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Moderators and predictors in a parent hearing aid management eHealth program

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Abstract

Objective: Consistent hearing-aid use is essential for spoken language development of children who are hard of hearing. A recent randomized controlled trial of an eHealth hearing aid management education program found the intervention increased knowledge, perceptions, confidence, and device monitoring among parents of young children. Yet, it is not known which variables can be a point of emphasis to improve treatment outcomes. The purpose of this study was to investigate potential moderators and predictors in the eHealth program.

Design: Randomized controlled trial

Study Sample: Parents (N=78) of children (42 months or younger) were randomized to the intervention or treatment-as-usual (TAU) group.

Results: Results revealed that high psychological inflexibility, low parent activation, and low hours of hearing aid use may moderate device monitoring frequency and knowledge; parents in the intervention improved over time compared to the TAU group. Psychological inflexibility and parent activation also predicted treatment outcomes.

Conclusion: The findings suggest the need to address parent psychological inflexibility related to hearing loss management, parents' role in their child's hearing aid management, and reported hours of hearing aid use as part of hearing aid service delivery. Identification of barriers to hearing aid management can assist audiologists in adjusting support to improve outcomes.

Keywords: hearing loss, hearing aids, parent education, moderator, child

Moderators and predictors in a parent hearing aid management eHealth program

Early and consistent audibility through well-functioning hearing aids are critical foundations for children with permanent hearing loss who are developing spoken language (McCreery & Walker, 2017). Parents have a key role in helping their young child access sound and adhering to hearing aid usage recommendations. Tomblin and colleagues (2015) found 10 or more hours of hearing aid use per day predicted better language outcomes for children with mild to severe hearing loss. Furthermore, oral language skills are foundational for academic performance, and have been found to be moderated by the extent hearing aids provide audibility in early elementary school (Tomblin et al., 2020). These together underscore the importance of parent learning and capacity building. Yet, parents often experience challenges learning to implement new information and skills to adhere to hearing aid management routines (Muñoz et al., 2015). Providers can support parent learning through education and guidance to help parents overcome barriers that interfere with their ability to take needed actions.

Research has described challenges (e.g., lack of confidence, insufficient information) parents experience related to hearing aid management (Muñoz et al., 2015; Muñoz et al., 2016); however, there is a scarcity of research on effective parent interventions to improve daily hearing aid routines. One study has offered a possible solution to increasing parent hearing aid knowledge, confidence, and frequency of monitoring device function (Muñoz et al., 2021). In their pilot randomized controlled trial, the researchers implemented an eHealth education program. Parents with children who use hearing aids were allocated into one of two groups (intervention condition vs. TAU). The six-week intervention condition included educational videos on hearing aid management along with weekly phone check-ins. Compared to the TAU condition, participants in the intervention group had a greater increase in knowledge, perceptions, confidence, and monitoring of hearing aid management. Additionally, both conditions had increased hearing aid use but there was not a statistically significant difference between groups at the conclusion of the study. To improve intervention outcomes by identifying

variables audiologists can focus on in treatment, it is important to investigate any potential moderating and predictive variables that can be addressed.

Parental thoughts and emotions about a child's hearing loss and hearing aid use could play a role in behavioral outcomes including daily hearing aid management. For example, if a parent has worries associated with having their child wear hearing aids (Muñoz et al., 2015), to avoid experiencing the uncomfortable feelings the parent may not put the hearing aids on their child. A concept out of psychology called psychological inflexibility can help explain how certain internal experiences affect behavior in some people and not in others. Psychological inflexibility describes when internal experiences (thoughts, feelings, sensations) are experienced as powerful and push people to engage in avoidance behaviors instead of mindfully noticing those thoughts and engaging in functional actions (Hayes & Strosahl, 2005). The inability to stay in constant presence of internal experiences is commonly measured using the Acceptance and Action Questionnaire (Bond et al., 2011). This instrument has been modified for specific conditions, including the internal experiences parents of children with hearing loss struggle with (Ong, Whicker, Muñoz, & Twohig, 2019). For pediatric hearing loss, this construct is measured by the Acceptance and Action Questionnaire-Managing Child Hearing Loss (AAQ-MCHL; Ong et al., 2019). Ong and others (2019) found the AAQ-MCHL to be a useful measure to assess psychological inflexibility in caregivers' thoughts related to their children with hearing loss. In theory, a parent who struggles against their internal experiences (e.g., frustration, sadness, worry) related to their child's hearing loss may be less likely to adhere to recommendations for their child's hearing aid management.

