

## Research Article

# Effects of Grade and School Services on Children's Responsibility for Hearing Aid Care

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**Purpose:** We investigated trends in hearing aid maintenance and assumption of responsibility for hearing aids in school-age children who are hard of hearing. Specifically, we examined the extent to which families own necessary hearing aid maintenance equipment, whether and by whom hearing aid maintenance tasks are being completed, and the effects of grade and receipt of an Individualized Education Program (IEP) or 504 plan on a child's assumption of responsibility for hearing aid care.

**Method:** Participants included 167 children who are hard of hearing in 1st to 4th grade. Caregivers reported whether the families owned various types of hearing aid maintenance equipment (listening tube, battery tester, and dri-aid kit) and who normally completes various hearing aid maintenance tasks. Information about children's audiological characteristics was also collected.

**Results:** Thirty-two percent of families reported not owning at least 1 piece of hearing aid maintenance equipment.

Using a battery tester and performing a listening check were the maintenance tasks completed the least frequently, with 49% and 28% of caregivers reporting that these tasks are not completed regularly, respectively. Children's responsibility for hearing aid maintenance increased with grade. After controlling for maternal education and degree of hearing loss, children with an IEP or 504 plan took more responsibility for hearing aid maintenance tasks than children without these services.

**Conclusion:** Important hearing aid maintenance tasks, such as listening checks, are not completed regularly for many children, even when families own the necessary equipment. Ensuring that children who are hard of hearing have an IEP or 504 plan throughout elementary school may support self-advocacy and encourage children to take responsibility for their hearing aids, which may lead to more consistent hearing aid functioning.

With the advent of universal newborn hearing screening (UNHS) in the United States, children with mild to severe hearing loss are fit with hearing aids and receive early intervention at a young age, which leads to better functional outcomes than prior to the implementation of UNHS (Sininger, Grimes, & Christensen, 2010; Yoshinaga-Itano, Sedey, Wiggin, & Chung, 2017). Although outcomes for children who are hard of hearing are more optimistic than prior to UNHS,

early intervention is not enough: Successful language development and academic functioning for these children require consistent use of hearing aids that provide optimal audibility (Tomblin et al., 2015; Walker et al., 2015). A potential barrier to receiving optimal audibility through amplification on a daily basis is device malfunction. Monitoring tasks such as listening checks and battery tests can reduce the amount of time until a device malfunction is addressed, and prevention tasks such as regularly cleaning the hearing aids and using a dri-aid kit reduce the occurrence of malfunctions (Langan & Blair, 2000). Increased caregiver competence and confidence with hands-on device monitoring and troubleshooting relate to caregiver reports of increased hearing aid use (Desjardin, 2003). However, it is unclear how children's responsibility for hearing aid maintenance tasks changes as children get older and expectations for independence increase. It is possible that increased hearing aid use is associated with high child responsibility for hearing aid maintenance, as it is with caregiver responsibility. In this study, we investigated whether families of

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children who are hard of hearing own necessary hearing aid maintenance equipment, as well as whether maintenance tasks are completed regularly by these children or the adults in their lives. Another goal of this study addressed the effect of educational support services on the extent to which school-age children take responsibility for their hearing aids.

The first step in consistent hearing aid maintenance is to own the proper equipment, such as a hearing aid listening tube, a battery tester, and a dri-aid kit. A listening tube allows any individual to listen to the output of a hearing aid, a battery tester indicates whether a battery is charged or dead, and a dri-aid kit pulls the moisture out of hearing aids. Elfenbein (1994) found that, out of 15 families of infants and toddlers with hearing aids, nine (60%) and 10 (67%) owned a battery tester and a listening tube, respectively. Only 33% of families owned dri-aid kits, which was viewed as concerning, given their important role in removing moisture from hearing aids during the humid summers of the midwestern United States, where Elfenbein conducted her study. Most of the families without monitoring equipment reported that professionals never recommended purchasing the items. More recently, Blair and Blair (2007/2008) and Muñoz et al. (2016) examined ownership of maintenance equipment in parents of infants and toddlers with hearing aids. Their findings were more optimistic than those of Elfenbein, with Blair and Blair finding that 97%, 94%, and 71% owned a battery tester, a listening tube, and a dri-aid kit, respectively. In Muñoz et al., 78% and 79% of parents reported receiving a battery tester and a listening tube from the audiologist. Thus, it appears that families of young children with hearing aids are more likely to own monitoring equipment than in years past, but it remains unknown if these equipment ownership trends hold true for older, school-age children. Furthermore, a family may receive maintenance equipment at the initial hearing aid fitting appointment shortly after the child's diagnosis of hearing loss but cease to use it once the child can self-report or if another adult is believed to have responsibility for the tasks, such as in a school setting. Thus, it is important to examine not only equipment ownership but also long-term usage of such equipment throughout elementary school.

The Educational Audiology Association (EAA) recommends daily inspection of children's amplification to ensure optimal audibility and device function (EAA, 1997). Unfortunately, caregivers and teachers continue to be inconsistent in monitoring children's hearing aids. In a study of infants and toddlers with hearing aids, Blair and Blair (2007/2008) found that, although 30 out of 31 families reported checking the child's hearing aids at least once a week, less than half (45%) conducted the recommended daily listening check. Of those families, only 21% used both a listening tube and a battery tester daily. Muñoz et al. (2015) similarly found that only one third of parents of infants and toddlers with hearing aids completed daily listening checks, even though 66% of parents received training from audiologists about how to do so. Furthermore, hearing

aid monitoring practices appear to become even less frequent as children get older, though it has been over 30 years since this topic was examined in school-age children. Elfenbein, Bentler, Davis, and Niebuhr (1988) found that only 61% of elementary school students and 30% of junior and senior high school students received at least weekly hearing aid monitoring at school. Together, these findings suggest that many children are wearing hearing aids that have not been monitored by an adult for days, which increases the possibility of unnoticed malfunctions limiting the child's access to sound.

