Pediatric Hearing Aid Use: Factors and Challenges

Mina Salamatmanesh

A thesis submitted in partial fulfillment of the requirements for Doctorate in Philosophy degree in Rehabilitation Sciences

School of Rehabilitation Sciences

Faculty of Health Sciences

University of Ottawa

To those who inspired it

and will not read it

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LIST OF ABBREVIATIONS

AVT: Auditory Verbal Therapist

CHEO: Children Hospital of Eastern Ontario

CI: Cochlear Implant

EHDI: Early Hearing Detection and Implementation

EPHPP: Effective Public Health Practice Project

HA: Hearing Aid

HBM: Health Belief Model

HL: Hearing Loss

Hr.: Hour

IHP: Infant Hearing Program

IT-MAIS: Infant-Toddler Meaningful Auditory Integration Scale

JCIH: Joint Committee on Infant Hearing

M: Mean

Mo: Month

NIH: National Institute of Health

ON: Ontario

PEACH: Parent's Evaluation of Aural/Oral Performance of Children

PHAMI: Parent Hearing Aid Management Inventory

PHQ-9: Patient Health Questionnaire – Version 9

REB: Research Ethics Board

SD: Standard Deviation

SLP: Speech Language Pathologist

SW: Social worker

UNHSL: Universal Newborn Hearing Screening

Yr.: Year

Dissertation Abstract

BACKGROUND: Population-based universal newborn hearing screening (UNHS) has been widely implemented in the developed world to ensure early detection of permanent hearing loss (HL) and improve the quality of speech and language outcomes of children with HL. Full-time hearing aid (HA) use is crucial for successful early intervention; most families face many challenges and uncertainties related to their child's HA use in the early years after HA fitting. To our knowledge, there is limited information on HA use in children from Canadian settings, and there is no research using data logging records to examine a child's HA use in the Canadian pediatric setting.

GOALS: This thesis compromised three inquiries, which aimed to 1) review pediatric HA use; 2) examine HA use trends based on data logging records; 3) explore needs and challenges of HA use in young children from clinicians' perspective.

METHODOLOGY: Following a systematic review of the current literature, this doctoral research used a mixed methodology approach to examine the objectives of inquiries 2 and 3. In inquiry 2, the HA use trends in a Canadian pediatric population were explored through a retrospective chart review. In inquiry 3, the needs and challenges of HA use in the pediatric population were studied through focus group discussions with healthcare professionals involved in providing services to children with HL and their families.

RESULTS: In the first inquiry, 15 studies met our review criteria. Only four studies reported HA use based on data logging records. Age, degree of HL and parents' education level were the most frequently reported factors associated with a child's amount of HA use. In the second inquiry, our study sample consisted of 80 children. The study results showed an average of 7.3 hours (SD: 4.27) HA use in the first data logging session, among all 80 cases. There was a significant association between a child's chronological age, laterality of HL, duration of HA use and the amount of HA use. For the last inquiry,

15 clinicians from the CHEO audiology clinic participated in focus group discussion. Clinicians indicated that key items for better HA use outcomes including child-specific factors, family-related factors and a multidisciplinary team approach.

CONCLUSION: Through this research program, we confirmed various factors, including child characteristics, family-related factors, and a child's setting, could affect a child's average daily HA use. From this thesis, we learned that attention should be given to families' unique challenges to provide efficient solutions in an understandable format according to their specific needs and challenges. This thesis lays a foundation for future research on HA use in early childhood, one of the important factors associated with a successful early intervention program in children's hearing rehabilitation.

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CHAPTER 1: INTRODUCTION

Background

Population-based universal newborn hearing screening (UNHS) has been widely implemented in the developed world to ensure early detection of permanent hearing loss (HL) and to improve the quality of communication outcomes of children with HL (JCIH, 2019; Watkin and Baldwin, 2010; JCIH, 2007, Evelyn, 2000). Based on the Joint Committee on Infant Hearing (JCIH) recommendations for Early Hearing Detection and Intervention (EHDI) programs, to reduce the negative impacts of HL, children with HL should be identified by one month of age through UNHS, diagnosed by three months of age and receive hearing devices and intervention by six months of age (JCIH, 2019; 2007; Alanazi & Nicholson, 2019; Ching et al., 2017; Lunner et al., 2016; Marnane & Ching, 2015; Bagatto, Tharpe & Northern, 2015).

Early Hearing Detection and Intervention (EHDI): The goal of EHDI programs is to maximize speech and linguistic competency and auditory development of children with HL. The goal of the Infant Hearing Program (IHP) was to supplement EHDI program components. In 1993, the National Institute for Health (NIH) introduced the universal hearing screening program to fit children with HL before six months. (Leo et al., 2016; Connolly et al., 2005; JCIH, 2007; Bess & Paradise, 1994). In 2002, a province-wide and comprehensive UNHS program, with a well-established protocol**,** was implemented in Ontario (CIHT, 2019; Hyde, 2005; Erenberg, 1999) to diagnose and manage HL in children. To date, Ontario has evidence-based protocols for three program components, including hearing screening, diagnostic and

intervention. Currently, more than 96% of infants in Ontario are being screened through the Ontario Infant Hearing Program (IHP) (CIHTF, 2019; Hyde & Malandrino, 2019).

Early Auditory Stimulation: The first two years of life are a critical period during which auditory experience has the most dramatic effect on postnatal development of the auditory system (Sininger, Doyle & Moore, 1999; Nicolas & Grees, 2006; Bagatto et al., 2010; 2011). The human auditory system development continues during the first years of life through auditory input, which sets the foundation for speech and language development (Moore & Linthicum, 2007; Moore, 2002; Sininger Doyle & Moore, 1999; Erenberg, 1999). Previous studies confirm that early auditory experience shapes the function of the auditory system**,** while a lack of auditory experience can have detrimental effects on a child's speech and language (Sharma, Nash & Dorman, 2009; Bergeson, Houston & Miyamoto, 2010; Davisdon, 2011).

Several published studies on children born with HL have documented that early improvement in hearing can facilitate the development of speech and perceptual skills, receptive-expressive language, and social-emotional growth (Daub et al., 2017; Geers, 2006; Sininger et al., 1999). Pediatric clinicians consequently promote the use of amplification as early as possible to improve and foster auditory foundations for speech and language learning (JCIH, 2019; Bagatto, 2010; Yoshinaga-Itano et al., 2008; Sininger, Grimes & Christensen, 2010; Moeller et al., 2009; Ching, Leigh & Dillon, 2013). Early amplification provides children who have HL with access to an optimal spectrum of speech sounds in the auditory environment (Walker et al., 2013). The early intervention aims to provide these children with the same opportunity as children with normal hearing by developing their functional capacity and improving their communication, cognitive, and literacy skills (Sininger et al., 1999; Patel & Feldman, 2011).

Consistency of Hearing Aid Use: Fitting children who are deaf and hard of hearing with appropriate hearing devices is the very first step in the process of habilitation. The advantages of early identification of HL**,** and appropriate hearing aid (HA) fitting**,** are expected to result in better communication outcomes

if children with HL consistently wear their HAs from the earliest stage of the intervention process (Marnane & Ching, 2015). Early intervention is crucial to ensure that HAs are being used consistently for optimal auditory stimulation, supporting the auditory system and language development in young children (Munoz et al., 2015; Walker et al., 2013).

The growing body of evidence shows that different factors can affect a child's HA use during and after the process of adjustment to the HA (Moeller, 2009; Walker et al., 2013, 2015; Marnane & Ching, 2015). The factors include a child's characteristics (e.g. age, degree of H, etc.), and the child's setting or family situation. Therefore, improving knowledge of challenges and factors that impact HA use in the pediatric population also helps clinicians examine HA use patterns and identify gaps in the early intervention program.

In addition to fine-tuning and adjusting the child's HA to ensure optimal amplification, clinicians monitor the consistency of HA use at ongoing follow-up sessions through two methods: a) parents' report of their child's HA use and b) data logging records. The advantage of monitoring a child's HA use is to remind and coach families about the importance of wearing HAs full time to achieve better auditory and speech development. As reported in previous studies, parents' report about a child's HA use is not always accurate, and most of the time, parents overestimate their child's HA use (Munoz, Preston & Hicken, 2014; Walker et al., 2013; 2015). Therefore, monitoring a child's HA use through data logging records is a more accurate method.

Data Logging: Historically, HA use has been monitored based on parental reports (Moeller, Hoover & Peterson, 2009; Walker et al., 2013; Munoz, Peterson & Hichen, 2014). In recent years, monitoring of HA use has become more feasible due to technological developments. Data logging is a feature that permits a glimpse into an individual's use of their HA. In 1990, the preliminary version of a HA with data logging capability was developed by Mangold and Rising (Patent No. 4,972,487; Mangold & Rising,

1991). In 2004, a new digital programmable HA with the capacity of recording the amount of HA use came to the market (Leen & Landman, 2007). This technology is currently integrated into HAs by almost all manufacturers. It is a powerful tool for clinicians and researchers to analyze the history of HA use. Data logging ranges from simple features that report the average hours of use of HAs to advanced features that can track, apply or change the battery use, alter volume control, and control noise levels (Leen & Landman, 2007). Data logging can provide valuable information about HA use for patients who cannot accurately describe their exact amount of HA use. It can be used to:

- ❏ Analyze a HA user's habits, which can lead to:
  - counselling and supporting the patient to improve hours of HA use.
  - changes in the HA program settings based on the patient's needs.
- ❏ Evaluate which program has been used more frequently by patients over time.
- ❏ Monitor which features have been activated depending on the listening environment.

Input from data logging provides information about a patient's progress in their daily use of HAs during and after adjustment to their HAs (Laplante-Lévesque et al., 2013; 2014). Reviewing the data logging records in the follow-up sessions with families gives the clinicians information about the family and child's status in the process of adjustment to the HA. When clinicians observe poor HA use through data logging records, they can engage with the families about their challenges with their child's HA use in different settings and offer them different supports to improve their child's HA use over time.

In the past few years, several studies have addressed average HA use, factors and challenges related to HA use in the pediatric population from different perspectives (Jones & Loaner, 2010; Munoz et al., 2014; 2015; 2017; Walker et al., 2013;2015). However, there is a lack of information about pediatric HA use in the Canadian population.

Objectives: This doctoral research was carried out within the Child Hearing Lab at the Children's Hospital of Eastern Ontario (CHEO) and sought to provide information on the use of HAs for children diagnosed with HL through the Ontario Infant Hearing Program (IHP). Currently, there is little to no information and research in this area in the Canadian context. The objectives of this thesis were to contribute to this developing field by 1) systematically reviewing the literature in the area of HA use; 2) evaluating HA use trends in a Canadian pediatric population, and 3) understanding the factors and challenges of HA use in children from healthcare professionals' viewpoint.

Methodology

A systematic review of the current literature on pediatric hearing aid use was conducted . Subsequently, a mixed methodology approach (quantitative and qualitative) was applied to examine these objectives through two interrelated inquiries: a) an exploration of data from a retrospective chart review investigating the amount of HA use in a Canadian pediatric population based on their data logging records, and b) a focus group discussion with healthcare professionals who were actively involved in providing healthcare services to children with HL and their families. This doctoral research was approved by the CHEO Research Ethics Board (REB). REB Protocol Numbers: 18/137X and 17/65X.

An overview of each study and objectives in this program of research is provided in Table 1.

Study	Methodology	Objectives
1. Pediatric hearing aid use: a systematic review of challenges and associated factors	Systematic review	1. Review HA use in the pediatric population. 2. Identify factors associated with HA use.
2. Hearing aid use trends based on data logging records	Quantitative	1. Quantify the amount of HA use in the first years after HA fitting based on data logging records. 2. Examine the association between factors such as child's chronological age, the onset of HL, laterality of HL, degree of HL, duration of HA use, and amount of HA use.
3. Needs and challenges of hearing aid use in young children from clinicians' perspective: A focus group study	Qualitative	1. To understand child-specific factors that can affect the amount of HA use. 2. To understand parents' challenges and concerns with their child's HA in the early years. 3. To learn about clinicians' practices and coaching strategies to help families early after their child's HA fitting.

Table 1. Overview of the studies in this program of research

Theoretical Basis

This research adopted the Health Belief Model (HBM) as a conceptual framework to anchor the three inquiries of this research program. The HBM is one of the most commonly used theoretical frameworks in health promotion**.** The model includes six primary constructs: (1) perceived susceptibility**,** (2) perceived

severity**,** (3) perceived benefits and barriers**,** (4) perceived threats**,** (5) cues to action and (6) perceived health behavior (Figure 1).

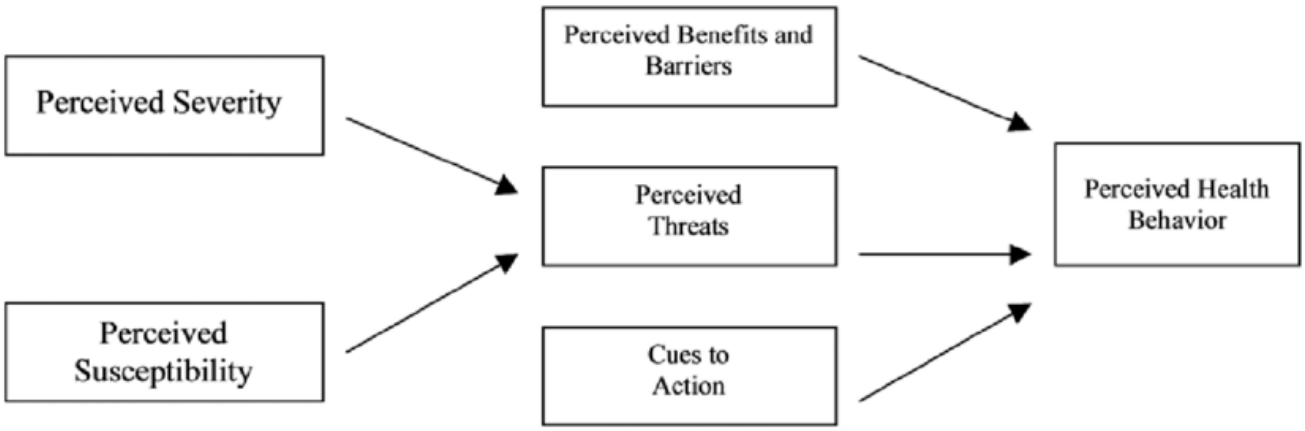

Figure. 1. Schematic representation of the HBM based on Jones et al. (2015) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4530978/

The framework has been applied in several studies examining hearing loss and hearing aid use (Schulz et al., 2016; Saunders et al., 2013; Calderon & Greenberg; 1999). Based on these studies using the HBM, the key constructs in the context of HA use include a) severity of hearing impairment, b) child's additional disabilities, c) barriers and challenges for parents, d) benefits of treatment, and e) reciprocal determinism (the impact of the environment on the quality of the outcomes). These constructs have an impact on the process of rehabilitation and help to understand the factors that affect the development of communication skills and the quality of language outcomes. These constructs map the complex interaction between parents' beliefs in the importance of HA use and their child's HA use consistency.

Using the HBM to guide this research is consistent with a patient/ family-centred approach in the process of care. Within this framework, we can evaluate factors that motivate or discourage families from adhering

or not adhere to the clinicians' recommendations regarding the importance of their child's full-time HA use. Thus, this model maps the factors for families' engagement through the early intervention process.

General Overview of Thesis

The methodology and findings for this research program are presented as a series of three articles that constitute Chapters 2 through 4 of this doctoral dissertation. Each chapter is a stand-alone article and formatted to be published in an appropriate peer-reviewed journal. The details of the methodology and results for each inquiry are presented through these chapters. A brief introduction to each chapter is presented below.

Chapter 2 synthesized information from the literature between 2005 to 2019 regarding the amount of HA use, factors, and challenges associated with HA use in children in a systematic review format. It also helped us to identify the gaps in the literature in this study context.

Chapter 3 provides results from a retrospective examination of the amount of HA use and factors associated with HA use before age 60 months in a sample of 80 Canadian children with mild to profound HL. To our knowledge, this is the first study that examined pediatric HA use based on data logging records in the Canadian context. This study provided information about the average amount of HA use in a small Canadian pediatric sample. It also examined the association between a child's characteristics, duration of HA use and the amount of HA use. This chapter also identified the need to learn about HA use challenges from the professionals' viewpoint.

Chapter 4 reports findings from an inquiry that used a focus group format to understand the factors and challenges associated with hearing aid use early after hearing aid fitting from the professionals'

perspective. This study was conducted with 15 clinicians from the Audiology clinic at CHEO. In this study, we systematically categorized HA use challenges based on professionals' knowledge and experiences. Then we proposed several strategies based on clinicians' experiences to improve a child's HA wearing.

The three article-based chapters are followed by an integrated discussion in Chapter 5 to summarize the key findings of this doctoral thesis. This chapter summarized the overall findings of Chapters 2, 3 and 4, and integrated the qualitative study results (Inquiry 3 – Chapter 4) into the HBM. The chapter concluded with the future research needs of pediatric HA use.

In summary, the findings in this doctoral thesis add to the knowledge about HA use in a cohort of young children and contribute to an understanding of the factors and challenges with HA management in the pediatric population. This program of research represents the first study in the Canadian pediatric population health context to investigate HA's factors and challenges in young children after HA fitting.

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CHAPTER 2: SYSTEMATIC REVIEW

Pediatric Hearing Aid Use: A Systematic Review

Mina Salamatmanesh, M.Sc. PhD.c.[*1, 5], Lindsey Sikora M.Sc. PhD.c.[2], Sayna Bahraini Ph.D.[3, 5], Melissa MacAskill M.Sc. [6], Josée Lagacé Ph.D. [1], Tim Ramsay Ph.D. [4, 6], Elizabeth M. Fitzpatrick Ph.D.[1, 5]

[1]School of Rehabilitation Sciences, Faculty of Health Science, University of Ottawa; [2]Health Sciences Library, University of Ottawa; [3]School of Nursing, Faculty of Health Sciences, University of Ottawa; [4]School of Epidemiology, Faculty of Health Science, University of Ottawa; [5]CHEO Research Institute; [6]Ottawa Hospital Research Institute; [6]Eastern Health, Clarenville, NL.

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[1]*Corresponding Author:

Mina Salamatmanesh, PhD.c.

CHEO-Research Institute, 401 Smyth Rd

Ottawa, ON K1H 8L1, msalamatmanesh@cheo.on.ca

Abstract

Context: Hearing loss (HL) is one of the most common disorders present at birth. Parents' management of their child's hearing aids (HAs) and regular follow-up with healthcare providers HA are fundamental components of effective intervention. **Objective**: The primary objective of this systematic review was to synthesize the current literature on HA use in the pediatric population, and the secondary objective was to review the factors associated with HA use. **Methods**: Electronic databases, including MEDLINE, EMBASE, CINAHL, and LLBA from 2005 to 2019, were searched. Two reviewers individually screened potentially relevant articles over two phases. **Results**: Fifteen studies met this review criteria. Four studies reported HA use based on data logging records. In nine studies, the amount of HA use was evaluated based on parents' reports, and three studies concluded that parents overestimate their child's HA use. Age, degree of HL and parents' education level were the most frequently reported factors associated with a child's amount of HA use. **Conclusions:** The results of this review will provide a foundation for future studies on the importance of monitoring HA use and the impact of consistent HA use on the language development of children with HL.

