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Improving outcomes for children at-risk for hearing loss

Samantha Daney
University of Toledo

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Improving Outcomes for Children At-Risk for Hearing Loss

by

Samantha Daney

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the

Master of Arts Degree in

Speech Language Pathology

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An Abstract of

Improving Outcomes for Children At-Risk for Hearing Loss

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Hearing loss is the most common sensory deficit, and constitutes a public health concern globally (World Health Organization [WHO], 2013a). These two small-scale studies examine hearing loss prevention and intervention for children living in an orphanage in a developing nation and fourth grade students attending an elementary school in the United States. The growing prevalence of noise induced hearing loss (NIHL) among children is an increasingly serious and growing concern in public health due to the negative impact of untreated hearing loss on communication, social interaction, education and quality of life (ASHA, 2015b). The purpose of this thesis is to share data, explore hearing loss identification and prevention and suggest ways in which professionals can raise awareness and develop programming to support children around the world and reduce NIHL. The development and implementation of hearing conservation programs, the necessity of advocating for policy change, and improved collaboration among professionals is addressed.

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Chapter One

Hearing Status of Children in Developing Nations: A Clinical Case Study

Daney, S., Lonsway, L., & Pakulski, L.A. (2016). Hearing status of children in developing nations: A clinical case study. *eHearsay, 6(2)*, 56-62. Retrieved from http://ohioslha.org/wordpress2/?cat=13. Previously published.

Abstract

This small-scale study examines the hearing screening data of children living in an orphanage in a developing country. Through a review of the literature, it is clear that little is known about hearing and hearing loss among children in developing countries, including those who are institutionalized. Despite the limited data available, the World Health Organization (WHO) has deemed hearing loss to be a global burden with substantial social and economic ramifications (Duthey, 2013). The development and implementation of hearing conservation programs, the necessity of advocating for policy change, and improved collaboration among professionals is addressed.

Introduction

Hearing loss is the most common sensory deficit, and constitutes a public health concern globally, especially among low- and middle-income countries (WHO, 2013a). Despite the high incidence of hearing loss among developing nations, there is limited information available about hearing and hearing loss (Stevens et al., 2013). In an effort to expand the knowledge and database regarding hearing and hearing loss in developing countries and specifically among children in an orphanage, two Speech-Language Pathology (SLP) student clinicians from a Midwestern university traveled to Honduras to perform hearing screenings. The students' goals were to gather data,

investigate the hearing needs of this population, and to raise awareness among professionals in the United States and in developing countries.

The SLP student clinicians participated in a service-based mission trip coordinated by a church affiliated with the university. The trip took place over eight days and was composed of a group of 12 student volunteers. As a group, the university volunteers completed a variety of service projects that included installing two water purification systems, painting the dormitories, delivering donated items, and conducting hearing screenings. Additionally, the university volunteers interacted with the children living in the orphanage in a variety of ways. The children and the volunteers cooked and enjoyed meals together, shared language and culture, and engaged in many meaningful experiences with one another.

Over three days of the visit, the student clinicians completed hearing screenings on 70 children (3-18 years of age) living at the orphanage. Another student volunteer served as a translator to ensure that a language barrier did not hinder the screening results.

The purpose of this article is to share the data, explore hearing and listening options aimed at this group of children, and suggest ways in which other students and professionals can raise awareness and develop programming to support children in developing countries. While this study focuses specifically on children in an orphanage in Honduras, comparative information about hearing loss in Latin American countries is limited, as it is considered a low priority for national health systems (Madriz, 2000).

Background

According to the WHO (2013a, 2013b), approximately 32 million children (< 15 years of age) globally live with disabling hearing loss (DHL) of which the majority of cases are preventable or treatable. Among children, the WHO defines DHL as unilateral or bilateral hearing loss greater than 30 decibels (dB) hearing level (HL) (WHO, 2013a). Eighty-nine percent of children with DHL live in low- and middle-income countries, and approximately 2.6 million of those children live in Latin and Caribbean America alone, including Honduras (WHO, 2012). This is significant compared to the .8 million children living with DHL in high-income nations (WHO, 2012).

Although the WHO defines DHL in children as greater than 30 dB HL; unilateral, minimal and mild hearing loss (UMMHL) of 15-25 dB HL is also detrimental (Bess, Dodd-Murphy, & Parker, 1998; Kaderavek & Pakulski, 2002). However, much less is known about UMMHL because it often goes undetected. Recent research suggests that as many as 1 in 5 US adolescents aged 12 to 19 years have (unilateral) minimal or mild hearing loss (Shargorodsky, Curhan, Curhan, & Eavey, 2010). Urban minority youth are especially at-risk, and represent an under-reported and under-studied group (Henderson, Testa, & Hartnick, 2011; Mehra, Eavey, & Keamy, 2009). While little is known about children in developing countries, they are most likely at-risk as well.

While the prevalence of UMMHL is not reported in low- and middle- income countries, DHL is nearly double that of high-income nations (WHO 2015b; WHO, 2013b). The high incidence of DHL in these nations is primarily due to insufficient health care (Duthey, 2013). Limited resources in ear and hearing care, a shortage of national attention to assistance programs, few professionals in the field, poor personal hygiene, overcrowding, and a lack of access to medical interventions all contribute to the

inadequacy of healthcare available in low- and middle-income nations (Duthey, 2013). According to the WHO, "public health measures" can successfully reduce the incidence and impact of DHL (WHO, 2013a). Along with these factors, minimal and mild hearing loss, in particular, may be a direct result of the "noise-scape," or ambient noise, many children experience on a daily basis including music, playground and street noise, heating and cooling systems, and common sounds.

Although hearing loss may not be considered a priority in developing countries, it is nevertheless a serious concern for children (Yammah, Mabrouk, Ghorab, Ahmady & Abdulsalam, 2012). Hearing is critical for language learning, which impacts education, communication and social skills (ASHA, 2015). Hearing loss can cause a delay in the development of speech and language resulting in negative implications on academic learning and social development. Specifically, delays in spoken language development can limit access to communication and hinder interactions with others, which may cause feelings of isolation and loneliness (ASHA, 2015). These factors impact career choices and adversely affect quality of life outcomes (ASHA, 2015).

Investigators have also documented that even a UMMHL can place youth at risk for academic learning problems (Daud, Noor, Rahman, Sidek & Mohamad, 2010; Lieu, Tye-Murray, Karzon, & Piccirillo, 2010; Shargorodsky et al., 2010). For example, one study reported that 37% of children with unilateral, mild-moderate hearing loss failed at least one grade in school, and an additional 13% required academic assistance or resource help. This grade failure rate was ten times that of the general school population for that geographic area (Bess & Tharpe, 1986). As a result, even more children than those

defined by the WHO may be at risk for the negative academic and learning implications of unidentified and/or untreated hearing loss.

In some countries untreated hearing loss is especially significant as it can limit education options. Consequently, limited opportunities for education may negatively impact employment and the economy at the level of the individual, the local community and the country (WHO, 2013b). Individuals with disabilities, including hearing loss, have a much higher unemployment rate due to limited resources and access to services (WHO, 2013a).

Effective early identification and management of hearing loss can significantly diminish its impact (WHO, 2013a). Although the positive implications of early identification are indisputable, the Center for Disease Control (CDC) (2015) does not have data available regarding early identification in Honduras. Subsequently, limited information exists concerning the prevalence of hearing loss and consequences of early identification in low- and middle-income countries.

