. E., Walker, E. W., Oleson, J. J., & Moeller, M. P. (2015b). Language outcomes in young children with mild to severe hearing loss. *Ear and Hearing, 36* (Suppl. 1), 76S – 91S. doi:10.1097/AUD.0000000000000219

U.S. Census Bureau (2013). *Household income: 2012 American Community Survey briefs* (Publication No. ACSBR/12-02). Washington, DC: U.S. Department of Commerce.

Walker, B. A., McCreery, R. W., Spratford, M., Oleson, J. J., Van Buren, J., Bentler, R., Roush, P., & Moeller, M. P. (2015a). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear and Hearing, 36* (Suppl. 1), 38S – 47S. doi:10.1097/AUD.0000000000000208

Walker, E. A., Holte, L., McCreery, R. W., Spratford, M., Page, T. A., Moeller, M. P. (2015b). The influence of hearing aid use on outcomes of children with mild hearing loss. *Journal of Speech, Language, and Hearing Research, 58*, 1611-1625. doi:10.1044/2015_JSLHR-H-15-0043

Watkin, P., McCann, D., Law, C., Mullee, M., Petrou, S., Stevenson, J., & Kennedy, C. (2007). Language ability in children with permanent hearing impairment: The influence of early management and family participation. *Pediatrics, 120*(3), e694-e701. doi:10.1542/peds.2006-2116

Wechsler, D. (2002) the Wechsler Preschool and Primary Scale of Intelligence III. San Antonio, TX: Harcourt Assessment, Inc.

Wechsler, D., & Hsiao-pin, C. (2011). Wechsler Abbreviated Scale of Intelligence-II. San Antonio, TX: Pearson.

White, K. R. (2006). Early intervention for children with permanent hearing loss: Finishing the EHDI revolution. *The Volta Review*, *106*(3), 237-258.

Woodford, C. (1987). Speech-language pathologists’ knowledge and skills regarding hearing aids. *Language, Speech, and Hearing Services in the Schools, 18,* 312-322. doi:10.1044/0161-1461.1804.312

Chapter 4: Assessment of 2- to 6-year-olds who are Hard of Hearing: Implementing Current Findings into Clinical Practice

Introduction

The National Institute on Deafness and Other Communication Disorders (NIDCD) estimates that there are over 1 million children with mild to severe hearing loss (HL) in the United States (NIDCD, 2006). Despite positive advances in hearing technologies and earlier identification of HL resulting in opportunities for earlier interventions, many children who are hard of hearing (CHH) continue to be vulnerable to communication delays lasting into their early academic years (Tomblin et al., 2015a).

Universal Newborn Hearing Screening

For CHH and their families, there have been a number of positive advances over the last two decades, but until very recently, evidence of these improvements to diagnosis and management have been underrepresented in the literature. Universal newborn hearing screening (UNHS) began to see widespread implementation in 1999 and has resulted in a cascade of improvements across service provision. Prior to UNHS, only newborns with risks factors associated with HL were primarily screened at or near birth. It is estimated that, at most, half of the children with HL were identified under these guidelines (NIDCD, 2013). Prior to 1999, children, on average, were identified near 3 years of age. Some, especially those with lesser degrees of HL, remained unidentified until age 5 or 6 (Harrison & Roush, 1996). Shortly after the implementation of UNHS, marked improvement in screening and diagnosis of HL was evident for children with all degrees of HL (Harrison, Roush, & Wallace, 2003). Currently, more than 95% of newborns are screened at birth and of those identified as deaf or hard of hearing, 67.9% are enrolled in services prior to 6 months of age (CDC, 2016). As a result, many more families are now aware of their child's HL at an early age and can begin early intervention and management, based on assessment, to promote optimal outcomes.

The Value of Assessment

Families and professionals rely on the assessment process to help identify, guide and monitor the abilities of a child and pinpoint areas in need of additional attention or intervention. With the majority of CHH identified at or near birth, families of young CHH must navigate an often uncharted and bewildering journey. A developmental assessment should be administered shortly after a diagnosis of HL to establish the concerns of the family and professionals, the abilities of the child, and the tools and team members needed to address those concerns. Reassessment occurs over the course of this journey, functioning to guide and recalibrate intervention. Ultimately, assessment will establish whether the child's abilities are commensurate with his/her peers, and dismissal from services can occur. Continual knowledge of the child's strengths, challenges, and progress towards shared goals ensures that the journey is both well planned and as predictable as possible. Assessment represents an essential tool that must be kept close, used regularly, and tailored to the individual needs of the child and family.

First and foremost, assessment should be individualized to the child's abilities, parental and provider concerns, and his/her home and learning environments. It follows then that assessment instrument(s) and the administration process chosen must be sensitive, specific, and comprehensive in response to these unique characteristics. Comprehensive assessment follows the Individuals with Disabilities Education Act (2004) guidelines, which in part, direct that a variety of assessment tools and strategies be used including parent report, observation, and technically sound standardized measures. And finally, assessment should be aligned with best practice standards, and therefore evidence-based.

Advances in Hearing Technology and the Need for Evidence

The passage of time has also brought technological advances in assistive hearing devices for CHH including hearing aids with increased bandwidth, directional microphones, noise reduction capabilities, advances in fitting and programming and personal FM systems used in conjunction with hearing aids at home and school. Combined with UNHS, more advanced hearing aids and related technologies are being fitted earlier for more children than ever before.