Background

BACKGROUND: Hearing loss interferes with typical speech, language, and literacy development. Hence, for children with hearing loss (HL), these skills are often lower than those of children with normal hearing abilities (Wake et al., 2005; Nicholas & Geers, 2007; Fitzpatrick, Crawford & Durieux-Smith, 2011; Kennedy et al., 2006). Studies have demonstrated that early diagnosis of HL and early intervention services, such as hearing aids (HAs) before six months of age, provides a child with access to an optimal spectrum of speech sounds and improves the development of auditory and linguistic skills (Deng, Finitzo & Aryal, 2018; Yoshinaga-Itano et al., 2017; Chung et al., 2017, Walker et al., 2013). Population-based universal newborn hearing screening (UNHS) is standard care in the developed world to identify hearing loss early and improve the quality of developmental outcomes for children with permanent HL (Joint Committee on Infant Hearing, 2019; 2007; Watkin and Baldwin, 2010). UNHS programs have been adopted based on the assumption that, with early identification of HL, children will have access to optimal amplification at a younger age. The human brain has maximal plasticity in the first year of life (Irvine, 2018; Sinninger Doyle & Moore,1999; Moor, 2002). Therefore, access to the full range of sounds should have positive effects on the development of the auditory system (Fulcher et al., 2015; Joint Committee on Infant Hearing, 2019, 2007; Sininger, Grimes & Christensen, 2010; Sininger, Doyle & Moore, 1999; Bagatto et al., 2010). Although early intervention programs provide frequent follow-up for children, after the HA fitting, parents still encounter various challenges when integrating HA management into their daily life (Walker et al., 2013). This process is unique to each family, and it is essential to understand parents' perspectives to provide effective family-centred services.

Hearing aid use directly affects access to the range of sounds for children with HL. In the past few years, various strategies have been developed to support families in achieving consistent HA use and the quality of outcomes through the critical period, early after HA fitting (Munoz, Preston & Hicken, 2014; Munoz et al., 2015; Moeller et al., 2009; Walker et al., 2013; Marnane & Ching, 2015). Munoz and Hill (2015) presented a rapid evidence assessment and provided a summary of information related to early childhood HA use between 1980 and 2012. Results of this review confirmed that minimal research was conducted related to the amount of HA use and factors associated with consistent HA use in the pediatric population. Given the importance of consistent HA use for children's hearing and language development, the primary goal of this systematic review was to synthesize the current literature on HA use in the pediatric population, and the secondary purpose was to review factors associated with HA use in the pediatric population.

Our interest was in addressing the following questions: What is the amount and consistency of HA use in young children? What are the factors associated with the amount of HA use in young children? What are parents' challenges and needs in managing their child's HA?

Methodology

The protocol for this review was registered in PROSPERO (Registration # CRD42019116207), an international register of systematic review protocols. In conducting this systematic review, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was followed, and a PRISMA-P checklist was completed. An integrated knowledge translation approach was undertaken by involving clinicians and educators in developing the research questions of this review in ensuring the relevance of the project from pediatric audiology and rehabilitation experts' viewpoints.

Literature Search: Medline, Embase, Cochrane Controlled Registry of Trials, CENTRAL were searched using the Ovid interface. Cumulative Index for Nursing and Allied Health Literature (CINAHL) database was searched by using the EbscoHost interface, as well as Linguistics and Language Behavior Abstract (LLBA). An experienced information specialist developed a preliminary search strategy in consultation with the review team (Appendix 1). The search was also subjected to independent peer review, using the Peer Review of Electronic Search Strategies (PRESS) guideline (McGowan et al., 2016). The search was restricted by age (0-5 yrs old), keywords (HL, HA, HA use), language (English) and date (January 2005 to January 2019). In addition, one grey literature source (A.G. Bell Association for the Deaf https://g.co/kgs/bKXznK) was searched. The bibliographies of selected articles were hand-searched for additional papers.

Eligibility Criteria

Study Designs: We included all types of study designs in this review. For case studies, we only included studies with seven patients or more in the study. ***Population***: Studies were eligible for inclusion if they included children (1) with permanent unilateral or bilateral HL of any degree; (2) using unilateral or bilateral HAs by age 5. ***Intervention***: We included studies addressing: (1) pediatric HA use, which involved any form of HA use reports such as the amount of HA use based on data logging records or estimated based on parents' reports, (2) factors associated with a child's HA use (e.g., chronological age, degree of HL, additional disabilities, parent education level and parents challenges in managing their child's HA in various settings). ***Outcomes***: Primary outcomes were all measures of HA use, including data logging records and parents' estimates of their child's daily HA use; these outcomes were selected as clinically relevant based on the literature (Walker et al., 2013; Munoz et al., 2015; Meibos et al., 2016). Secondary outcomes included factors associated with the consistency of HA use such as age at HA fitting,

degree of HL, additional disability and family's characteristics in achieving consistent HA use for their young children. ***Time Frame:*** We included all studies after 2005 (January 2005-January 2019) to capture publications after implementing data logging features into HAs.

Study Selection: All records were compiled in Mendeley, a reference manager software, and duplicates were removed. Study selection included two distinct stages, which were carried out using Covidence, an internet-based systematic software. (www.covidence.org). Screening forms were developed based on the inclusion criteria. Before each screening stage, a subset of records was calibrated among reviewers. A broad screening was done based on title and abstract screening by two independent reviewers, and all potentially relevant articles were retrieved for full-text screening. In focused screening, both reviewers independently screened all potentially relevant full-text articles. Disagreements were resolved by consultation and consensus with a third researcher as needed.

Data Collection/Extraction: A study-specific data extraction form was developed in Microsoft Excel to extract predetermined data variables. Extracted items included: (1) study characteristics (citation, year, setting, country and source of funding), (2) study design, (3) sample size, (4) population characteristics (e.g., age, the severity of HL), (5) assessment measures (e.g., data logging, questionnaire), and (6) outcome data (e.g., number of hours HA use). One researcher did the data extraction, and the second researcher verified the extracted information. Disagreements and unclear data were resolved and checked by a third researcher, who was an expert in audiology.

Quality Assessment: The Quantitative Assessment Tool for Studies developed by the Effective Public Health Practice Project (EPHPP) at McMaster University (https://merst.ca/ephpp/) was used to assess the quality of the studies. The tool provides a methodological rating for studies based on a critical appraisal in eight areas, including (1) selection bias, (2) study design, (3) confounders, (4) blinding, (5) data collection method, (6) withdrawals and dropouts, (7) intervention integrity, and (8) analyses. One

researcher conducted the quality assessment, and the second reviewer verified the results of the assessment. Any differences were discussed to reach a consensus.

Data Synthesis: Quantitative data from included studies, such as the number of hours of HA use, were extracted along with the mean and standard deviation (SD) (if provided by the authors). Continuous outcomes were presented for the amount of HA use and other outcomes with 95% confidence intervals, wherever possible. Due to the heterogeneity in methods and outcome metrics of included studies, subgroup analysis and meta-analysis were not possible. Qualitative data were extracted and classified under categories based on the frequency of the factors (such as families SES and parents' needs for more support from clinicians)

Results

Based on the search results, 2898 records were identified via the selected databases, and 10 records were identified through other sources (grey literature search and hand-searching of citations); 2679 were retained for screening after duplicates were removed. Figure 1 shows the PRISMA flow diagram of records through the screening process. We reviewed 38 articles at the full-text level, and 23 articles were excluded due to the following reasons: (a) not an English article, (b) not the intervention, and (c) not the

target population. Therefore, 15 unique studies were included in this review.

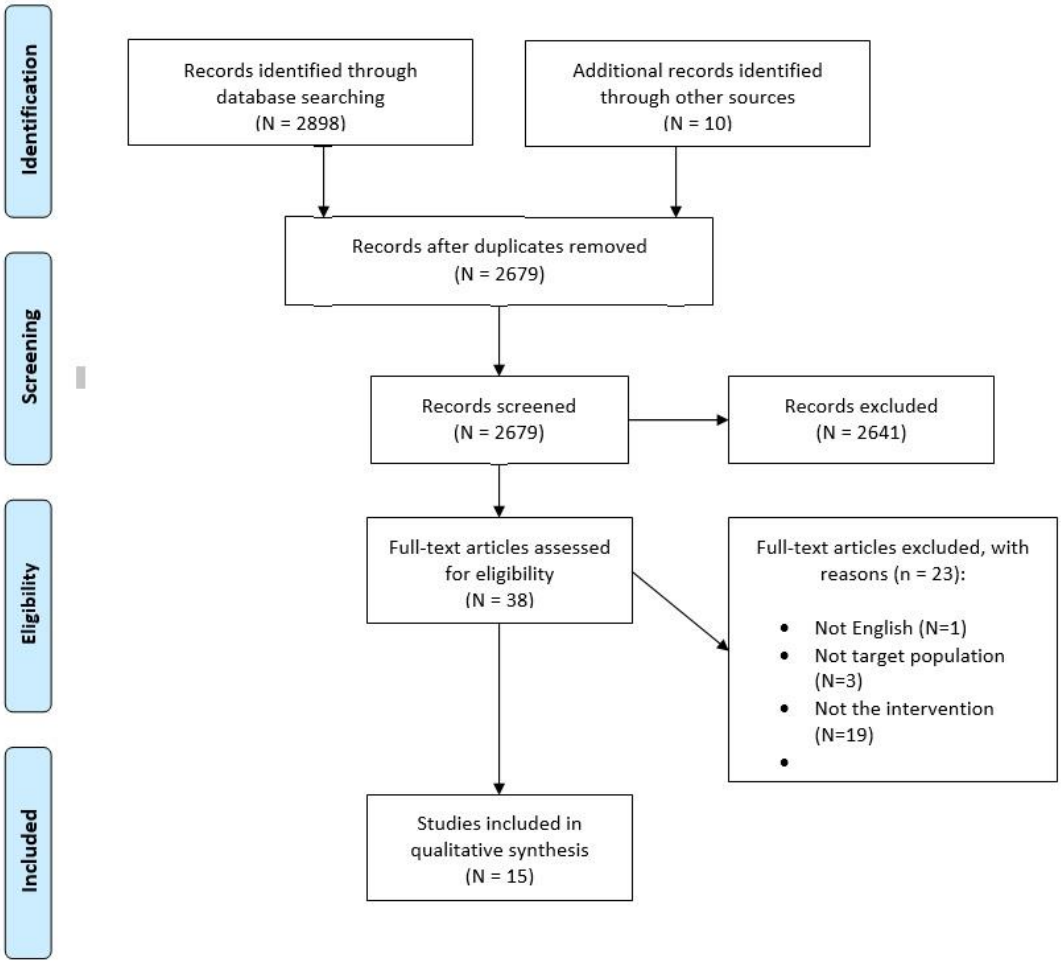

Figure 1. Study selection: The PRISMA diagram (Moher et al., 2009)

Study Characteristics

In total, 15 studies were included in this review, of which four studies were cohort study designs (including prospective and retrospective), and 11 were cross-sectional. The majority of studies were published in the United States (n=11) (Caballero et al., 2017; Jones and Launer, 2010, McCreery et al., 2015; Meibos et al., 2016; Moeller et al., 2009; Munoz et al., 2016; 2015; 2014; 2013; Walker et al., 2013, 2015). The remaining studies were conducted in different countries, including Denmark (Dammeyer, Lehane & Marschark, 2017), Australia (Marnane et al., 2015), Finland (Marttila & Karikoski, 2006) and Brazil (Novaes et al., 2012). Selected studies reported a range of 7 to 5000 participants in their population. Children with mild to severe degrees of HL, from birth to 18 years of age, were the target population of the included studies. We only included studies that provided separate data based on age range and that clearly reported HA use for the 0-5 year age range.

Table 1 describes population characteristics, study design, sample size, and the main objectives of the included studies. The main objectives of included studies were:

a) to evaluate the amount of child HA use based on parents' reports and/or data logging records.

b) to identify factors associated with a child's HA use, including child's characteristics (e.g., age, sex, severity of HL), family characteristics (e.g., parents' level of education, and SES) as well as families needs' and challenges in managing their child's HA in different settings and situations (e.g., in the car, or during summer activities such as swimming).

ID	Study, Country	Study Design	Sample Size	Population Characteristics	Assessment Measures	Study Objectives
1	Caballero et al., 2017, USA	Cross-sectional	N=42	0-5 yrs., bilateral between 40-90 dB HL, Spanish speaking families	PHAMI PHQ-9	To describe challenges with HA management and use, as reported by Spanish-speaking parents in the United States, and factors that may influence HA use.
2	Dammeyer , Lehane and Marschark, 2017, Denmark	Cross-sectional	N=269	0-15 yrs., different degrees of HL HL< 70dB	National survey for parents	To give an overview of frequency and type of service use among individuals with HL in Denmark and interpret service use concerning demographic variables
3	Jones and Launer, 2010, USA	Cross-sectional	N=5000	0-18 yrs. average 63 dB PTA	Data logging	To use data logs to understand issues around the provision of instruments for children
4	Marnane and Ching, 2015, Australia	Cohort Study	N= 413	Up to 36 mo	PEACH	To examine patterns of HA use: How Aa use changes longitudinally and factors associated with device use.
5	Marttila and Karikoski, 2006, Finland	Cross-sectional	N=328	1-18 yrs., HL >=30dB in the better ear	Hospital records of HA use	To study the factors contributing to the mode of HA use with particular emphasis on HL variables.
6	McCreery et al., 2015, US	Cohort Study	N=306	1-9 yrs., bilateral HL (Mean 48.5 dB; SD 14.4 dB)	HA use Q; PEACH LittlEARS;	To describe the effects of variability in children's auditory experience on parent-report auditory skills questionnaires
7	Meibos et al., 2016, US	Cross-sectional	N=349	Pediatric audiologists	Survey	To explore current practices of pediatric audiologists regarding their support of parent learning in achieving effective HA management, identify existing gaps in service delivery.
8	Moeller et al., 2009, US	Cross-sectional	N=7	Mothers of infants (9 to 13 mo), mild to moderately severe HL	Structured Interview; amplification Q	To examine the consistency of HA use by infants.
9	Munoz, Blaiser and Barwick, 2013, US	Cross-sectional	N=352	Parents/caregivers children, HL	Survey	To investigate parent experiences as they access and manage HAs for their child.
10	Munoz, Preston and Hicken, 2014, US	Cross-sectional	N=29	7 mo - 6 yrs	Data Logging; Parental Report	To examine whether HA use time increased when parents were given periodic objective

						feedback about average daily use time.
11	Munoz et al., 2015, US	Cross-sectional	N=37	0 -22 mo, bilateral HL, English-speaking families	PHAMI	To investigate parent-reported challenges related to HA management and parental psychosocial characteristics during the first 3 yrs of the child's life.
12	Munoz et al., 2016, US	Cross-sectional	N=318	Parents of children (0-3yrs), bilateral HL	PHAMI; PHQ-9	To investigate parent learning and support needs related to HA management and factors that influence parent-reported hrs of HA use
13	Novaes et al., 2012, Brazil	Cohort Study	N=35	Bilateral HL without neurological cognitive or motor impairment Tympanometry (Type A), parents/grandparents with normal hearing	Data Logging IT-MAIS; MUSS	To establish relationships between different factors regarding the language development of children diagnosed with HL during the first three yrs of life.
14	Walker et al., 2013, US	Cross-Sectional	N=272	3mo to 7yrs., mild to severe HL without additional disabilities	HA provider survey; HA use questionnaire	To investigate predictors of HA use, barriers to consistent HA use and reliability of parent report HA use measures
15	Walker et al., 2015, US	Cohort Study	N=290	Parents of children (5mo to 7yrs)	Data Logging, Parental reports	To characterize long-term HA use based on parent report measures and identify factors that influence longitudinal trends in HA use.

Table 1. Table of characteristics for included studies in alphabetic order. Statistical information (e.g. SD, Mean, etc.) is included in the table if the authors reported it in the paper. Q: questionnaire; mo: month(s); yrs: years; hrs: hours; HL: Hearing Loss; HA: Hearing Aid; PHAMI: Parent Hearing Aid Management Inventory; PHQ-9: Patient Health Questionnaire-9; PEACH: Parents' Evaluation of Aural/Oral Performance Of Children; LittlEARS: Little Ears Auditory Questionnaire; IT-MAIS: Infant-Toddler Meaningful Auditory Integration Scale; MUSS: Meaningful Use of Speech Scale

In Table 2, we classified frequently reported items related to HA use under two main categories: a) outcomes and b) factors. The items reported under the outcomes category were: parents' estimates of their child's HA use, parents overestimation of their child's HA use (reported hours compared with child's data logging records), child's amount of HA use based on data logging records, and parents' need for more support to manage their child's HA. Factors associated with HA use reported frequently in the studies were age, sex, the severity of HL, parents' level of education, family socioeconomic status (SES) and child's setting (including environment, activity and safety).

Study ID	Outcomes				Factors					
	Parents HA	Parents HA	Data-loggin	Need more	Age	Sex	everity of HL	arental educat	SES	Setting
1	X			X						X
2	X					X	X			
3			X							
4	X				X		X	X	X	
5					X		X			
6					X		X	X		
7				X					X	
8					X					X
9	X			X	X				X	
10	X	X	X		X		X			
11	X			X						
12	X			X				X	X	X
13			X							
14	X	X			X		X	X		
15	X	X	X				X	X		

Table 2. Outcome domains

Quality Assessment

Details related to the study outcomes and quality are shown in Table 3. As noted, we applied the McMaster Quality Assessment Rating tool for the quality assessment by the EPHPP to the included studies (https://merst.ca/ephpp/). Based on the McMaster framework, an overall weak rating is assigned to a study if ≥ 2 areas are rated as weak. Due to the nature of studies on this topic (amount of HA use and parents' challenges with their child's HA), there is no blind study in this context. Therefore, all studies received a weak rating for this item in the quality assessment. Other reasons contributing to an overall weak quality rating were limited information on data collection methods, such as the percentage of individuals who agreed to participate in the studies. Moreover, some of the included studies were not specifically designed to answer the review questions, which may have influenced their quality rating.

Summary of Outcomes:

Table 3 presents a summary of all the outcomes from the included studies as well as factors associated with outcomes.