The level of knowledge, skill, and confidence parents have in their child's hearing aid care is also a factor that can influence outcomes. Among those with chronic conditions, an increase in patient activation (knowledge, skill, and confidence for self-management) over time has been shown to improve health-related outcomes and better self-management behaviors (Hibbard, Greene, Shi, Mittler, & Scanlon, 2015; Hibbard, Mahoney, Stock, & Tusler, 2007).

Measuring this same activation in parents – better known as parent activation – with a child who has a chronic condition is still in its infancy but is promising. For example, parent activation has shown to have positive correlations between parent satisfaction and child behaviors among parents of children with autism spectrum disorder (Ruble, Murray, McGrew, Brevoort, & Wong, 2018). While research has explored parent activation for various health illnesses (e.g., pediatric hematopoietic stem cell transplant; Pennarola et al., 2012), this research does not extend to children with hearing loss. Investigating the role parent activation for children with hearing loss plays in hearing aid management would bridge that gap.

Finally, the daily number of hours reported for hearing aid use is an important indicator for future linguistic development (Tomblin et al., 2015), but it may also play a vital role in determining outcomes for an eHealth education program. When children are using their hearing aids more consistently, this may indicate higher levels of parent knowledge, monitoring, confidence, and perceptions thus those parents would have better intervention outcomes. Conversely, lower number of hours reported for hearing aid use may suggest the lack of knowledge and confidence to properly adhere to hearing aid management for their child. That is, those that report a lower number of hours of hearing aid use may be in a better position to glean the most from an eHealth education program.

The current study presents secondary analyses from Muñoz and colleagues (2021) that seeks to explore potential moderating and predictive variables involved in parent education for hearing aid management. Specifically, we are exploring (a) whether AAQ-MCHL moderates the relationship between intervention groups and intervention outcomes (i.e., parent knowledge, monitoring, confidence, and perceptions); (b) whether parent activation moderates the relationship between intervention groups and intervention outcomes; and (c) whether parent reported hours of hearing aid use moderates the relationship between intervention groups and intervention outcomes. We also explored whether (d) AAQ-MCHL explains intervention outcomes, and (e) whether parent activation explains intervention outcomes.

Methods

Participants

The sample consisted of 78 parents of children – from 36 states and 2 countries – who are deaf or hard of hearing (DHH) and use at least one behind-the-ear hearing aid. Forty-two percent of the children were identified as female, and the mean age of the children was 15 months (median = 14 months). Mothers represented most of the parents participating in the study (93%), and the majority of the parents identified as White (77%). Just over half of the children had a moderate degree of hearing loss (53%), most had bilateral hearing loss (88%), and most used spoken language as their primary mode of communication (89%). From the 78 parents that were randomized, 37 were allocated into the intervention condition and 41 were allocated into TAU¹. Parents were considered eligible if they had a child with a behind the ear hearing aid, child was aged 42 months or younger, had access to the internet, and English was their primary language. Parents were considered ineligible if their child did not have hearing aids or if they used only cochlear implants or bone conduction hearing aids. See Table 1 for additional demographic information and for a full description see Muñoz et al. (2021).

Procedure

Data from the current study were taken from a 12-week pilot randomized controlled trial developed to assess a six-week long eHealth hearing aid management education program among parents with children who are DHH and use at least one behind-the-ear hearing aid. Data were collected from 2019 through 2020 with half of the study occurring at the start of the COVID-19 outbreak in the United States. Participants were recruited through online advertisements (e.g., Facebook), in clinic, and through state Early Hearing Detection and Intervention programs. Interested and eligible participants completed child/family demographics

¹ The intervention condition had 4 less individuals than the TAU condition because of 4 individuals that were included at pre-intervention did not provide data at subsequent time points.

and baseline measures then were randomized into one of two conditions – intervention and TAU. After being randomized, each condition completed measures at pre-intervention, mid-intervention (4th week since randomization; hours of hearing aid use only measure completed by participants), post-intervention (8th week since randomization), and at follow-up (12th week since randomization). Participants in the intervention condition were assigned a coach (audiology graduate student; pediatric audiologist) whom they spoke with on the phone once per week for six weeks. Participants were also asked to watch two hearing-aid management videos per week between week two and week five. Compensation was allocated to participants after completing questionnaires at three timepoints (i.e., baseline, 8 weeks, 12 weeks). Participants randomized into the TAU were offered an opportunity to take part in the intervention after data collection was completed. Further details about study procedures and materials can be found at Muñoz and colleagues (2021). The Utah State University institutional review board approved all procedures.