If caregivers and other adults are inconsistently monitoring children's hearing aids, it becomes especially important for children to take responsibility for performing monitoring and maintenance tasks for their own hearing aids. For several decades, researchers have recommended that children, as age appropriate, take a central role in the maintenance of their hearing aids (Elfenbein et al., 1988; Lipscomb, Von Almen, & Blair, 1992; Maxon & Smaldino, 1991). Langan and Blair (2000) noted that, even if caregivers actively perform maintenance tasks on the hearing aids at home, the hearing aids may still malfunction once the child is at school. It remains important for children to take active responsibility for their hearing aids so that appropriate maintenance can be performed as soon as a malfunction occurs. Additionally, it is important to develop the knowledge and skills needed for hearing aid maintenance in elementary school so that these practices can easily be applied by the time children reach middle school. Once middle school begins, children rotate between many teachers throughout the day, so older children may not have consistent access to an adult who is knowledgeable about hearing aid maintenance. If children can troubleshoot hearing aid problems themselves, they will likely have more consistent access to spoken instruction in the classroom than children who rely on a caregiver or teacher for hearing aid maintenance. Programs that encourage children to take responsibility for hearing aid care lead to more consistent use of functioning hearing aids following the intervention (Lipscomb et al., 1992; Most, 2002). Thus, encouraging children to self-advocate by taking responsibility for hearing aid maintenance tasks from an early age may help to fortify against inconsistent hearing aid use in both early and later grades.

Many children with hearing loss are eligible for special services in school, which may help promote responsibility for device maintenance. One such service is an Individualized Education Program (IEP). An IEP is a written legal document that provides a plan for individualized special instruction and related services through Part B of the Individuals with Disabilities Act. IEPs are intended for students with disabilities that impede access to free and appropriate public education. Hearing loss may constitute such a disability if it has an educationally significant impact on a child's academic and social functioning (Smith, 1990). Some states have additionally implemented the Expanded Core Curriculum for Students Who are Deaf or Hard of Hearing (Iowa Department of Education, 2019;

Johnson et al., 2014), which allows IEP services to focus on intervention that is specific to the needs of children with hearing loss. With the Expanded Core Curriculum, IEP goals can include areas such as amplification management and self-advocacy, in addition to more traditional academic goals.

Another service available to children with hearing loss is a 504 plan, which provides for classroom accommodations for children with disabilities through Section 504 of the Rehabilitation Act of 1973. While an IEP provides special services outside the regular classroom, a 504 plan makes accommodations within the regular education setting. These accommodations are meant to improve access to instruction and can include provisions such as preferential seating, a note taker, and, sometimes, hearing assistive technology systems. An IEP and 504 plan are similar in that they both recognize the potential negative impact of hearing loss on academic functioning, as well as the important role of consistent auditory access in mediating detrimental effects of hearing loss on learning. It is possible that children with hearing loss who have an IEP or 504 plan take greater responsibility for hearing aid monitoring and care than children without such services because they are made aware of the impact of hearing loss on classroom functioning. Some children also receive explicit instruction on hearing aid care, directly supporting self-advocacy. Currently, it is unknown whether children who receive academic support through an IEP or 504 plan demonstrate greater responsibility for hearing aid maintenance tasks than children without such support.

In summary, it is clear that regular hearing aid maintenance is essential for consistent auditory access through hearing aids for children who are hard of hearing, but the extent to which school-age children take responsibility for the maintenance of their own hearing aids as they age remains unknown. Additionally, it is unknown if academic support services bolster children's ability to take responsibility for their hearing aids. In this article, we address the following questions related to hearing aid maintenance and responsibility in school-age children: (a) Do families of school-age children who are hard of hearing own the necessary hearing aid maintenance equipment? (b) Are hearing aid maintenance tasks being conducted to ensure consistent device functioning? and (c) What are the effects of grade and receipt of an IEP or 504 plan on the extent to which children take responsibility for their hearing aids?

## Method

### *Participants*

Participants included 167 first to fourth graders who are hard of hearing and use hearing aids. Seventy-six children had data available from multiple (two or three) time points, resulting in data for 56 children in first grade, 104 children in second grade, 49 children in third grade, and 71 children in fourth grade. For children with data from multiple time points, data from only one time point

were used in analyses. For all children, the first available time point was used unless the child was assigned via a random number generator to use either the second or third time point, to preserve relatively equal numbers of children that had hearing aid responsibility data across each grade. This left data for 42 first graders, 46 second graders, 39 third graders, and 40 fourth graders that were used in final analyses. Eight children (seven second graders and one fourth grader) were missing data about who completes hearing aid maintenance tasks, so data from these children were only used when summarizing trends in maintenance equipment ownership and/or IEP/504 plan status.

All children participated in the longitudinal, multi-center Outcomes of School-Age Children who are Hard of Hearing and Complex Listening studies and had permanent bilateral hearing loss ranging from mild to severe. Seven children used unilateral behind-the-ear hearing aids, four children used bone conduction hearing aids, and one child used Bilateral Contralateral Routing of Signal hearing aids. All other children ( $n = 155$ ) used bilateral behind-the-ear or receiver-in-the-canal hearing aids. None of the children had additional disabilities known to affect academic performance, and all children spoke English as a first language. Demographic information about participants is available in Table 1. Years of maternal education, age at confirmation of hearing loss, and age at hearing aid fitting were determined by caregiver report. Better-ear pure-tone average (BEPTA) was calculated as the mean of the audiometric thresholds at 0.5, 1, 2, and 4 kHz in the better hearing ear. Average amount of daily hearing aid use was measured with data logging, and aided audibility (i.e., the amount of access to the speech signal the child has through a hearing aid) was measured using real-ear probe microphone measures and quantified with the aided speech intelligibility index (American National Standards Institute, 1997).

Data for most of the participants were collected during the summer following first, second, third, or fourth grade. This study was approved by the institutional review boards of the University of Iowa, Boys Town National Research Hospital, and University of North Carolina-Chapel Hill. All participants provided informed consent.