ID	HA Use Outcomes	Factors Associated with HA Use	Other Outcomes	Overall EPHPP
1	**Parents HA use estimate:** 66% (N=27) reported all waking hrs (8-9hrs) on a good day. 37% (N=15) said all waking hrs HA to use even on bad days		**Parents' challenges/needs:** Fear of losing HA s and not seeing benefit from HA. 48-66% of parents wanted more information and more support from audiologists.	Moderate
2	**Parents HA use estimate:** 23.9% not using HA(s), 52.2% use HA(s) >10hrs	**Sex**: Girls try to hide their HA s more than boys.	**The severity of HL**: Children with severe to profound HL used HAs less often compared to those with HL lower than 70 dB.	Weak
3	**Data Logging**: Infants and young children <4yrs, HA use ~ 5 hrs. 40% of children use HA s ≥ 4 hrs; 10% of children use HA <12 hrs.		N/A	Weak
4	**Parents HA use estimate:** 62% use HAs >75% of waking hrs within the first year of amplification.	Relationship between the following factors & more early intervention hrs: **Severity of HL:** Higher degree of HL (P<0.001). **Age:** Younger age of initial HA fitting (P<0.001). **Parents' education:** Higher level of maternal education (P<0.001). **Parents SES**: Higher SES (P<0.01) and more early intervention hrs.		Moderate
5	N/A	**Severity of HL**: Children with 50 to 90 dB HL used more regularly their HA. **Age:** Proportion of children not using HAs increasing by age (28%).		Weak
6	N/A	**Severity of HL:** Children with higher degree of HL more hrs of HA use. **Age:** Consistent HA use more challenging for infants and toddlers, more consistency as age increases. **Parents' education**: Greater HA use was associated with higher parent rating of auditory skills.	**Language development:** Consistent HA use supports auditory development.	Moderate

7	N/A		**Parents' challenges:** 25% of audiologists did not provide info related to loaner HA, HA options, financial assistance, HA maintenance. **Audiologists' needs**: 53% desired more training in counselling skills.	Moderate
8	N/A	**Age**: HA use improves by age, especially over the second yr. of life.	**Parents' challenges:** damage/loss of HA, retention problem because of child activity/ environmental. Harder to manage HA use in weekend.	Moderate
9	**Parents HA use estimate**: All waking hrs HA use: > 25% (0-18 mo), 57% (19-36 mo); 71% (37-62 mo)	**Age**: 55% of parents reported more difficulty keeping HAs for children 0-18 mo.	**Parents' challenges/needs:** HA expenses, accepting HAs and wait time. 48% need more support from audiologists.	Moderate
10	**Data Logging:** 7-35 mo: M 4.6 hrs, SD 4.07; 36-60 mo: M 7.0hrs, SD 4.13; >60mo: M 11.9 hrs, SD 0.86. **Based on severity of HL**: Mild HL users: M 4.3hrs, SD: 3.39; Moderate users: M 8.5hrs, SD: 4.37; Severe users: M11.9 hrs, SD 2.86. **Parents HA use estimate**: Parents overestimated HA use by an average of 3.36 hrs (range, 0.5-7hr)	**Severity of HL:** HA use increases with severity of HL. **Age:** HA use increases with age.	**Parents' Challenges**: 1. retention, 2. lack of awareness, 3. lack of perceived benefit of HA use.	Strong
11	**Parents HA use estimate:** Ranges (>5hrs - all waking hrs). 34% reported all waking hrs Mothers: M 2.40, SD 1.27; Fathers: M 2.35, SD 1.27.		**Parents' challenges/needs**: 84% preferred to information at the beginning; 47% need more time to talk about their emotions with the audiologist. 69% reported the audiologist did not provide information and parents need more support.	Moderate
12	**Parents HA use estimate:**	Higher degree of HL, Higher level of maternal education, higher SES and more early intervention hrs.	**Parents' challenges/needs:** 27% parents, children not wanting to wear the HA during activities and	Moderate

	42% reported using HA all waking hrs on good days. 18% reported wearing HA all waking hrs even on bad days.		fear of losing or damaging the HA**.** 35% required more info on a variety of topics.	
13	**Data Logging:** P=0.082, ranged 0-14 hrs/day		**Language development:** Majority considered the use of HA is a significant factor related to parents' satisfaction with the development of hearing and language.	Weak
14	**Parents HA use overestimate**: Difference between reported hrs of use by mothers with college education and mother with high school education.	Longer HA use was related to poorer hearing, higher maternal education. Every 10 mo increase in age, average of HA use time increased by 0.71 hrs/day. More challenges with consistent HA management for infants (0-2 yrs).		Moderate
15	**Parents HA use estimate:** 10.63 hrs **Data Logging:** **6-24 mo:** 4.36 hrs **24-48 mo:** 7.57 hrs	**The severity of HL**: Parents of children with better hearing were more likely to overestimate the HA use. **Parents' education**: Higher maternal education level is associated with higher HA use.		Moderate

Table 3. Summary of outcomes and quality assessment rating. HA use reported in included studies (either by parents or in data logging records) is presented under the "HA Use" column. Parents' challenges, clinicians' comments and other comments are presented as "other outcomes." HA: Hearing Aid; HL: Hearing Loss; hrs: hours; SD: Standard Deviation; M: Mean.

As shown in Table 3, HA use was reported in two formats: (a) parent report, and (b) data logging records. The association between HA use and factors including age, sex, the severity of HL, parents' education level, socioeconomic status and child's setting was addressed in three studies (Caballero et al., 2017; Moeller et al., 2009; Munoz et al., 2016).

Parent Reports of Their Childs Hearing Aid Use*:* In 7 of 15 studies, the amount of HA use was reported based only on parents' reports, and more than 50% of parents reported their children wore their HAs during all waking hours (average 10 hours/day) (Caballero et al., 2017; Dammeyer, Lehane and Marschark, 2017; Marnane and Ching 2015; Munoz et al., 2013, 2015, 2016;Walker et al., 2013). One parent-report study examined HA use for different ages of children. Results of this study showed that less than 25% of children with HL aged 0-18 months use their HAs all waking hours, and 71% of children with HL aged (37-62 months) wear their HAs during all waking hours (Munoz, Blaiser & Barwick, 2013). Based on parents' reports, Walker et al. (2013) reported that the amount of HA use on weekdays is significantly higher than on weekends ($P<0.0001$).

Data Logging Records*:* Two studies evaluated children's HA use based only on their data logging records (Jones & Launer, 2010; Novaes et al., 2012). Jones and Launer (2010) reported the average amount of HA use in infants and young children was 5 hours and that less than 10% of young children used their HAs all waking hours (defined as 10-12 hours/day). However, in the other study (Novaes et al., 2012) reported a range of 0-14 hours per day HA use among children with an average age of 48 months (SD: 21).

Parent Report Compared to Data Logging Records: In two studies, parent-reported hours of HA use were compared to the child's data logging records (Munoz, Preston & Hicken, 2014; Walker et al., 2015). Munoz and colleagues (2014) found that parents overestimate their children's HA use by an average of 3.36 hours. Walker et al. (2015) also confirmed parents of children with better hearing are more likely to overestimate use.

Child Characteristics and HA use: Several studies confirmed an association between the amount of HA use and factors including age, degree of HL and auditory and language development.

Age: Seven studies provided information about the association between chronological age of the child and amount of HA use (Marnane and Ching, 2015; Marttila and Karikoski, 2006; Moeller et al., 2008; McCreery et al.,2015; Munoz, Blaiser & Barwick 2013; Munoz, Preston & Hicken 2014; Walker et al., 2013). These studies showed the amount of HA use in infants and young children is significantly lower than for older children. In the study by Munoz et al. (2013), 55% of parents reported more difficulty keeping on the HAs for children aged 0-18 months. In another study by Munoz et al. (2014), hours of HA use were categorized by age and severity of HL. This study reported the median HA use for children age 7-35 months old was 6 hours/day, increasing to double for children over age 60 months (Mean= 11.9 hours/day; SD= 0.86). Additionally, five studies confirmed that the pattern of HA use improved by age (Marttila and Karikoski, 2006; McCreery et al., 2015; Moeller et al., 2009; Munoz, Preston and Hicken, 2014; Walker et al., 2013). Based on the study by Walker et al. (2013), the average HA use time increased by 0.71 hr. /day with every ten-month increase in age.

***Degree of HL*:** Seven studies reported the importance of HL severity and its impact on the amount of HA use (Dammeyer, Lehane and Marschark, 2017; Marnane and Ching, 2015; Marttila and Karikoski, 2006; McCreery et al., 2015; Munoz, Preston and Hicken, 2014, Walker et al., 2013; 2015). Based on the degree of HL, the amount of HA use varied from 3 hours/day for children with mild HL to 9.9 hours/day for those with moderate HL and reached a maximum of 12.3 hours/day for children with severe HL (Munoz, Preston & Hicken, 2014). Dammeyer and colleagues (2017) reported children with severe HL use

their HAs less often than those with HL lower than 70 dB HL. Six other studies confirmed children with degrees of HL, ranging from 50-90 dB HL, use their HAs longer and more regularly than children with milder degrees of HL (Marnane and Ching, 2015; Marttila and Karikoski, 2006; McCreery et al., 2015; Munoz, Preston and Hicken, 2014, Walker et al., 2013; 2015).

Auditory/Language Development: While the association between HA use and speech and language development was not primary interest of this review, two of the included studies reported an association between auditory skills, language development, and HA use (McCreery et al., 2015; Novaes et al., 2012). McCreery and colleagues (2015) reported that children with a higher amount of HA use had higher parent ratings for language skills on the LittlEARS questionnaire. In another study, Novaes et al. (2012) used the IT-MAIS and MUSS questionnaires and confirmed that systematic use of HAs showed a strong relationship with auditory and language skills. They also concluded that HA use is a significant factor related to parents' satisfaction with their children's hearing and language development (Novaes et al., 2012).

Family Factors:

Parents' Education Level: In five studies, higher maternal education level was mentioned as a factor that resulted in a greater amount of HA use (Marnane and Ching, 2015; McCreery et al., 2015; Munoz et al., 2016; Walker et al., 2013; 2015). One study found two hours difference between hours of HA use reported by mothers with a college education compared to mothers with a high school education (Walker et al., 2015).

Income and Settings: Four studies reported that children from families with higher SES have more early intervention hours. (Meibos et al., 2016; Marnane and Ching, 2015; Munoz et al., 2013; 2016). Three studies (Caballero et al., 2017; Munoz et al., 2016; Moeller et al., 2009) reported that in some countries, a child's HAs expenses, including the costs of purchasing HAs, is not covered by insurance; therefore, parents with lower income may have some concerns about losing or breaking their child's HA. Consequently, they may remove their child's HA in some settings/environments such as playgrounds resulting in lower HA use on some days.

Discussion

Early Hearing Detection and Intervention (EHDI) Programs provide an opportunity for children with HL to access an optimal range of sounds within the first few months of their life. The primary goal of this study was to review HA use in the pediatric population, and the secondary objective was to identify factors associated with HA use.

To address the primary objective of this review, we reviewed the actual amount of HA use reported in the studies through data logging records or parents' estimates of their child's HA use. We only found four studies (Jones & Launer, 2010; Munoz, Preston & Hicken, 2014; Novaes et al., 2012; Walker et al., 2015) with weak to moderate qualities that addressed the amount of HA use by monitoring data logging records. The results of those studies showed that daily average HA use ranged from 5 to 12 hours and was very dependent on the child's characteristics and the child's setting.

To address the secondary objective of this review, we found factors including age, sex, degree of HL, parents' educations level, and family-specific unique challenges as the main factors that can

affect a child's HA use. Our results were consistent with the previous literature review (Munoz & Hill, 2015). We found that the severity of HL was one of the frequently reported factors that can significantly impact the amount of HA use. Children with severe degrees of HL are usually better users of HAs than children with milder degrees of HL. It is thus essential for clinicians and researchers to focus on the interventions that help the improvement of HA use among children with a milder degree of HL and unilateral HL. The main factors addressed in the literature regarding parents' challenges in achieving optimal HA use were (a) fear of losing their child's HA, (b) not seeing the obvious benefit of using HAs in the short term, and (c) HA fitting and maintenance expenses. The main categories of parents' expectations and needs in the studies were: (a) more information regarding HA use management and HA maintenance and (b) the need for more support from audiologists.

From the results of this review, we learned that various factors during a child's hearing rehabilitation process could impact HA use. Managing consistent use of HAs and any other hearing devices during a child's daily activities is challenging for families and yet an essential step for successful early intervention.

In a previous literature review on the topic of HA use, Munoz and Hill (2015) reported only two studies that used data logging records or parent reports to address the quantity of HA use among children with HL. The results of our review contributed ten additional studies on this topic. Since 2012 (the end year for the Munoz & Hill search), several relevant research papers have been published, which provide more comprehensive information on this topic.

Limitations: We limited our search to HA users only; therefore, we may have missed some papers based on the word restrictions. Only articles written in English were included in this review; therefore, we potentially missed relevant papers in other languages. Consequently, we may have

missed the culturally related limitations of HA use in different countries. Four studies out of 15 were not designed to answer the questions in this review directly. Thus, limited information was retrieved from those studies. The number of participants and reasons for withdrawal were not mentioned in several studies, which resulted in a low rating for the dropout section in the quality assessment tool. Furthermore, the full process of data collection and analysis was not explained adequately in most of the included studies. Therefore, studies with clearer methodologies are needed to supplement the evidence base. None of the studies included in this review reported on HA use in children with unilateral HL. While the use of strategies utilized by audiologists or healthcare professionals to assist parents with unique challenges in the adoption process after their child's HA fitting was not one of the primary interests of this review. It worth noting that none of the included studies discussed this topic specifically. Therefore, there may be a gap in the literature on this subject, however, further research using specific search terms is required to identify any possible publication on this topic.

Conclusions

The combination of early HA fitting and effective HA use can result in more successful hearing and language development in children. Given the current context of widespread EHDI programs, it is essential to frequently monitor HA use in young children as they progress through the rehabilitation process. Data logging records may be a more accurate choice than parents' reports to monitor the consistency of HA use early after HA fitting when parents are learning HA management skills. Improving knowledge of challenges and factors that impact HA use in the pediatric population also helps clinicians examine HA use patterns and identify gaps in the early

intervention program. Further research is required to identify clinician counselling and coaching strategies that can improve parents' HA management skills.

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CHAPTER 3: Hearing Aid Use Trends Based on Data Logging Records

Abstract

Purpose: To assess the amount of hearing aid use in a clinical sample of young Canadian children with permanent hearing loss based on data logging records and identify factors associated with the consistency of hearing aid (HA) use among these children. **Design:** In this retrospective cross-sectional study, we used a clinical HA database (Noah) to access data logging records of children fitted with HAs before 60 months of age. **Results:** The study sample consisted of 80 children. Our study results showed an average of 7.3 hours (SD: 4.27) HA use in the first data logging session. The child's chronological age was associated with a higher amount of HA use. There was also a significant association between laterality of HL, duration of HA use and the amount of HA use. **Conclusions:** The results showed that most preschool-age children do not achieve full-day HA use. A child's age and longer duration of HA use influenced the amount of HA use.

Keywords: Pediatric, Hearing Loss, Hearing Aid, Data Logging, Hearing Aid Use.

Background

Hearing loss (HL) is one of the most common disorders present at birth. Annually, 2-4 out of 1000 infants are born with various degrees of hearing loss (Lieu et al., 2013; Watkin, Tomlin & Baldwin, 2011; Briggs et al., 2011; Prieve & Stevens, 2000). Previous studies have shown that children with HL's communication skills have lagged behind typical developmental trajectories, which has negative consequences on children's' lives and affects essential experiences such as their performance at school or communication with other children. (Kennedy et al., 2006; Eraser, Hansmann & Saladin, 2019; Elbeltagy, 2020).

There is an evidence-based consensus that early auditory stimulation is necessary for developing a child's auditory system when the brain has the maximum plasticity (Gordon, Harrison & Mount, 2005; Bagatto et al., 2010). Therefore, the age of identification of HL and intervention is considered critical in developing a child's auditory system, speech, and psychosocial skills. The development of the human auditory system continues during the first year of life through auditory input, which sets the foundation for speech and language development. The first two years of life are a critical period in which auditory experience has the most dramatic effect on postnatal development of the auditory system (Sininger, Doyle & Moore, 1999; Bagatto et al., 2010; 2011). Therefore, early identification of HL provides an opportunity for children to access the optimal range of sounds. Consequently, hearing and speech development can occur with minimal delay. (Sininger, Doyle & Moore, 1999; Nicolas & Grees, 2006; Bagatto et al., 2010; 2011).

In 1993, the National Institute of Health (NIH) recommended universal newborn hearing screening (UNHS). The purpose of UNHS is to detect any degree of HL in infants by three months of age and fit them with appropriate hearing technology by six months of age to improve the quality of

their communication outcomes (Leo et al., 2016; Connolly, Carron, & Roark, 2005; Bess et al., 1994; NIH Consensus Statement, 1993; Joint Committee on Infant Hearing, 2007; Nelson et al., 2001; Watkin, Tomlin & Baldwin, 2011). Due to widespread implementation of UNHS programs and subsequently, Early Hearing Detection and Intervention (EHDI) programs, permanent childhood HL has gained increasing attention, and pediatric audiologists promote the use of amplification as early as possible to foster a child's auditory foundations for speech and language learning (Bagatto, 2010; Yoshinaga-Itano et al., 2008; Sininger, Doyle & Moore, 1999; Moeller et al., 2009; Ching et al., 2013).

A growing body of evidence confirms the positive correlation between early detection of hearing loss and the development of auditory and speech skills in children with HL during early and later childhood (Thompson et al., 2001; Fitzpatrick, Crawford & Durieux-Smith, 2011; Ching, Leigh & Dillon, 2013; Presson, Al-khatib & Flynn, 2020). UNHS is only one component of a comprehensive Early Hearing Detection and Intervention (EHDI) program. To enhance outcomes in children with HL, other components, including appropriate use of hearing technology and language development support, family support and evaluation of the program, are required. Therefore, the advantages of UNHS will only be seen if all aspects of an EHDI program are provided, and children wear their HA devices consistently from the earliest stage of the intervention process (Marnane & Ching, 2015).

Historically, HA use has been monitored based on parental reports (Moeller et al., 2009; Walker et al., 2013; Munoz, Peterson & Hichen, 2014). However, objective monitoring of HA use has become more feasible due to technological developments. Data logging is a feature that permits a glimpse into an individuals' use of their HA. The original version of a HA with data logging capability was developed by Mangold and Rising in 1990 (Patent No. 4,972,487; Mangold &

Rising, 1991). The first HA device with the capability of recording the history of HA use came to the market in 2004. This technology is currently integrated into hearing instruments by all HA manufacturers and is a powerful tool permitting clinicians and researchers to analyze the history of HA use.

Data logging ranges from simple features that report the average hours of use of HAs to advanced features that can track, apply or change the battery use, alter volume control, and control noise levels. It can be used to:

- analyze a HA user's habits, which can lead to (a) counselling to support the patient to improve HA use and (b) changes in the HA program settings based on the patient's needs.
- evaluate which program has been used more frequently by the patient over time.
- monitor which feature(s) of the HA has been activated depending on the listening environment.

Data logging can provide valuable information about HA use, especially for patients who cannot provide HA use feedback. In 2010, Jones and Launer studied HA use in 5000 children (birth to 19 years of age) through data logging information. They concluded that only 10% of the children used their HAs more than 12 hours per day, and 40% used their HAs less than four hours per day (Jones & Launer, 2010).

Based on previous studies and the results of our systematic review (inquiry 1 – Chapter 2), there is a growing body of evidence about the factors and challenges that impact HA use during all waking hours (Moeller, 2009; Walker et al., 2013, 2015; Marnane & Ching, 2015). Several studies have confirmed that factors such as age and severity of HL can significantly affect HA use (Marnane and Ching, 2015; Marttila and Karikoski, 2006; McCreery et al.,2015; Munoz, Blaiser

& Barwick 2013; Munoz, Preston & Hicken 2014; Walker et al., 2013). These studies have shown that the amount of HA use in infants and young children is significantly less than in older children and that average HA use increases with age. These studies also confirmed that children with severe degrees of HL, ranging from 50-90 dB, use their HAs longer and more regularly than children with a milder degree of HL (Marnane and Ching, 2015; Marttila and Karikoski, 2006; McCreery et al., 2015; Munoz, Preston and Hicken, 2014, Walker et al., 2013; Walker et al., 2015).

Several factors can make HA use more challenging for families. Moeller et al. (2009) found three types of circumstances where it is difficult for parents to keep the HA on the child. These include (1) the child's listening environments, including noise level, weather and season, (2) the child's temperament due to fatigue, illness or other disabilities, and (3) activity-related issues such as being in daycare or playing alone. Some child settings (e.g. in the car, playground, etc.) are likely harder for parents to manage, which vary with the child's age (Moeller et al., 2009).

To date, there is limited research monitoring the amount of HA use in the pediatric population, and to our knowledge, there is no study reporting the amount of HA use, based on data logging records, in the Canadian pediatric population. This gap in the literature motivated the objectives of this study.

The main objectives of this study were to:

Objective 1. Quantify the amount of HA use in the first years after HA fitting based on data logging records.

Objective 2. Examine the association between factors such as child's age, the onset of HL, laterality of HL, degree of HL, duration of HA use, and amount of HA use.

Methodology

Design: This study was a retrospective chart review to examine the quantity of HA use in a pediatric population. This study was approved by the Children Hospital of Eastern Ontario (CHEO) Research Ethics Board (REB). REB Protocol Number: 17/65X and the University of Ottawa.

Setting: This study was conducted at CHEO, a research affiliated hospital in Ontario, Canada, where the pediatric audiology clinic provides various services, including diagnostic services, amplification program, cochlear implant as well as auditory verbal therapy, to a catchment area of about one million in Ottawa and the surrounding area. We examined the amount of HA use by children (0- 60 months old) identified with HL from 2006-2017.