Regrettably, the research literature to guide assessment practice has not kept pace with the advances in identification and technology. Current clinical practice is based on the principle that earlier identification, technology and intervention yield improved outcomes for CHH, yet little research had been conducted with solely CHH since these advances (Moeller & Tomblin, 2015). Historically, most outcome research had focused on children who are deaf, a portion of the population more readily available for research as many were educated in schools for the deaf or followed by audiology and cochlear implant centers (Calderon, 2000; Fink et al., 2007). For the limited evidence on CHH, the majority of studies carried out prior to UNHS had methodological issues that hinder ecological validity. For example, samples were too broad (e.g., inclusion of children with all degrees of HL, use of different hearing devices such as hearing aids and cochlear implants or inclusion of multiple communication modalities) or too small in size. Prior to 2009, the largest number of participants in a study of CHH consisted of a cohort of 40 children located in one midwestern state (Davis, Elfenbein, Schum, & Bentler, 1986), making the ability to generalize the overall impact of HL in this population challenging. Also, because there had been a lack of control for audibility and amplification histories in longitudinal outcomes research, there was little evidence that adequately explained the connections between HL, assistive technologies, and individual development, knowledge so fundamental that its absence from the literature was startling. In summary, because much of the research was limited in scope, lacked specificity for CHH, or was dated by advances in technology and policy, the majority of studies do not accurately represent the current population of CHH. Updated evidence-based rationales to guide assessment and intervention remained a crucial need.

To address many of these issues, in 2006 the NIDCD convened a working group to determine the current state of knowledge regarding outcomes and influential factors for CHH. This panel of researchers scoured the amassed literature, determined remaining areas in need of additional information, and provided methodological guidance to implement research to address these gaps. Due to the limited amount and/or dated research focusing solely on CHH, the domains identified in significant need of further research included speech production, grammatical morphology, and vocabulary (Eisenberg, 2007; Eisenberg et al., 2007; Moeller, Tomblin, Yoshinaga-Itano, Connor, & Jerger, 2007). Subsequently, the longitudinal, multicenter study, Outcomes of Children with Hearing Loss (OCHL; Holte et al., 2012; Moeller & Tomblin, 2015), was funded by the NIDCD to address these challenges.

The Outcomes of Children with Hearing Loss Study

Initially funded by the NIDCD in 2009, the OCHL study is a five-year, multi-center investigation designed to characterize the developmental, behavioral, and familial outcomes of children with mild to severe HL and to explore how variations in child and family factors and intervention characteristics relate to functional outcomes. Participants included 317 CHH and a comparison group of 117 children with normal hearing (CNH), who were matched by age, maternal education, and household income. The CHH had a permanent bilateral HL, with better ear pure tone averages (BEPTA) at 500, 1000, 2000, and 4000 Hz between 25 and 75 dB HL. None had additional significant sensory or developmental challenges, and all had at least one primary caregiver who spoke English in the home. Families were recruited and seen in the home states of the three research teams (Iowa, Nebraska, and North Carolina), as well as at cooperating sites in neighboring states, 16 in all. This carefully selected cohort was recruited in an attempt to isolate the effects of HL on outcomes, without the confounding effects of comorbid conditions or lack of exposure to English at home. The design allowed for continuous recruitment, and participants could enter from 6 months to 7 years of age. Test protocols spanned from 6 months through 9 years of age. Infants and toddlers were seen every six months until 24 months of age and annually from that age on. Highly trained study personnel conducted all assessments, and reliability measures were administered at least annually. In total, 1,454 study visits were completed over the course of the five-year period. An in-depth description of the overall OCHL study design, including details of the testing administration and protocols can be found at www.tinyurl.com/hzt5ryk (Tomblin et al., 2015b).

To date, the OCHL study is the only comprehensive investigation conducted in the United States with a large cohort of CHH between the ages of 6 months to nine years that documented adequacy of hearing aid (HA) fitting and use with concurrent assessments of developmental outcomes over time (Moeller & Tomblin, 2015). In order to assess the specific skills within cognitive, communication, and early academic domains for a wide age range, the OCHL study administered an expansive array of assessment measures with specific test batteries developmentally tailored to every child at each study visit, gaining insight about testing practice that can be shared here. Findings from the OCHL study has been presented and published extensively. Many are available online, free of charge, allowing the reader to seek out supplemental information. The study website, www.ochlstudy.org, contains updated information about the project, findings, and links to numerous articles.

Primary OCHL Findings. The majority of the OCHL participants demonstrated growth in their overall language abilities overtime (Tomblin et al., 2015a). By 6 years of age, nearly half of the CHH demonstrated language scores similar to their normal hearing peers. Children whose HAs provided good audibility and were worn consistently were more likely to achieve higher language levels than those that did not. These findings are bittersweet; half of the children are performing at or close to age expectations as they enter into kindergarten, while half did not achieve the same level of development. The present paper focuses on the previously identified areas of vulnerability targeting the 2- to 6-year-old CHH in the study, and the assessment process used to evaluate their skills and progress. This age range is targeted because, 1) wider variation in communication abilities was found for these younger children, 2) speech and language skills set the stage for future academic achievement, and 3) most CHH likely receive services into the preschool and elementary school years, (Page et al., in press).

Current testing practices and/or measures, especially those that only rely upon standardized measures, may not be sensitive to specific areas of weakness in CHH (Tomblin et al., 2015a; Werfel & Douglas, 2017). This is especially true for younger CHH where less evidence-based guidance exists, and in settings like public schools where testing tools, resources, and time are more likely to be constrained and clinicians are expected to provide services to students across the range of all communication and academic disorders.

This paper provides clinical guidance for professionals by highlighting vulnerable domains in CHH, and ways to identify them through assessment. In line with the identified research gaps focused on CHH, the following review will highlight the available literature in speech production, grammatical morphology, and vocabulary, paired with recent findings and assessment insight from the OCHL study to inform current clinical assessment for CHH in these critical domains of communication. Lastly, clinical implications gleaned from the current evidence will be presented.