### *Hearing Aid Responsibility Questionnaire*

A parent or guardian of each child completed the "OSACHH Hearing Aid and FM Checklist" (n.d.), which contains items related to hearing aid maintenance. The questionnaire asked who normally performs the following tasks related to hearing aid care and maintenance: (a) uses a battery tester, (b) performs a listening check on hearing aids, (c) cleans earmolds of wax, (d) places hearing aids in a protective case, (e) uses a dri-aid kit, and (f) discovers hearing aid malfunction (e.g., distorted sound, cutting in and out, or weak sound). Caregivers reported whether each task is usually completed by the child, child or parent, parent, or the school, or the task is not done regularly. Only one response was allowed for each question. Responses to

**Table 1.** Demographic information about study participants by grade.

Variable	Grade 1	Grade 2	Grade 3	Grade 4
Age in years	7.52 (0.43)	8.60 (0.40)	9.39 (.045)	10.37 (0.31)
Proportion: female	.43	.46	.49	.50
Recruitment site as a proportion				
Boys Town	.64	.35	.62	.30
University of Iowa	.36	.13	.38	.30
University of North Carolina	.00 <sup>a</sup>	.52	.00 <sup>a</sup>	.40
Maternal education in years	15.4 (2.44)	15.4 (2.71)	15.3 (2.28)	15.5 (2.77)
Age of hearing loss confirmed in months	9.44 (17.9)	18.1 (21.3)	17.1 (20.9)	21.1 (22.0)
Age at HA fitting in months	12.7 (20.1)	20.4 (21.8)	21.0 (21.0)	28.3 (23.5)
Better-ear PTA in dB HL	47.0 (16.6)	47.3 (12.7)	47.3 (15.0)	47.4 (16.2)
Data-logged HA use in average hours per day	9.41 (4.46)	9.82 (4.08)	9.29 (3.68)	10.0 (4.47)
Better-ear aided SII	76.7 (15.3)	80.1 (11.0)	76.8 (14.7)	79.0 (14.1)

Note. Values reported as mean (standard deviation), unless otherwise specified. HA = hearing aid; PTA = pure-tone average; SII = speech intelligibility index.

<sup>a</sup>The University of North Carolina did not participate in the Complex Listening study, which included data collection at first and third grades.

each question were assigned a score of 2 if the child usually performs the task, 1 if the child or parent performs the task, and 0 for any other response (the parent usually performs the task, the school usually performs the task, or the task is not performed regularly). The child responsibility score reflects the degree to which the child takes part in caring for the hearing aids, with a score of 0 indicating no responsibility and 12 indicating complete independence.

Caregivers also reported if the family owns a battery tester, a listening tube, and a dri-aid kit. If the family did not own a battery tester or dri-aid kit, the corresponding question(s) was/were removed from consideration when calculating responsibility scores. In other words, if the family did not own a dri-aid kit, the maximum responsibility score would be 10 instead of 12 for that child. Because a listening check can be completed without the use of a listening tube (e.g., holding the hearing aid up to the ear to listen to it), the maximum responsibility score was not changed if the family did not own a listening tube. Note that, although caregivers reported who cleans wax from the child's earmolds, they were not asked to report whether they owned a wire loop cleaning tool, which is often provided to patients as a method of wax removal. Although caregiver report of whether families owned a wax cleaning tool would have been informative, it was assumed that with or without this specific tool, all families had the capability of removing wax from earmolds (e.g., by washing the earmolds with soap or using a tool such as a toothbrush or toothpick). The question about who cleans wax from the earmolds was removed for children with a bone conduction hearing aid, if the caregiver did not provide a response or indicated that this task was not done regularly. One caregiver of a child with a bone conduction hearing aid indicated that the parent or child usually cleans the earmolds; this response was included in the analyses, as it is possible the caregiver was referring to cleaning the hearing aid and/or softband. Responsibility scores were converted into proportion values by dividing the raw responsibility score by

the maximum responsibility score. This scoring system prevented a family's lack of equipment from negatively affecting the responsibility score.

### *IEP and 504 Plan Status*

IEP and 504 plan status was determined by caregiver report. Caregivers reported if their child had an IEP, a 504 plan, or neither. Responses were available for 32 of the first graders, 34 of the second graders, 27 of the third graders, and 38 of the fourth graders. The percentage of children with an IEP or 504 plan was 84.4% for first graders, 82.4% for second graders, 81.5% for third graders, and 81.6% for fourth graders. Table 2 shows the separate proportions of children with IEPs and 504 plans, according to grade.

### *Statistical Analyses*

Questions 1 and 2 (caregiver responses regarding equipment ownership and performance of maintenance tasks) were addressed visually by plotting them on bar graphs. Question 3 was addressed quantitatively using an analysis of covariance (ANCOVA) model, which measured the effect of grade and IEP or 504 plan receipt on responsibility score while controlling for the covariates BEPTA and maternal education. BEPTA was included as a covariate because children with more hearing loss are more likely to receive special services in school than children with milder hearing loss (Page et al., 2018). Maternal education was included as a covariate because it was expected that higher maternal education would be associated with higher child hearing aid responsibility, possibly due to increased self-advocacy support from the caregiver. Although this expected association between maternal education and child hearing aid responsibility is speculative and variance in maternal education was low in this sample, we retained maternal education as a covariate to be conservative in our



**Table 2.** Individualized Education Program (IEP) and 504 plan receipt and responsibility score by grade.

Measure	Grade 1	Grade 2	Grade 3	Grade 4
<i>n</i>	32	34	27	38
Proportion with IEP	.78	.74	.74	.71
Proportion with 504 plan	.06	.09	.07	.11
Proportion without IEP or 504 plan	.16	.18	.19	.18
Responsibility score: children with IEP or 504 plan ( <i>M</i> [ <i>SD</i> ])	.46 (.22)	.42 (.20)	.51 (.20)	.56 (.21)
Responsibility score: children with no IEP or 504 plan ( <i>M</i> [ <i>SD</i> ])	.17 (.12)	.36 (.12)	.40 (.18)	.38 (.14)

analyses. Removing maternal education as a covariate did not change the pattern of results.

## Results

### Ownership of Hearing Aid Maintenance Equipment

The proportions of families that reported owning a listening tube, a battery tester, and a dri-aid kit are shown in Figure 1, plotted alongside the equipment ownership reported in previous studies. In this study, each item was owned by over 80% of families (listening tube = 81%, battery tester = 82%, dri-aid kit = 86%), and 68% of families reported owning all three of these items.