Participants

The sample frame for this study was drawn from the CHEO audiology clinic database based on the following criteria: (a) children with permanent unilateral or bilateral HL of any degree, (b) fitted with HAs between 2006-2017, and (c) fitted with hearing aids before 60 months of age. The preliminary sample of children who met the criteria was reviewed to determine how many of the children in the sample had datalogging records in the Noah database and how many had their first datalogging records before 60 months of age.

Demographics: Data were gathered on patients' characteristics, including child-specific information (e.g. age, sex and other medical complications/additional disabilities) and HL specific information (i.e. age of HL confirmation, laterality and degree of HL, age at HA fitting and current type of amplification) from both traditional paper and electronic medical charts; electronic records

were available through the hospital electronic health record system (EPIC) after fall 2013. (https://www.epic.com/software).

Procedure: All selected cases in this study received standard HA follow up care through the CHEO audiology clinic. We used Noah software to collect the average amount of HA use from data logging records (O'Donnell, 2015). The software provides clinicians with a unified system for performing client-related HA management. The data logging records are automatically saved into a common database. In this study, we used the Noah software database to collect the device usage time based on each individual's data logging records.

Statistical Analysis

Statistical analysis was performed using SPSS version 25 (IBM Corp., Armonk, NY). The primary intention was to examine the average amount of HA use in children. The secondary target included the association between factors such as the child's chronological age, degree of HL, laterality of HA, duration of HA use and the amount of HA use. We chose these factors based on previous studies (Walker et al., 2013;2015).

Baseline characteristics were summarized using descriptive statistics, including means, standard deviations (SD), minimum and maximum of the variables (as appropriate). We utilized (a) univariate linear regression analysis to study the relationship between each factor (age, the onset of HL, laterality of HL, degree of HL, and the duration of HA use) and the average amount of HA use; and (b) multivariate regression analysis to examine the association between all factors and the amount of HA use.

Results

The Proportion of Identified Cases: The selection of participants for the study is provided in Figure 1. During the study period, 350 children were fitted with HAs in the clinic.

Out of 222 children who met this study's criteria, 80 had valid data logging records; the remaining 142 were excluded from the study for the following two reasons: a) chronological age over 60 months at first data logging record; b) data logging records with invalid values: for example, records of 24 hours per day HA use, which suggest the HA device had been left on overnight; or records without any actual wearing time (e.g. 0.01 hour) from the last time that a clinician had tested the HA.

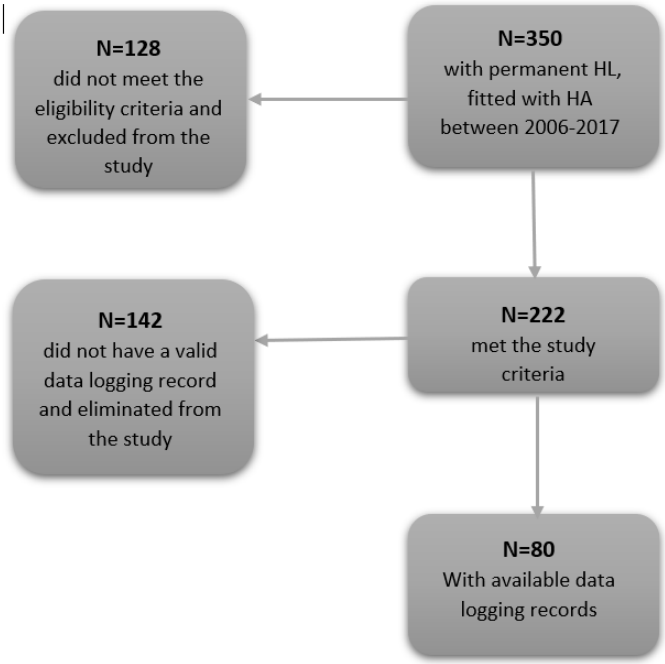

Fig. 1. Selection of study participants.

Details of children's clinical characteristics are presented in Table 1. We had an almost equal number of male (47.5%) and female (52.5%) children in our sample population. Half (51.2%, N=41) of the sample had congenital or early-onset hearing loss, 28 of 80 (35.0%) had late-onset or acquired hearing loss, and the remaining 11 of 80 (13.8%) had unknown onset. Half of the sample was diagnosed before one year of age. The minimum age for HL diagnosis in the sample population was less than one month of age, and the maximum was 53 months old (M=16.12 months). The minimum age of HA fitting was 2.63 months of age, and the maximum was 56.87 months old (M=16.1 months).

Characteristics	**Value (N=80)**	**Characteristics**	**Value (N=80)**
Sex		**Degree of HL:**	
Female	42 (52.5%)		
Male	38 (47.5%)	PTA in Ear with highest data logging value (dB HL)*	
		mean, SD	(45.01; 16.39)
		Mild	30 (37.5%)
		Moderate	35 (43.8%)
		Moderately severe	8 (10%)
		Severe	6 (7.5%)
		Profound	1 (1.3%)
Age of HL Diagnosis (months)		**Type of HL**	
		Sensorineural HL	56 (70 %)
mean, SD	17.07 (16.12)	Mixed HL	16 (20%)
		Permanent Conductive HL	7 (8.8%)
		Auditory Neuropathy Disorder	1 (1.3%)
Age at HA fitting (months)		**Onset of HL**	
mean, SD	24.4 (16.1)	Congenital/Early-onset	41 (51.2%)
		Late-onset/Acquired	28 (35.0%)
		Unknown	11 (13.8%)

Laterality of HL			
Unilateral	5 (6.3%)	**Etiology****	
Bilateral	75 (93.8%)	**No**	35 (43.8%)
		Yes	45 (56.2%)
		Hereditary/ genetic HL	20 (25%)
		Syndromic	9 (11.3%)
		NICU Graduate	7 (8.8%)
		ENT Malformation	5 (7.5%)
		Meningitis/post-natal Infection	3 (2.5%)
		Prenatal Infection	1 (1.3%)

Table 1. Baseline demographic and clinical characteristics of children.* For each child, we used the data logging record from the ear with the greatest amount of HA use. Accordingly, the PTA (frequencies 500, 1000, 2000 k Hz) of the ear with a greater amount of HA use was chosen as the child's degree of HL; Mild= 20-40 dB HL; Moderate= 41-55 dB HL; Moderately severe= 56-70 dB HL; Severe= 71-90 dB HL; Profound= 91+ . Congenital: HL present at birth; Early-onset: HL diagnosed before six months of age; Late-onset: children who passed screening in infancy and were diagnosed after six months of age; Unknown: children not screened or missing information because they were screened outside the local area. **Etiology: Hereditary/genetic children with a history of HL in the family (siblings/parents with HL) or gene mutation; Syndromic: children with syndromes associated with sensorineural HL including Down, CHARGE, Branchio-Oto-Renal; ENT Malformation: children with morphological abnormalities not associated with an identified syndrome including outer ear malformations, middle ear or inner ear anomalies; Prenatal infection (e.g., CMV).

Description of Data Logging Values

For each child, the recorded amount of HA use (per hour) in Noah for the ear with the highest amount of HA use was reported as the data logging record. In this clinical population, data logging was recorded at various times and ages after HA fitting as children were seen at their clinical follow-up visits. Out of 80 children, 56 (70%) had at least two data logging sessions, and 35 (43.75%) had at least three. Less than 25% (N=18) of the study population had more than three data logging sessions. Details about the average amount of HA use, as well as the duration of HA use, and age at data logging for each session are presented in Table 2. The data logging results showed that the average HA use in session 1 (M:7.33 hours/day; SD: 4.7) and session 2 (M:7.18

hours/day; SD: 3.67) were similar. However, HA use slightly increased in the third session (M:8.44 hours/day; SD: 3.33).

Session	Duration of HA Use*	N	Age at Data Logging Completion (months) Mean, SD	HA use (hrs.) Mean, SD
Session 1		**80**	33.96, 15.91	7.33, 4.27
	→ (≤6 months post HA fitting)	46	31.84, 16.83	6.96, 3.87
	(7-12 months post HA fitting)	13	27.84, 12.64	5.73, 4.30
	(13-24 months post HA fitting)	11	37.87, 13.93	8.89, 5.82
	(25-36 months post HA fitting)	7	43.67, 7.84	8.71, 5.26
	(>36 months post HA fitting)	3	56.06, 3.62	10.96, 1.95
Session 2		**56**	36.11, 15.32	7.18, 3.67
	(≤6 months post HA fitting)	18	32.31, 17.85	7.32, 3.82
	→ (7-12 months post HA fitting)	21	35.31, 15.30	7.19, 3.72
	2 (13-24 months post HA fitting)	9	38.51, 14.30	7.18, 3.59
	2 (25-36 months post HA fitting)	5	40.54, 5.45	7.0, 3.11
	n 2 (>36 months post HA fitting)	3	49.96, 5.00	6.66, 5.98
Session 3		**35**	39.72, 13.71	8.44, 3.33
	(≤6 months post HA fitting)	2¥	34.84, 8.61	2.30, 1.27
	(7-12 months post HA fitting)	8	33.04, 14.53	8.83, 1.84
	→ (13-24 months post HA fitting)	13	35.52, 14.80	9.66, 2.81
	(25-36 months post HA fitting)	5	45.39, 5.57	9.10, 1.87
	(>36 months post HA fitting)	7	52.51, 4.93	7.02, 4.68

Session 4		**18**	43.51, 11.93	8.38, 2.65
	(≤6 months post HA fitting)	1	41.16	6.70
	→ (13-24 months post HA fitting)	11	41.34, 3.19	8.28, 3.19
	(25-36 months post HA fitting)	3	43.02, 12.37	8.53, 0.83
	(>36 months post HA fitting)	3	52.72, 4.34	9.20, 2.34
Session 5		**9**	48.24, 6.87	9.16, 3.11
	(13-24 months post HA fitting)	3	43.18, 8.46	10.10, 0.62
	(25-36 months post HA fitting)	3	50.63, 7.30	6.56, 4.74
	(>36 months post HA fitting)	3	50.91, 2.52	10.83, 0.65

Table 2. The amount of HA use based on data logging records; * Duration of HA use is the number of months since HA fitting; → shows the highest N in each session.

The results showed significant variability in the amount of HA use among children at the time of the first data logging session. This variation in HA use values is presented in Figure 2.

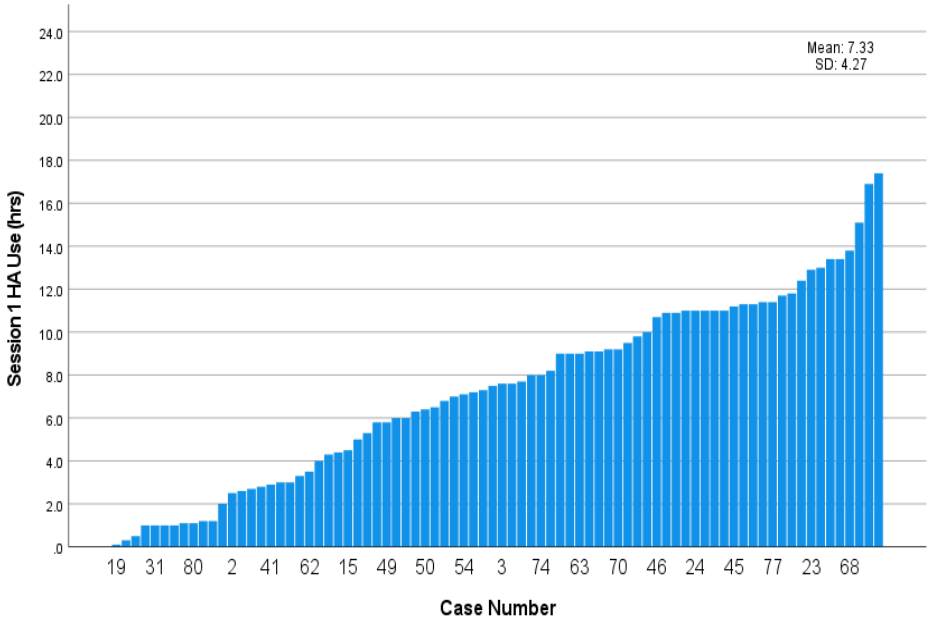

Fig. 2. Variability of HA use in the first data logging session based on the case number.

Association between Hearing Aid use and Child's Characteristics

Chronological Age:

At the time of the first data logging record, the average age of children in our study population was 33.96 months (SD:15.91). Of 80 children, 31.2% (N= 25) had their first data logging record before 24 months of age (Mean:14.54 months; SD: 5.66) and had average HA use of 6.36 hours per day (SD: 4.19); 42.50% of children (N=34) had their first data logging record between 24 to 48 months of age (Mean: 36.04 months; SD: 6.15) and had average HA use of 7.04 hours per day (SD: 4.47). The rest of the children (N=21) were older than 48 months of age (Mean: 53.73 months; SD: 3.06) when they had their first data logging record. For these 21 children, the average HA use was 8.97 (SD:3.74) hours.

Onset of Hearing Loss: Most children in this sample population (N=41; 51.2) had congenital or early-onset HL, while (N= 28; 35%) had acquired or late-onset HL. Among children with congenital or early-onset HL, the HA fitting was completed at 13.34 months old (SD: 11.10) on average, and the average HA use at their first data logging session was 6.88 hours per day (SD: 4.65). In children with acquired or late-onset HL, the average age of HA fitting was 36.66 months (SD:10.94), and the data logging records of these children showed an average of 8.31 hours/day (SD: 3.78) HA use at the first data logging session.

Laterality of Hearing Loss: Only five children in our sample had unilateral HL; four children had moderate HL in the impaired ear, and one had mild HL (The first data logging record of these five children showed an average of 4.26 hours HA use per day, which is lower than the amount of HA use in children with bilateral HL (7.64 hours; SD: 4.15).

Degree of Hearing Loss: Most of our study population had mild (N=30; 37.5%) or moderate (N=35; 43.8%) degrees of HL (categorized based on the ear with the greatest amount of HA use according to data logging records). Results of the first data logging records showed that children with mild HL used their HAs, on average, 6.87 hours per day (SD: 4.29). Children with a moderate degree of HL used their HAs on average, 7.54 hours per day (SD: 4.65), which is slightly higher than their peers with a mild HL but similar to the children with moderately severe or greater degrees of HL (M: 7.76 hours; SD: 3.40).

Duration of Hearing Aid Use: The duration of HA use is defined as the number of months since the HA fitting. More than half of our sample (N=46; 52.5%) had their first data logging record by six months post HA fitting (M:6.96 hours HA use; SD: 3.87), 13 children (16.25%) had their first data logging session 7 to 12 months post HA fitting (M: 5.73 hours HA use; SD: 4.3) and 21 children (26.25%) had their first data logging session more than 12 months post HA fitting (M:9.03 hours HA use; SD: 5.01).

In total, we had 201 sessions for the 80 children in our sample, so we examined the overall association between the duration of HA use and the amount of HA use across all 201 sessions for all children. The results showed that for each month increase in the duration of HA use, the amount of HA use increased 0.16 hours (9.6 minutes).

We conducted multiple regression analyses to study what factors predict HA use over time. The independent variables included the onset of HL, degree of HL, laterality of HL, age at HA fitting, child's chronological age (at the data logging completion date), and duration of HA use. The dependent variable was the amount of HA use in the first session. The overall regression model showed the independent variables significantly predict the amount of HA use (P: 0.02; R^2: 0.18).

Among independent variables, laterality of HL (P: 0.013; β: 0.27) and child's chronological age (P:0.04; β: 0.55) were statistically significant predictors of HA use. The results showed that for the first data logging session, each month increase in a child's age resulted in an increase in HA use of 0.24 hours (14.40 minutes). Therefore, each year increase in a child's age is equivalent to 128 minutes increase in HA use.

Discussion

In this retrospective chart review, the overall goal was to objectively evaluate HA use in the early years after HA fitting in the pediatric population. This study's primary objective was to quantify the amount of HA use in a clinical population of young children with HL. In our sample (N=80), 70% had two data logging records, 43.75% had three data logging records, and less than 25% had more than three data logging records. The average amount of HA use in the first data logging session was 7.33 hours per day, which was very similar to the average amount of HA use in the second session (7.18 hours per day). The 35 cases with a third data logging record suggested that the average HA use for the third session was slightly higher than session 1 and 2 (8.44 hours per day).

The secondary objective of this study was to examine the association between factors including child's age, the onset of HL, laterality of HL, degree of HL, duration of HA use, and amount of HA use. We found a significant association between a child's chronological age and the amount of HA use (P= 0.013). This is consistent with previous studies (Marnane and Ching, 2015; McCreery et al.,2015; Munoz, Preston & Hicken, 2014).

Our study results showed the amount of HA use in children who had their first data logging record before 24 months of age was, on average, 6.36 hours per day. In children between 24-48 months of age, the HA use amount was 7.20 hours per day, and in children older than 48 months of age, this amount was 8.97 hours per day, which is higher than the number of hours reported in the previous studies (Muñoz et al., 2014; Walker et al., 2015). Our study results also confirmed by each month increase in a child's age, the amount of HA use increased by 14.40 minutes. So after a year, the amount of HA use increases by 2.88 hours.

In 2014, Munoz and colleagues reported an average amount of 4.60 hours (SD: 4.07) of HA use in children between 7-35 months old and the average amount of HA use increased to 7 hours per day (SD: 4.13) in children between 36-60 months old (Muñoz et al., 2014). Another study (Walker et al., 2015) reported an average of 4.36 hours per day in children up to 24 months old and an increased amount of HA use in children between 24 to 48 months old (7.57 hours per day). The difference in findings in our study may be due to the small sample size. Therefore, caution must be taken to interpret the results and further studies with a larger sample size are needed.

More than half of (N=41; 51.2%) of 80 children in the sample had congenital or early-onset HL, and 35% (N=28) had acquired or late-onset. However, we did not find a significant association between the onset of HL and the amount of HA use (P= 0.72).

The majority of our study population had mild or moderate degrees of HL, and we did not find a significant difference (P: 0.77) between the amount of HA use and the degree of HL. However, two studies reported children with more severe degrees of HL, ranging from 50-90 dB, were more consistent in using their HAs compare to their peers with milder degrees of HL (Walker et al., 2015; Munoz, Preston and Hicken, 2014). The difference in findings in our study may be due to the small sample size. Therefore, further studies (i.e. with higher N) are needed to verify this result.

The amount of HA use in our study was similar in boys (Mean 7.25, SD: 4.40) and girls (mean 7.41, SD: 4.20), a finding that is consistent with results reported by Walker and colleagues (Walker et al., 2013)

Limitations: An important limitation of the study was the limited information available through data logging records. For example, day by day, HA use cannot be monitored through the software, and data logging records only provided average HA use in a time period since the last recording. Therefore, if a child had less than an hour of HA use for a couple of days but used the HA full time for the rest of the period, those days (with less than an hour of use) impact the average HA use for the whole period of the data logging record. Another limitation was missing data in Noah for the data logging records that were not saved automatically into patients' profiles.

There are also some limitations to this study that limit the generalizability of the results. This study's sample size was small since the data was collected retrospectively. Moreover, the data were only retrieved from one patient group (up to 60 months of age) and from one site (CHEO audiology clinic), which limits the generalizability of results to all Canadian pediatric populations. Due to the small sample size, we were unable to study longitudinal trends and examine the association between factors and the amount of HA use over time. Therefore, our analysis of factors affecting use was limited to data from the first data logging session. There were very few children in our sample with unilateral HL; therefore, the finding related to less use for these children needs to be investigated in a larger sample.

Conclusion

In this program of research, we examined the quantity of HA use in a Canadian pediatric population, and we explored the association between age, the onset of HL, laterality of HL, degree of HL, duration of HA use and the amount of HA use.