Areas of Vulnerability for Children who are Hard of Hearing

Speech Production

Literature review. Much of the evidence related to speech production in CHH is based upon children who are relatively late identified and who have less sophisticated hearing aids (McGowan, Nittrouer, & Chenausky, 2008). From the available studies, it is generally accepted that speech production development is age-dependent, and that the developmental rate and relative complexity is more severely impacted by greater degrees of HL (Oller, Eilers, Bull & Carney, 1985; Yoshinago-Itano & Sedey, 1999). In a review of the literature, Eisenberg (2007) highlighted prominent research of speech production in CHH, most of which had been conducted prior to UNHS. Early vocalizations, though similar in type to their same-aged hearing peers, developed at a reduced rate for infants who were hard of hearing (Oller, Eilers, Bull, & Carney, 1985). As babbling begins, between 6 and 14 months of age in typically developing children, the type and complexity of speech development diverges for CHH. In a small sample of children with moderate (n=2) and severe-profound (n=11) HL, Stoel-Gammon and Otomo (1986) found that the children with HL demonstrated reduced consonantal repertoires and a slower rate of development than their typically-hearing peers. The two children with moderate HL produced more consonant types had better imitation abilities and their phonemic repertoire grew at a faster pace than the children with severe-profound HL.

Similar results have been found as phonetic and syllabic complexity increases. Children with moderately severe to severe HL have demonstrated greater delays in their production of vowels and consonants than similarly aged children with mild-moderate HL (Yoshinago-Itano & Sedey, 1999). Across these two groups, vowel production normalized by 31 months of age, but consonant production remained a greater challenge for the children with more severe HL until 43 months of age. Additionally, this pattern of increased vulnerability in speech production with greater degrees of HL was observed in school-age children (Elfenbein, Hardin-Jones, & Davis, 1994; Gordon, 1987). Specifically, these children had greater difficulty with higher-frequency phonemes, fricatives and affricates, with substitutions and omissions being the most common error types. Eisenberg (2007) acknowledged the paucity of studies of speech production in CHH, noting that most had been conducted before widespread hearing screening was implemented. Although research has shed light on the broad differences across groups who differ in the degree of HL, information specific to CHH remains limited.

OCHL Findings. Due to the rapid rate at which early vocalizations and sound production typically develop in young children with normal hearing and the evident weakness in consonant and syllable development for CHH (Moeller, Hoover, et al., 2007), the OCHL study administered speech production measures every six months between 6 months and 2 years of age, and then at 3, 5, and 7 years. Due to the limited number of available measures for very young children (under 3 years of age), the Open- and Closed-set Test (O&C; Ertmer, 2015) was administered to the OCHL 2-year-old cohort. The O&C is a clinical, criterion-referenced measure that uses play-like imitation to assess a child's speech production (phoneme and word-level) and word comprehension. In the task, the child imitates early developing words presented by a parent or clinician, and then identifies a picture that corresponds to that word in a set of three pictures. The child's production is transcribed and scored by phoneme and word intelligibility, as well his/her ability to identify the pictured stimuli.

In a study of OCHL 2- and 3-year-olds, Ambrose and colleagues (2014) found that consonant sound development in CHH followed a typical pattern of developmental acquisition, but was delayed compared to their same-aged, hearing peers. Additionally, even in this younger cohort of CHH who were fit with HAs around 6 months of age (M = 6.89), they were more likely to omit final consonant sounds than the CNH. Further, better performance on the O&C predicted higher scores on standardized articulation measures at 3 years of age, demonstrating our ability and need to assess and target speech production in CHH before 3 years of age.

At 3 and 5 years of age, OCHL participants were administered the Goldman-Fristoe Test of Articulation-2 Sounds-in-Words subtest (GFTA-2; Goldman & Fristoe, 1999). This standardized measure assesses consonant mastery at the word level in the initial, medial, and final position of words. Children are asked to verbally identify pictured stimuli, the response is then compared to the expected production, and deviations (errors) are tallied to determine the raw and standard scores. At both ages, CHH with mild degrees of HL performed in the average to low-average range, and those with moderate to severe HL averaged over 1 standard deviation (SD) below the GFTA-2 mean across 3 and 5 years of age (Tomblin, Oleson, Ambrose, Walker, & Moeller, 2014). For both age groups and all degrees of HL, there was much wider variability in GFTA-2 performance compared to CNH controls. This level of variance remained at 7 years of age when nearly 30% of CHH exhibited below average scores (Walker, Ambrose, & Page, 2012).

In the OCHL study, 3-year-old articulation skills also predicted overall accuracy with morphological structures in CHH (Koehlinger, Van Horne, Oleson, McCreery, & Moeller, 2015). Children with poorer scores on the GFTA-2 were more likely to demonstrate reduced accuracy with s-related morphemes in connected speech elicited in language samples.

These OCHL results confirm many of the concerns raised by previous research in speech production of CHH. Similar to children studied prior to UNHS with less-advanced hearing technologies, CHH with greater degrees of HL remain at greater risk for delays in speech production accuracy and development compared to those with lesser degrees, including their typically hearing peers (Eisenberg, 2007).

Grammatical Morphology

Literature review. As part of the 2006 NIDCD working group, a thorough literature review of morphological and vocabulary development in CHH was conducted by Moeller, Tomblin, Yoshinago-Itano, Connor, & Jerger (2007). The authors theorized that delays seen in morphological development might be, in part, a result of limited or inconsistent auditory access to morphological markers in spoken English. These delays were most often exhibited in high frequency phonemes, like fricatives, which were more likely to be beyond the bandwidth capabilities of hearing aids at that time. The rationale of reduced access and its effect on the consistency of the child's linguistic input also supports the delayed speech production abilities found in CHH (Elfenbein, Hardin-Jones, & Davis, 1994; Gordon, 1987; Moeller et al., 2007). Stelmachowicz, Pittman, Hoover, and Lewis (2001) determined that hearing aids provided limited audibility to /s/, a high-frequency phoneme critical to grammatical morphemes that mark plurals, possessives, third-person singular, auxiliary, and copulas in English. In addition, perception of plural morphemes over time was highly variable for children with moderate HL compared to peers with typical hearing. In a separate study, the accuracy of morphological use in children with moderate HL differed from that of children with typical hearing who were matched by mean length of utterance (McGuckian & Henry, 2007). Children who were hard of hearing showed significant weakness with tensing forms (i.e., third singular –s and past –ed) and the possessive –s. The authors noted that the varied development observed in CHH shared similarities with second language learners who often struggle with reduced or inconsistent access to linguistic input critical for morphological development.