Concerns for Orphanages in Developing Nations

Albeit minimal, there is a growing body of research related to hearing and hearing loss among children in developing countries. Yet, studies of hearing loss among children in orphanages in developing countries are essentially nonexistent. There are, however, active mission groups that provide hearing health care and related services. Currently, the student clinicians are working with one such group to organize a follow-up trip with the orphanage in Honduras.

Methods

Subjects. Eighty children resided at the orphanage; 70 of those children served as subjects. Ten children were not screened because of scheduling issues or age (younger than 3 years). The subjects ranged in age from 3 to 18 years, and lived at the orphanage for a varying number of years, and for a multitude of reasons. Personal and medical records were limited.

Instrumentation. Two portable audiometers (Micro Audiometrics Earscan 3) were used to complete the hearing screenings. Each had been calibrated within the past three months and was found to be in good working order each day. Specifically, the student clinicians performed a visual inspection to confirm there was no sign of wear or damage on the instruments including cords and earphones. In addition, a listening check was conducted following the Martin (1997) protocol, which includes evaluating sounds delivered through the earphones in each ear at each decibel and frequency level used for the screening.

Screening Protocol. Two student clinicians, enrolled in an accredited university program, worked with a faculty advisor to develop a hearing screening protocol for children living in an orphanage in a developing country. Both students had successfully completed an introductory audiology course and were familiar with both the hearing screening and basic audiometric techniques. The faculty advisor further trained the students and observed their competency prior to the mission trip.

Children were screened at 25 dB HL, rather than the recommended 20 dB HL due to background noise that could not otherwise be controlled, for each of the recommended frequencies of 1,000 Hertz (Hz), 2,000 Hz, and 4,000 Hz. (ASHA, 1997). Through a translator, each subject was told that the student clinician was putting earphones on

his/her ears to check his/her ability to hear soft sounds, and that they would receive a small reward (i.e., sticker and chocolate) when they were finished. Subjects were then instructed to raise their hands each time they heard a soft beep, varying in pitch, in either ear. None of the children had been screened prior, thus the directions were repeated or adjusted until the subject demonstrated understanding of the expectations. A nurse was available on the campus to provide assistance, and generally oversee the screenings.

Those that failed the hearing screening on the first day were screened on another occasion to ensure accurate results. At that time, an otoscopic examination was also completed to rule out any obvious causes such as cerumen blockage; no abnormalities were noted.

It should be noted that prior to the screening, one additional female in the 11 to 18 years age group had been identified with a congenital hearing loss. She communicated using Spanish Sign Language. She was screened, as she wanted to participate and be included in the program; however, her results were not included in the analysis. She was given the same rewards as the other subjects.

Challenges to the Protocol. The student clinicians identified the most suitable screening environment available on the orphanage campus. While visual distractions were controlled, significant noise was an unavoidable concern. Due to persistent car alarms in the neighborhood and 80 children playing and working on the grounds, finding quiet space was a difficult task. The student clinicians utilized their clinical judgment to locate an environment with minimal ambient noise. As a result, the hearing screenings were conducted in several locations to meet the environmental requirements. Further, fans and air conditioning were turned off to reduce background noise. Even after

minimizing the background noise as much as possible, it was determined that a screening level of 25 dB HL was necessary to offset the noise level for each room in which screenings were conducted. This is 5 dB higher than the recommended hearing screening level for children (ASHA, 1997), but a commonly used technique to assure adequacy of the screening protocol. An additional challenge was the fact that tympanometry, common to pediatric screening protocols, was not available. However, otoscopy was completed on those who did not pass the initial screening prior to rescreening.

Results

Hearing screenings were conducted on seventy children (3 to 18 years of age) residing in an orphanage; the results (Table 1.1) were analyzed under the supervision of a licensed and certified audiologist. Sixty children passed the screening (26 females and 34 males). Of the 10 participants referred for a complete hearing evaluation because they did not pass the screening, eight were female and two were male. The eight female participants, who failed the hearing screening, ranged between 11 to 18 years of age. Of the two male participants, who failed the screening, one was in the 5 to 10 years age group, and the other in the 11 to 18 years age group.

Table 1.1 Hearing Screening Results.

Participants	Age (years)	Passed	Referred (Failed)	% Passed
	3-4	2	0	100
Females	**5-10**	8	0	100
	11-18	15	8	65.23
	3-4	6	0	100
Males	**5-10**	10	1	90
	11-18	19	1	95
Total		60	10	83.3

In this small-scale study, most males, and younger females, passed the hearing screening, which suggests hearing within the normal range. However, a high percentage of females (34.7%) 11 to 18 years of age failed the hearing screening.

Follow-up and Conclusions

An important aspect of any screening protocol and one that is challenging in a developing country is follow-up; however, further evaluations are vital for the future of these children. One of the authors is currently communicating with a nonprofit organization that donates services (including evaluations) and refurbished hearing aids to individuals in need internationally. They are planning for a future trip to evaluate and address the needs of the children that did not pass the screening. With the help from this company, the children that did not pass the initial hearing screenings will be evaluated by an audiologist to identify their needs. If a child is found to have permanent hearing loss, the organization will be able to provide the child with hearing aids. The amplification will, in turn, provide auditory access to the children with hearing loss, which can lead (with intervention) to improved outcomes in spoken language development, socialization, and academic learning (WHO, 2013a). Those audiologists will also be able to further address prevention education.

While severity or type of hearing loss could not be ascertained in this hearing screening protocol, it should be noted that these subjects, like their counterparts in middle- and high- income countries, are at-risk for both middle ear problems related to general health as well as noise induced hearing loss. In fact, it is estimated that as many as 50% of teenagers and young adults (12 to 35 years of age) in middle- and high-income countries are exposed to hazardous noise levels from personal listening devices (PLDs),

such as iPods and MP3 players, which can lead to permanent hearing loss (Shargorodsky et al., 2010; WHO, 2015a). Although much less is known about noise-related hearing loss in low- and middle-income countries, many of these subjects are also at-risk due to use of PLDs. Specifically, it was reported that the females in particular frequently complete their duties at the orphanage while listening to music with ear buds/PLDs. Considering the noise-scape of the orphanage, a higher PLD volume would likely be needed to compete with the background noise while completing daily chores.

Clinical Implications and Future Directions

The aim of this study was to begin the process of identifying children at-risk for hearing loss, or who may have potentially DHL, and to discuss the global burden of hearing loss among children in developing countries, specifically Honduras. Although it was beyond the scope of this study to include tympanometry, otoacoustic emissions, and noise level measurements, findings support the need for further study of hearing status, daily noise-scape and other risk factors, as well as the impact of unidentified and untreated hearing loss among these children. This data may be useful for the collaboration of professionals that have a concern for global hearing loss. Additionally, it has the potential to provide data for the development and implementation of hearing conservation programs in areas where the consequences of hearing loss may not be fully understood. Lastly, this study shows why it is necessary to advocate for policy change.

Limitations

The inability to perform tympanometry or otoacoustic emissions is a major limitation of the screening protocol that could be completed for this study. These tests are critical in identifying the presence of hearing loss as well as the possible causes.