Measures

The Acceptance and Action Questionnaire-Managing Child Hearing Loss (AAQ-MCHL; Ong et al., 2019) measures a parent’s psychological inflexibility in the context of parenting a child with hearing loss (see Supplementary document 1). Specifically, the AAQ-MCHL is assessing the degree to which a parent is unwilling to encounter their thoughts, feelings, emotions, and sensations that are related to their child’s hearing loss (e.g., “I suppress negative thoughts and feelings related to my child’s hearing loss”). Each item of this 8-item self-report measure is rated on a 7-point scale ranging from 1 (never true) to 7 (always true). A total score is calculated from the sum of all items with higher scores indicating higher levels of psychological inflexibility. Reliability for this measure in this sample was high (Cronbach’s alpha = 0.90).

Patient Activation Measure – Hearing Care (PAM-HC; Hibbard, Mahoney, Stockard, & Tusler, 2005) is designed to assess parent hearing aid management on behalf of their child with each item on the 9-item self-report measure rated on a 4-point scale (0 = strongly disagree; 1 =

disagree; 2 = agree; 3 = strongly agree; see Supplementary document 2). Higher scores on the PAM-HC denote higher parent participation in hearing aid management for their child. The PAM used in the current study is a modified version (i.e., including items closely relating to hearing aid management) of the 13-item Parent-PAM (Pennarola et al., 2012) and original 13-item PAM (Hibbard et al., 2005), which is designated to test patient knowledge, skill, and confidence for self-management. The PAM is a well validated measure (Hibbard et al., 2005; Moljord et al., 2015) and the Parent-PAM has successfully been utilized to assess parent self-management on behalf of their child in other studies (Pennarola et al., 2012; Thomas et al., 2017). Reliability for PAM in this sample was reasonably high (Cronbach's alpha = 0.76).

Number of hours reported is a self-reported single item designed to track number of hours the child uses their hearing aids per day. Two separate questions were asked to participants depending on how they responded to a question regarding the participant's audiologist sharing data logging data with the participant. If the participant responded, "not yet" they were presented with "how many hours per day do you think your child typically uses the hearing aids?" If the participant responded "yes," they were presented with "how many hours of use were recorded for the most recent data logging result?"

Hearing Management Knowledge measures level of understanding. Specifically, the 15-item self-reported questionnaire assessed the level of understanding parents have as to why each hearing aid related item is important (e.g., "clean earwax out of my child's earmolds"). The current study utilized a modified version that was in a previous study (Muñoz et al., 2016) and used a rating scale (1 = very poor; 2 = poor; 3 = fair; 4 = good; 5 = very good). The instrument was modified to explore extent of parent understanding rather than information and training parents received. A total score is calculated from the sum of all items with higher scores indicating greater knowledge of hearing aid importance. Reliability in this sample was very high (Cronbach's alpha = 0.94).

Parent Perceptions – is a 17-item self-reported measure designed to assess extent of agreement. The first eight items (“Scale 1”) measured parent perceptions (e.g., “My child needs to use the hearing aids”) using a 6-point scale (1 = strongly disagree; 2 = disagree; 3 = somewhat disagree; 4 = somewhat agree; 5 = agree; 6 = strongly agree) with higher scores signifying greater parent perceptions in hearing aid benefits and hearing aid use for their child. Reliability for “Scale 1” in this sample was acceptable ($\alpha = 0.71$). The remaining nine items (“Scale 2”) measured confidence (e.g., “putting the hearing aid on my child”) using a scale of 0-100. The current study utilized a modified version of the Parent Perceptions used in a previous study (Muñoz et al., 2015). Higher scores indicate greater confidence in participating in hearing aid management practices. Reliability for “Scale 2” in this sample was very high (Cronbach’s $\alpha = 0.93$).

Hearing Aid Monitoring was used to assess frequency of device monitoring (i.e., not yet; when needed; weekly, daily; other). The 6-item measure is self-reported. The current study utilized a modified version used in a previous study (Muñoz, Larsen, Nelson, Yoho, & Twohig, 2019), with higher scores indicating a greater number of hearing aid monitoring practices an individual participates in. Reliability for this measure in this sample was high (Cronbach’s $\alpha = 0.80$).

Depression Anxiety Stress Scales-21 (DASS-21; Lovibond & Lovibond, 1995) is a shortened version of the original 42-item measure designed to assess overall distress within the past week. The DASS includes three subscales: depression, anxiety, and stress. Each item of this 21-item version is rated on a 4-point scale ranging from 0 = *did not apply to me at all* through 3 = *applied to me very much, or most of the time*. Reliability for the overall measure (the combination of the stress, anxiety, and depression subscales) was high (Cronbach’s $\alpha = 0.92$).