Broadly, the development of speech and spoken language in children relies upon sufficient linguistic input. If that access is limited, inconsistent, or distorted by differences in hearing acuity as currently theorized for CHH (Moeller & Tomblin, 2015), then there is potentially a higher likelihood for delayed and/or atypical patterns of development. As many CHH rely upon the audibility provided by hearing aids to access spoken language, research that considers the strengths and limitations of current technology is paramount. Due to the limited evidence that pairs language development with perceptual abilities in CHH, Moeller et al. (2007) identified this gap in the literature as a pressing need in order to improve hearing technologies and thus optimize auditory access for CHH.

OCHL findings. As stated earlier, global language abilities were especially vulnerable to delays for OCHL participants between 2 and 6 years. By 6, the average language composite score for CHH was nearly one standard deviation below the participants with typical hearing (Tomblin et al., 2015a). Grammatical morphology represented a particular area of vulnerability in young CHH. Similar to speech production assessment, both non-standardized and standardized measures were routinely administered to detect differences between the hard of hearing and control groups. Koehlinger, Van Horne, & Moeller (2013) analyzed conversational language samples and performance on the Comprehensive Assessment of Spoken Language Syntax subtest (CASL; Carrow-Woodfolk, 1999) of 3- and 6-year-old CHH. They found significantly reduced utterance length and grammatical complexity for verb morphology compared to the CNH at both ages, and nearly half of the CHH were below the 25th percentile on the CASL Syntax subtest at 6 years of age. All of these findings are in-line with earlier investigations highlighting grammatical morphology as a skill at-risk in CHH (McGuckian & Henry, 2007).

Vocabulary Development

Literature review. Conflicting findings regarding vocabulary development in CHH have been reported. Delays have been shown in younger CHH, even those with milder degrees of HL (Mayne, Yoshinaga-Itano, Sedey, & Carey, 1999a; Mayne, Yoshinaga-Itano, Sedey, & Carey, 1999b), but findings vary as to the extent that lexical weakness persists through childhood (Davis et al., 1986; Wake, Hughes, Poulakis, Collins, & Rickards, 2004; Wolgemuth, Kamhi, & Lee, 1998). Studies have found that school-age children with mild-moderate HL demonstrate vocabulary abilities on par with their typically hearing peers (Gilbertson & Kamhi, 1995; Wolgemuth, Kamhi, & Lee, 1998). Similar to the vulnerable domains discussed thus far, vocabulary development may be more negatively impacted in children with greater degrees of HL (Kiese-Himmel & Reeh, 2006), and outcomes are partly attributed to family involvement and intervention history (Moeller, 2000). Due to the ambiguous findings within the limited evidence surrounding vocabulary development in CHH, Moeller et al. (2007) have argued for research that identifies factors that influence vocabulary development and document long-term outcomes.

OCHL findings. The ambiguous findings related to vocabulary development noted earlier are reflected to some degree among the children in the OCHL study. Receptive vocabulary appears to be an area of relative strength when measured at 5 and 7 years of age on the Peabody Picture Vocabulary Test-2 (PPVT; Dunn & Dunn, 2007), but expressive vocabulary abilities seem to be less resilient. At 2 and 3 years of age, the majority of CHH in the OCHL study demonstrated significantly fewer words produced on the MacArthur Bates Communicative Development Inventories (CDI; Fenson, Marchman, Thal, Reznick, & Bates, 2006) compared to CNH (Page & Unflat-Berry, 2013). At 4 and 6 years of age, expressive vocabulary was assessed with subtests from the Wechsler Preschool & Primary Scale of Intelligence-III (WPPSI; Wechsler, 2002) and the Wechsler Abbreviated Scale of Intelligence-II (WASI; Wechsler & Hsiao-Pin, 2011), respectively. These subtests assess a child's definitional vocabulary ability. Children are asked to provide the meaning of words with increasing complexity. For example, a child is asked, "What is a shoe?" (with little or no visual stimuli). The quality of the child's response is scored based on normative examples provided in the assessment manual. On average, CHH in the OCHL study demonstrated significantly lower performance and much wider variance at both ages in their definitional vocabulary abilities than the CNH controls suggesting that complex semantic abilities are vulnerable in this population (Page & Unflat-Berry, 2013). Four-year-old CHH vocabulary scores were lower than at 6 years, but significant differences in ability with their CNH peers remained nonetheless. Recent analyses of 7-, 8-, and 9-year-olds in the OCHL study showed continued significant delays for CHH in definitional vocabulary scores as compared to their typically hearing peers (Redfern, Walker, & Oleson, 2017).

Clinical Implications

The outcomes and assessment processes used in the OCHL study can provide guidance to practitioners working with young CHH. In order to assess an array of communicative domains in 2- to 6-year-olds with increasingly complex developmental expectations, a wide range of assessment measures was employed including standardized and non-standardized tools, developmental checklists, parent report, observation and language sampling. To obtain a more complete understanding of the speech and language abilities of the youngest children in the OCHL study, a greater proportion of parent report and semi-structured tasks often involving toys and manipulatives was used in testing protocols until 3 years of age. After three, the children could more reliably perform in standardized, structured language assessments.

Given the risk of depressed and atypical speech production for CHH, early and continued assessment of speech production skills is warranted. However, not all professionals who work with CHH are skilled or comfortable in assessing these children. In a survey of professionals providing birth to three services to OCHL study participants, interventionists commonly reported low levels of comfort in assessment of speech in young CHH (Harrison et al., 2016). A viable explanation for this lower level of confidence may be related to the limited amount of resources and measures surrounding the assessment of speech production in children under 3 years of age, especially those who are hard of hearing. Many of the commonly used speech/articulation measures primarily assess consonant sounds, often in words standardized for administration beginning at 2.5-3 years of age. As a result, clinicians should rely upon a combination of standardized and non-standardized instruments to adequately assess articulation and speech intelligibility.