### Performance of Hearing Aid Maintenance Tasks

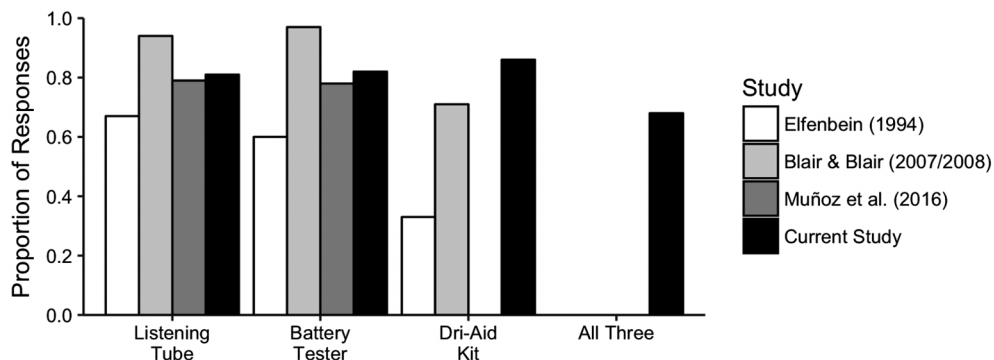
Figure 2 shows which individuals are typically responsible for completing each maintenance task, as well as the proportion of children for whom each task is not completed regularly. At all grades, using a battery tester was the maintenance task that was completed by the fewest respondents, with 41%–57% of caregivers reporting that this task was not performed regularly by anyone (far right columns in Figure 2). Performing listening checks and using a dri-aid kit were the next least performed tasks, with 21%–31% and 21%–26%, respectively, of caregivers reporting that the task is not performed regularly. In third grade, 26% of caregivers reported that putting hearing aids in a case was not done regularly; otherwise, at every grade, the

tasks of cleaning earmolds, putting hearing aids in a case, and discovering hearing aid malfunction were reported as being completed by someone for at least 80% of children whose caregivers responded to the survey.

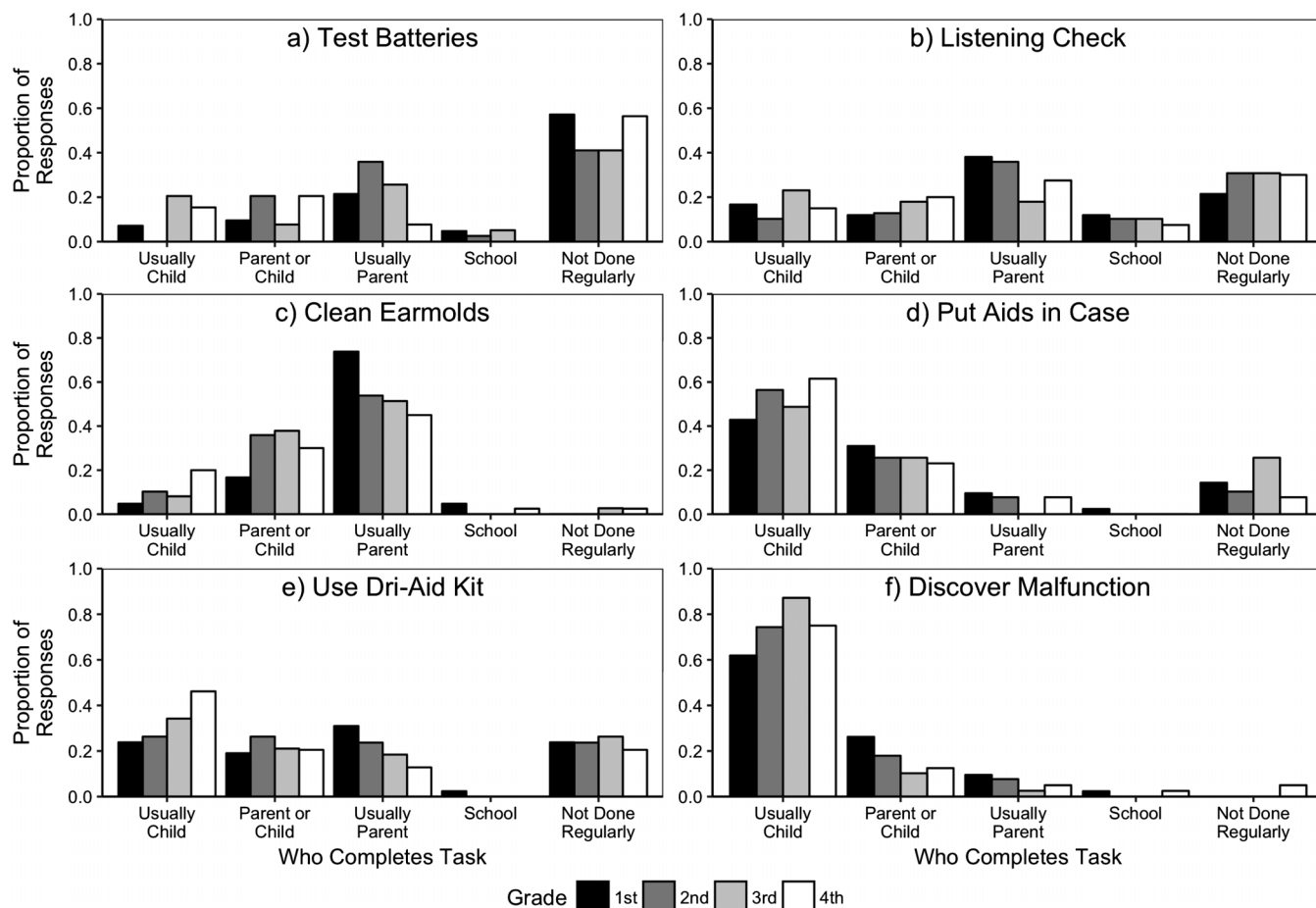
### Child Hearing Aid Responsibility by Grade and IEP/504 Plan Receipt

Child hearing aid responsibility scores are shown by grade in Figure 3 and by grade and IEP/504 plan status in Figure 4. An ANCOVA was used to identify the effect of grade and receipt of an IEP or 504 plan on child hearing aid responsibility scores, while controlling for maternal education and BEPTA. The interaction effect between grade and IEP/504 plan status was also examined to determine if the association between service receipt and hearing aid responsibility changes as children progress through elementary school. Levene’s test of equality of error variances was conducted, and assumptions were met. First, the main effect of grade on child hearing aid responsibility was significant,  $F(3, 114) = 2.77, p = .045$ , partial  $\eta^2 = .068$ . This indicates that, while controlling for maternal education and BEPTA, child hearing aid responsibility increases as a function of grade. Second, the effect of IEP/504 plan receipt on child hearing aid responsibility was significant,  $F(1, 114) = 10.33, p = .002$ , partial  $\eta^2 = .083$ . This indicates that, while controlling for maternal education and BEPTA, child hearing aid responsibility is higher for children with an IEP or 504 plan than children without an IEP or 504 plan.