Analysis

Linear mixed effects models were used to answer each of the research questions. This approach was selected to account for its ability to handle repeated measures design, to provide estimates of moderation effects, and to include multiple indicators simultaneously. For the first three research questions (i.e., moderation of AAQ-MCHL, parent activation, and reported hours of hearing aid use), linear mixed effect models assessed whether the effect of the intervention from pretest to posttest on the outcomes depended on any of the potential moderators. This series of models can be expressed as:

$$\begin{aligned}
 Y_{it} = & \beta_1 Treatment_i + \beta_2 Time_{it} + \beta_3 Moderator_{it} + \beta_4 Intervention_{it} \times Time_{it} \\
 & + \beta_4 Intervention_{it} \times Moderator_{it} + \beta_5 Time_{it} \times Moderator_{it} \\
 & + \beta_6 Intervention_{it} \times Moderator_{it} \times Time_{it} + \alpha_i + \epsilon_{it} \\
 & \alpha_i \sim N(\mu_i, \sigma_i^2) \\
 & \epsilon_{it} \sim N(0, \sigma^2)
 \end{aligned}$$

where Y_i is each of the outcomes (i.e., parent knowledge, monitoring, confidence, & perceptions), β_6 is the estimate of interest, and α_i is the random intercepts by participant. For instance, one of the models tested whether AAQ-MCHL moderated the effect of the intervention on parent knowledge. All moderators were treated as continuous measures in each model while time was treated as categorical to allow for non-linear change over time. Notably, although not shown in the equation, we account for AAQ-MCHL (when it is not the moderator) and DASS scores in each model.

For the final two research questions (i.e., testing for a relationship between AAQ-MCHL and the outcomes, and the relationship between parent activation and the outcomes), linear mixed effect models tested whether AAQ-MCHL and/or parent activation predicted the outcomes, regardless of its role as a moderator. The random effects structure and the use of control variables was the same for this series of models as they were for the moderation models shown previously. We also controlled for whether the individual was in the intervention condition or not.

All p-values reported are based on likelihood ratio tests of the full model with the variable or interaction of interest compared to a nested model without the variable or interaction of interest. Where significant moderation was found, graphical displays of the data are provided as well as measures of effect sizes for the simple slopes. All analyses included pre-intervention, post-intervention, and follow-up data. All analyses were completed R version 4.0.2 (R Core Team, 2020) using the *gtsummary*, *effectsize*, and *tidyverse* packages (Ben-Shachar & Lüdtke, 2020; Sjöberg et al., 2021; Wickham et al., 2019). All code and output for this study can be found at osf.io/yvn82/.

Results

Moderators

Results of the moderation analyses using linear mixed effects models are shown in Table 2 for each potential moderator and each outcome. The p-values shown are based on likelihood ratio tests of the model that specifically tests for the moderation of the specified variable on the intervention condition by time effect. Importantly, all moderators were continuous measures and were included as continuous measures in all models. For any visuals to probe the moderation, the moderators were categorized into low, mid, and high levels. These levels were at 1 standard deviation below the mean (“low”) of that moderator, at the mean (“mid”), and at 1 standard deviation above the mean (“high”). This was done to more clearly show the meaning of the moderation. Below, the results for each moderator are described.

AAQ-MCHL

The AAQ-MCHL significantly moderated the relationship between the intervention conditions and frequency of device monitoring over time, $\chi^2(5, N = 78) = 12.6, p = .028$. This moderation is shown in Figure 1a. As shown, there is very little difference between the groups over time when the participant has a low score on the AAQ-MCHL, but this changes for those participants with a high AAQ-MCHL score, that is, more psychological inflexibility. Among

parents with higher AAQ-MCHL scores, those in the intervention group showed larger increases in monitoring frequency from pre-intervention to follow-up than the TAU. This means parents in the intervention condition with a greater unwillingness to encounter their private experiences (e.g., thoughts) towards parenting their child with a hearing loss had greater increases in frequency of device monitoring over the course of the study compared to parents in the TAU condition. AAQ-MCHL did not moderate the relationship between the intervention condition and any other outcomes.

<insert figure 1 here>

<insert table 2 here>

PAM-HC

Parent activation moderated the effect of the intervention condition on parent knowledge over time, $\chi^2(5, N = 78) = 17.1, p = .009$. Figure 1b shows the meaning of the significant moderation of parent activation over time between the conditions and parent knowledge. Participants who reported lower parent activation scores at baseline tended to have larger increases in parent knowledge over time within the intervention condition compared to the TAU. That is, parents who reported less participation in self-management in relation to their child's hearing aids benefited greater by gaining more knowledge in the intervention condition compared to the TAU. Activation did not moderate the relationship between any other outcomes.