Overall, this study's findings are consistent with the existing knowledge about pediatric HA use and factors associated with the amount of HA use. We found the average amount of HA use in our population ≤ 24 months old is slightly higher than the reported hours in previous studies. Achieving full-time HA use in young children remains a constant challenge for parents. The data logging feature can be a strong tool for successful early intervention. Sharing data logging information with families may assist clinicians in coaching parents about the importance of full-time HA use for their child's hearing and language development. Future studies should examine the amount of HA use in children with unilateral HL or mild degrees of HL as well as factors associated with HA use from clinicians' and families' perspectives.

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CHAPTER 4: Needs and Challenges of Hearing Aid Use in Young Children from Clinicians' Perspective: A Focus Group Study

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Abstract

It is well established that early identification of hearing loss (HL) leads to positive developments in auditory and speech skills during early and later childhood. Appropriate use of hearing technology is necessary to enhance hearing and language-related outcomes in children with hearing loss. The overall goal of this study was to understand the factors and challenges associated with hearing aid (HA) use early after HA fitting from the professionals' point of view. In this study, we conducted focus groups with clinicians who are providing healthcare services to children with HL. In total, 15 clinicians from one audiology clinic from CHEO participated in this study. Five main categories were identified from the focus group data: child-specific factors, family-related factors, parents' challenges and concerns, parents' needs, and clinicians' strategies.

Background

Healthy hearing and the ability to communicate with others are essential foundations of a child's social, emotional and educational development. Previous studies have shown that the communication skills of children with hearing loss (HL) may lag behind typical developmental trajectories, which affect children's performance at school or communication with their friends. (Kennedy et al., 2006; François, Boukhris& Noel-Petroff, 2015; Eraser, Hansmann & Saladin, 2019; Elbeltagy et al., 2020). A growing body of evidence supports a positive association between early detection of HL and the development of auditory and speech skills in children with HL during early and later childhood (Bagatto et al., 2010; Marnane & Ching, 2015). However, to enhance hearing and language-related outcomes in children with HL, other components, including appropriate use of hearing technology, language development support, and family support, are required.

The results of our systematic review (Chapter 2) confirmed that there is a growing body of evidence concerning factors and challenges that impact hearing aid (HA) use in the pediatric population. The results of our quantitative study results, in chapter 3-inquiry 2, showed that children younger than 48 months old wore their HAs less than 8 hours per day and that HA use increases by age.

In 2015, Munoz and colleagues reported that parents might experience frustration, confusion, and a lack of confidence with their child's HA management in different settings. They also found that those parents who perceive significant benefits from HA use achieved higher HA use amounts. In that study, parents also highlighted the need for comprehensive written information on the

technical aspects of HA use. The authors also discussed the importance of providing practical guidance to parents, such as teaching them how to manage a child's HA in different settings to improve their child's HA use (Munoz et al., 2015).

Other studies on this topic have also addressed the association between factors such as parents' levels of education, socioeconomic status (SES) and hours of HA use (Walker et al., 2015; Munoz et al., 2015; Marnane and Ching, 2015). In those studies, higher parents' education level translated into a greater awareness of the importance of full-time HA use and its impact on a child's speech-language development (Walker et al., 2015; Munoz et al., 2015; Marnane and Ching, 2015). A study by Bagatto and Tharpe (2014) showed that the number of hours of HA use for children in a daycare placement was higher compared to children spending most of their time at home. In another study, Walker and colleagues (2013) reported that children's HA use is significantly higher on weekdays compared to weekends.

Healthcare professionals in pediatric audiology clinics spend a significant amount of their time supporting children with HAs and helping their families to address the difficulties in keeping the HAs on their child. They support families by helping parents improve their skills in managing their child's HA use and consequently improve their daily use of HAs. Therefore, learning from clinicians' experiences who are actively involved in the early intervention process with children with HL can provide valuable information about factors associated with HA use and common challenges with HA use in the pediatric population.

The overall goal of this study was to understand the factors and challenges associated with HA use from the professionals' point of view.

Objectives: We used focus groups to elicit clinicians' comments regarding the needs and challenges of HA use in the pediatric population. The participants in this study were clinicians involved in providing healthcare services to children with HL. We hope this study results lead to a deeper understanding of the essential elements related to using HA in the early intervention process. The objectives of this qualitative study were to (1) understand child-specific factors that can affect the amount of HA use; (2) understand parents' challenges and concerns with their child's HA early after HA fitting; and (3) learn about clinicians' practices and coaching strategies to help families early after their child's HA fitting.

Methodology

Context: Most provinces in Canada have implemented Newborn Hearing Screening services. In Ontario, CHEO is the main diagnostic centre for the region's provincially mandated Early Hearing Detection and Intervention (EHDI) program established in 2002.

Design: This study used a qualitative research approach in a focus group format to understand the factors and challenges associated with HA use from the professionals' perspectives. This study was approved by the CHEO Research Ethics Board (REB). REB Protocol Number: 18/137X, and the University of Ottawa.

Participants: The sample frame for this inquiry was drawn from all clinicians, including audiologists, auditory-verbal therapists (AVTs), speech-language pathologists (SLPs), and a social worker (SW) at the CHEO audiology clinic who were providing early HL intervention and family support services to children with permanent HL. For the focus groups, the researcher the CHEO audiology clinic to identify eligible participants. Clinicians who were willing to participate in the

focus groups were then contacted by the researcher to arrange a time for the discussion. The participants completed a brief demographic form prior to the interviews, which included information such as their professional title, number of years of experience, and their amount of experience working in early intervention programs for children with HL.

Description of Participants: In total, 15 clinicians (9 audiologists, 5 auditory verbal therapists and one social worker) participated in three different focus groups during the study, with five clinicians in each group. Participants' characteristics are presented in Table 1.

Characteristics	Participants (n=15)
Sex	
Female	14 (93%)
Male	1(7%)
Tile	
Audiologist	9 (60%)
AVT	5 (33%)
PPC	1 (7%)
Years of experience with children with HL	
>20 yrs	6 (40%)
11-20 yrs	2 (13.5%)
6-10 yrs	2 (13.5%)
0-5 yrs	5 (33%)
HA fitting experience	
Yes	10 (67%)
No	5 (33%)

Table 1. Clinicians' Characteristics

Procedures

We applied a semi-structured interview format with a predetermined list of questions to guide our focus groups (Appendix 5). We chose a semi-structured format so that clinicians with different expertise could openly describe their experiences with the families of children who use HA. An iterative approach was taken to adapt the questions in the interview guide based on the information from the first focus group discussion. To encourage participants to share their knowledge, the focus groups started with a general question about clinicians' experience with the difficulties related to HA use, for children and their families, early after the HA fitting. Then questions probed clinicians' views about factors associated with HA use, such as child-specific factors and family-related factors. Focus groups were audio-recorded with participants' consent and transcribed verbatim in text format to facilitate detailed analysis.

Data analysis:

The researchers who conducted the focus groups listened to the recordings and read the written transcripts. Two researchers performed open coding of the transcripts separately. The open coding method includes breaking down data into discrete parts to define label statements as concepts. Codes were then compared, and the discrepancies were discussed to ensure the consistency of the extracted concepts or categories. Transcripts were then entered into N-Vivo (version.12), a qualitative research software. For detailed coding, matching between answers to each question was conducted. Subsequently, an inductive data analysis technique was conducted to highlight thematic patterns and commonalities and characterize categories of codes and the links between categories and sub-categories. In the final round of coding, categories were condensed into major themes/domains.

Results

The overall goal of this study was to understand the factors and challenges associated with HA use from the professionals' point of view. Five main domains were identified from the focus group data: child-specific factors, family-related factors, parents' challenges and concerns, parents' needs, and clinicians' strategies. Each domain is elaborated below, supported by example(s) of clinicians' comments. The letter-number at the beginning of the clinician quotes refers to the participant.

Child-specific Factors:

1. ***Child age***: Most clinicians mentioned that children at each age present different types of challenges related to HA use. For example, infants do not touch their HAs, but it is harder for parents to notice their hearing ability. In contrast, in toddlers, the improvement in their hearing ability after HA fitting is easily noticeable, but they are also able to take their HAs out, so it can be difficult to keep HAs on the child at that age.

"C5: There are advantages and disadvantages to fitting at each age. If you fit an infant, then the advantage is that the baby doesn't have the coordination to take the HA out. But they don't have the development to be able to show you that they hear a lot of the time. Toddlers, you can see them react; they are really good at taking the HAs out because they have control over it."

"C7: When they're hitting 8, 9, 10 years old, they take them off most of the time. My patient was almost ten years old; she was like ah, I don't want to wear my HA at summer camp."

***2. Degree and laterality of HL*:** Almost all clinicians agreed that children with milder degrees of HL or with unilateral HL are more inconsistent with wearing their HAs since parents do not get meaningful feedback from their child to indicate that HAs are providing benefit.

"C1: Many children with unilateral and mild hearing loss prefer not to use the HAs consistently or take the weekend off. Those are the ones who have the worst data logging."

"C3: Unilateral and the mild HLs are still the ones that we have the most counselling to do."

"C2: I would say milds are the most challenging group."

"C3: I think unilateral is a big challenge; the kids mostly wear the hearing aid at school or only wear it when there is a context that they think they might need it."

3. Comorbidity: Several clinicians pointed out the challenges of HA retention in children with comorbidities, such as children with developmental delay or attention deficit hyperactivity disorder (ADHD).

"C5: If the kid is developmentally delayed, and starting HAs, not from a young age, it is often hard to have the kid accept and keep the HAs in because they're not able to express that their HAs [are] helping"

"C6: Complex cases, like a kid with ADHD or a kid with a certain more oppositional kind of personality, are more tactile defensive."

4. Child's setting: One of the important discussions about the factors associated with the amount of HA use was about the influence of different settings and activities. Child setting refers to situations such as placement at daycare, weekdays compared to weekends, summertime compared to school time, and family trips. Several clinicians indicated that a child's HA management is harder for parents during vacation, summertime and weekends.

"C1: I have parents that were travelling for 12 hours, and the mum told me that she would take off her child's HA during the trip."

"C7: A couple of seasons that have hats, bicycle helmets, swimming pools are rough. They take them off for swimming, and they forget to put them back in. Summertime is very rough with HAs."

"C3: I have cases who are wearing their HAs only at school, or they're only wearing them at odd times here and there. Maybe not on weekends."

Clinicians shared diverse experiences about the effect of daycare placement on HA use. A couple of clinicians mentioned that daycare could improve HA use, specifically for children whose parents have many other challenges. In contrast, some clinicians mentioned that daycare settings could be an even more challenging environment for most children concerning using their HAs.

"C8: Sometimes, kids obey their daycare workers more than their mum;. The daycare workers won't be bothered by a whining child. They put the HA on the kid, but the kid acts differently at home than at daycare."

"C9: One of my kids right now keeps opening the battery door, and the daycare [says] it's too dangerous for the kid to wear HAs because the batteries keep falling out."

"C4: No. I think it's more challenging in a daycare setting to keep the HAs on because you have five kids for one childcare provider. So, you only have two hands, and you've got 10 ears. So that may not be very easy. Whereas at home, it's a more one on one or two on one basis."

Family-related Factors

Family-related factors were categorized into two main groups: family characteristics and HA stigma.

1. ***Family characteristics***: Several clinicians mentioned that factors such as parents' age, level of education, socioeconomic status (SES) and having more than one child with HL could dramatically affect parents' involvement and attention to their child's HA use.
    a. *Parents' age*: Some clinicians commented that young parents, including teenage parents, struggled more with managing their child's HA since they have other challenges, such as family and financial issues.

    "C6: Teenage parents are struggling with a lot; they have a lot on their plate, lots of family stress, financial issues, and a lot to struggle with."

    b. *Parents' level of education*: Clinicians had diverse experiences related to parents' level of education and how it affected their engagement with their child's HA. They noted parents' level of education is not a dominant factor, and other family-related factors such as parents' personality and their family situation play a more critical role than their level of education.

    "C2: Anecdotally, it seems to me that poor usage and poor engagement in the process is more associated with poverty and low education than it is with culture."

    "C10: We've had exceptionally highly educated parents who couldn't do it. Then we've had teenaged tattooed single moms who are doing amazing".

    c. *Family's Socioeconomic Status (SES):* Many clinicians commented that financial concerns related to HAs are one of the issues that families talk about frequently.

    "C7: Well, the financial part of HAs is always addressed, always [repeated], by all of my families as soon as I discuss hearing technology [purchase]. So I do approach [them], like if you don't have private insurance, if we have a complex family situation, just to let you know that we have help."

d. *Family situation***:** According to the clinicians, issues such as mental health problems in one of the parents, single-parent families, and families with more than one child with HL can affect a child's HA use. In this situation, parents are coping with different issues at a time that may make them incapable of focusing on their child's HA use.

"C7: It is to keep consistency, and I do have separated parents who took me as their counsellor, to blame it on the other parent."

"C6: I have had cases where the mum is clearly overwhelmed because of mental health issues, too many kids at home that kind of thing, and other complex sorts of family circumstances. The kid wasn't wearing his HAs, and he wasn't getting any language stimulation, both."

A number of clinicians expressed that families with more than one child with HL have more difficulties in managing their children's HAs.

"C10: Some families are okay with the first one, and then the next one is more than they can handle."

"C6: I have had the experience of a child on my caseload, where the second child was a grief thing. It was much more difficult for the parent to step up with child number two. I think there is an element like I can handle one kid being deaf, but that second one is just too hard."

2. ***Hearing aid stigma***: Several clinicians commented that the use of HA is against some cultural and religious beliefs. Therefore, ethnicity or religious beliefs can be a barrier for families to accept their child's HA and navigate through the whole process of fitting and rehabilitation.

Many clinicians described some cultures and religious beliefs that define wearing HA as a sign of disability. Therefore, families with this type of strong beliefs do not like their child being seen with HAs in public places.

"C11: I had one mum who was in buckets of tears saying that she was going home to her country, and her son wouldn't be able to wear his HAs the whole time they were gone. But when they came back, she told me that her son wore his hearing aid the whole time! She said: I couldn't deal with him not wearing them. My family can feel the way they want to feel, but I couldn't deal with my son not wearing his hearing aid. That was huge."

"C9: It was a big deal for this mom; she did not want to have HAs on because it was too obvious. I mean, physical appearance is another big thing that I think can tie into the culture too. Some parents don't like to have something on their child's ears 'cause then it attracts people to look, and then they're like there's something wrong with my child if they can see it."

"C8: I remember a mum told me when they go back home to their country, they weren't going to bring the HAs, and when they go to the church, he was not going to wear the HAs."

Another point described by a clinician was about children with HL who are members of Deaf families. In this case, HAs may not be a preferred option for parents because they prefer to teach and use sign language as their primary communication method with their children.

"C2: It depends on the values of the culture. For instance, if you belong to the Deaf culture, it is hard for me to fit HAs on you because that goes against the culture that you have."

Parents Challenges and Concerns:

1. ***Perceptions of benefit from HA*:** Recognizing the benefit of HAs is an essential factor that may affect parents' perspective about the importance of wearing HAs. Unfortunately, in children with mild or profound degrees of HL, the benefit of HA use is not quickly noticeable. Parents cannot see significant differences in their child's reaction to the sounds with and without HAs. therefore, they may lose their motivation to work on improving HA use.

   "C12: I've had some families, depending on the age you know, some families will say well you know there's no benefit. I do not see any benefit at all, so they haven't worn it in the last week."

   "C5: It is sometimes a harder sell to get parents and kids on board as consistently for milder hearing loss or unilateral hearing loss because they seem to think that they're doing okay. So, it may not be as blatantly obvious to see the benefit. I find those the most challenging to get them to see the light and to really be on board."

2. ***Parents concern about child's discomfort**:*

   a. *Progressive hearing loss*: Several clinicians mentioned that some parents do not like their child wearing their HA full time because they are worried that full-time HA use will result in progressive worsening of their child's hearing.

      "C7: Well maybe less now, but once upon a time, I had some parents that say I don't want my child to wear a HA because I don't want him to become lazy. So, there was a reluctance to amplify."

   "C1: It's not as often as C7 mentioned, but they thought that the hearing aid would hurt the hearing, hurt the residual hearing. If she's mild, or he's mild or moderate, it might

become progressive because of the hearing aid. So, some parents refuse to put on the HAs."

b. *Damage hearing***:** A couple of clinicians stated that some parents were concerned about the loudness of the HA and that overamplification might damage their child's hearing even more.

"C7: I had a kid with hearing loss who did not have siblings, but the data logging is showing very reduced use of HAs because the mother really thinks the HAs are too loud even if I spend hours explaining to her, this is her audiogram this is how we program HAs and everything."

3. ***Parents' emotional state***: Several clinicians commented that parents of younger children are more vulnerable with respect to their child's HL and their future speech and language ability. Therefore, they may have a harder time overcoming their sadness and accepting their child's hearing condition.

"C6: When you start with infants, it's not a concern that the parent has, it's not like the parents have been home with their baby and see what looks like a hearing loss and searches out an answer. Instead, they just have a baby; they do not really see the hearing loss, and they don't know their baby so well yet. They referred to the screening program, and then they come for an assessment, and then we give them the bad news. That's a very different experience for the parents. They are more shocked, sadder and more emotional."

Parents' Needs:

Need more information: Several clinicians stated that parents need more specific information according to their child's age, degree and laterality of HL.

a. *Terminologies*: The terminology is not entirely clear for all parents, so they need more information about the difference between degrees of HL and the impact on a child's level of hearing as well as about the importance of wearing a HA for children with unilateral HL.

"C3: I've had some parents ask me, in the case of like a bilateral hearing loss, well, does my child need two HAs, or do they only need one? So, I think there's still this idea that exists that you would only amplify one ear versus amplifying both. Not exactly sure where it stems from, but I've had quite a few parents ask me that."

a. **About potential hearing improvement:** According to the clinicians, most parents are looking for information about the possibility of hearing improvement based on their child's degree of HL.

"C8: If it's conductive, then we say there's a potential for it to improve, and they would need to see a specialist, a physician, an ENT to see if it's medically or surgically fixable."

In the final step of the interview, we discussed different approaches and strategies that clinicians use to help families to work through the adaptation period and overcome challenges with their child's HA use.

Clinicians' Strategies:

Clinicians identified several strategies that they have adopted to help families improve their child's HA use. These were classified under three main categories: 1. frequent follow-up and ongoing counselling with families; 2. coaching; and 3. a multidisciplinary team approach.

1. ***Frequent follow-up and ongoing counselling with families***: By having frequent follow-up visits, parents can share their concerns with clinicians as they arise and ask their questions. Frequent interactions with families provide an opportunity for clinicians to:
    a. Gain families' trust and empathize with them so that families will feel more comfortable sharing their concerns with the clinician.
    b. Understand the families' learning style and provide information in a format that is more understandable for them.
    c. Share the results of recent research on the association between full-time HA use and children's hearing and language development.
    d. Check the child's data logging record regularly to monitor their HA use and address concerns.
2. ***Coaching procedures***: Using different coaching strategies helps families develop skills to foster HA use adapted to their child's situations. The coaching procedures include:
    a. Sharing data logging information with families and comparing it with the number of hours parents report on their child's daily HA use.
    b. Setting goals for families to help them understand the importance of full-time HA use and to manage their expectations about their child's hearing improvement early after HA fitting.
    c. Adapting the coaching strategies based on families' unique challenges to help them manage their child's HA use in different settings/environments, such as using a helmet/bonnet if a child has retention problems.
    d. Offering parent to parent contact allows families to talk to other families to share their experience and concerns.

3. ***Team setting***: A multidisciplinary team approach, including AVTs, family support workers, and ENTs, helps monitor and remind parents about the importance of full-time HA use through consistent messaging in different sessions.

These three categories of clinicians' approaches were further divided into sub-categories and are presented in Table 2 with illustrative quotes.