Although the most commonly used protocol for hearing screenings is pure-tone hearing screenings at the frequencies of 1,000 Hz, 2,000 Hz, and 4,000 Hz (Meinke & Dice, 2007), utilizing tympanometric measures and, specifically, otoacoustic emissions may improve early identification of possible hearing loss related to middle ear dysfunction as well as noise damage (Helleman, Jansen & Dreschler, 2010; Lapsley Miller, Marshall, Heller, & Hughes, 2006).

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Chapter Two

Development of a Hearing Conservation Program for Elementary Students

Daney, S., Pakulski, L., Diehm, E., & Glassman, J. Development of a hearing conservation program for elementary students. *Rehabilitation Research, Policy and Education.* In review.

Purpose

Despite evidence supporting the positive implications of hearing conservation programs (HCPs) on hearing loss prevention among children, hearing conservation is still not taught routinely in schools for many reasons including lack of time, limited personnel and materials, and lack of public awareness (Folmer, Griest, & Martin, 2002; Hendershot, Pakulski, Thompson, Dowling, & Price, 2011; Thompson, Pakulski, Price, & Kleinfelder, 2013). To address the need for more hearing health education in schools, this exploratory case study investigates one approach to bringing a hearing conservation program (HCP) to fourth grade students and the impact of the program on students' knowledge, attitudes and behaviors.

Methods

A speech-language pathology (SLP) graduate student partnered with a local elementary school to bring a national campaign from the American Speech-Language Hearing Association (ASHA) to 56 fourth grade students. The teacher provided a 45-minute interactive HCP to students as part of the health education curriculum. Students completed a questionnaire pre-intervention, immediately post-intervention and four-weeks post-intervention to assess changes in knowledge, attitudes and behavior as a result of the program.

Results

Following the program, students' knowledge and attitudes towards noise exposure improved; however, few students reported behavioral changes related to potentially damaging noise exposure.

Conclusions

Although students did not report improvements in intended future behavior, students have the knowledge and attitudes to change their behavior when confronted with potentially damaging noise exposure. Through this study, ASHA's Listen To Your Buds national campaign is now more accessible to education personnel and students. In addition, this investigation demonstrates how partnerships with universities and elementary schools can help to address the gaps in dissemination of hearing health education.

Introduction

Since the 1980s, national health agencies and organizations have recognized the need to minimize young individuals' exposure to potentially damaging noise (ASHA, 2004; Folmer, 2008; World Health Organization [WHO], 2015b). Whether exposure to excessive noise levels is chronic or brief, it has the potential to permanently damage the sensory hair cells within the cochlea, resulting in permanent sensorineural hearing loss, termed noise induced hearing loss (NIHL) (Levey, Fligor, Ginocchi, & Kagimbi, 2012). NIHL, even when minimal, negatively impacts one's ability to understand spoken language and as a result the ability to communicate (Holmes, Olsen-Widen, Erlandsson, Carver, & White 2007) and learn (Bess & Tharpe, 1986; Kesser, Krook, & Gray, 2013; Lieu, 2004). Despite the need for hearing health to be taught to children, HCPs are still not included in the majority of schools' curriculum because of a lack of time, limited

personnel and materials, and lack of public awareness (Folmer, Griest, & Martin, 2002; Hendershot et al., 2011; Thompson et al., 2013). To address the need for more hearing health education in schools, this exploratory case study investigates one approach to delivering a national hearing health campaign to fourth grade students and the effect of the program on students' knowledge, attitudes and behaviors.

Literature Review

Need for hearing conservation. Despite the potentially detrimental impact of damaging noise exposure and the preventable nature of NIHL, there is considerable evidence that NIHL is on the rise, and becoming more prevalent among teenagers and young adults. An analysis of data from the U.S. Third National Health and Nutrition Examination Survey (NHANES-III) found that the prevalence of hearing loss among children 12-19 years of age increased from 12.5% between 1988-1994 to 19.5% between 2005-2006 (Shargorodosky, Curhan, Curhan, & Eavey, 2010). Further, results showed a rise in high frequency minimal and mild hearing loss, which is consistent with damaging noise exposure (Shargorodosky et al., 2010). Other research suggests that the prevalence of minimal and mild hearing loss among children is less than the measures reported by Shargorodosky et al. (2010) (Wake et al., 2006). Yet, it remains difficult to compare studies, as there is no consensus among researchers on the definition of slight/minimal or mild hearing loss. ASHA defines minimal/slight hearing loss as a pure tone average (PTA) between 16 decibels (dB) hearing level (HL) and 25dB HL and mild hearing loss as a PTA between 25-40dB HL (Clark, 1981). Researchers most often define hearing loss within this decibel range, yet variations in the descriptors (e.g., bilateral/unilateral) and

type (e.g., conductive/sensorineural) may contribute to the differences in the reported prevalence and impact of hearing loss among children.

In children, minimal and mild losses caused by noise are often overlooked because (a) the symptoms are not necessarily associated with hearing loss, (b) children may initially compensate for related problems, such as academic or social difficulties, and (c) initial signs vary greatly and are frequently confused with other problems, such as distractibility or inattention (Pakulski, DeVantier, Thompson, & Hendershot, 2011). States are not mandated to perform hearing screenings on students and those who are screened in schools are generally not tested beyond 9th grade (Hendershot et al., 2011). As children age, they are exposed to increasingly more dangerous noise levels during recreation activities (Serra et al., 2005). Screening older students is crucial for identifying hearing loss, especially prior to students' entry into the workforce. Due to the subtle nature of the symptoms of NIHL, children may be at a greater risk for suffering the negative social and educational consequences associated with hearing loss (Pakulski et al., 2011; Marschark, Shaver, & Lynn, 2015).

Another important consideration is that children are less apt to perceive changes in hearing ability from noise exposure, especially when the damage to the hair cells is concentrated in the high frequency region of the cochlea, and hearing in the low- and mid-frequencies remains functional. As a result, many minimal and mild losses associated with NIHL may go undetected (Hendershot et al., 2011). Due to the subtle nature of NIHL, identification may not occur until later in adulthood when the hearing loss is intensified by aging (Folmer et al., 2008; Hendershot et al., 2011; Kujawa & Liberman, 2006).

More recently, the WHO (2015a) reported that more than one billion young people worldwide could be at risk for hearing loss due to unsafe listening practices including the use of personal listening devices (PLDs) (e.g., iPod or MP3 player), and exposure to damaging noise levels at recreational venues such as nightclubs and sporting events. Specifically, studies in middle- and high-income countries analyzed by the WHO (2015a) suggest that amid young people, aged 12-35 years, almost 50% are exposed to hazardous sound levels from the use of personal listening devices and around 40% are exposed to potentially damaging noise levels at entertainment venues. Unsafe noise levels are those in which the volume of sound across time ranges in excess of 85 decibels (dB) (e.g., heavy traffic) for eight hours to 100 dB or more (e.g., riding a motorcycle) for 15 minutes or less (National Institute for Occupational Safety and Health [NIOSH], 1998). Maximum output levels of PLDs can reach up to 97-107 dB (Keppler et al., 2010) with variations in loudness occurring as a result of the type of device and headphones used. Due to the potential volume output of PLDs and the possibility of extended exposure, individuals' PLD listening habits can pose a threat to hearing.