Parent Reported Hours of Hearing Aid Use

Parent reported hours of hearing aid use had a moderating effect for two outcomes—parent knowledge, $\chi^2(5, N = 78) = 15.1, p = .013$, and monitoring, $\chi^2(5, N = 78) = 23.8, p < .001$. Figure 1c demonstrates the moderation of parent reported hours of hearing aid use on the difference between the conditions on parent knowledge over time. Parents with lower hours of child hearing aid use at baseline had larger increases in parent knowledge scores in the intervention condition compared to the TAU condition. For higher hours of reported child hearing

aid use, the change over time is nearly identical between both conditions, although the intervention condition is on average higher regardless of timepoint. Figure 1d shows the moderation of parent reported hours of hearing aid use on the effect of the conditions on monitoring. Similar to parent knowledge, the intervention provided the most benefit from pre-intervention to follow-up for monitoring among parents with low reported hours. Specifically, parents in the intervention condition with lower hours of child hearing aid use at baseline had greater increases in frequency of device monitoring compared to the parents in the TAU condition. For high reported hours, there is very little difference between the conditions.

Predictors

AAQ-MCHL

Linear mixed effects models suggested scores on AAQ-MCHL were associated with four (i.e., parent knowledge, monitoring, perceptions, and confidence) of the outcome measures. AAQ-MCHL was negatively associated with parent knowledge ($\beta = -.35, p < .001$), negatively associated with monitoring ($\beta = -.09, p = .03$), and negatively associated with both perceptions scale 1 ($\beta = -.17, p < .001$) and perceptions scale 2 ($\beta = -5.38, p < .01$). That is, as AAQ-MCHL score reduces (i.e., less psychological inflexibility), there is an associated increase in each of these four outcome measures.

PAM-HC

Results further indicated parent activation had a positive relationship with parent knowledge ($\beta = .53, p < .01$) and monitoring ($\beta = .14, p = .049$). That is, parents who reported higher scores on the PAM-HC were more likely to score higher on the Hearing Management Knowledge and Hearing Aid Monitoring measures. Parent activation did not have a significant association with any other outcome.

Discussion

The current study tested moderation effects of the psychological inflexibility, parent activation, and parent reported hours of hearing aid use on parent knowledge, frequency of device monitoring, perceptions, and confidence. These variables (i.e., psychological inflexibility, parent activation, and parent reported hours of hearing aid use) were also tested for any possible predictive power on the same treatment outcomes. Data were extracted from a study testing a 6-week eHealth intervention among parents with children who are DHH and use at least one hearing aid where participants were randomized into an intervention condition and TAU or TAU only (results from the primary study can be found at Muñoz et al., 2021). Results revealed that psychological inflexibility, low parent activation, and low hours of hearing aid use moderated device monitoring frequency and knowledge; parents who received the intervention improved over time compared to the TAU only group. In addition, predictors were found for treatment outcomes for psychological flexibility (i.e., knowledge, monitoring, perceptions, confidence) and parent activation (i.e., knowledge, monitoring). To date, no previous studies have investigated parent hearing aid related variables as perspective moderators and predictors for an eHealth parent education and support program. These findings raise important considerations for clinical practice.

Early identification and amplification for permanent hearing loss is critical for spoken language development and later academic success. Parents are essential partners in this process; however, they often experience challenges in navigating their role. Audiologists have a commitment to educate and support parents, although there is limited evidence-based information on how to effectively help parents overcome barriers with hearing aid management. The current analysis revealed that psychological inflexibility, parent activation, and hours of hearing aid use are important indicators in the change process for parent learning in an eHealth program.

Parents who had more psychological inflexibility (i.e., a higher score on the AAQ-MCHL), related to not accepting their internal discomfort (e.g., thoughts) for managing their child's

hearing loss, at baseline and received the intervention had an increase in the frequency of hearing aid monitoring practices at follow up compared to parents in TAU only. Monitoring device function is a critical component of hearing aid management as hearing aids require maintenance (e.g., cleaning earmolds) and can malfunction for various reasons (e.g., dead battery, moisture). Furthermore, the findings found psychological inflexibility to predict the outcomes measured (i.e., knowledge, monitoring, perceptions, confidence) and showed that as scores for parents decreased (less inflexibility) on the AAQ-MCHL outcomes improved over time, suggesting the importance of identifying parents with higher scores (more inflexibility) to help audiologists better determine when additional or different support is needed. Mediation and moderation analysis have highlighted psychological inflexibility as one of the components involved in the process of psychological change during interventions (Hayes, Levin, Plumb-Villardaga, Villatte, & Pistorello, 2013). Yet, with research being limited among people with chronic conditions there is little empirical evidence to suggest psychological inflexibility has the same impact when it comes to health-related outcomes. One study among parents of children with acquired brain injury found psychological inflexibility as a mediating variable between treatment allocation and two parent outcomes (dysfunctional parenting styles and parent stress; Brown, Whittingham, & Sofronoff, 2015). Data from this study extends on the important role psychological inflexibility plays in health-related outcomes.