Domains	Sub-domains	Example quotes
Frequent follow-up and ongoing coaching with families	***Gain families' trust and empathize with them***	**C9**: "I had a patient last year, we were checking datalogging, and it was very low. I pretended to the parent; maybe you were not closing the battery door properly. So I did not lose their trust. I'm checking on them, I'm spying on them, but I still give them the benefit of the doubt. Maybe the HAs were not working properly, make sure to check the battery door. Boom, the week after it was higher."
	Understand the families' learning style	**C2**: "you must understand their learning style, how they like to get information. Because you have to change their inside motivation." **C11**: "I usually as an AVT ask the parents what is their best way of learning if it's through written material I ensure that they have our written material and a list of websites that I know because some websites you don't want them going to. Again, it's multimodal."
	Share the results of recent research	**C6**: "We want to preserve their dignity and their motivation. So, we talk about what research is showing and saying maybe you weren't aware that, and then we talk about the importance of wearing HAs 10 hours per day. Otherwise, it'll be hard to keep pace with the same age or catch up to the same age peers. So, if we approach it that way, it works better softly than say, "you know we check on you last you, and now we're checking again."
	Check the child's data logging record regularly	**C3**: "I like to use datalogging. I don't always tell them what the datalogging shows on the hearing aid, but I use it as a conversation starter. Like, if I only see data logging that's 4 or 5 hours a week, I can assume that the child is only wearing their HAs at school or at odd times here and there maybe not on weekends. So I'll use it as a conversation starter to say ok, so how much have you been wearing the HAs? and using it as a counselling opportunity."
		Interpretation: Clinicians need more sophisticated data logging, so only the mean of HA use in not enough, and clinicians like to see HA use records day by day. C2: "Sometimes the data logging is going from too long ago, averaging from the very first fitting day. So they may spend a month not using the hearing aid well and being grieving, and the data logging was into six months, but the last few months are still affected by the really poor start."
Coaching procedures	***Share data logging information with families***	**C13**: "I explain to them that it's a tool that's going to help us as a team like the AVTs always ask like what's the datalogging looking like and the parents are usually pretty cool about it too. They don't realize they can be tracked that way. **C9**: "Some parents use it as a motivator. Like oh, I only got 7 hours, I'm going to try to get 8 hours before next month."
	Set goals for families	**C2**: "If they're not wearing their HAs all the time, I like to go back to when you think of little Johnny in grade 1, how would you like to see his grade 1 look like with his hearing loss? I keep going back to what's your goal. It's not a problem that we don't see a difference with and without the HAs, and the child looks just like their normal-hearing peers: if families come with it as a problem and if we give them the right information, we can change it into the goal."

		Interpretation: It takes time to see the benefit of HA use; parents should manage their expectations: C4: "We prepare them in a way where they're not expecting like the YouTube videos of the kid turning when hearing his mother's voice and smiling for the first time. We would prepare them not to expect too much."
	Use adaptive coaching	**C7: "** I do approach unilateral hearing loss with the perspective that you have two ears and two sides of your brain, so if one of your ears is lower, so part of your brain is not going to receive the same input as the other one. So, let's keep it very equal on ears." **C1**: "There's a very important point about complex cases and hyperactive kids sometimes they cannot keep the hearing aid all the time on, so we advise them of certain bonnets bands and keep tracking the data logging every week. We use hockey helmets sometimes. Anything to keep [HAs on]."
	Offer parent to parent contact	**C1**: "We use VOICE [parents' association], we advise parents to join it, join activities there, so they talk and meet each other there in the waiting room, and if we see particular parents need another parent to talk I usually ask permission and let them contact each other." **C6**: "Sometimes another patient will spring into mind and we'll think, that's a very similar family situation, maybe you know the first mum would be able to be a support to this mum who's struggling so occasionally we'll reach out like that."
		Interpretation: Parent to parent contact is limited for school-age children. C5: "Sometimes I find with the older kids like teenagers that the connection is not as easy to find. The peer connection. I've been to itinerant teachers of the hearing impaired in the schools that seem to be with the tween and teenage group, that peer connection seems to be lacking, I guess."
Team approach	***Adopt a multidisciplinary team approach*** ***(AVTs, family support worker, ENTs, school specialist)***	**C2**: "Our AVTs are our best first support. If they're coming to see AVT, they have an expert that they're coming to see every week and an audiologist can come and visit them during their AVT visit." **C10**: "When families are devastated with acceptance of their child hearing loss, we lean on our family support workers a lot. So that's somebody who goes in and can talk to them over and over again and set them up with the emotional supports, counselling and the community and just continue to follow up with them until we can get them back on board." **C4**: Having access to ENT for a kid you who has a hearing loss and then if they have the bad luck of getting recurrent ear infections, we go rattle ENTs cage, and that kid gets tubes within a month. Nowhere else, I don't think, maybe in the world, would you get that. So we are very lucky."

Table 2. Clinicians' strategies in each domain and sub-domains with quotes.

DISCUSSION

The overall goal of this study was to better understand factors associated with HA use in pediatric populations from the professionals' viewpoint and to learn how professionals support parents in improving their skills to manage their child's HA in different settings. This study is important because it answered some questions raised by our previous study, which involved reviewing children's HA use through their data logging records. In the present study, factors associated with HA use in pediatric populations were classified into three main groups: 1. child-specific factors, 2. family-related factors that affect the amount of HA use, and 3. clinicians' strategies to support families in developing HA management skills.

Clinicians described child-specific factors that can impact their overall HA use, including a child's age, degree and laterality of HL, additional health condition(s), and a child's setting. Although it was mentioned that children at different ages have various challenges with wearing their HAs, some clinicians commented that older children are relatively resistant to wearing HA compared to younger children. In contrast, the results of previous research and our quantitative study (Munoz et al., 2015; Walker et al., 2015) concluded that the amount of HA use slightly increases as children age. Children with mild degrees of HL or unilateral HL are more likely to be inconsistent with their HA use since their parents do not see notable differences in their children's hearing ability with or without HAs. The existence of other medical complications also influences child HA use. Clinicians also frequently underlined that the amount of HA use significantly decreases during the weekends, summertime, and family vacations.

Family-related factors were another domain that emerged from the results of this study. The main family-related factors were parents' age, education level, SES, family situation, and cultural/religious beliefs. For example, clinicians stated that teenage parents are more likely to have trouble managing their child's HA use because they may struggle with other issues that are amplified in situations of lower SES and relationship issues. Clinicians had diverse perspectives about the association between parents' level of education and their HA management skills. However, other studies have confirmed that parents with a higher education level have a better understanding of child HL and the importance of full-time HA use on child language development. Consequently, they are more likely to realize the importance of wearing HAs for their child's language development (Walker et al., 2015; Munoz et al., 2015; Marnane & Ching, 2015).

Clinicians believe that families have different needs when learning skills in managing their child's HA, all of which are very dependent on the family's situation. Nevertheless, they confirmed that most families need to learn some necessary information about their child's HL and some general terminologies such as degrees of HL and laterality of HL that clinicians may use during the sessions with families. This information may help families to gain a better understanding of their child's hearing needs, and consequently, they can effectively collaborate in their child's hearing rehabilitation process.

There are different coaching procedures that clinicians use to support families to cope with their children's HA wearing challenges. Regular follow-up visits and ongoing guidance allows clinicians to check a child's HA through data logging records, gain families' trust by listening to their concerns and empathizing with them. In a study by Munoz and colleagues in 2017, the authors

suggested virtual visits to provide timely access to support families who have challenges with their child's HA use. The other benefit of the virtual visit is the timing flexibility, so families can have a follow-up visit without spending a couple of hours of their time for transportation to the clinic. The viewpoint about the importance of a multidisciplinary team setting was noted multiple times during the focus groups in this study. The impact of a multidisciplinary team setting for better communication with families, families' satisfaction with provided healthcare services and better HA use outcomes have been addressed in previous studies (Lim, 2008; Hoffman , Findlen et al., 2019).

Limitations: There were some limitations regarding the participants in our focus groups. This study was limited to the healthcare professionals' viewpoint. We did not invite parents of children with HL to the focus groups. Therefore, family challenges and concerns that we reported in this study may not necessarily reflect concerns and challenges from the parents' perspective. Hence caution should be exercised when interpreting the findings. Clinicians who participated in this study were all recruited from one site (CHEO audiology clinic); consequently, our findings are limited to one group of clinicians and may not be transferable to all pediatric audiology clinics with different early intervention programs.

Clinical Implications: Our study is one of the first to examine factors associated with HA use in a Canadian pediatric population from the clinicians' perspective. Learning about factors associated with HA use helps us to understand families' challenges and expectations and identify ways to support their needs. The findings of this study suggest that at least based on professionals' viewpoint, not only the degree of HL, per se, but also many other child-specific and family-related

factors affect a child's HA wearing time. Since we did not invite parents to the focus groups, there is still a need to learn about the challenges and barriers of HA use management from families' perspective to have a comprehensive understanding of families' needs and challenges after HA fitting.

Conclusion

In this study, we systematically categorized the challenges of HA use in young children based on professionals' knowledge and experiences. In this study, we listed several strategies based on clinicians' experiences to improve a child's HA wearing time. By using coaching strategies adapted to individual families, clinicians can provide supports based on each family's unique needs and challenges for their child's HA use. Future research is needed to study children and parents' specific needs and challenges based on their unique characteristics.

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CHAPTER 5: Integrative Discussion and Conclusion

Research Context and Objectives

More than 90% of children who are identified with HL do not have any family history of hearing loss. It is a very stressful situation for families, as many of them have had little to no communication with somebody with HL, and they know very little about the implications of HL. The HA is an important tool, and full-time HA use is crucial for successful early intervention. However, most families face many challenges in managing their child's HA use, specifically early after HA fitting. Consequently, the amount of HA use in young children is relatively low early after HA fitting (Munoz, Preston & Hicken, 2014; Walker et al., 2015). Therefore, in addition to coping with the stress of the initial diagnosis of HL, families require an understanding of the complex body of knowledge about HA management and the importance of full-time HA use for

their child's hearing rehabilitation. To assist families through this adaptation period, we need to learn about family difficulties and other factors that can interfere with a child's HA use.

The overall goal of this thesis was to document child-specific and family-related factors that impact a child's HA use. Therefore, this thesis compromised three specific inquiries:

1. A systematic review of current literature on HA use and factors associated with HA use in the pediatric population.
2. An objective evaluation of HA use after HA fitting in children aged 0-60 months in a Canadian context.
3. Interviews to understand the factors and challenges associated with HA use early after HA fitting from the professionals' viewpoint.

Theoretical Basis of the Research

The Health Belief Model (HBM) was adopted as a framework for this thesis. The original model includes six main constructs: (1) perceived susceptibility, (2) perceived severity, (3) perceived benefits and barriers, (4) perceived threats, (5) cues to action and (6) perceived health behaviour. The principles of this conceptual framework are relevant to an individual's experience during the process of rehabilitation. The HBM tries to explain or predict levels of acceptance of health care recommendations (Green & Murphy, 2014; Hochbaum & Rosenstock, 1952). Applying the HBM constructs to the context of HA use allow factors to emerge that are essential for successful early intervention. The factors include (1)parents' belief of the severe consequences of HL on their child's life if no action is taken, (2) parents' sufficient insight about the importance of consistent HA use, (3) parents' self-efficacy (belief in their ability to manage their child's HA in different

settings), and (4) parents' belief that professional recommendations will improve their child's hearing and consequently their language development.

Methodology

In Chapter 2, the systematic review of the literature provided necessary knowledge about previous research on the factors affecting HA use and the challenges of full-time HA use in the pediatric population. The topic of this dissertation could not be comprehensively investigated through a unique method, and various methodologies were required to illuminate a different aspect of this program of research. Therefore, we chose a mixed methodology approach to collect data and provide insight that each method alone could not provide. A quantitative approach was adopted in Chapter 3 to investigate HA use in a small Canadian pediatric population in one pediatric audiology clinic in Canada. The mixed methodology helped ensure that the quantitative inquiry on HA use (Chapter 3) was grounded in the participants' experiences (Chapter 4). At the final step, a qualitative method was utilized in Chapter 4 to understand the professionals' viewpoints and approaches to improving a child's HA use.

Interpretation of Findings

Inquiry 1 (Chapter 2): Systematic Review

The first inquiry of this thesis involved a systematic review of the literature on pediatric HA use. The review was explicitly carried out to comprehensively study the previous research on factors that influence children's HA use and parents' challenges with their child's HA. To our knowledge, prior to our systematic review, there was only one literature review on this topic (Munoz et al., 2015). Therefore, the advantage of our review was that we performed a systematic search that encompassed all relevant literature on this topic from 2005 to 2018. In total, 15 studies met our review criteria. The amount of HA use was reported in two formats: data logging records and/or parents' estimates. The association between factors including age, sex, the severity of HL, parents' education level, families' SES and the amount of HA use were reported in several studies on this topic. The impact of age and degree of HL on a child's HA use was more significant than other factors. Fear of losing HA and being incapable of managing their child's HA in different settings were the main themes of parents' challenges with respect to the management of their children's HA. Parents' need for more information regarding HL and HA use was another topic frequently reported in the literature. The main lesson that we learned from the systematic review that leads to doing the rest of the research in this doctoral thesis was that there is no study in the Canadian context that addressed pediatric HA use in the past 14 years. This review reinforced the importance of examining the amount of HA use in the early years (Chapter 3) and guided our research questions for the qualitative study (Chapter 4).

Inquiry 2 (Chapter 3): Quantitative Study of HA Use Based on Data Logging Records

Following the systematic review and the research gaps found in the literature, a quantitative study was conducted in a Canadian audiology setting. The overall goal of this inquiry was to evaluate objective HA use in a pediatric population aged 0- 60 months.

Our study results showed the amount of HA use in children who had their first data logging record before 24 months of age was, on average, 6.36 hours per day. In children between 24-48 months of age, average HA use was 7.20 hours per day, and in children older than 48 months of age, it was 8.97 hours per day. These results were within the reported range of HA use in previous studies (Jones and Launer, 2010; Munoz, Preston and Hicken, 2014; Walker et al., 2015). In this study, we also examined the association between a child's characteristics, including chronological age, the onset, laterality, and degree of HL, and duration and amount of HA use. Previous studies showed that children with a severe degree of HL used their HA more regularly, and those with milder degrees of HL were inconsistent in wearing their HA full time (Dammeyer, Lehane & Marschark, 2017; Munoz et al., 2016;2014; McCreery et al., 2015). The results of our study showed, among independent variables, child's chronological age (P:0.04) and laterality of HL (P: 0.013) were statistically significant predictors of HA use; however, our study included only five children with unilateral HL. The results showed that for each month increase in a child's age, the amount of HA use increased by 0.24 hours (14.40 minutes). This study was important because, to the best of our knowledge, it was the first that explored HA use in the pediatric population in a publicly funded program in the Canadian pediatric population. Our sample included very few children with unilateral HL; therefore, the finding related to less use for these children needs to be tested in a larger sample.

Overall, the findings of this study were aligned with the results of previous research in this context (Jones and Launer, 2010; Munoz, Preston and Hicken, 2014; Walker et al., 2015).

This study was only a snapshot of HA use in one pediatric centre in Canada. Therefore, it cannot represent all Canadian pediatric populations. So, we were cautious in interpreting the results and providing general recommendations based on the results of our small sample size. To confirm the finding of our study and provide more information (such as the association between laterality of HL or comorbidity and amount of HA use) multicenter study with a broader sample size is needed.

Inquiry 3 (Chapter 4): Focus Group Study with Healthcare Professionals

The final inquiry (Chapter 4) of this thesis involved focus groups with healthcare professionals, both audiologists and therapists, who actively provide services for children with HL in the audiology clinic. The information gleaned through the discussions helped to improve the interpretation of the quantitative study (inquiry 2 – Chapter 3) and to gain a deeper understanding of the challenges of HA use in the pediatric population. This qualitative study revealed that clinicians perceived multiple factors that can influence HA use in children after HA fitting and throughout the whole rehabilitation process.

Based on the results of this inquiry, we classified factors associated with a child's HA use into four main groups: child-specific factors, family-related factors, parents' challenges and concerns, and parents' needs. Clinicians frequently stated factors such as age, the severity of HL, and medical complications as child-specific factors that can influence their amount of HA use. Most clinicians mentioned that children at each age present different types of challenges related to HA use. For example, infants do not touch their HAs that much, but it is harder for parents to notice their hearing ability. In contrast, older kids can resist wearing their HAs because they are more aware of the differences than their friends. So we cannot precisely be sure about a child HA use improvement by age.

They also indicated that children at the two ends of the hearing spectrum (with mild or profound degrees of HL) have more challenges wearing their HAs regularly. Other factors, such as the existence of additional health conditions, a child's setting or activities such as swimming, can affect HA use.

Several parent-related factors that can affect a child's HA use were immerged through the focus group discussion. Parents' characteristics and issues can substantially change the outcome of HA use in young children. Parents with low SES and those with family issues (e.g., single parents, parents with depression) struggle more with their child's HA management. Clinicians reported that factors such as ethnicity and religious beliefs could also dramatically change parents' perspectives about the importance of HA use. The point that ethnicity or religious beliefs can stop families from accepting their child HL as a sign of disability or parents trying to hide their child's HA in public places was another topic that came up multiple times. However, there are many published studies on the general disability stigma and its impact on the rehabilitation process; surprisingly, we could not find a study that directly addresses the cultural and religious barriers of HA use, especially for parents of children with HL. The importance of an interdisciplinary team approach and its impact on better HA use outcomes was noted multiple times during the focus groups. This study included only clinicians' perspectives from one clinical site; therefore, future studies with clinicians from different pediatric audiology clinics with various team arrangements across Canada are needed.

The implication of the Health Belief Model:

Due to the nature of the mixed methodology design, applying the HBM model to every chapter of this thesis was challenging. Basically, this model tries to explain or predict levels of acceptance of health care recommendations by patients or their families. As we worked through the thesis chapters, we found the model applies to the systematic review (Inquiry 1- Chapter 2) and the focus group (inquiry 3- Chapter 4) study of this thesis.

Results of our systematic review (Chapter 2) reflected on three constructs of the HBM.

Perceived susceptibility reflected on parents' emotional challenges once they learn about their child's HL and their need for consultation and clinicians' support to make the process of accepting their child's HL easier for them.

Perceived threats addressed through parents' challenges in managing their child's HA in different settings (e.g. in the car, swimming pool, summer vs school time, etc.)

Family SES and their need for financial support (precisely dose who do not have insurance coverage to pay their child's HA costs) and parents' fear of losing their child's HA were representatives of perceived barriers.

In Chapter 4 (inquiry 3), the elements of our focus group study were precisely aligned with most constructs of HBM. Based on the findings of this inquiry, various motivators that influence a family's ability to manage their child's HA are reflected in the constructs of the HBM model and depicted in Figure 1.

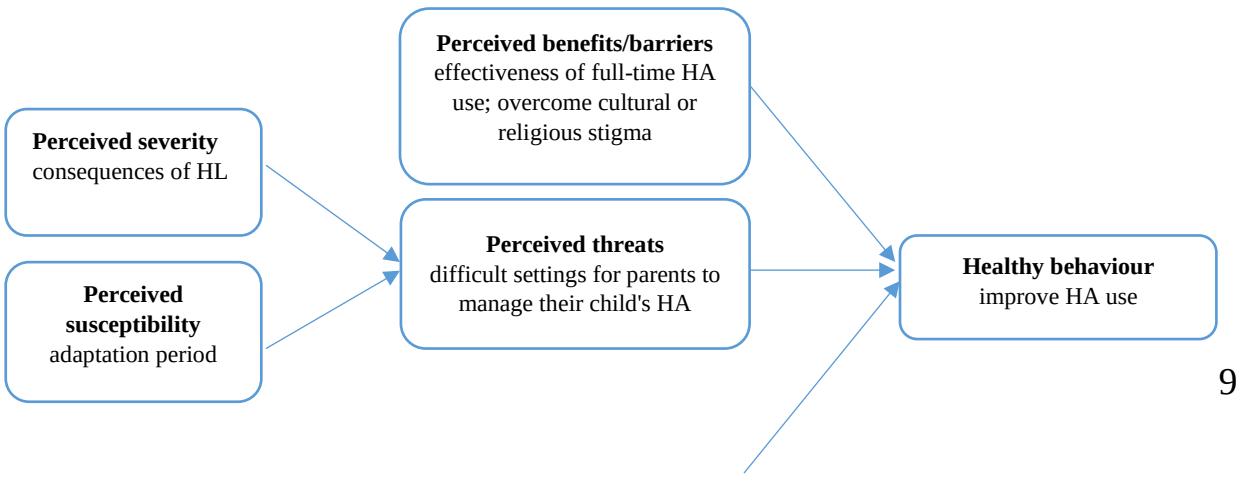
Perceived susceptibility refers to the adaptation period for parents to accept their child's HL. There is a wide variation in parent's feelings of personal vulnerability related to their child's HL.