The prevention of NIHL is of particular concern among younger individuals because it has potentially devastating consequences for physical development, mental health, and education, resulting in lifelong consequences (Daud, Noor, Rahman, Sidek, & Mohamad, 2010; Delage & Tuller, 2007; Lieu, Tye-Murray, Karzon, & Piccirillo, 2010; Shargorodsky et al., 2010; Tharpe, Sladen, Dodd-Murphy, & Boney, 2009). Specifically, unidentified and unmanaged hearing loss is associated with delays in receptive and expressive speech and language development (ASHA, 2015b). The resultant language delay or disorder may create serious educational and learning implications (ASHA,

2015b). Problems with speech and language development may also hinder social communication, sometimes resulting in isolation and low self-esteem (ASHA, 2015b). As children age, the gap between communication and academic abilities may continue to grow in comparison to same-aged peers (Delage & Tuller, 2007; Moeller et al., 2010). Delays in speech and language, which may impact psychosocial development and academic achievement, have the potential to negatively impact a child's occupational outcomes and overall quality of life (ASHA, 2015b).

Impact of minimal and mild hearing loss. Although less is known about NIHL, there is a growing body of evidence in support of the deleterious effects of minimal and mild hearing loss (MMHL) in general, which is often associated with unmanaged NIHL. MMHL has shown to negatively impact academic achievement (Bess, Dodd-Murphy, & Parker, 1998; Blair, Peterson, & Viehweg, 1985, Davis, Elfenbein, Schum, & Bentler, 1986; Marschark et al., 2015). Bess and Tharpe (1986) found that 35% of students with unilateral MMHL repeated at least one grade in school and an additional 13% of students studied required academic assistance (Bess & Tharpe, 1986). Other more recent studies have suggested similar negative effects of MMHL on education and learning (Kesser, Krook, & Gray, 2013; Lieu, 2004)

Children with mild hearing loss may also be more at-risk for speech and language delays than their typical hearing peers (Bess et al., 1998; Davis et al., 1986; McKay, Gravel, & Tharpe, 2008; Tomblin et al., 2015). Studies have reported language impairments, specifically related to deficits in phonology and morpho-syntax, among individuals with mild to moderate hearing loss (Delage & Tuller, 2007; Moeller et al., 2010). Park and Lambardino (2012) reported that deficits in phonological awareness

caused by mild sensorineural hearing loss may negatively impact literacy acquisition. Unmanaged mild hearing loss during the critical period (below 3 years of age) may also impair the development of the central nervous system causing deficits in perception and speech and language that continue beyond when access to sound is returned (Sanes, 2016).

The impact of unmanaged MMHL goes beyond speech and language development and academic success. Researchers have reported that untreated MMHL may lead to behavioral problems, and difficulties with psychosocial/social-emotional well-being (Bess et al., 1998; Davis et al., 1986; McKay et al.,2008; Yoshinaga-Itano et al., 2008) including, decreased energy levels, amplified stress levels, and problems with social support and self-esteem (Bess et al., 1998; Tharpe, 2008; ASHA, 2015b). McFadden and Pittman (2008) found that children with minimal hearing loss demonstrated more difficulty multi-tasking in noise than children with typical hearing.

Cumulative hearing damage that occurs in childhood as a result of noise may also impact hearing loss experienced in advanced age (i.e., presbycusis). Kujawa and Liberman (2006) studied noise-induced hearing loss in young mice and found exposure to damaging noise levels resulted in changes in the inner ear. The changes made the mice more susceptible to hearing loss caused by aging compared to those not exposed to damagingly loud sounds. In addition, as individuals with MMHL age, hearing loss may become more debilitating when intensified by presbycusis (Folmer, Griest, & Martin, 2002).

It is important to note that some of the deficits associated with NIHL described above are multidimensional. The irreversible damage to the sensory cells from noise

exposure is difficult to identify because diminished audibility typically occurs among the high frequency sounds (i.e., 3000-6000 Hz); however, if the damage is severe, audibility may erode at other frequencies as well. McCormick Richburg and Hill (2014) emphasize that the inability to hear some sounds (i.e., audibility issues) is only one component of MMHL in childhood. The ability to understand others' speech (i.e., speech intelligibility) is key to oral communication and may be affected by hearing loss (Konings, Van Laer, & Van Camp, 2009; McCormick Richburg & Hill, 2014), especially during childhood (McCormick Richburg & Hill, 2014). Speech intelligibility also relies upon the neuro-maturation of the child's central auditory nervous system (CANS); myelination of the CANS may not be complete until adolescence. Further, children are more susceptible to the impact of background noise, and require a more favorable signal-to-noise ratio (SNR) in comparison to adults (Fallon, Trehub, & Schneider, 2002). Children have more difficulty recognizing distorted speech caused by reverberation and other acoustic issues. Those with hearing loss will encounter greater audibility issues than their peers with typical hearing. There is also evidence that adults with a history of hearing loss may also be susceptible to SNR loss (Adams, Gordon-Hickey, Morlas, & Moore, 2012; Dubno, Dirks, & Morgan, 1984; Killion, Niquette, Gudmundsen, Revit, & Banerjee, 2004).

Research on the impact of childhood hearing loss also provides evidence that not all individuals are equally susceptible to NIHL (Konings et al., 2009; Lewis, 2014; Tharpe, 2016). Genetic and environmental factors, such as cigarette smoking, high blood pressure and diabetes, can influence an individual's susceptibility to the physiological changes that occur within the ear from exposure to harmful noise (Konings et al., 2009; Basner et al., 2014). It is unclear as to why some individuals are genetically more

vulnerable to NIHL (Konings et al., 2009; Lewis, 2014; Tharpe, 2016). As a result, prevention through education is the best way to reduce the impact of NIHL across the lifespan (WHO, 2015b).

Changing hearing behaviors. The WHO and ASHA have developed hearing conservation programs (HCPs) aimed at educating young people and encouraging safe listening practices when they participate in recreational activities, such as listening to personal audio technology, attending concerts or sporting events, or engaging in other forms of entertainment. Many of the currently available HCPs are based on the widely accepted Theory of Planned Behavior (TPB). The TPB suggests that an individual's intended behavior is determined by (a) attitude, (b) perceived control over the behavior or self-efficacy and (c) social norms; ultimately these factors determine the individual's actual behavior (Ajzen, 1991). Along these lines, numerous HCPs have effectively increased students' hearing health knowledge (Addison & Gilliver, 2012; Bennett & English, 1999; Chermak & Peters-McCarthy, 1991; Gilles & Paul, 2014; Griest, Folmer, & Martin, 2007; Keppler, Ingeborg, Sofie, & Bart, 2015; Knobel & Lima, 2014; Martin, Griest, Sobel, & Howarth 2013; Taljaard, Leishman, & Eikelboom, 2013; Weichbold & Zorowaka, 2007) and improved students' attitudes and intended behaviors related to potentially damaging noise exposure (Gilles & Paul, 2014; Griest et al., 2007; Keppler et al., 2015; Knobel & Lima, 2014; Martin et al., 2013; Taljaard et al., 2013).

Hearing conservation program protocols. ***Instructional method.*** A variety of instructional methods for implementing hearing conservation programs have been described in the literature. Martin et al. (2013) found that interactive HCPs presented in the classroom were more effective than self-directed learning programs completed online

or at museum exhibits. Programs provided in the classroom that encourage interaction among students through problem-based learning result in increased understanding and retention of material when compared to HCPs that are presented in a lecture-format (Bennett & English, 1999). In addition, multiple activities increase the effectiveness of health education campaigns (Black, Tobler, & Sciacca, 1998; Chermak, Curtis, & Sekel, 1996).