While standardized measures like the GFTA-2 may identify areas of need at the phoneme or word level, they may not be designed to assess vocalic or non-word production. Additionally, children who demonstrate average scores at the word-level, may still have reduced comprehension in more complex connected speech (Ertmer, 2010). Supplemental assessment tools to address these issues include early vocalization and speech checklists, maintaining a speech journal with the family and/or educators, as well as assessment of speech production and intelligibility in language samples (Bradham & Houston, 2014; Ertmer, 2007).

Findings from the OCHL study found that children who experienced inconsistent access to linguistic input stemming from their HL, reduced audibility, and/or inconsistent HA use, struggled with the structural aspects of language (Moeller, Tomblin, & Collaboration, 2015). Much like speech development, increased vulnerability across other areas demands early evaluation in grammar and syntax. Assessment and intervention should identify and target morphological markers that are commonly delayed in CHH, including those that are high-frequency (sonically) like plural and possessive –s and morphemes that exist in the middle of utterances, as in the auxiliary form "is."

As there were no assessment tools that focused exclusively on these morphosyntactic structures for pre-kindergarten children, OCHL investigators created the Morphological Elicitation Procedure (Moeller & Bass-Ringdahl, 2009), which was administered to 3- and 4-year-old participants. This measure is presented on a computer, and uses videos and pictures along with verbal instructions to assess grammatical morphology use in a cloze procedure (e.g., Assessor: "What did he find? He found the ______" Child: "key*s*"). Specifically, the measure elicits nine morphological endings including plural –s, possessive –s/-z, third person singular –s, regular and irregular past tense –ed, copula be (i.e., is), and auxiliary be with progressive –ing, and includes an initial phonological probe to screen final consonant production. As children reach elementary school ages, several widely available assessments of grammar and syntax are appropriate for efficiently identifying these delays in CHH.

For younger children, non-standardized parent interviews, developmental checklists, and language samples are recommended. As noted earlier, it is vitally important to routinely monitor or assess speech development, as early production may inform future grammatical structure use. While there was a significant correlation between shorter utterance length and grammatical morphology for children with poorer articulation, all of the CHH were at significantly greater risk for these delays at 3 and 6 years compared to their aged-matched peers (Koehlinger, Owen Van Horne, & Moeller, 2013). These findings suggest that while speech production abilities may impact grammatical morphology use, sensitive language measures are also warranted in assessment of young CHH.

Stronger expressive vocabulary repertoires on the Words Produced portion of the CDI at 2 years of age were associated with better speech production abilities on the GFTA-2 at 3 years (Ambrose et al., 2014). It is important to assess and monitor receptive and expressive lexical development at this age. For CHH, expressive vocabulary difficulties are more likely to show up early and have the potential to persist into elementary ages. Many vocabulary tests utilized and marketed to SLPs require children to identify (receptive) or label (expressive) an object or picture to assess a child's repertoire; there are fewer options that assess definitional vocabulary, especially for young children. This, in part, may explain the mixed results across previous research of vocabulary abilities of CHH. Vocabulary assessment consisting solely of object or picture identification and labeling may not be sensitive enough to identify more complex semantic proficiency. Definitional vocabulary ability is tied to higher level cognition and language skills, and therefore is likely to be a more challenging endeavor for children with delays in language, including many CHH. Definitional vocabulary, as tested in the WPPSI & WASI, can provide an assessment of a child's deeper lexical abilities, and can be administered as early as 4 years of age. This type of vocabulary assessment is often found in psycho-educational measures, thus the availability of and administration by SLPs or teachers may be limited depending on the measure and/or the clinician's training/degree area. If available, school psychologists could be called on to assess these skills. Definitional measures like the Test of

Preschool Early Literacy (Lonigan, Wagner, & Torgeson, 2007), the Definitional Vocabulary subtest or the Clinical Evaluation of Language Fundamentals-4 (CELF; Semel, Wiig, & Secord, 2004) that are within the scope of practice of SLPs can also be used..

OCHL Findings: Audiological Management

Although audiological management is not the focus of this paper, it underlies the speech and language domains previously discussed. If asked to share a single finding from the OCHL study, it would be that consistent auditory access to linguistic input is critical for optimal auditory and language development (McCreery et al., 2015; Tomblin et al., 2014; Tomblin, Harrison, et al., 2015; Walker et al., 2015a). Ensuring this access represents a foundational priority for families, service providers, and educators working with CHH. For young CHH, greater severity in unaided hearing thresholds increased the risk for future language delays (Tomblin et al., 2015a). While this finding has important clinical implications and is useful for assessing developmental risk, a child's unaided degree of permanent HL remains a factor that cannot be changed. Most CHH rely upon HAs to mediate their access to the language in their environments, and earlier provision of HAs with good audibility and consistent use has resulted in improved early language outcomes (Tomblin et al., 2014). Even children with mild degrees of HL demonstrate better language growth from consistently worn, well-fit HAs (Walker et al., 2015).

Caregivers of young CHH were more likely to report higher levels of inconsistent HA use than those of older children, and for households with lower levels of maternal education, consistent HA use remained a concern through school-age (Walker et al., 2013; Walker et al., 2015). Especially for young children, it is often the responsibility of interventionists to educate and guide families. Unfortunately, many SLPs working with CHH report reduced confidence around many aspects of hearing technology (Harrison et al., 2016). Because spoken language development for CHH is dependent upon linguistic access, it is the responsibility of any interventionist, regardless of profession, to not only understand and support the use of hearing technologies, but to convey its utmost importance to families, educators, and peers. Moeller et al. (2015) provide a list of evidence-based, recommendations specific to the optimization of auditory access, as well as other areas of risk for CHH.