Perceived severity refers to a parent's beliefs and feelings about the seriousness of their child's HL and the consequences of HL on their child's development. There is variation in parents' feelings towards severity, but medical consequences and social consequences are often affecting parents' perceptions of the severity of their child's HL.

Perceived benefits refer to a parent's perception of full-time HA use to improve their child's hearing and language development. This course of action that parents take in improving their child's hearing ability relies on consideration and evaluation of constructs 1 and 2 (perceived susceptibility and perceived severity). Perceived barriers refer to parent's feelings about the barriers of HA use for their child. This impediment may include factors such as the family's SES and the cost of HAs or the cultural or religious stigma of wearing HAs that can affect or limit a child's HA use.

Perceived threats refer to situations that were difficult or troubling for parents in managing their child's HA. A parent's level of confidence to manage their child's HA in a new challenging setting is reflected in this construct.

In this inquiry, the last construct of the HBM, cue to action, can reflect clinicians' strategies to (1) remind parents about the importance of HA use for their child's speech development, and (2) teach them different tips and methods of HA management to improve their child's amount of HA use.



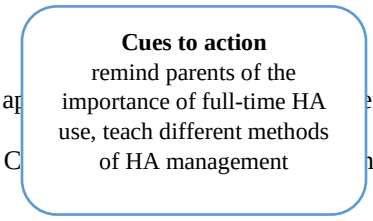


Figure 1. Theoretical framework ap ents' HA management skills. The results of our qualitative study in C nformation in this revised model.

Clinical Implications

This thesis was motivated mainly by questions and concerns regarding the use of HAs in children in early intervention programs. Our study was the first one of its kind to explore these factors in one clinic in the Canadian context in a publicly funded model of care. Through this doctoral thesis, we confirmed factors including the child's chronological age, degree and laterality of HL, and child setting/circumstances such as weekdays versus weekends, family vacation, summertime or activities such as swimming could change a child's average daily HA use. The main contribution of this thesis in the state of knowledge was that HA use is still a concern critically in very young children, and the amount of HA use that has been reported in all studies is significantly below the number of waking hours.

The quantitative study (inquiry 2- chapter 3) contributed to a clearer understanding of HA use outcomes in a small Canadian population. In this chapter, we concluded achieving full-time HA use in young children is a constant challenge for parents. We also recommended that the data logging feature can be a strong tool for successful early intervention. Sharing data logging

information with families may assist clinicians in coaching parents about the importance of full-time HA use for their child's hearing and language development.

The qualitative study (inquiry 3- chapter 4) provided new insights into factors associated with HA use and clinicians' strategies to help parents manage their child's HA early after fitting. While previous research focused on the challenges from families' perspectives (Mehta et al., 2019; Munoz et al., 2015; Walker et al., 2013), this study focused on the viewpoints of clinicians who had extensive experience supporting many families with various challenges managing their child's HAs. The findings of this study suggested that at least based on professionals' viewpoint, not only the degree of HL, per se, but also many other child-specific and family-related factors affect a child's HA wearing time. The focus group study stressed the importance of investing in working as a team for clinicians and more focus on parent coaching to perceive severity and understand the importance of their child hearing loss. Because if parents deeply perceive severity, they will do whatever they can for their child's hearing.

Limitations

In the systematic review (Inquiry 1- chapter 2), we limited our search to HA users (but not other types of hearing technologies) and articles written in English. Therefore, we may have missed some papers based on word restrictions or potentially relevant papers in other languages. As a consequence of the language limitation, we may have missed the culturally related HA use challenges and barriers in different countries.

In the quantitative inquiry (Inquiry 2- chapter 3), the data were collected retrospectively. In the absence of a central-synchronized Canadian database across pediatric audiology clinics, our access to the HA use data was limited. Consequently, the data were only retrieved from one site (CHEO audiology clinic), which limits the generalizability of results to all Canadian pediatric populations Due to the small sample size, we were unable to study longitudinal trends and examine the association between factors and the amount of HA use over time. Therefore, caution should be practiced when interpreting the findings.

In the qualitative inquiry (chapter 3), our focus group participants were only from the CHEO audiology clinic. Therefore, we missed other healthcare professionals' viewpoints from different sites with diverse experiences and where access to healthcare services may differ. Since our focus group was restricted to the clinicians, we did not include parents' perspectives about their child's HA management challenges. Therefore, research should be done to address the HA use challenges from parents' perspectives.

Future Studies

An important next step would be to evaluate HA use in a larger population to determine whether the results of this study are typical or are restricted to the particular clinic setting that we studied in this thesis. Second, although the EHDI components are well-defined and incorporated into clinical programs, there is a variation in service delivery through different clinics. The particular audiology clinic we used has a multidisciplinary team setting, including audiology, audiology-verbal therapists, speech-language pathologists and otolaryngologists. Therefore, the impact of an

interdisciplinary team setting as an element of successful early intervention in pediatric HA use needs to be studied in the Canadian context. Third, children's HA use data should be collected prospectively to determine the association between the amount of HA use and the child's speech and language outcomes in the long term.

Summary

Very young children gain 90% of their learning about the world incidentally (Broadbent et al., 2018). This incidental learning happens through overhearing and allows auditory system development in young children and, in turn, facilitates language and vocabulary development. Children with HL may miss the opportunity to overhear the world; consequently, they miss a significant amount of information and learning opportunities. Early and consistent HA use means that children with HL are more likely to have auditory access to an appropriate level of information that more closely matches the opportunities of their typical hearing peers. The articles in this thesis (Chapters 2-4) summarized a comprehensive study of factors and challenges of early HA use in the pediatric population. This thesis represents the first study in a Canadian pediatric clinical context to investigate the factors and challenges of HA in young children after HA fitting. In this research program, based on healthcare professionals' viewpoints, we highlighted the importance of identifying a child's unique challenges with wearing HAs and providing families with adapted coaching strategies to improve their HA management skills. However, we still need to learn about the challenges of HA use from the parent's perspective. In summary, this thesis lays a foundation

for future research on the factors associated with one component of a successful early intervention program in the Canadian pediatric population.

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Statement of Contributions

Systematic review (Chapter 2): Mina Salamatmanesh performed all screening, data abstraction, analysis, synthesis. Lindsey Sikora assisted with the search strategy. Melissa MacAskill provided secondary screening and verified the abstraction. Mina Salamatmanesh wrote the original draft of the paper. All co-authors provided support regarding the research design and provided feedback on the manuscript.

Quantitative Study – Retrospective Chart Review (Chapter 3): Mina Salamatmanesh was responsible for designing the database, collecting data, analyzing, synthesizing, and preparing the

original draft. All the data analysis was conducted by Mina Salamatmanesh and verified by JoAnne Whittingham. Elizabeth Fitzpatrick and Tim Ramsay reviewed the analysis results and provided feedback on the statistical analysis methods and results. All co-authors provided support regarding the research design and provided feedback on the manuscript.

Qualitative Study – Focus Group (Chapter 4): Mina Salamatmanesh was responsible for developing the focus group interview guide, conducting the focus groups, transcribing, analyzing, synthesizing, and preparing the original draft of the manuscript. Melissa MacAskill converted the audio files into text format, and Mina Salamatmanesh verified all transcriptions. Mina Salamatmanesh and Elizabeth Fitzpatrick carried out independent coding of the focus group transcripts. Mina Salamatmanesh did the analysis, and Elizabeth Fitzpatrick reviewed and provided feedback on the analysis. All co-authors provided support regarding the research design and provided feedback on the manuscript.

Knowledge Translation

Poster Presentation

Mina Salamatmanesh (Poster presentation accepted) ISAAR 2017: 6th International Symposium on Auditory and Audiological Research ISAAR 2017 "Adaptive Processes in Hearing" Denmark, 2017.

Mina Salamatmanesh, Elizabeth Fitzpatrick, Tim Ramsay, Josee Lagacé, Lindsey Sikora, JoAnne Whittingham (2017). Pediatric Hearing Aid Use: A Study Based on Data Logging Information, ICARHD 2017: 19th International Conference on Auditory Rehabilitation and Hearing Devices, France, 2017.

Journal Articles

Mina Salamatmanesh, Lindsey Sikora, Sayna Bahraini, Melissa MacAskill, Josée Lagace, Tim Ramsay, Elizabeth M. Fitzpatrick. (Under review). Pediatric Hearing Aid Use: A Systematic Review. International Journal of Audiology, TIJA-2020-11-0577.

Appendix 1

Search Strategy

LLBA:

(((hearing aid*) OR BAHA OR (middle ear implant*) OR (auditory implant*)) AND ((hearing loss) OR (loss of hearing) OR (hearing impairment*) OR (hearing disorder*) OR (occupational deafness) OR tinnitus OR (noise injur*) OR (vestibulocochlear nerve disease)) AND (pediatric* OR paediatric* OR newborn* OR infant* OR preschool* OR pre-school* OR child OR children))

MEDLINE:

1. exp Hearing Loss/

2. Hearing Disorder*.tw. or Hearing Disorders/

3. (hear* adj3 (distort* or impair* or disorder* or loss*)).tw.

4. deaf*.tw.

5. (auditory adj3 (neuropath* or conduc* or sensor*)).tw.

6. exp Hearing Aids/

7. (hear* adj3 (aid* or instrument* or device* or prosthes?s* or technolog*)).tw.

8. (ear adj2 (mold* or mould*)).tw.

9. earmold*.tw.

10. earmould*.tw.

11. ((auditory or middle ear*) adj3 (implant* or prosthes?s*)).tw.

12. amplification.tw.

13. BAHA.tw.

14. or/1-5

15. or/6-13

16. 14 and 15

17. limit 16 to yr="2005 -Current"

18. limit 17 to ("all infant (birth to 23 months)" or "newborn infant (birth to 1 month)" or "infant (1 to 23 months)" or "preschool child (2 to 5 years)")

19. 16 and 17 and 18

EMBASE:

1. *hearing impairment/

2. *hearing disorder/

3. *occupational deafness/ or *hearing disorder/ or *methodology/ or *audiometry/ or *tinnitus/ or *noise injury/ or *noise/ or *hearing/ or *hearing impairment/ or *inner ear disease/

4. *vestibulocochlear nerve disease/

5. *hearing aid/

6. *hearing aid/

7. *bone anchored hearing aid/

8. *acoustics/

9. *middle ear/

10. *auditory implant/

11. *hearing aid/

12. or/1-4

13. or/5-11

14. 12 and 13

15. limit 14 to (english and yr="2005 -Current" and (infant or child or preschool child <1 to 6 years>))

16. 14 and 15

COCHRANE:

1. exp Hearing Loss/

2. Hearing Disorder*.tw. or Hearing Disorders/

3. (hear* adj3 (distort* or impair* or disorder* or loss*)).tw.

4. deaf*.tw.

5. (auditory adj3 (neuropath* or conduc* or sensor*)).tw.

6. exp Hearing Aids/

7. (hear* adj3 (aid* or instrument* or device* or prosthes?s* or technolog*)).tw.

8. (ear adj2 (mold* or mould*)).tw.

9. earmold*.tw.

10. earmould*.tw.

11. ((auditory or middle ear*) adj3 (implant* or prosthes?s*)).tw.

12. amplification.tw.

13. BAHA.tw.

14. or/1-5

15. or/6-13

16. 14 and 15

17. limit 16 to yr="2005 -Current"

18. limit 17 to ("all infant (birth to 23 months)" or "newborn infant (birth to 1 month)" or "infant (1 to 23 months)" or "preschool child (2 to 5 years)")

19. 16 and 17 and 18

EBSCO (CINAHL):

EBSCOhost

#	Query	Limiters/Expanders	Last Run Via
S10	S1 AND S8	Limiters - Published Date: 20050101-20170531; Age Groups: Infant: 1-23 months, Child, Preschool: 2-5 years, Child: 6-12 years, Adolescent: 13-18 years Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S9	S1 AND S8	Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S8	S6 OR S7	Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S7	"hearing aid use"	Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S6	S2 OR S5	Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S5	"BAHA"	Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S4		Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S3		Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S2	(MM "Hearing Aids") OR (MM "Hearing Aid Fitting") OR (MM "Hearing Aid Care (Saba CCC)") OR (MM "Hearing Aid Care")	Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S1	(MH "Hearing Loss, Functional") OR (MH "Hearing Loss, Partial") OR (MH "Hearing Loss, Sensorineural") OR (MH "Hearing Loss, Conductive") OR (MH "Hearing Loss, Central") OR (MH "Hearing Disorders") OR (MH "Deafness") OR "hearing loss"	Expanders - Apply related words Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL

Appendix 2

PROSPERO Registration

PROSPERO Registration [116207]

CRD-REGISTER <irss505@york.ac.uk>

Dear Mina Salamatmanesh,

Thank you for submitting details of your systematic review "Pediatric

hearing aid use" to the PROSPERO register. We are pleased to confirm that the record will be published on our website within the next hour.

Your registration number is: CRD42019116207

You are free to update the record at any time, all submitted changes will be displayed as the latest version with previous versions available to public view. Please also give brief details of the key changes in the Revision notes facility. You can log in to PROSPERO and access your records at
https://www.crd.york.ac.uk/PROSPERO

Comments and feedback on your experience of registering with PROSPERO are welcome at: crd-register@york.ac.uk

Best wishes for the successful completion of your review.

Yours sincerely,

PROSPERO Administrator
Centre for Reviews and Dissemination
University of York
York YO10 5DD
t: +44 (0) 1904 321049
e: CRD-register@york.ac.uk
www.york.ac.uk/inst/crd

PROSPERO is funded by the National Institute for Health Research and produced by CRD, which is an academic department of the University of York.

Appendix 3

Research Ethics Board Certificate – Children Hospital of Eastern Ontario

Research Ethics Board Certificate – University of Ottawa

CHEO Research Ethics Board Approval - Delegated Review

Principal Investigator: Dr. Elizabeth Fitzpatrick
REB Protocol No:17/65X
Romeo File No:20170187

Project Title: CHEO REB# 17/65X - Hearing aid use in the early intervention of infants diagnosed with hearing impairment and family support: Preliminary feasibility data collection
Primary Affiliation: Clinical Research\Audiology
Protocol Status: Active
Approval Date*:June 08, 2017
Valid Until:**April 15, 2018
Annual Renewal Submission Deadline: March 15, 2018

Documents Reviewed & Approved:

Document Name	Comments	Version Date
Case Report Form	Case Report Form version 1 - June 16 2016	2016/06/16
Investigator Response	Response #2 to additional REB feedback	2017/06/01
Protocol	Clean version of modified protocol	2017/05/04

This is to notify you that the Children's Hospital of Eastern Ontario Research Ethics Board has granted approval to the above named research study on the date noted above. Your project was reviewed under the delegated review stream, which is reserved for projects that involve no more than minimal risk to human subjects.

Final approval is granted for the above noted study, with the understanding that the investigator agrees to comply with the following requirements:

1. The investigator must conduct the study in compliance with the protocol and any additional conditions set out by the Board.
2. The investigator is responsible for complying with all applicable guidelines and regulations regarding human research ethics conduct, as applicable to the research project.
3. Approval for studies that include an investigational device(s) is contingent upon the investigator securing an Investigational Testing Authorization notice from Health Canada.
4. Investigators must submit an annual renewal report to the REB 30 days prior to the expiration date stated above.
5. The investigator must not implement any deviation from, or changes to, the protocol, consents or assents without the approval of the REB.
6. The investigator must, prior to use, submit to the Board changes to the study documentation, e.g., changes to the informed consent letters, recruitment materials.
7. Investigators must provide the Board with French versions of the consent form, unless a waiver has been granted. An interpreter should be offered to participants as required or at the request of the participant throughout the course of research.
8. The investigator must promptly report to the REB all unexpected and untoward occurrences (including the loss or theft of study data and other such privacy breaches).
9. Investigators must notify the REB of any study closures (closed to accrual, temporary, premature or permanent).
10. Investigators must submit a final report at the conclusion of the study.

Should you have any questions or concerns, please do not hesitate to contact the Research Ethics Board Office at 613-737-7600 ext. 3350 or 2128.

Regards,

Richard Carpentier, PhD
Chair, Research Ethics Board
Président, Comité d'éthique de la recherche

*The final approval date for initial delegated study applications approved with or without modifications will be the date the REB has determined that the conditions of approval have been satisfied.

**The expiry date of REB approval for initial study application that required no modifications will be as follows:
• If the date of review and approval was **on or before**the 15th of the month, the expiry date will be the 15th of the month prior to the date of review and approval by the Chair and/or delegate *in the following year*;
• If the date of review and approval was **after**the 15th the expiry date will be the 15th of the month in which the date of review and approval by the REB *in the following year*.

The expiry date of REB approval for initial study applications that**require modifications**will be as follows:
• If the initial feedback was sent **on or before**the 15th of the month, the expiry date will be the 15th of the month prior to the date the letter of REB feedback is issued to the investigator(s) *in the following year*;
• If the initial feedback was sent **after**the 15th the expiry date will be the 15th of the month in which the feedback was sent *in the following year*.

Principal Investigator: Dr. Elizabeth Fitzpatrick
REB Protocol No: 18/137X
Romeo File No: 20180516
Project Title: CHEOREB# 18/137X - Needs and Challenges of Hearing Aid Use in Young Children: A Focus Group Study
Primary Affiliation: Clinical Research\Audiology
Protocol Status: Active
Approval Date*: November 22, 2018
Approval Expiry Date:** November 15, 2019

Documents Reviewed & Approved:

Document Name	Comments	Version Date
Investigator Response	Investigator Response to REB Additional Feedback	11/21/2018
Consent Form	Consent Professionals	11/19/2018
Recruitment Materials	Recruitment Email Health Care Professionals, Version #1 dated November 2018	11/21/2018
Questionnaire/Survey	Child and Family Questionnaire Nov 5th 2018	11/5/2018
Consent Form	Parental Consent	11/20/2018
Questionnaire/Survey	Healthcare Professionals Questionnaires Nov 2018	
Case Report Form	Case Report Form Version # 2, Nov 2018	

This is to notify you that the Children's Hospital of Eastern Ontario Research Ethics Board has granted approval to the above named research study on the date noted above. Your project was reviewed within the delegated stream, which is reserved for projects that involve no more than minimal risk to human participants.

Final approval is granted for the above noted study, with the understanding that the investigator agrees to comply with the following requirements:

1. The investigator must conduct the study in compliance with the protocol and any additional conditions set out by the Board.
2. The investigator is responsible for complying with all applicable guidelines and regulations regarding the ethical conduct of research with humans, as applicable to the research project.
3. Approval for studies that include an investigational device(s) is contingent upon the investigator securing an Investigational Testing Authorization notice from Health Canada.
4. Investigators must obtain annual renewal approval prior to the expiration date stated above.