Similarly, and highly evident, is the replication of emotional avoidance producing poor outcomes seen in psychopathology (Chawla & Ostafin, 2007). In theory, actively avoiding internal experiences (e.g., thoughts) can perpetuate maladaptive behaviors. For example, if a parent has uncomfortable thoughts or emotions related to their child's hearing aids, avoiding these emotions by not dealing with hearing aids helps minimize those negative emotions but actively harms the child's development. Learning from previous studies linking avoidance to psychopathology may offer insights to possibly providing similar treatment options (e.g.,

acceptance and commitment therapy) for parents of children who are DHH and are struggling with psychological inflexibility interfering with hearing aid use and management.

Parent activation as a moderator was only significant in relation to the parent knowledge outcome measure. Also, parent activation as a predicting variable was significant in relation to the parent knowledge and hearing aid monitoring outcome measures. This could be primarily due to the fact that the PAM-HC (i.e., parent activation) takes into account parent knowledge on hearing aid self-management on behalf of their child. While the Hearing Management Knowledge extends into level of understanding for different aspects of hearing aid management and the Hearing Aid Monitoring assesses frequency of device monitoring, they still both require knowledge of hearing aids overall. Regardless, parent activation offers significance to improve health outcomes (i.e., parent knowledge) over time, which is comparably seen in another longitudinal studies of individuals with (Greene, Hibbard, Sacks, Overton, & Parrotta, 2015) and without chronic diseases (Harvey, Fowles, Xi, & Terry, 2012).

Reported hours of hearing aid use by the parents had moderating effects between conditions and two treatment outcomes: parent knowledge and monitoring. A closer look at this shows only lower reported hours of hearing aid use at baseline among parents in the treatment condition created potential for parents to learn about the importance and necessity of hearing aids for the child that the eHealth intervention provided. There was little difference between conditions among parents that reported high hours of hearing aid use. A higher number of hours at baseline most likely created a ceiling effect. While the primary analysis from the randomized controlled trial of this data was collected from Muñoz and colleagues (2021), the study did not observe significant differences between the groups post-intervention. The more detailed evaluation from this analysis shows the impact from the eHealth intervention for parents who reported low hours of hearing aid use. Parent reported hours of hearing aid use did not have any significance when it came to predicting any treatment outcome variables.

There were limitations presented by these moderation and predictive analyses. First, it is a relatively small sample size (intervention: 37; TAU: 41) which may have affected power to detect some marginal findings. Second, while the PAM-HC and Hearing Management Knowledge have some overlap – in regard to the construct – making it difficult to distinguish specific differences among these measures. Third, the measure of hearing aid use relied on parent report rather than hearing aid data logging. Parent report has been found to be variable and over-estimate hours of use compared to data logging (Walker et al., 2013), the reduced accuracy of this approach may have obscured hearing aid use differences. Fourth, there was no exclusion criteria regarding additional disabilities. While the demographics did capture these additional characteristics from the children in the sample, we do not know the impact this could have had on the treatment outcomes. Finally, during the process of the study the world entered into a pandemic with COVID-19. Since there were no measures to account for fear of COVID-19 or any other related measures to COVID-19, it is difficult to determine the impact the pandemic played on the intervention. Notably, there were a few participants that reported frustrations with an inability to visit their audiologist due to the shutdown. Future research is needed to better understand other important intervention variables that may influence outcomes, such as dosage, delivery, and content to optimally support parents in achieving daily hearing aid management routines that are effective and sustainable.

The current study sought to find significant moderators and predictors in an eHealth parent hearing aid management program (Muñoz et al., 2021). Overall, our results support the moderation effects of parent psychological inflexibility and parent activation on frequency of device monitoring and parent knowledge, respectively. In addition, the path between treatment conditions and parent knowledge and frequency of device monitoring were moderated by parent reported hours of hearing aid use. Parent psychological inflexibility predicted parent knowledge, device monitoring, and parent perceptions, while parent activation predicted parent knowledge. Parent psychological inflexibility is a variable audiologists may consider assessing in addition to

teaching parents new skills and monitoring how many hours children are using their hearing aids, as they educate and support parents in developing effective hearing aid routines.