Conclusion

Historically, much of the research regarding the development of early speech and language in CHH has been conducted prior to newborn hearing screening and advances in hearing technologies or limited to small sample sizes and/or mixed degrees of HL and assistive technology use, leaving very little evidence upon which to base current clinical practice in assessment. The cohort of CHH under 6 years of age in the OCHL study demonstrated poorer speech and language outcomes compared to those of hearing children with comparable home characteristics, demonstrating that any degree of HL places children at greater risk for communication and academic delays (Markman et al., 2011; Tomblin et al., 2014; Tomblin et al., 2015a; Walker et al., 2015a). For CHH, particular vulnerabilities were found in speech sound production and grammatical morphology. Vocabulary and complex semantic abilities appeared threatened as well. As proficiency in these early speech and language domains are critical for literacy development, these vulnerabilities pose a threat to later challenges in reading and reading comprehension (Catts, Fey, Zhang, & Tomblin, 2001; Fey, Catts, & Larrivee, 1995; Scarborough, Neuman, & Dickinson, 2009). It is important to note that compared to the U.S. population, the OCHL sample was better educated and better resourced financially (Tomblin et al., 2015b) than reported by the U.S. Census. Additionally, a majority of the children in the research study had a HL that was identified early, all were from English speaking households, and had no other major disabilities. Thus, the characteristics of the OCHL cohort likely reflect a best-case scenario. Yet, despite their optimal circumstances, they still demonstrate a number of vulnerabilities in regards to communication development, and the majority of these children continue to receive services to address these concerns well into elementary school (Page et al., in press).

Early assessment of these critical skills is imperative; however, standardized assessments for very young children in these domains may not be sensitive to detecting delays, and in some domains do not exist. Therefore, professionals working with young CHH and their families may need to include non-standardized assessment tools, such as language sampling and criterion-referenced measures to identify and track concerns and progress. This is especially true in regards to speech production, grammatical morphology, and semantic concerns in younger children where there are very few standardized measures available. Even beyond these three communication domains, the OCHL evidence showed a much wider range of performance for CHH compared to their typically hearing peers.

This paper has aimed to provide insight to communication domains more the most vulnerable to delays in young CHH, and therefore only focused on aspects of assessment pertaining to a specific cluster of findings from one, albeit comprehensive, longitudinal study of CHH. When planning to assess a child who is hard of hearing, these potential areas of vulnerability are worthy of close consideration, especially when accompanying concerns exist. In and of themselves, speech production, grammatical morphology, and vocabulary represent but a fraction of developmental domains and components within a comprehensive assessment for young CHH.

REFERENCES

Ambrose, S. E., Unflat-Berry, L., Walker, E. A., Harrison, M., Oleson, J., & Moeller, M. P. (2014). Consonant production in two-year-olds who are hard of hearing. *American Journal of Speech-Language Pathology*, *23*(2), 91–104. doi:10.1044/2014_AJSLP-13-0039

Bradham, T. S., & Houston, K. T. (2014). *Assessing listening and spoken language in children with hearing loss*. San Diego, CA: Plural Publishing, Inc.

Calderon, R. (2000). Parental involvement in deaf children's education programs as a predictor of child's language, early reading, and social-emotional development. *Journal of Deaf Studies and Deaf Education*, *5*(2), 140–155. doi:10.1093/deafed/5.2.140

Center for Disease Control and Prevention (2016). *Summary of 2014 national CDC EHDI data*. Retrieved from https://www.cdc.gov/ncbddd/hearingloss/2014-data/2014_ehdi_hsfs_summary_h.pdf

Carrow-Woodfolk, E. (1999). *Comprehensive Assessment of Spoken Language*. Circle Pines, MN: American Guidance Services Inc.

Catts, H. W., Fey, M. E., Zhang, X., & Tomblin, J. B. (2001). Estimating the risk of future reading difficulties in kindergarten children: A research-based model and its clinical implementation. *Language, Speech, and Hearing Services in Schools*, *32*(1), 38–50. doi:10.1044/0161-1461(2001/004)

Davis, J. M., Elfenbein, J., Schum, R., & Bentler, R. A. (1986). Effects of mild and moderate hearing impairments on language, educational, and psychosocial behavior of children. *Journal of Speech and Hearing Disorders*, *51*(1), 53–62. doi:10.1044/jshd.5101.53

Dunn, L. M., & Dunn, D. M. (2007). *Peabody Picture Vocabulary Test* (4th ed.). Circle Pines, MN: American Guidance Services Inc.

Eisenberg, L. S. (2007). Current state of knowledge: Speech recognition and production in children with hearing impairment. *Ear and Hearing*, *28*(6), 766–772. doi:10.1097/AUD.0b013e318157f01f

Eisenberg, L. S., Widen, J. E., Yoshinaga-Itano, C., Norton, S., Thal, D., Niparko, J. K., & Vohr, B. (2007). Current state of knowledge: Implications for developmental research - key issues. *Ear and Hearing*, *28*(6), 773–777. doi:10.1097/AUD.0b013e318157f06c

Elfenbein, J. L., Hardin-Jones, M. A., Davis, J. M. (1994). Oral communication skills of children who are hard of hearing. *Journal of Speech and Hearing Research*, *37*(1), 216-226.

Ertmer, D. J. (2007). Assessing speech intelligibility in children with hearing loss: Toward revitalizing a clinical tool. *Language, Speech, and Hearing Services in Schools*, *42*(1), 52–58. doi:10.1044/0161-1461(2010/09-0081)

Ertmer, D. J. (2010). Relationships between speech intelligibility and word articulation scores in children with hearing loss. *Journal of Speech, Language, and Hearing Research*, *53*(5), 1075–1087. doi:10.1044/1092-4388(2010/09-0250).

Ertmer, D. J. (2015). *The Open- & Closed-set Task*. Durham, NC: MED_EL Corporation.

Fenson, L., Marchman, V. A., Thal, D., Reznick, S. L, & Bates, E. (2006). *The MacArthur-Bates Communicative Development Inventories: User's guide and technical manual* (2nd ed.). Baltimore, MD: Paul H. Brookes Publishing Co.

Fey, M. E., Catts, H. W., & Larrivee, L. S. (1995). Preparing preschoolers for the academic and social challenges of school. In *Language intervention: Preschool through the elementary years. Communication and language intervention series, Vol. 5* (5th ed., pp. 3–37). Baltimore, MD: Paul H. Brookes Publishing Co.