Content. Common topics in hearing education include normal and damaged ear anatomy and physiology, the impact of NIHL, damaging behaviors, symptoms of NIHL, and preventative practices. However, researchers found that specific program content should be tailored to the characteristics or activities of the participants (Martin, Sobel, Griest, Howarth, & Yongbing, 2006). Levy et al., (2012) recommended that HCPs consider how loud is too loud, so that students have the knowledge to identify potentially damaging noise levels. Education regarding listening practices should address a safe volume level and duration of exposure, along with information regarding modification of behavior.

Effective campaigns raise awareness regarding the symptoms of NIHL, such as tinnitus or temporary threshold shifts (Gilles, Van Hal, De Ridder, Wouters, & Van de Huynig, 2013; Keppler et al., 2015; Punch, Elfenbein, & James, 2011). Students often see symptoms of NIHL as normal, thus programs should address symptoms as warning signs of possible damage to hearing (Gilles et al., 2014). Including symptoms in hearing conservation programs increases awareness and encourages behavioral and attitudinal changes to protect hearing levels (Keppler et al., 2015).

Collaborative team. Parents/guardians and educators play a primary role in modifying children's behavior and fostering hearing loss prevention practices (Punch et al., 2011). Students studying and practicing hearing conservation skills will be more likely to attend to and apply the learning if they find that their guardian, teachers and/or other meaningful adults identify the issue as important as well (Martin et al., 2006). Consequently, teachers, guardians, and other school personnel should be equipped with information regarding NIHL, noise management, and protection to prevent potentially damaging noise exposure for themselves and children (Pakulski et al., 2011). Young children may have especially limited awareness of their noise exposure. Therefore, it is parents/guardians responsibility to deter them from potentially damaging noise levels. Yet, adults are not immune to the risks of NIHL themselves. According to the NIDCD (2014), 15% of American adults also have hearing loss due to noise that could have been prevented. Consequently, parents and teachers can benefit from education and training on hearing and hearing loss prevention (Thompson et al., 2013).

According to the ASHA Scope of Practice (2016), SLPs play a critical role in hearing loss education and prevention. Specifically, the ASHA Scope of Practice (2016) indicates that SLPs should advocate for the discipline and for individuals through a variety of mechanisms, including community awareness, prevention activities, and health literacy. Given their existing role on the educational team, coursework and clinical training, SLPs, along with educational audiologists, are well positioned to collaborate with teachers to develop and implement HCPs.

Target audience. Studies have shown that children should participate in HCPs prior to 14 years of age due to early construction of attitudes and beliefs that impact

behavior (Chermak & Peter-McCarthy, 1991; Gilles et al., 2013). Early exposure to HCPs may formulate negative attitudes and beliefs toward damaging noise levels resulting in the development of protective hearing behaviors at a young age (Gilles et al., 2013). A study by Griest et al. (2007) found that fourth grade students had more long-term retention of material presented in an HCP than seventh grade students who received a similar program. In addition, previous research has demonstrated positive results from hearing health education programs with elementary school students (Bennett & English, 1999; Chermak et al., 1996; Chermak & Peters-McCarthy, 1991; Griest et al., 2007; Knobel & Lima, 2014; Martin et al., 2013; Taljaard et al., 2013). A survey of U.S. college students found that most students believed that hearing loss was serious; however, 76% of students believed that hearing loss would not occur until later in life (Rawool & Colligon-Wayne, 2008). The results of this study demonstrate that young adults in college may not have a clear understanding of the effect of noise on hearing loss.

Aim of Current Study

While many nationally known organizations have developed HCPs and award winning campaigns, many children and schools do not have access to the programming, or do not have the personnel or resources to bring the programs to their hometown. Thus, the aim of this study was to investigate, and report on, the feasibility of implementing an HCP developed through a national campaign to one public school in a Midwestern city that did not previously include hearing health education as part of elementary students' curriculum.

Methodology

Participants. Approval for the study was obtained from the participating school district and the University Institutional Review Board (IRB). A fourth grade teacher and a total of 56 fourth grade students (32 males and 24 females) between nine years and eleven years of age (Mean = 9 years, 9 months; SD = 4 months) at one elementary school participated in an HCP. The school was located in a suburban, Midwestern town with a large farming community and university and a population of approximately 31,800 residents. The school had approximately 400 students of which 40.8% qualified as "economically disadvantaged" (i.e., students were eligible for the free and reduced lunch program).

A consent form explaining the details and purpose of the study and questionnaire was sent home to students' guardians one week prior to the study. Only the data from the students who returned the consent form signed by a guardian was collected for research. No identifying information (e.g., student names, date of birth) was recorded to connect the students back to the results.

Intervention. ASHA began the national Listen to Your Buds web-based public education campaign in 2006 with the goal of educating parents and children on safe listening practices related to personal listening devices (e.g., iPod or MP3 player) and other potentially damaging noise exposure (ASHA, 2014). Since 2008, the education program has been reproduced in large cities around the U.S. including Denver, CO, New York, NY, San Diego, CA, New Orleans, LA, Chicago, IL, Philadelphia, PA, Washington D.C., and Glendale, CA (ASHA, n.d.). Typically, the program is presented by paid professional musicians as a weeklong concert series for numerous public schools in the target city. In order to present the program to a local school, this researcher

obtained a copy of the Listen to Your Buds lesson plans through e-mail correspondence with the ASHA Public Relations team.

ASHA's listen to your buds lesson plans. The goals of the Listen to Your Buds lesson plans are to help students understand: (a) the importance of hearing health, (b) how loud noise, specifically music, affects hearing, and (c) how to prevent damage from dangerous noise levels (ASHA, 2013). The protocol was designed for teachers/education personnel to lead students through four simple lesson plans and discussions to learn how loud noise can damage hearing, the permanent effect of NIHL, and how to listen safely and protect hearing from damage (ASHA, 2013). The researcher developed a PowerPoint presentation based on the Listen to Your Buds lesson plans as a guide for the teacher to implement the program accurately and consistently among the three classes. The teacher delivered the program to all three classes, individually, during the students' regularly scheduled class time in one school day. The intervention was approximately 45-minutes in length. An in-depth explanation of the implemented HCP is listed in the Appendix.

Following the intervention, students were given one pair of foam earplugs along with written directions and a model for proper insertion of the earplugs. Attached to the earplugs was a handout addressed to students' guardians, which reviewed the topics that were discussed during the HCP. The handout suggested that guardians discuss the described healthy hearing behaviors with the students as a review of the information presented in class.

The HCP was included as part of the students' health curriculum. Under Ohio law, the Ohio State Board of Education is not permitted to mandate health education standards (Ohio Department of Education [ODE], 2015). Ohio law "directs schools and

districts to include health education and other related topics at various times throughout the K-12 curriculum" (ODE, 2015). The Ohio Department of Health (ODH) (2014) promotes hearing health through infant hearing programs, early intervention, annual hearing screenings in certain grades, hearing aid assistance programs, and promotion of hearing conservation programs and materials. Considering that the ODH promotes hearing health, hearing conservation practices were deemed suitable for the Ohio school health education curriculum. This is consistent with researchers recommendations that HCPs are included as part of the students' existing music, science, math and/or health curriculum (Folmer, 2008; Folmer et al., 2002).