**Figure 1.** Proportion of families who own hearing aid maintenance equipment, as reported in prior studies and the current study. “All Three” indicates that the family owns a listening tube, a battery tester, and a dri-aid kit. Note that, in all but the current study, participants included only families of infants and toddlers.



**Figure 2.** Individuals who usually (a) use a battery tester, (b) perform listening checks, (c) clean earmolds, (d) put hearing aids in the case, (e) use a dri-aid kit, and (f) discover malfunctions, according to grade. The proportions of caregivers reporting that these tasks are not done regularly are also displayed. The number of responses per grade varies per question:  $n = 42$  in first grade,  $n = 38$ – $39$  in second grade,  $n = 37$ – $39$  in third grade, and  $n = 39$ – $40$  in fourth grade.



Note, however, that the main effects of both grade and IEP/504 plan receipt on child hearing aid responsibility are small. Finally, the interaction between grade and IEP/504 plan status in the ANCOVA was not significant ( $p = .338$ ), indicating that the effect of IEP or 504 plan receipt did not vary according to grade. When maternal education is removed as a covariate in the model, all effects remain essentially the same, though the  $p$  value for the main effect of grade increases slightly, from .045 to .052.

## Discussion

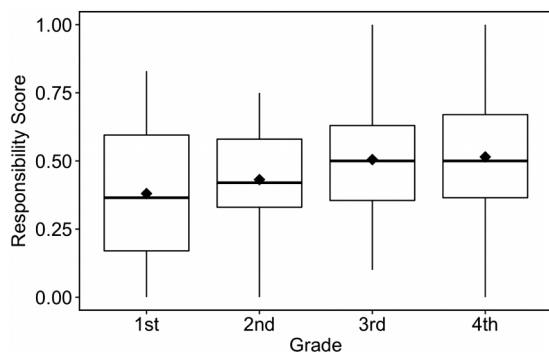
In this study, we investigated the following questions: (a) Do families of school-age children who are hard of hearing own the necessary hearing aid maintenance equipment? (b) Are hearing aid maintenance tasks being conducted to ensure consistent device functioning? and (c) What are the effects of grade and receipt of an IEP or 504 plan on the extent to which children take responsibility for their hearing aids? To our knowledge, this is the first study to

examine the first two questions in a sample of elementary school children who are hard of hearing and the first study to examine the third question in any children who are hard of hearing. This study offers novel contributions to the literature because it illuminates the current status of hearing aid maintenance practices for school-age children who are hard of hearing. The study suggests a positive effect of grade and receipt of an IEP or 504 plan on child hearing aid responsibility.

## Ownership of Hearing Aid Maintenance Equipment

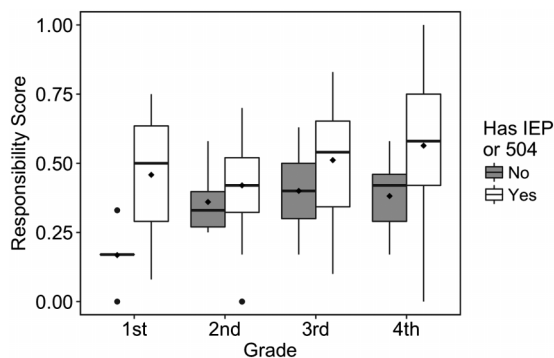
Although most families reported owning all necessary hearing aid maintenance equipment (i.e., listening tube, battery tester, and dri-aid kit), 32% lacked at least one of these items. As shown in Figure 1, the 81% of families who owned a listening tube in this study is higher than the 67% of families with a listening tube reported by Elfenbein (1994), similar to Muñoz et al.'s (2016) finding of 79%, and lower than Blair and Blair's (2007/2008) report of 94%. A similar

**Figure 3.** Hearing aid responsibility scores by grade. Dark horizontal bars indicate median values, and diamonds indicate mean values. Boxes represent the 25th–75th percentiles (interquartile range), and whiskers extend to the smallest and largest values.



pattern appears for battery tester ownership, which was 82% in this study: Elfenbein, Muñoz, and Blair and Blair, respectively, found that 60%, 78%, and 97% of families owned a battery tester. It is possible that the higher equipment ownership found in this study relative to Elfenbein is due to increased awareness among clinicians and caregivers over the last two decades regarding the importance of owning maintenance equipment. Equipment ownership is also made easier because maintenance equipment is often included from manufacturers in pediatric hearing aid fitting kits, which may not have been the case in the early 1990s. In this sense, the values found in this study should be viewed as progressive, relative to past findings. On the other hand, ownership percentages in this study are lower relative to Blair and Blair's findings. This discrepancy may be because Blair and Blair surveyed parents of children under the age of 3 years. As children get older, families may be less likely to own maintenance equipment due to loss of equipment or

**Figure 4.** Individualized Education Program (IEP)/504 plan status and hearing aid responsibility scores by grade. Dark horizontal bars indicate median values, and diamonds indicate mean values. Boxes represent the 25th–75th percentiles (interquartile range), and whiskers extend to the smallest and largest values that are  $\pm 1.5 \times$  the interquartile range. Filled circles represent outliers. Note that, for first graders without an IEP or 504 plan, three of the five children had the same responsibility score (.17).



reduced perception of need for equipment. It should also be noted that the 86% of families with a dri-aid kit in this study is higher than the 71% reported by Blair and Blair. This trend may reflect the increased physical activity levels of school-age children relative to infants and toddlers, which would heighten the importance of removing moisture in the hearing aids due to sweat (though approximately 10% of the children in this study who owned dri-aid kits did not use them regularly). Note, however, that direct comparisons with some previous studies should be interpreted cautiously, due to the relatively small sample sizes of these studies ( $N = 15$  for Elfenbein and  $N = 31$  for Blair and Blair).

Despite the relatively high overall equipment ownership observed in this study, nearly one third of the families surveyed did not own all recommended maintenance equipment. Nine caregivers (5%) reported owning none of the recommended equipment. These results suggest that audiologists should ensure that families of school-age children with hearing aids continue to have access to such equipment. Audiologists can do this by making these items available through the clinic or providing the family with information about other ways of obtaining maintenance equipment. Even if the child has worn hearing aids since infancy, the audiologist should not assume that the family owns all of the necessary maintenance items because items can get lost or worn out over time.