5. The investigator must not implement any deviation from, or changes to, the protocol, consents or assents without the approval of the REB except where necessary to eliminate hazard to the research subject, or when the change involves only logistical or administrative aspects of the study (e.g., change of telephone number or research staff). As soon as possible, however, the implemented deviation or change, the reasons for it, and, if appropriate, the proposed protocol amendment(s) should be submitted to the Board for review and approval.
6. The investigator must, prior to use, obtain approval from the Board for changes to the study documentation, e.g., changes to the informed consent letters, recruitment materials.
7. Investigators must obtain approval from the Board of French version(s) of the consent/assent form(s), unless a waiver has been granted. An interpreter should be offered to participants as required or at the request of the participant throughout the course of research.
8. The investigator must promptly report to the REB all unexpected and untoward occurrences (including the loss or theft of study data and other such privacy breaches).
9. Investigators must notify the REB of any study closures (closed to accrual, temporary, premature or permanent).
10. Investigators must submit a study closure event form at the conclusion of the study.

Should you have any questions or concerns, please do not hesitate to contact the Research Ethics Board Office at 613-737-7600 ext. 3350 or 2128.

Regards,

Richard Carpentier, PhD
Chair, Research Ethics Board
Président, Comité d'éthique de la recherche

* The final approval date for initial delegated study applications approved with or without modifications will be the date the REB has determined that the conditions of approval have been satisfied.

** The expiry date of REB approval for initial study applications will be as follows:
- If the date of approval was **on or before** the 15th of the month, the expiry date will be the 15th of the month prior to the date of review and approval by the Chair and/or delegate *in the following year*;
- If the date of review and approval was **after** the 15th of the month, the expiry date will be the 15th of the month in which the date of review and approval by the REB *in the following year*.

Université d'Ottawa University of Ottawa
Bureau d'éthique et d'intégrité de la recherche Office of Research Ethics and Integrity

LETTRE D'APPROBATION ADMINISTRATIVE | LETTER OF ADMINISTRATIVE APPROVAL

Numéro de dossier / Ethics File Number	A07-17-02
Titre du projet / Project Title	Hearing aid use and family support in the early intervention of infants diagnosed with hearing impairment: Preliminary Feasibility data review
Type de projet / Project Type	PhD
CÉR primaire / Primary REB	CHEO REB
Statut du projet / Project Status	Approbation administrative / Administrative Approval
Date d'approbation (jj/mm/aaaa) / **Approval Date** (dd/mm/yyyy)	24/07/2017
Date d'expiration (jj/mm/aaaa) / **Expiry Date** (dd/mm/yyyy)	15/04/2018

Équipe de recherche / Research Team

Chercheur / Researcher	***Affiliation***	***Role***
Elizabeth Fitzpatrick	Audiology and Speech Language Pathology	Supervisor
Mina Salamatmanesh	Audiology and Speech Language Pathology	Principal Investigator

Conditions spéciales ou commentaires / Special conditions or comments:

CHEO REB # 17/65X

L'Université d'Ottawa a signé une Entente, conforme aux exigences de la plus récente version de l'EPTC et tout autre règlement ou législation applicable, permettant au CÉR ci-haut nommé d'être désigné comme CÉR primaire pour les projets de recherche où

1) les activités principales de recherche sont menées sous l'autorité ou sous les auspices de l'établissement lié au CÉR primaire et
2) Une partie du projet est également réalisé sous l'autorité ou sous les auspices de l'Université d'Ottawa.

Cette lettre confirme que l'Université d'Ottawa a autorisé que le CÉR primaire soit le CÉR officiel pour l'évaluation et la supervision de ce projet de recherche. Ceci n'est pas une approbation éthique.

Afin de nous aider à garder votre dossier à jour, veuillez soumettre une copie de toutes demandes de modification, renouvellement d'approbation éthique etc. soumis à et approuvé par le CÉR primaire dès qu'elles sont disponibles.

Cette approbation administrative est valide pour la durée indiquée ci-haut et est sujette aux conditions énumérées dans la section intitulée « Conditions spéciales ou commentaires ».

The University of Ottawa has signed an Agreement, compliant with current TCPS guidelines and any other applicable guidelines or legislation regarding multisite review, allowing the REB named above to serve as Board of Record (BoR) for research projects where

1) the main research activities are conducted within the auspices or jurisdiction of the BoR's institution and
2) parts of the project are also conducted under the jurisdiction or auspices of the University of Ottawa.

This letter confirms that the University of Ottawa has authorized the REB named above to serve as Board of Record for the review and oversight of this research project. This is not an REB approval.

In order to help us keep your file up to date, please submit a copy of all amendment requests, project renewals or any other changes submitted to and approved by the BoR, as they become available.

Administrative approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special conditions or comments".

Catherine Paquet
Directrice/Director

CHEO Research Ethics Board
Permanent Study Closure

REB Protocol No: 18/137X
ROMEO File No: 20180516
Principal Investigator: Dr. Elizabeth Fitzpatrick
Project Title: CHEOREB# 18/137X - Needs and Challenges of Hearing Aid Use in Young Children: A Focus Group Study

Date Closure Acknowledged: October 26, 2020

Thank you for advising the Board that the above-mentioned study is permanently closed.

Please note that all research records pertaining to studies that fall under Health Canada Division 5 regulations must be retained for 25 years after closure. All other studies should retain records for 7 years after the study closure, unless otherwise approved by the REB.

For investigator initiated regulated trials (e.g., drug, device or natural health products) the investigator/sponsor is requested to notify the relevant Directorate(s) (via CTA-Notification) when a clinical trial is completed or a clinical trial site is closed. For additional information on this process, please contact the Quality Assurance & Risk team.

Please note that if your study is registered on www.clinicaltrials.gov and CHEO is listed as the sponsor and/or the lead coordinating center, please ensure that the study results are posted on clinicaltrials.gov within a year of study completion.

If you have any questions, pertaining to this letter, please contact the Research Ethics Board office.

Regards,

Cécile Bensimon, MA, PhD
Chair, Research Ethics Board
Président, Comité d'éthique de la recherche

Appendix 4

Informed Consent Form

Information &
Consent Form

Protocol Title: Need and Challenges of Hearing Aid Use in Young Children: A Focus Group Study

Investigator: Dr. Elizabeth Fitzpatrick

Co-Investigator: PhD.(Candidate) Mina Salamatmanesh

Address: CHEO, Research Institute II, 401 Smyth Road, Ottawa, ON K1H 8L1

Telephone Number: (613) 737-7600 Ext. 3907

For more simplicity, the word "you", when used in this form, means "yourself" or "your child".

You are being invited to join this research study because you are a healthcare professional working with children with hearing loss at the Audiology Clinic and CHEO and uses a hearing aid. This study is designed to find out from healthcare professionals what the challenges are to achieve consistent hearing aid use for their child. Before agreeing to take part in this study, it is important that you read and understand this document.

Taking part in this study is voluntary. Your decision to participate or not in this study will not affect your professional position at CHEO. You are free to withdraw from the study at any time and there will be no penalty to you or your child.

Why is this study being done?
In this study we want to take the advantages of healthcare professionals' experiences, who have been actively involved with a child hearing aid use management. With the focus group interview we hope to gain a deeper understanding of the important challenges of hearing aid use in infants and very young children. We expect to receive feedback regarding the provided services from healthcare professionals' point of view and recommendations on what service is necessary to add into the services to facilitate the process of hearing aid use management for families, early after hearing aid fitting.

How many people will participate?
At CHEO, we expect to have a total number of 10-12 clinicians to participate in the focus group interviews. The study is expected to be recruiting for 2018-2019

What will I have to do?
If you decide to participate in this study we will ask you to participate in a focus group interview. Focus group interview is not an individual interview. All participants (5-6 people) will sit around a table and answer to some general questions that we designed. The questions are about your experience with your patients' hearing aid use and parent challenges early after child hearing aid fitting. The question will be asked and everybody around the table will give their idea or experience regarding the proposed question.

The interview is expected to take about an hour. We will book the interview at a time that is best for everyone. The interview will be audio-recorded and transcribed for analysis.

A step-by-step description of the study procedures:

- A one-time focus group interview, which is expected to take 45-60 minute to complete.
- The interview will be audio recorded for analysis.
- Audio records will be stored in encrypted and password protected devices (e.g. CHEO laptops and USB) and will be kept at Child Hearing Lab at CHEO RI Centre.

Are there any risks to participating?

We know of no harm or risk that taking part in this study could cause you. A potential discomfort may include you feeling uncomfortable with some of the questions being asked if they are sensitive or evocative. If you feel uncomfortable, you may choose not to answer a question. During the group meeting we will remind everyone that the information shared is private and should not be repeated outside the group but we cannot be sure that information about you will be kept private. People in groups may share information with others outside the group.

Are there any benefits to participating?

If you decide to participate, you may or may not benefit from participating in this study; however, by identifying the main challenges in pediatric hearing aid use managements, we hope to make useful recommendations for a better support in the process of rehabilitation.

Will I be paid to participate?

You will not be paid to take part in this study.

Can I Withdraw?

Taking part in this study is voluntary. Your decision to participate or not in this study will not affect your employment at CHEO. You are free to withdraw from the study at any time and there will be no penalty to you. At any time during the study, you may decline to stop an interview. If you withdraw your consent, the investigator will no longer collect and disclose information for the purpose of this study. Based on the participant's request, all the information that was already collected will still be used by the investigator or all information collected will be discarded.

Will I be told about new information?

We will inform you of any new information that might influence your decision to continue to participate in this research project. We will ask you again if you still want to be in the study. You can receive a copy of the study results at the end of the study. Please let the study team know if you like to receive a copy.

What about confidentiality and privacy?

Your information will be kept strictly confidential except as required or permitted by law.

Prior to the interviews, you will be asked to complete a brief form "Healthcare Professionals Questionnaire" in order to record key information. The information will include professional title, years of experience, as well as percentage of time working with parents and children with HL.

Representatives from the CHEO research Ethics Board and a member of the CHEO RI Quality Assurance and Risk Program may review your records, and the research data under the supervision of the Investigator and staff, to ensure that all research standards, guidelines and regulations are met.

The research data and audio recordings produced from this study will be stored in a secure, locked location at R1133, Child Hearing Lab at CHEO Research Institute. Only members of the research team and the individuals described above will have access to the data. Following completion of the research study the data will be kept for 7 years after the last publication of this study. They will then be destroyed.

You will not be identified in any publication or presentation of this

study. A copy of the signed consent form will be provided to you.

Is the research team benefiting from the study?

The research team members are not benefiting personally, financially or in some other way from this study.

What if I have questions?

If you have any questions concerning participation in this study, or if at any time feel that you have experienced a study-related injury or reaction to the study medication, contact: Child Hearing Lab at CHEO RI Centre: 613- 737 7600 Ext. 3907

This study has been reviewed and approved by the CHEO Research Ethics Board. The CHEO Research Ethics Board is a committee of the hospital that includes individuals from different professional backgrounds. The Board reviews all human research that takes place at the hospital. Its goal is to ensure the protection of the rights and welfare of people participating in research. The Board's work is not intended to replace a parent or child's judgment about what decisions and choices are best for them. You may contact the REB, for information regarding patient's rights in research studies at (613) 737-7600 (3272), although the REB cannot provide any health-related information about the study.

Consent form Signatures

By signing this consent form I agree that:

- I am voluntarily agreeing to participate in this research study;
- I understand the information within this consent form;
- All of the risks and benefits of participation have been explained to me;
- All of my questions have been answered;
- I allow access to my child's medical records and/or personal information as described in this consent form; and I do not give up my legal rights by signing this form.

Signature of Participant	Name of Participant	Date

Printed Name of Person Who Conducted Consent Discussion	Signature of Person Who Conducted Consent Discussion	Date

Appendix 5

Case Report Form

Partial Date of Birth: ___ ___ ___/___ ___ Gender: ☐ Male ☐Female

(MMM/YY)

Date of Last Visit: ___ ___/___ ___ ___/___ ___

ROUTE TO REFERRAL	
☐Screened	☐Not screened (Referred)

SCREENING

Date of Screening:___ ___/___ ___ ___/___ ___ Location: _____

Outcome: ☐Pass ☐Refer ☐No Result/Incomplete ☐Did Not Test ☐Not Screened

HEARING LOSS DIAGNOSIS			
Date of Referral:	___ ___/___ ___ ___/___ ___		
Date of First Assessment:	___ ___/___ ___ ___/___ ___	Location:_____	
Hearing Loss:	☐Yes	☐No	☐Inconclusive; monitored
Date of Hearing Loss Confirmation:	___ ___/___ ___ ___/___ ___	Location:_____	

Notes on HL Diagnosis

RISK STATUS At Risk Not At Risk Not at CHEO

ETIOLOGY

Known: YES NO

*Category	*Etiology	
1	familial	_____
2	defect ENT	_____
3	syndromic	_____
4	prenatal infection	_____
5	NICU graduate	
6	meningitis	
7	middle ear disease	
8	ototoxic meds/oncology	
9	unknown	

ONSET OF HEARING LOSS

Congenital	☐	A PHL that is confirmed after a refer result on screening
Early onset	☐	A PHL that is recognized in the neonatal period, defined for this study as including children referred and diagnosed before 6 months of age.
Late onset	☐	A PHL that is diagnosed following screening pass and/or a least one diagnostic assessment with thresholds within normal limits
Progressive	☐	A change in audiometric thresholds after diagnosis of ≥ 20 dB in the pure tone average
Unknown	☐	A permanent hearing loss (PHL) diagnosed after infancy with no history of screening, no risk factors identified and unknown etiology

INTERVENTION: HABILITATION TYPE

A) Amplification

Amplification:

☐ Hearing aids ☐ Left ear ☐ Right ear

☐ Cochlear implants ☐ Left ear ☐ Right ear

INTERVENTION: HABILITATION TYPE			
Intervention Type	☐ AVT	☐ SLP services	☐Other
Intervention Start	___ ___/___ ___ ___/___ ___	Intervention Discharge	___ ___/___ ___ ___/___ ___
Language	☐ENGLISH	☐FRENCH	Therapist: _____
Intervention Notes			

Is the patient receiving health care services other than for hearing loss?

_____

_____

Latest Audiology Evaluations

Date	Source		Click Threshold	250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz	8000 Hz	Tymp	OAE's	Type of HL
		R												
			PTA/SRT											
		L												
			PTA/SRT											
			Rx and Amplification Use							**Middle Ear Status**				

Appendix 6

Focus Group Question Guide

Clinicians Focus Group Interview Questions

1. What type of information do parents commonly ask for after their child's hearing loss diagnosis?

   Prob. What are their main concerns?

2. What are the main challenges for families early after hearing aid fitting?

   Prob. How much do they talk about their challenges?

3. What type of supports/services do you provide for families early after HA fitting?

   Prob. Do you phone families to check up with them? If yes, how many times in average?

   Prob. Based on your experience, what type of supports/services do parents prefer to receive?

4. Do you talk to the parents about their child's HA usage based on the Data Logging records information?

   Prob. Do you explain the Data logging feature for families? Are they aware of this feature?

   Prob. How do you communicate to parents about the importance of consistency in hearing aid use?

5. How frequently do you check the data logging for each patient?

6. How are the support services structured to support families?

   Prob. Explain the strength and weaknesses of family support services.

7. What key improvement(s) could be made to the support services to improve the quality of outcomes?

   Prob. How can the support of families be used/applied to improve the average hours of HA use for their children? (Regular phone call follow up, Reminder emails,…)

Appendix 7

Poster

Pediatric Hearing Aid Use: A Preliminary Study Based on Data Logging Information

Mina Salamatmanesh [1,2], Elizabeth Fitzpatrick [1,2], Tim Ramsay [1,3], Josée Lagacé [1], Lindsey Sikora [1], JoAnne Whittingham [2]

[1] University of Ottawa, [2] Children's Hospital of Eastern Ontario Research Institute, [3] Ottawa Methods Centre (OMC)

BACKGROUND

One of the most common abnormalities present at birth is hearing loss (HL). Annually, 2 to 4 per 1000 infants are born with permanent HL. Newborn hearing screening has been widely implemented due to the prevalence of childhood hearing disorders, the risk of negative developmental consequences, and the documented improvement in communication skills. There is good evidence for the effectiveness of early identification of HL in improving language development. It is well recognized that early intervention including optimal hearing aid use is key to improving a child's auditory and linguistic experience (4). However, the advantages of early identification of HL are not always maximized because of difficulties with hearing aid use in young children (1,2). Early hearing aid use is critical because during the early stages of life, the brain has maximum plasticity for auditory development.

A feature of hearing aids that permits a glimpse into an individual's use of their device is data logging. With data logging, hearing care professionals capture objective data on the average number of hours of use, which provides important information for parent guidance to optimize hearing aid use(3). The data can be used during follow up appointments to targeted counseling with families.

Figure 1. Data Logging Feature

STUDY DESIGN & OBJECTIVE

In this report, we present preliminary data logging information of the average hearing aid usage time from 21 young children. The results of this preliminary study provide insights into the amount and change in hearing aid use. The data also serves to identify important factors for the next phase of the project including: the predictors of hearing aid use in young and the impact of factors including: age, sex, severity of hearing loss and amount of hearing aid use.

METHOD

Study Design

This retrospective study involved hearing aid and medical chart reviews undertaken for children who were diagnosed with HL and fitted with hearing aids from 2006 to 2015 at the Children Hospital of Eastern Ontario (CHEO), a pediatric audiology clinic in Canada. Children met the following inclusion criteria:

Age	0-72 months
Degree of HL	All degrees
Age of amplification	0-24 months
Data logging	At least one available data logging record

Table 1. Table of characteristics

Procedures

For each child all recorded data logging information, documented in the first three years after HA fitting, was extracted and coded in a SPSS file. Clinical characteristics including age of diagnosis, age of fitting, level of hearing loss, and type of hearing aid, recorded in the medical charts were also extracted and coded in the SPSS file.

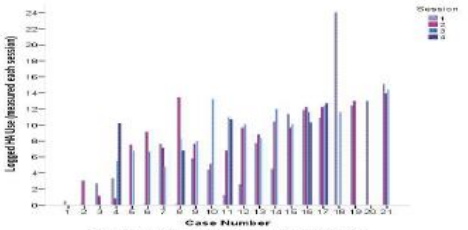
***Data analysis**: A descriptive analysis was carried out to describe the average amount of usage in the time period between follow up sessions at the audiology clinic.*

RESULTS

Preliminary analysis of the results for 21 children showed that all (100%) have at least one data logging session recorded in the clinical audiology system (Noah). Of the 21 children, 16 (76%) have more than two data logging events recorded in the first three years after HA fitting in the figure below.

Based on the analysis of the first 21 cases, the median hours of use in the first follow-up session after hearing aid fitting in the right ear is 3.9 hours (Interquartile range-IQR: 0.92, 11.12). For the left ear the median is 4.4 hours (IQR: 1.2, 10.9). In the first session, 47% of the children used their hearing aids ≤5 hours, 12% between 5 to 10 hours and 22% ≥10 hours a day.

However, these children showed increased use by the third follow-up session with a median of 9.1 hours for the right ear (IQR: 2.5, 11.60) and (IQR: 3.1, 11) for left ear. By the third follow-up session, 14% of children used hearing aids ≤5 hours, while 38% of children used them ≥10 hours. These preliminary results, age and level of HL significantly impacted the hours of use. Older children or those with more severe HL use their hearing aids more than others.



Patients average hearing aid usage in each session.

CONCLUSION

The use of data logging information to assess the actual hours of hearing aid use provides an opportunity to examine the: a) challenges of families of young children with hearing aids, b) factors that impact use in very young children. Data logging when used collaboratively with parents, can be a powerful tool to identify problems and to encourage and assist families in maximizing their child's hearing potential (1,3). Reviewing hours of HA use based on recorded data logging information allows the clinician to tailor counseling to families, to systematically identify and address issues, and actively implement custom rehabilitation programs (e.g. telephone call follow up, home visits to improve amount and consistency of hearing device use.

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