Knowledge and experience questionnaire. The teacher administered a questionnaire to the students five days prior to the intervention, immediately following the intervention, and four weeks following the intervention to determine the impact of the intervention on the classes' knowledge, attitudes and behaviors related to potentially damaging noise exposure. The questionnaire was primarily composed of questions developed by Griest et al. (2007) to assess the implications of a similar HCP on fourth grade students. Four questions from the Youth Attitude Noise Scale (YANS), by Olsen and Erlandsson (2004), were included. The included questions evaluated the components of the Theory of Planned Behavior (i.e., knowledge, attitudes, and intended changes in behaviors) in relation to NIHL. Information regarding participants' descriptive data (e.g. age, gender, personal listening habits) was also obtained. Class-wide administration time for the questionnaire was approximately 10-12 minutes.

Students were not required to complete the questionnaire and could choose to discontinue participation at any time without consequence. The teacher provided

appropriate modifications and accommodations for students with individualized education plans (IEP) or 504 plans. In addition, the teacher deemed that all students were capable of reliably completing the questionnaire. All fourth grade students participated in the class and questionnaire; however, only those with consent were included in the data.

A measure of fidelity of implementation was utilized to determine the extent to which the intervention was delivered as designed (Horner, Rew, & Torres, 2006). The fidelity of implementation measure was composed of a checklist to identify the specific content that was covered, the time allotted, expected student behaviors, and materials needed for each lesson plan. The content included in each lesson plan was determined by the researcher as "covered" or "not covered." The time allotted, expected student behaviors and materials needed for each plan were identified as either "met" or "not met." The researcher observed the teacher deliver the HCP to all three classes and identified the above elements to assist in the maintenance of the internal validity of the study.

Results

Feasibility of implementing the listen to your buds campaign. The researcher conducted the hearing conservation program as a component of a Master's thesis project. To begin the project, the researcher contacted the principal at a local elementary school to discuss the importance of providing hearing conservation programs for students. The principal recommended a fourth grade science teacher to implement the program as part of the health curriculum. Prior to delivery of the hearing conservation program, the researcher also met with the superintendent to outline the program and discuss the importance of providing hearing conservation programs for students.

Two months prior to the HCP, the researcher provided education for the teacher about the content that would be included in the program, such as typical hearing, hearing loss, and noise damage using the *Ohio Hearing Conservation Program* resource guide from the ODH (n.d.). A copy of the Listen to Your Buds lesson plans and the resource guide were provided. The researcher developed a PowerPoint presentation based on ASHA's Listen to Your Buds lesson plans and research of other previously implemented and successful hearing conservation programs for the teacher to use as a guide during the intervention. A YouTube video, appropriate for young audiences, was included as part of the intervention to provide an overview of basic anatomy and physiology. One week prior to the intervention, the researcher and teacher met to discuss the curriculum, execution of the program, and materials. The researcher and the affiliated University provided the materials for the HCP at no cost to the school.

Qualitative analysis of questionnaire responses. Results of the questionnaires were analyzed for demographic data and qualitative responses of the group.

Students' exposure to potentially damaging noise sources. Prior to the interventions, students reported a large range of potentially damaging noise exposure within the past year. The highest reported potentially damaging noise experience was the use of headphones to listen to iPod or MP3 players (78%) followed by concert attendance (41%), gunfire (39%), attendance at a tractor pull or monster truck show (39%), set off fireworks (37%), used a gas-powered lawn mower or leaf blower (37%), rode on a jet ski, snowmobile or motorcycle (26%), went to a motor cycle or car race (20%), and played in a band (11%). Figure 1-1 illustrates male and female students' reported noise experience.

Both males and females reported headphone use as their most frequent potentially damaging noise exposure within the last year.

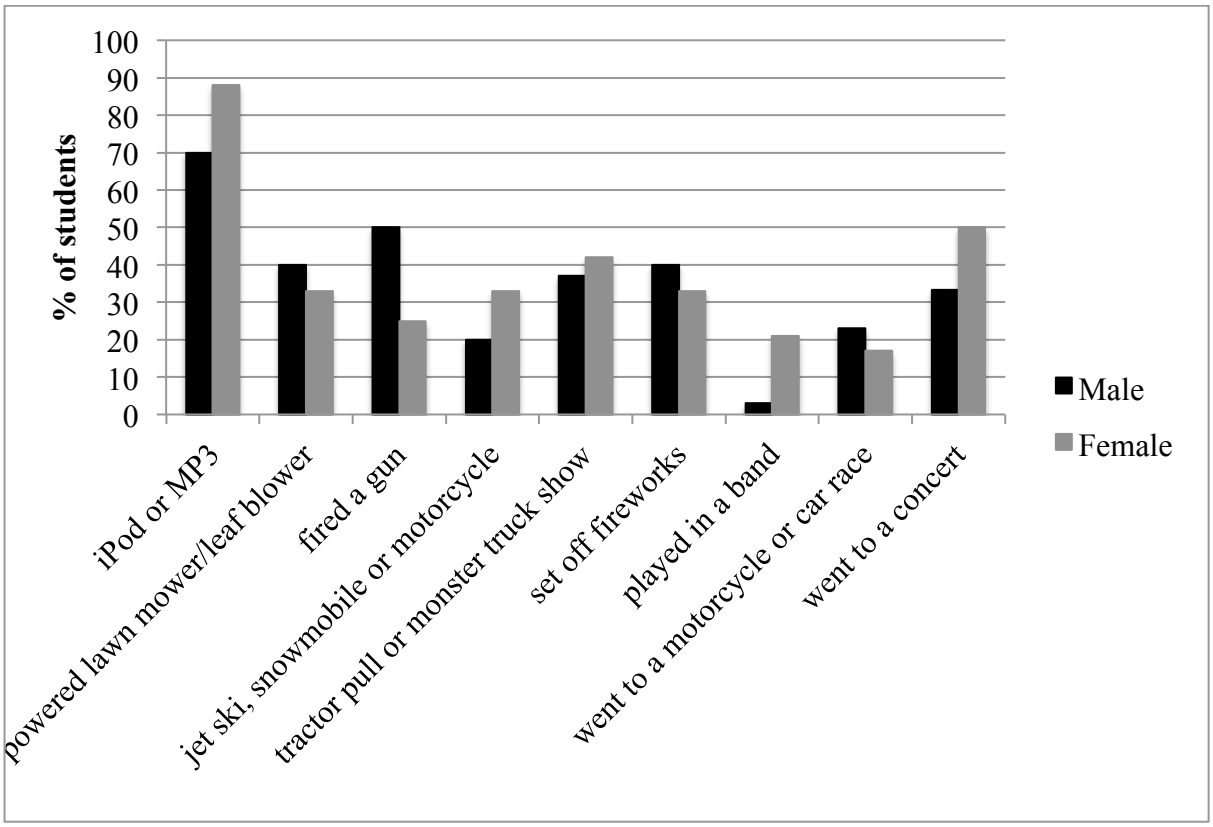

Figure 1-1: Male and female reported exposure to potentially damaging sound within the last year.