### Performance of Hearing Aid Maintenance Tasks

Most maintenance tasks, including cleaning earmolds, putting hearing aids in their case, using a dri-aid kit, and discovering hearing aid malfunction, were reportedly completed by someone for the vast majority of the children in this study. However, listening checks and battery tests were not completed regularly for 28% and 49% of children, respectively. These results suggest that many children are not receiving the services advocated for by the EAA (1997), whose guidelines recommend daily listening checks of all children's hearing aids. In light of previous studies of hearing aid maintenance, however, the present results are unsurprising. Elfenbein et al. (1988) found that 61% of 248 school-age children received at least weekly hearing aid monitoring. In infants and toddlers, Blair and Blair (2007/2008) found that only 45% of families performed daily listening checks; of those 45% of families, 21% used both a listening tube and a battery tester on a daily basis. Similarly, Muñoz et al. (2015) found that one third of 37 families of infants and toddlers performed daily listening checks. Although participant ages and assessment methods differed between this study and previous ones, it is clear that, on the whole, the hearing aids of many children from infancy to school age do not receive adequate maintenance at home or school. Because listening tubes and battery testers were each owned by over 80% of families in this study, it is apparent that lack of equipment ownership cannot fully explain the fact that these items are not used regularly by many families. Regular hearing aid maintenance can significantly reduce the rate of malfunctioning hearing aids in school-age children

(Langan & Blair, 2000). It is essential that hearing aid maintenance tasks be performed regularly to ensure that children have consistent access to learning opportunities in and outside the classroom. Furthermore, families typically pay for hearing aids out of pocket because most insurance companies do not cover the cost of hearing aids. It is therefore in the best interest of the families to keep the hearing aids in good working order to prolong the life span of the devices.

The results demonstrate that many families of school-age children might not understand the importance of performing regular maintenance tasks, such as listening checks. Even though most of the children in this study had many years of hearing aid experience, audiologists and other professionals should not assume that these years of experience translate directly into families realizing best practices. Professionals should therefore continue to emphasize to families the importance of regular hearing aid maintenance. This discussion should not take place exclusively at the initial hearing aid fitting, but rather throughout childhood. In a survey of audiologists working with children up to 5 years of age, Meibos et al. (2016) measured how many audiologists provide information about hearing aid maintenance to parents of children with hearing aids. Over 90% of the 349 audiologists surveyed regularly taught parents how to use a listening tube, clean earmolds, and change batteries, but less than half (48%) taught parents how to perform a Ling 6 listening test. Furthermore, Muñoz et al. (2016) found that parents of children with hearing aids desired more training on how to use a listening tube (18%), perform a Ling 6 listening check (26%), and perform hearing aid maintenance (40%). Combined with the results of the current study, it is apparent that some audiologists do not equip caregivers or service providers with all pieces of information that will help to maximize consistent hearing aid functioning, both at the initial hearing aid fitting and as the child gets older. If the caregivers are receiving inadequate training on hearing aid management, it is unlikely that the children themselves are receiving direct, thorough information about using maintenance equipment from their audiologists. Without this information, children may be limited in their ability to share in the responsibility for such maintenance.

An additional interpretation of the results of the current study and those of Muñoz et al. (2016) is that caregivers may receive appropriate information about hearing aid maintenance from the audiologist, but they forget much of the information after the appointment. Following medical appointments, patients forget 60%–85% of what is told to them (J. L. Anderson, Dodman, Kopelman, & Fleming, 1979; McGuire, 1996). A way to address this issue is for professionals such as speech-language pathologists (SLPs), itinerant teachers, and early interventionists to reiterate information about hearing aid maintenance and monitoring to caregivers in between audiology appointments. For this interprofessional collaboration to be implemented effectively, the audiologist should ensure that the other relevant professionals are knowledgeable and competent with regard to performing hearing aid maintenance

tasks. In turn, other professionals should be comfortable reaching out to the audiologist when additional information or training is needed.

### ***Hearing Aid Responsibility Throughout Elementary School***

School-age children are capable of taking responsibility for their hearing aids, and this responsibility for hearing aids increases as a function of grade. This result is encouraging because it suggests that children become increasingly active participants in the care of their hearing aids as they get older, which may lead to both more consistent use and more frequently functioning hearing aids. As early as 1988, Elfenbein suggested that, if children take responsibility for their own hearing aid maintenance, they will be more likely to have consistent access to appropriate amplification. More recent studies have shown that, when children are explicitly encouraged to take responsibility for hearing aid maintenance tasks, they are more likely to use functioning hearing aids than before they were encouraged to do so (Lipscomb et al., 1992; Most, 2002). Findings from this study also suggest that, in many cases, hearing aid maintenance tasks may not be performed if the child is not primarily responsible for their completion. For the tasks of testing batteries, putting hearing aids in the case, and using the dri-aid kit, if the child was not involved, it was more likely that the task was not regularly completed than it was that the task was usually completed by an adult (i.e., a parent or the school). Averaged across grades, the proportion of caregivers reporting a task was usually completed by an adult versus not regularly completed was .26 versus .49 for testing batteries, .07 versus .14 for putting hearing aids in the case, and .22 versus .24 for using the dri-aid kit, respectively. The apparently low involvement of school personnel in completing hearing aid maintenance may be in part because many SLPs who serve children with hearing loss are not comfortable managing hearing aids and other hearing assistive technology, and many SLPs do not have access to educational audiologists (Page et al., 2018; Richburg & Knickelbein, 2011). Ultimately, it is the responsibility of school personnel to be knowledgeable of which maintenance tasks should be completed and ensure that these tasks are done regularly. However, it is also important that children learn to manage their own equipment because it is not guaranteed that a knowledgeable adult will complete the maintenance for them.