Fink, N. E., Wang, N. Y., Visaya, J., Niparko, J. K., Quittner, A., Eisenberg, L. S., & Tobey, E. A. (2007). Childhood development after cochlear implantation (CDaCI) study: Design and baseline characteristics. *Cochlear Implants International*, *8*(2), 92–116. doi:10.1002/cii.333

Gilbertson, M., & Kamhi, A. G. (1995). Novel word learning in children with hearing impairment. *Journal of Speech, Language, and Hearing Research*, *38*(3), 630–642. http://doi.org/10.1044/jshr.3803.630

Goldman, R., & Fristoe, M. (1999). *Goldman-Fristoe Test of Articulation-2*. Circle Pine, MN: American Guidance Services Inc.

Gordon, T. G. (1987). Communication skills of mainstreamed hearing-impaired children. In H. Levitt, N. C. McGarr, & D. Geffner (Eds.), *Development of language and communication skills in hearing-impaired children* (ASHA Monographs no. 26, pp. 108-122). Rockville, MD: American-Speech-Language-Hearing Association.

Harrison, M., & Roush, J. (1996). Age of suspicion, identification, and early intervention in infants with hearing loss: A national study. *Ear and Hearing*, *17*(1), 55–62. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8741968

Harrison, M., Roush, J., Wallace, J. (2003). Trends in age of identification and intervention in infants with hearing loss. *Ear and Hearing*, *24*(1), 89-95. doi:10.1097/01.AUD.0000051749.40991.1F

Harrison, M., Page, T. A., Oleson, J., Spratford, M., Unflat Berry, L., Peterson, B., … Moeller, M. P. (2016). Factors affecting early services for children who are hard of hearing. *Language, Speech, and Hearing Services in Schools*, *47*(1), 16–30. doi:10.1044/2015_LSHSS-14-0078

Holte, L., Walker, E. A., Oleson, J., Spratford, M., Moeller, M. P., Roush, P., … Tomblin, J. B. (2012). Factors influencing follow-up to newborn hearing screening for infants who are hard of hearing. *American Journal of Audiology*, *21*(2), 163–174. doi:10.1044/1059-

0889(2012/12-0016)

Individuals with Disabilities Education Act, Pub. L. No. 20 U.S.C. § 1400-614 (2004).

Kiese-Himmel, C., & Reeh, M. (2006). Assessment of expressive vocabulary outcomes in hearing-impaired children with hearing aids: Do bilaterally hearing-impaired children catch up? *Journal of Laryngology and Otology*, *120*(8), 619–626. http://doi.org/10.1017/S0022215106001319

Koehlinger, K. M., Owen Van Horne, A. J., & Moeller, M. P. (2013). Grammatical outcomes of 3- and 6-year-old children who are hard of hearing. *Journal of Speech, Language, and Hearing Research : JSLHR*, *56*(5), 1701–14. doi:10.1044/1092-4388(2013/12-0188)

Koehlinger, K., Owen Van Horne, A. J., Oleson, J. J., McCreery, R. W., & Moeller, M. P. (2015). The role of sentence position, allomorph, and morpheme type on accurate use of s-related morphemes by children who are hard of hearing. *Journal of Speech, Language, and Hearing Research*, *58*(2), 396–409. doi: 10.1044/2015_JSLHR-L-14-0134

Lonigan, C. J., Wagner, R. K., & Torgeson, J. K. (2007). *Test of Preschool Early Literacy*. Austin, TX: Pro-Ed.

Markman, T. M., Quittner, A. L., Eisenberg, L. S., Tobey, E. A., Thal, D., Niparko, J. K., & Wang, N. Y. (2011). Language development after cochlear implantation: An epigenetic model. *Journal of Neurodevelopmental Disorders*, *3*(4), 388-404.

Mayne, A. M., Yoshinaga-Itano, C., & Sedey, A. L. (1999a). Receptive vocabulary development of infants and toddlers who are deaf or hard of hearing. *Volta Review*, *100*(5), 29–52.

Mayne, A. M., Yoshinaga-Itano, C., Sedey, A. L., & Carey, A. (1999b). Expressive vocabulary development of infants and toddlers who are deaf or hard of hearing. *Volta Review*, *100*(5), 1-28.

McCreery, R. W., Walker, E. A., Spratford, M., Bentler, R., Holte, L., Roush, P., … Moeller, M. P. (2015). Longitudinal predictors of aided speech audibility in infants and children. *Ear and Hearing*, *36*(Suppl. 1), 24S–37S. doi:10.1097/AUD.0000000000000211

McGowan, R. S., Nittrouer, S., & Chenausky, K. (2008). Speech production in 12-month-old children with and without hearing loss. *Journal of Speech, Language, and Hearing Research*, *51*(4), 879–888. doi:10.1044/1092-4388(2008/064)

McGuckian, M., & Henry, A. (2007). The grammatical morpheme deficit in moderate hearing impairment. *International Journal of Language & Communication Disorders / Royal College of Speech & Language Therapists*, *42 Suppl 1*, 17–36. doi:10.1080/13682820601171555

Moeller, M. P., Hoover, B., Putman, C., Arbataitis, K., Bohnenkamp, G., Peterson, B., … Stelmachowicz, P. (2007). Vocalizations of infants with hearing loss compared with infants with normal hearing: Part I - phonetic development. *Ear and Hearing*, *28*(5), 628–642.

doi:10.1097/AUD.0b013e31812564c9

Moeller, M. P., & Tomblin, J. B. (2015). An Introduction to the outcomes of children with hearing loss study. *Ear and Hearing, 36*(Suppl. 1), 4S–13S. doi:10.1097/AUD.0000000000000210

Moeller, M. P., Tomblin, J. B., & the OCHL Collaboration. (2015). Epilogue: Conclusions and implications for research and practice. *Ear and Hearing*, *36*(Suppl. 1), 92S–98S. doi:10.1097/AUD.0000000000000214