Knowledge. Students demonstrated improvements in identification of potentially damaging sound sources following the intervention. For example, prior to the intervention, when asked what sounds could be potentially damaging to hearing, 43% of students identified iPods and MP3 headphones, setting off fireworks (54%), gunfire (67%), attending a concert (48%). Immediately following the intervention, students identified more potentially damaging noise sources (e.g., iPod or MP3 headphones, fireworks, gunfire and concert) and maintained this knowledge four weeks later.

Prior to the intervention, over 70% of students identified walking away from loud sound, spending less time around loud sounds whenever possible, turning doing the volume and using hearing protection as adequate hearing protection measures when around loud sounds. Thirty-eight percent of students incorrectly identified putting cotton or Kleenex in the ears as providing adequate hearing protection prior to the intervention; however, immediately following the intervention, and four weeks later, less than 18% identified this method as proper hearing protection. Prior to the intervention, 55% of students reported that they knew a lot about how to protect their hearing around loud sound. Although there was an initial spike in the number of students that identified with this statement immediately following the intervention, no long-term changes were noted.

Attitude. Improvements in students' attitude towards hearing loss and noise exposure were noted immediately following the intervention and these changes were maintained four weeks later. For example, prior to the intervention, the majority of students agreed, "having a hearing loss is not a big deal." Immediately following the intervention and four weeks later, the majority of students disagreed that "having a hearing loss is not a big deal," demonstrating a more negative attitude towards the impact of hearing loss.

Some of the students' responses to questions regarding attitude maintained relatively stable throughout the study. Among the questions in which students' attitudes did not change, the majority of students responded with a negative attitude toward noise and noise exposure prior to the intervention and maintained this attitude through the program. For example, prior to the intervention the majority of students disagreed with the statement "I can concentrate even if there are many different sounds around me" and

these responses maintained throughout the program. This suggests that many already had some negative attitudes towards specific concepts associated with noise exposure.

Intended behavior. Prior to the intervention, 22% of students agreed, "if I go to a loud concert, I will wearing hearing protection" and these results remained stable throughout the program. The number of students who reported that they would not wear hearing protection at a loud concert decreased from 61% to 39% of students and the number of students who reported that they were "not sure" doubled from 17%, prior to the intervention, to 36% four weeks after the intervention.

Parents and friends. Almost three quarters of students reported that they "never" discussed hearing protection with their parents; these findings remained stable following the intervention and four weeks later. Prior to the intervention, the majority of students reported that they believed it was "sometimes" important to their friends to protect their hearing. However, immediately following the intervention and four weeks later, the majority of students reported that it was "always" important and fewer than 10% believed that it was "never" important to their friends that they wear hearing protection.

Discussion

Implementing the listen to your buds campaign: school-university partnership. Although resources are available and HCPs have shown to be of value for students, HCPs nevertheless continue to be excluded from the majority of schools' curriculum (Thompson et al., 2013). Research suggests that limited distribution of hearing health education may be due to (a) a "lack of public awareness" regarding the impact of damaging sound, (b) a lack of distribution of hearing education resources and materials to schools, (c) a limited number of personnel to implement programs (Folmer et

al., 2002), and (d) lack of time due to increased demands of classroom curriculum (Hendershot et al., 2011). Within the current investigation, the researcher and the affiliated university partnered with a local elementary school to address these gaps in hearing health education and to assess the feasibility and effectiveness of a readily available instructional program on students' knowledge, attitudes and behaviors related to NIHL and prevention.

To gain support for the program, the researcher met with school personnel to discuss the harmful effects of NIHL on students' academic achievement, communication, health and overall quality of life, and to advocate for the implementation of an HCP as part of the health education curriculum. The educators and administrators at this school considered the issues significant, and agreed to include an HCP as part of the fourth grade students' curriculum. Although the teacher recognized the program as sufficiently important to present to the current students, after the program, she reported that she was unsure if she would implement an HCP in the future because of the demands of the curriculum. As previously seen in other studies, the busy curriculum continues to be a barrier for implementing HCPs in schools (Addison & Gilliver, 2012; Thompson et al., 2013).

Small-scale conservation programs, such as this, benefit children and continue to raise awareness about NIHL and hearing protection; however, these issues need to be considered sufficiently important by school personnel to continue to incorporate into the curriculum year after year. Promoting hearing health issues outside of the classroom and in the community is necessary as they continue to be low-priority issues in schools (Addison & Gilliver, 2012). To carryover healthy hearing messages to home,

parents/guardians should be included in programs as they continue to be at-risk for NIHL themselves. In addition, university partnerships with local schools can help to provide hearing conservation programs for young children.

Exposure to potentially damaging sound.

Personal listening device use. Research has found that children continue to have access to personal listening devices (PLDs) (e.g., iPod or MP3 player) at increasingly younger ages (ASHA, 2015a; Taljaard et al., 2015). A recent parent survey found that children eight years of age spent an average of 67 minutes a day using personal audio technology that required earphones, headphones, or ear buds (ASHA, 2015a). In the current investigation, PLD/headphone use was the most common source of potentially damaging noise exposure among both males and females, and yet less than half of the students identified headphones as a potentially damaging noise source prior to the intervention. These results are consistent with those found by Griest et al., (2007), who reported that 80% of fourth grade students surveyed listened to music using a stereo or personal listening device; yet again, less than half of students identified personal listening devices as loud enough to cause hearing damage. These results suggest that among this age group of students, headphone use is still a necessary topic to be included in HCPs.

Other noise sources. Children are exposed to various noise sources depending on their daily noise-scape. Children, who live in metropolitan cities for example, are known to use their personal listening devices at high intensity levels to offset the noise of the city including commutes on trains (Dinno, Powell, & King, 2011). Among this particular group of students studied, 39% reported attending a tractor pull or monster truck show. This number is much higher than that reported by the fourth grade students in the study

by Griest et al. (2007) in which less than 20% of fourth grade students reported similar exposure. These students also live in an area with a large farming community, which may place these students at risk for potentially damaging noise exposure (McCullagh, Banerjee, & Yang, 2015; Woodlord, Lawrence, & Bartrug, 1993). Specific content discussed in HCPs should reflect the characteristics and lifestyles of the participants, so that the information is relevant to the participants' particular experiences in their noise-scape (Addison & Gilliver, 2012; Martin et al., 2006). Future studies should consider surveying participants and their noise exposure prior to selecting content for the program, so that the content can reflect students' noise-scape.

Changes in knowledge, attitudes, and behaviors. Students increased their knowledge of hearing loss and noise-exposure, and demonstrated positive changes in attitude related to these topics following the intervention. These changes are consistent with the Theory of Planned Behavior (Ajzen, 1990). On the contrary, questions related to intended hearing behaviors remained relatively stable with 22% reportedly planning to use hearing protection in the future. Research focused on behavioral health interventions has suggested that interventions are more likely to evoke lifestyle changes when provided in multiple formats on several occasions rather than a single program (Addison & Gilliver, 2012; Black et al., 1998). Given the single 45-minute intervention permitted within this school's curriculum, changes in intended hearing behaviors were unlikely. Similarly, some researchers have argued that HCPs have attributed to only minimal changes in students' actual behavior due to broader and complex societal factors (e.g., noise regulations, culture) and individual factors (e.g., gender, socioeconomic status) that impact behavior (Weichbold & Zorowka, 2007; Widen, 2013). A study by Weichbold

and Zorowka (2007) found that a hearing health education campaign for high school students yielded minimal results in improving protective hearing practices among students. The study concluded that providing hearing health education is beneficial and necessary; however, more efforts from legislators and health-care providers need to be made to modify the environment and stimuli (e.g., advocate for policy change, provide financial incentives, provide hearing protection at entertainment venues) in order to reduce adolescents' exposure to damaging noise. Hence, while professionals should continue to provide students with the knowledge necessary to decide to change future behaviors, legislators and professionals should continue to push for sweeping changes within the environment to reduce damaging noise exposure.