Although overall the children in this study took substantial responsibility for their hearing aid maintenance, children varied considerably in the extent of responsibility for hearing aids. In all four grades, some children performed zero or very few maintenance tasks and some children performed all or nearly all of the six maintenance tasks (see Figure 3). From the present results, it is unclear why some children show minimal involvement with hearing aid maintenance, even in fourth grade. It is possible that some of the observed differences in responsibility for hearing aids stem from differences in self-advocacy. Self-advocacy is a broad



concept that includes several dimensions of knowledge and skills that are essential for individuals with disabilities to live an independent life. Test, Fowler, Wood, Brewer, and Eddy (2005) describe several interrelated components of self-advocacy, including knowledge of self and communication. Knowledge of self is a foundational aspect of self-advocacy and involves knowledge of one's own support and accommodation needs, as well as characteristics of one's own disability. For children who are hard of hearing, understanding the importance of consistent hearing aid functioning, including the maintenance tasks that are necessary to ensure consistent functioning, is an essential aspect of self-advocacy. According to Test et al., knowledge of self supports development of the communication aspect of self-advocacy, which includes assertiveness, problem solving, and use of assistive technology. For children who are hard of hearing, these skills may manifest as assertiveness in taking responsibility for hearing aid maintenance and problem solving to determine which troubleshooting tasks are necessary to improve hearing aid function. Responsibility for hearing aid maintenance and monitoring tasks is thus an important component of self-advocacy for school-age children who are hard of hearing.

It is possible that some caregivers, teachers, SLPs, and audiologists do not explicitly encourage children to be active participants in their hearing aid care. It has been recommended that children should regularly monitor, maintain, and troubleshoot their own hearing aid equipment by the time they reach late elementary and middle school (Iowa Department of Education, 2019). To reach this goal, children should become involved in performing hearing aid maintenance tasks prior to the end of elementary school. A team including the child, caregivers, audiologist, classroom teacher, SLP, and itinerant teacher should collaborate to determine specific goals regarding the extent to which the child will be responsible for hearing aid maintenance; this type of collaborative approach has seen many advocates over the years (Johnson et al., 2014; Maxon & Smaldino, 1991; Meibos et al., 2016; Muñoz, Preston, & Hicken, 2014; Pratt, 1999). These individuals should maintain open communication regarding the specific tasks the child is expected to perform and the timeline over which the child is expected to develop independence in these tasks. In this way, both the child and the involved adults will have a clear understanding of how the child's responsibility for hearing aid maintenance and monitoring tasks should develop over time. This collaborative approach is especially important in light of recent findings from Gustafson, Ricketts, and Tharpe (2017), suggesting that caregivers and teachers often disagree regarding a child's ability to manage his or her own hearing aids. Because the audiologist's job is ultimately to ensure that the child has consistent and optimal auditory access, the audiologist should regularly discuss with children and their parents who is primarily responsible for each maintenance task at home, school, and other environments. If it is discovered that the child is receiving little support at school for hearing aid maintenance tasks, the audiologist may emphasize the

importance of the child self-advocating at school by taking responsibility for such tasks at an earlier age.

Because children can vary substantially in terms of needs and abilities, the optimal time frame for shifting responsibility from adults to the child will likely differ based on the individual. Further research is necessary to examine when children should take responsibility for various hearing aid maintenance tasks, as well as what this transition of responsibility should look like. For example, daily listening checks by adults may be necessary for young children, but as the child gets older, listening checks by adults that are less frequent and prompted by the child's perception of a malfunction may be more appropriate. Regardless of how the responsibility shift looks for individual children, the transition should not be a random or unsupported process. Instead, the shift should be implemented purposefully through the collaborative efforts of the relevant clinicians, educators, and caregivers. The child should also be included in every step of the planning process so that the child has a clear understanding of what is expected of him or her. Implementation of an IEP or 504 plan is one way to facilitate this collaborative approach.

### ***IEP/504 Plan Service Receipt and Hearing Aid Responsibility***

After controlling for maternal education and BEPTA, children with either an IEP or 504 plan demonstrated higher hearing aid responsibility scores than children who did not receive such services. This is the first study to show a positive effect of business-as-usual special education services on responsibility for hearing aids in children who are hard of hearing. There was not a significant interaction between IEP/504 plan receipt and grade, suggesting that the positive effect of an IEP or 504 plan remains consistent throughout elementary school.

Multiple factors might underlie the connection between IEP/504 plan receipt and hearing aid responsibility in school-age children. Some children in this study may have received direct instruction from an itinerant teacher, SLP, or audiologist regarding responsibility for hearing aids as part of their IEP services. A preliminary review of the educational records of the children in this study indicates that several of the children had self-advocacy goals written into their IEPs, which can include amplification management. Because information about specific IEP goals were available only for a limited number of children, we did not have enough statistical power to examine the effect of self-advocacy IEP goals on hearing aid responsibility scores in school-age children. Although an examination of specific IEP goals in children who are hard of hearing is outside the scope of the current study, this area warrants further investigation.

Even for children who do not have self-advocacy goals in their IEPs, improved self-advocacy skills may help to explain the association between IEP/504 plan receipt and hearing aid responsibility scores. By school age, children with an IEP or 504 plan likely understand that they

receive special services or accommodations because having a hearing loss puts them at risk for missing out on spoken instruction and discussion in the classroom. Being generally aware of the potential negative ramifications of hearing loss on academic achievement may improve the child's understanding of the important role of hearing aids in improving access to spoken language. Developing a deeper understanding of the importance of consistent hearing aid use may increase the child's sense of ownership of the hearing aids, thus motivating the child to take more responsibility for regular care of the devices.

### Limitations

The approach used in this study to measure performance of hearing aid maintenance and monitoring tasks had several limitations. The primary limitation was the reliance on caregiver report to obtain information. It is possible that caregivers are unaware of the frequency with which various maintenance tasks are completed by teachers or other professionals at school. In this study, caregivers reported that schools had a minimal role in the performance of maintenance tasks. The maintenance task with the highest school involvement was performing listening checks, and still only 10% of all caregivers reported that the school is primarily responsible for this task. Note that this number may be limited because caregivers were only allowed to choose one response for each task. For example, they could not report that listening checks are usually completed by both parents and school personnel. More complete information could be obtained if teachers, including itinerant teachers, reported their performance of regular hearing aid maintenance tasks. Collecting information directly from the children would also provide an important perspective on the frequency that tasks are completed by the child and the school, which may or may not agree with caregiver report.

Additionally, it is unclear how listening checks are being performed from the information obtained through this study. Several caregivers who did not own a listening tube reported that they completed listening checks. It is possible that these caregivers use an alternate method to perform a listening check, such as holding the hearing aid up to the listener's ear. Although methods such as these can confirm that the hearing aid is amplifying sound, they provide limited information regarding possible hearing aid weakness or changes in sound quality.