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Table 1. Demographics of the sample.

Demographic Characteristics	Overall Sample (N = 78)	Randomized Groups	
		Intervention (N = 37)	TAU (N = 41)
Child age in month, median (IQR)	14 (8, 25)	12 (6, 24)	18 (8,25)
Child gender - female, % (n)	42 (33)	38 (14)	46 (19)
Hearing loss laterality, % (n)			
Bilateral	89 (69)	81 (30)	95 (39)
Hearing loss degree, % (n)			
Mild	21 (16)	14 (5)	27 (11)
Moderate	54 (42)	57 (21)	51 (21)
Severe	15 (12)	19 (7)	12 (5)
Profound	10 (8)	11 (4)	10 (4)
Additional disabilities - yes, % (n)	32 (25)	30 (11)	34 (14)
Child race, % (n)			
White	77 (60)	76 (28)	78 (32)
Latinx/Hispanic	9 (7)	5 (2)	12 (5)
Multiracial	7 (6)	11 (4)	5 (2)
Black	3 (2)	3 (1)	2 (1)
Asian	1 (1)	0 (0)	2 (1)
Native American*	1 (1)	3 (1)	0 (0)
Prefer not to answer	1 (1)	3 (1)	0 (0)
Relationship to child, % (n)			
Mother	94 (73)	89 (33)	98 (40)
Caregiver race, % (n)			
White	82 (64)	78 (29)	85 (35)
Latinx/Hispanic	7 (6)	5 (2)	10 (4)
Multiracial	3 (2)	5 (2)	0 (0)
Black	3 (2)	3 (1)	2 (1)
Asian	3 (2)	3 (1)	2 (1)
Native American*	1 (1)	3 (1)	0 (0)
Prefer not to answer	1 (1)	3 (1)	0 (0)
Caregiver education, % (n)			
College education/Graduate degree	82 (64)	81 (30)	83 (34)
High school graduate/Partial college (at least one year)	18 (14)	19 (7)	17 (7)
Family annual income, % (n)			
More than \$80,000	49 (38)	49 (18)	49 (20)
\$41,000 to \$80,000	31 (24)	27 (10)	34 (14)
Less than \$40,000	13 (10)	19 (7)	7 (3)
Prefer not to answer	8 (6)	5 (2)	10 (4)

Note: TAU = Treatment as Usual. *includes American Indian, Alaskan Native, Indigenous

Table 2. Results of the linear mixed effects modeling testing for moderation of the effect of the intervention on each listed outcome using likelihood ratio tests.

	Chi-Square	df	P-Value
Moderator: AAQ-MCHL			
Outcome: Knowledge	4.643	5	.461
Outcome: Monitoring	12.55	5	.028
Outcome: Parent Perceptions (Scale 1)	8.743	5	.120
Outcome: Parent Perceptions (Scale 2)	3.628	5	.604
Moderator: Parent Activation			
Outcome: Knowledge	15.34	5	.009
Outcome: Monitoring	1.901	5	.863
Outcome: Parent Perceptions (Scale 1)	7.899	5	.162
Outcome: Parent Perceptions (Scale 2)	7.202	5	.206
Moderator: Parent Reported Hours of Hearing Aid Use			
Outcome: Knowledge	14.49	5	.013
Outcome: Monitoring	23.78	5	<.001
Outcome: Parent Perceptions (Scale 1)	2.791	5	.732
Outcome: Parent Perceptions (Scale 2)	9.499	5	.091

Table 3. Results of the linear mixed effects modeling testing whether AAQ-MCHL and Parent Activation predict outcomes over time on each listed outcome using likelihood ratio tests.

	Knowledge	Monitoring	Parent Perceptions (Scale 1)	Parent Perceptions (Scale 2)
(Intercept)	49.20***	11.35***	42.16***	578.92***
AAQ-MCHL	-0.35***	-0.09*	-0.17***	-5.38**
Parent Activation	0.53**	0.14*	0.02	4.38
Time (Reference = Pre)				
Post	4.46***	1.62***	1.39**	87.81***
Follow Up	3.98***	2.00***	0.82	88.01***
Group (Reference = TAU)				
Intervention	5.22***	-0.08	0.77	45.95
DASS	0.01	0	0.03	1.09
AIC	1617.7	1220.12	1230.83	2898.94
BIC	1645.21	1247.62	1258.34	2926.45
Number of Observations	230	230	230	230
Number of Participants	78	78	78	78
Variance of Random Intercept	37.36	2.83	9.48	8910.86
Residual Variance	39.9	8.37	6.25	13124.41