Moeller, M. P., Tomblin, J. B., Yoshinaga-Itano, C., Connor, C. M., & Jerger, S. (2007). Current state of knowledge: Language and literacy of children with hearing impairment. *Ear and Hearing*, *28*(6), 740–753. doi:10.1097/AUD.0b013e318157f07f

National Institute for Deafness and Other Communication Disorders Epidemiology & Statistics Program. (2006). *NIDCD statistical report: Prevalence of hearing loss in U.S. children, 2005.* Retrieved from https://www.nidcd.nih.gov/health/statistics/nidcd-statistical-report-prevalence-hearing-loss-us-children-2005

National Institute for Deafness and Other Communication Disorders. (2013). *NIH fact sheet: Newborn hearing screening fact sheet*. Retrieved from https://report.nih.gov/NIHfactsheets/ViewFactSheet.aspx?csid=104

Oller, D. K., Eildrs, R. E., Bull, D. H., & Carney, A. E. (1985). Prespeech vocalizations of a deaf infant: A comparison with normal meta-honological development. *Journal of Speech and Hearing Research, 28*, 47--63.

Page, T. A., & Unflat-Berry, L. M. (2013). *Speech and language assessment of children with hearing loss: Challenges in qualifying for services*. Paper presented at the American Speech-Language-Hearing-Association Convention, Chicago, IL.

Page, T. A., Harrsion, M., Moeller, M. P., Oleson, J. J., Arenas, R. M., Spratford, M. (in press). *Service provision for children who are hard of hearing at preschool and elementary school ages*. *Language, Speech, and Hearing Services in Schools*.

Redfern, A., Walker, E. A., & Oleson, J. J. (2017). Beyond breadth: Diving into depth of vocabulary knowledge in children who are hard of hearing. Poster presented at the American Speech-Language-Hearing Association Convention. Los Angeles, CA.

Scarborough, H. S., Neuman, S. B., & Dickinson, D. K. (2009). Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In *Approaching Difficulties in Literacy Development: Assessment, Pedagogy and Programmes* (pp. 23–28). Retrieved from http://books.google.com/books?hl=en&lr=&id=sfKpsYBGX2MC&pgis=1

Semel, E., Wiig, E., & Secord, W. (2004). *Clinical Evaluation of Language Fundamentals* (4th ed.). San Antonio, TX: PsychCorp.

Stelmachowicz, P. G., Pittman, A. L., Hoover, B. M., & Lewis, D. E. (2001). Effect of stimulus bandwidth on the perception of /s/ in normal- and hearing-impaired children and adults. *The Journal of the Acoustical Society of America*, *110*(4), 2183–2190. http://doi.org/10.1121/1.1400757

Stoel-Gammon, C. & Otomo, K. (1986). *Journal of Speech and Hearing Disorders*, *51*(1), 33-41.

Tomblin, J. B., Oleson, J. J., Ambrose, S. E., Walker, E. A., & Moeller, M. P. (2014). The influence of hearing aids on the speech and language development of children with hearing loss. *JAMA Otolaryngology - Head and Neck Surgery*, *140*(5), 403–409. doi:10.1001/jamaoto.2014.267

Tomblin, J. B., Harrison, M., Ambrose, S. E., Walker, E. A., Oleson, J. J., & Moeller, M. P. (2015a). Language outcomes in young children with mild to severe hearing loss. *Ear and Hearing*, *36*(Suppl. 1), 76S–91S. doi:10.1097/AUD.0000000000000219

Tomblin, J. B., Walker, E. A., McCreery, R. W., Arenas, R. M., Harrison, M., & Moeller, M. P. (2015b). Outcomes of children with hearing loss: Data collection and methods. *Ear and Hearing*, *36*(Suppl. 1), 14S–23S. doi:10.1097/AUD.0000000000000212

Wake, M., Hughes, E. K., Poulakis, Z., Collins, C., & Rickards, F. W. (2004). Outcomes of children with mild-profound congenital hearing loss at 7 to 8 years: A population study. *Ear and Hearing*, *25*(1), 1–8. doi:10.1097/01.AUD.0000111262.12219.2F

Walker, E. A, Spratford, M., Moeller, M. P., Oleson, J., Ou, H., Roush, P., & Jacobs, S. (2013). Predictors of hearing aid use time in children with mild-to-severe hearing loss. *Language, Speech, and Hearing Services in Schools*, *44*(1), 73–88. doi:10.1044/0161-1461(2012/12-0005)

Walker, E. A., Holte, L., McCreery, R. W., Spratford, M., Page, T. A., & Moeller, M. P. (2015). The influence of hearing aid use on outcomes of children with mild hearing loss. *Journal of Speech, Language, and Hearing Research*, *58*(5), 1611–1625. doi:10.1044/2015_JSLHR-H-15-0043

Walker, E. A., McCreery, R. W., Spratford, M., Oleson, J. J., Van Buren, J., Bentler, R., … Moeller, M. P. (2015). Trends and predictors of longitudinal hearing aid use for children who are hard of hearing. *Ear and Hearing*, *36*(Suppl. 1), 38S–47S. doi:10.1097/AUD.0000000000000208

Wechsler, D. (2002). *The Wechsler Preschool and Primary Scale of Intelligence* (3rd ed.). San Antonio, TX: PsychCorp.

Wechsler, D. & Hsiao-Pin, C. (2011). *Wechsler Abbreviated Scale of Intelligence* (2nd ed.). San Antonio, TX: PsychCorp.

Werfel, K. L. & Douglas, M. (2017). Are we slipping them through the cracks? The insufficiency of norm referenced assessments for identifying language weaknesses in children with hearing loss. *Perspective of the ASHA Special Interest Groups: Sig 9. 2*(1), 43-53.

Wolgemuth, K. S., Kamhi, A. G., & Lee, R. F. (1998). Metaphor performance in children with hearing impairment. *Language, Speech, and Hearing Services in Schools*, *29*(4), 216–223.

Yoshinago-Itano, C., & Sedey, A. (1999). Early speech development in children who are deaf or hard of hearing: Interrelationships with language and hearing. *The Volta Review, 100*(5), 181-211.