Another study limitation was the way that hearing aid responsibility was quantified. Responsibility scores were calculated based on the performance of four to six maintenance tasks, depending on which pieces of maintenance equipment the family owned. Other activities may be relevant when considering responsibility for hearing devices, such as changing batteries, putting hearing aids in and taking them out of the child's ears, and managing hearing assistive technology.

A final limitation of this study is that information was not collected regarding the frequency with which each maintenance task was performed. For example, 28% of

caregivers reported that listening checks are not performed regularly, but the term *regularly* was not defined in the questionnaire (see Appendix). Because the questions about performance of hearing aid maintenance tasks asked *who* usually completes the tasks, caregivers may have been biased against selecting the "not done regularly" option, even if the task was completed relatively infrequently. It is therefore possible that the current results represent an underestimation of the proportion of maintenance tasks that are not completed on a daily, or even weekly, basis.

### Future Directions

Based on the increase in hearing aid responsibility scores from first to fourth grade observed in this study, we expect that children will continue to become more responsible for hearing aid care throughout their later school years. According to the EAA (1997), the functioning of children's hearing aids should be monitored daily. Furthermore, it has been recommended that most children should monitor and maintain their own hearing aids by the time they reach late elementary to middle school (e.g., K. Anderson, 2011; Johnson & Spangler, 2013). However, it is not clear how children should transition from partial responsibility in fourth grade to complete responsibility in middle school.

Additionally, future studies should examine the association between responsibility for hearing aids in elementary school and concurrent amount of hearing aid use and use in later years, such as during middle school. From fifth to seventh grade, children who are hard of hearing, especially those with mild hearing loss, are at an increased risk of becoming inconsistent users or nonusers of their hearing aids (Gustafson, Davis, Hornsby, & Bess, 2015). It is possible that children who show early self-advocacy and acceptance of their hearing aids through increased responsibility for maintenance tasks are more likely to continue with consistent device use as they progress into middle school, when adults are less likely to regularly ensure that the child's hearing aids are functioning appropriately and being worn. Further research on older children with hearing aids is needed, however, to fully understand the effects of other factors, such as social pressures, on hearing aid use throughout adolescence.

One finding of this study that invites further investigation is that approximately half of caregivers reported that a battery tester is used for the child's hearing aids. Dead batteries are a leading cause of hearing aid malfunction (Langan & Blair, 2000), and Blair and Blair (2007/2008) recommended that parents of infants and toddlers use a battery tester daily. However, battery testers may not be as essential with today's technology as in previous years. Muñoz et al. (2016) found that only 9% of parents of children with hearing aids desired further information about when to change hearing aid batteries. Many current hearing aids can be programmed to provide a warning tone or message to the user when the battery needs to be replaced. Hearing aids can also produce blinking lights that indicate when a battery is running low. Children and adults might

rely on these warnings to determine when a battery should be changed, rather than relying on a battery tester. Additionally, it is possible that, by the time children reach school age, caregivers, teachers, and children are aware of the typical battery life span and thus do not need to complete daily battery tests. Future research should investigate the cues and tools that elementary school children, caregivers, and teachers use to know when to change hearing aid batteries. This information would help guide audiologists regarding the extent to which they should encourage the use of battery testers or other tools to ensure consistent battery functioning.

Furthermore, the association between IEP/504 plan receipt and hearing aid responsibility warrants further investigation. Currently, it is unclear why exactly service receipt is related to responsibility for hearing aid care, though self-advocacy as a mediating variable offers a reasonable explanation. Examining degree of hearing aid responsibility as a function of the extent to which the child's IEP/504 plan focuses on responsibility and self-advocacy would help to clarify the link between IEP/504 plan receipt and responsibility for hearing aids. Investigating the effects of frequency of service receipt and involvement of specific professionals (e.g., audiologist, itinerant teacher, or SLP) on responsibility for hearing aids would also help to effectively utilize school resources to increase child responsibility. Similarly, understanding the role of caregivers in modeling and encouraging self-advocacy would help clarify how responsibility for hearing aids can be promoted in the home from a young age.

Finally, the results of this study invite further exploration regarding the optimal time course by which children should take over responsibility for their hearing aids, as well as the particular role audiologists should play in facilitating this shift in responsibility. Our results indicate that children tend to take increasing responsibility for hearing aid maintenance as they get older. However, because the data are descriptive, they do not suggest at what age children should begin to take responsibility or over what time frame children should transition toward independence. Further research should also examine how audiologists can and should be more inclusive of the child while providing instructive counseling regarding hearing aid maintenance during clinical appointments.

## Conclusion

Although most families own hearing aid maintenance equipment, listening checks and battery tests are not completed regularly for 28% and 49% of children, respectively. While substantial individual variability exists, many children take responsibility for the maintenance of their hearing aids, and this responsibility increases progressively from first to fourth grade. Caregivers and school personnel often do not complete all necessary maintenance tasks, so it is important that children learn to take responsibility for their own hearing aid maintenance to ensure consistent device functioning. Children who receive IEP or 504 plan services

show higher hearing aid responsibility than children who do not receive these services. Audiologists and other professionals should encourage children to take increasing responsibility for their hearing aids as they progress through elementary school. Services provided by IEPs and 504 plans may support child self-advocacy, thereby leading to increased responsibility for hearing aid maintenance in school-age children who are hard of hearing.

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**Appendix**Excerpt From the OSACHH Hearing Aid and FM Checklist. Available at <http://www.ochlstudy.org>

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**CARE OF THE HEARING AIDS**

22. Does your family own the following?

- Dry Aid Kit?     Yes     No  
Listening Tube?     Yes     No  
Battery Tester?     Yes     No

**We are interested in knowing at what ages students become increasingly independent in caring for their hearing devices. Please use the scale below to indicate whether you, your child or someone else (school staff or other professional) usually completes the following care/maintenance activities. Check the appropriate boxes.**

	Usually Parent	Parent or Child	Usually Child	Other (School)	Not done regularly
25. Uses battery tester	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. Performs a listening check on hearing aid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. Cleans earmolds of wax	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28. Places hearing aids in protective case	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29. Uses dry aid kit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30. Discovers hearing aid malfunction (distorted sound, cutting in and out, weak sound)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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