Note: *** p < .001, ** p < .01, * p < .05

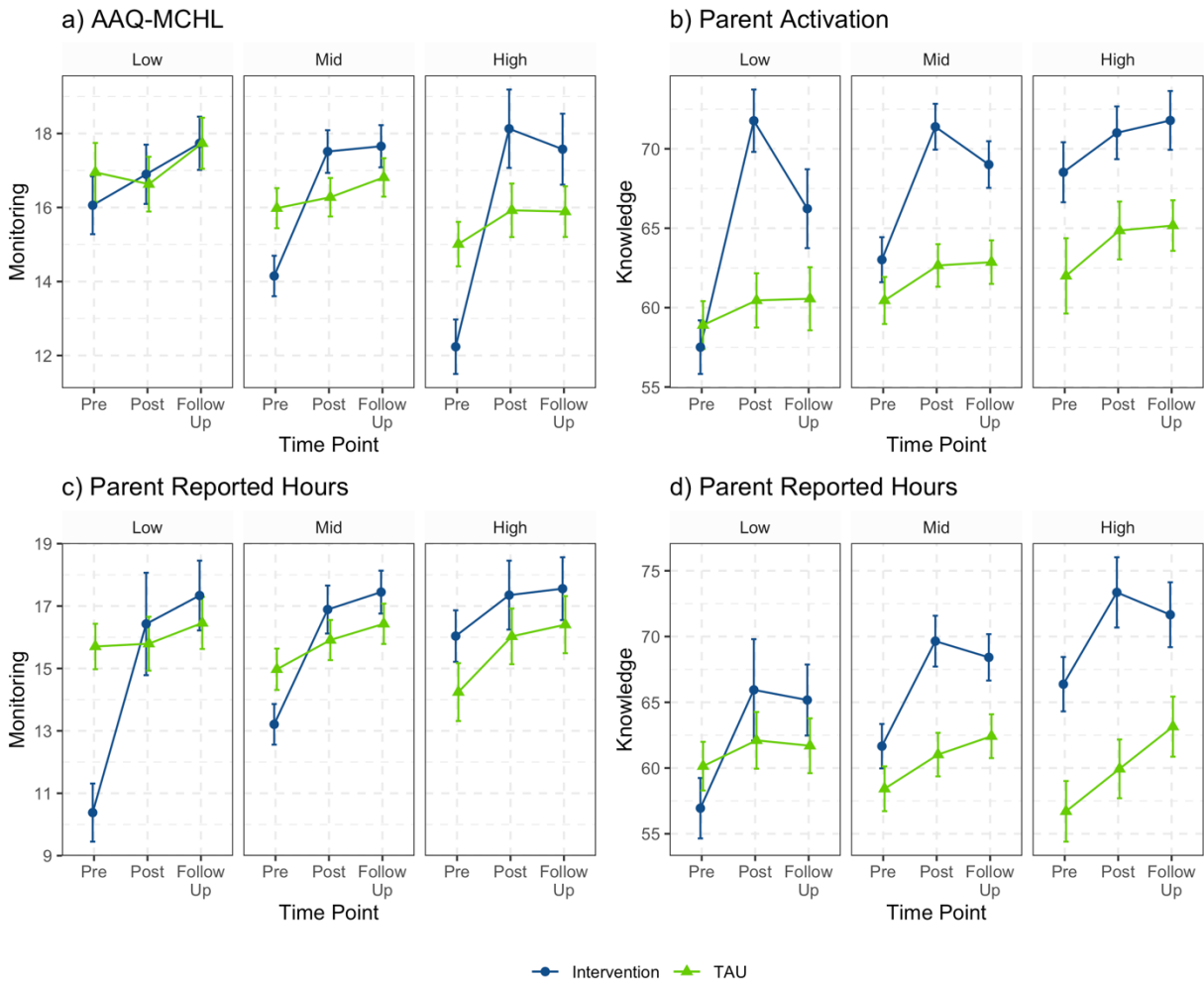


Figure 1. Each significant moderation is shown, highlighting the estimated means of each outcome (monitoring and knowledge) for three moderators: AAQ-MCHL (a), Activation (b), and Parent Reported Hours of Hearing Aid Use (c) and (d). Low, mid, and high levels of the moderators were at 1 standard deviation below the mean (“low”), at the mean (“mid”), and at 1 standard deviation above the mean (“high”). Error bars show +/- 1 standard error of the mean.