In addition to an intervention such as this, schools should consider including healthy hearing practices in classroom activities regularly. Further carryover of experiences in the community may help to prevent NIHL and students' change listening practices (Addison & Gilliver, 2012). One strategy might be to discuss safe listening practices during regular classroom instruction in a way that would not interrupt or burden the curriculum. For example, before students put on headphones to work at classroom computers, the teacher could routinely spend a minute discussing safe listening practices related to headphone use. In addition to providing an HCP, students may reduce noise exposure when given repeated discussion and exposure, rather than when exposed to a single HCP.

Self-efficacy. Immediately following the intervention, the majority of students correctly identified potentially damaging sounds and appropriate hearing protection; however, four weeks after the intervention, the students did not identify themselves as

more knowledgeable about these topics. These results indicate poor self-efficacy and/or a loss of self-efficacy between the delivery of the intervention and four weeks following the intervention. According to the Theory of Planned Behavior (TPB) (Azjen, 1991), self-efficacy is associated with an individual's perceived control over a behavior, which impacts an individual's future actions (Noar & Zimmerman, 2004). This group of students did not consider themselves as well informed about potentially damaging noise exposure after the HCP; therefore, the students may be less likely to take action in the future to protect their hearing.

Parental influence. Parents/guardians and teachers play a critical role in modifying children's behaviors; therefore, they should be included in HCPs, so that they are equipped with the knowledge necessary to change their children's and their own behaviors (Martin et al., 2006; Pakulski et al., 2011; Punch et al., 2011). In an effort to involve parents/guardians in this HCP, an informational handout was sent home with the students. Prior to the intervention almost three quarters of students reported that they never discussed hearing protection with their parents. These results remained relatively stable following the intervention, which suggests that sending an informational handout home with students did not generate major changes in reported discussion of NIHL between parents/guardians and students. Therefore, future studies should involve parents/guardians directly. Some possible solutions may include inviting parents/guardians to participate in the HCP, providing incentives to students for returning a hearing conservation handout that requires a parents'/guardians' signature, providing parent/guardian education during after school hours, and conducting public health campaigns to promote hearing conservation among the general population.

Conclusions

Due to the prevalence and harmful impact of noise induced hearing loss among children, noise exposure continues to be a relevant topic for elementary schools' curriculum. The results of this HCP demonstrated changes in students' knowledge and attitudes related to hearing conservation practices; however, changes in students' self-reported intended behaviors were not evident. Although students did not report improvements in intended future behavior, they reported having the knowledge and attitudes necessary to change their behavior when confronted with potentially damaging noise exposure. Until legislation to reduce noise exposure is enacted, hearing conservation programs, such as this, are crucial to equipping students with the necessary skills and information to reduce potentially damaging noise exposure.

Parents/guardians and educators play an important role in changing children's behaviors and choices regarding health behaviors. As a result, parents/guardians and educators should participate in education programs, so that they learn to modify their own listening practices and improve children's practices. Without parent and educator support, the impact of programs such as this on students' healthy listening behaviors may be limited.

A step-by-step explanation for education personnel to implement ASHA's Listen To Your Buds lesson plans as part of future hearing conservation programs in the classroom is provided as an appendix. Through this study, a national campaign is now more accessible to other education personnel and students. In addition, this study demonstrates that partnerships with universities and elementary schools can help to address the gaps in dissemination of information related to hearing protection.

Further measures beyond a one-time HCP may be necessary to induce changes in students' behaviors. Providing access to hearing health education campaigns is only a small solution to the low-priority of hearing health education among individuals. National hearing health campaigns can help to raise awareness among the general public. Legislation is necessary to require hearing education to be included in students' curriculum regularly, so that all students have access to preventative hearing health education.

Limitations

Due to the relatively small sample size (n=56), the data has limited generalizability. In addition, data for this study was collected as a group rather than individuals. Therefore, changes among individuals could not be observed and the identified change in students' knowledge, attitudes and behavior is limited. The follow-up questionnaire was delivered four weeks post intervention, but tracking data over a longer time period may identify more reliable results of long-term changes. Another limitation was that there was no way to confirm that the students presented the handout to their guardians. The teacher participating in this project indicated that she preferred not to require a signature because she did not want to punish students for not returning the handout due to the already heavy demands of the curriculum.

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Appendix

The following appendix provides a step-by-step guide to the hearing conservation program based on the ASHA (2013) Listen to Your Buds public education campaign that was implemented at one elementary school for fourth grade students.

Section 1	**Students learned basic ear anatomy. Students demonstrated the normal and damaged function of hair cells in the cochlea through a hands-on activity.**	
Activity 1: Ear Anatomy	The teacher explained the basic anatomy of the ear using a large three-dimensional ear model and YouTube video.	
Activity 2: Spaghetti Demonstration	The teacher and students each held three to four pieces of spaghetti in their hands. While music played softly in the background, they waved the spaghetti back and forth slowly to portray healthy movement of the hair cells in the cochlea. The teacher slowly increased the volume of the music while waving her hands with the spaghetti more quickly. As the volume of the music increased, she began to wave the spaghetti more vigorously until it broke. Students followed the teacher's model. Once the noodles were broken, the students and teacher discussed the permanent damage of loud noise on hair cells of the cochlea.	
	Class discussion addressed these questions:	How is the spaghetti like the inside of our ears?
		Do the hair cells still look the same?
		Can the hair cells be repaired to look as they did?
Section 2	**Students identified sound sources that could produce potentially damaging noise levels. Students learned the signs of damaging noise exposure (e.g., tinnitus, temporary threshold shift).**	
Activity 1: Identifying the Noise-scape	During class discussion, students named familiar sounds in their environment that they believed might be damagingly loud.	
Activity 2: Loud, Louder, & Loudest	Students were given colored, pictures of eight noise sources that could produce potentially damaging noise levels. In groups of four to six students, students organized the sounds from loud to loudest. Next, the teacher taped the sounds on the whiteboard in order from loud to loudest. The teacher explained the meaning of decibels (dB) and the length of time that it could take for these sounds to cause damage to the hair cells of the cochlea (e.g., if an individual listened to headphones at full volume, approximately 105 dB, it could take less than five minutes to cause damage to the hair cells of the	

	cochlea). A chart with estimated decibel levels of various sound sources from the National Institute of Deafness and Other Communication Disorders (2015) was projected on the board to further explain the loud sounds and their decibel levels. (The loud sounds discussed included: firecracker, ambulance siren, rock concert, headphones/stereo turned all the way up, snowmobile, motorcycle, lawn mower, heavy city traffic).	
	Class discussion addressed these questions:	How do you feel when a sound is too loud?
		What kinds of signs show you that sounds are too loud?
Section 3	**Students learned to protect their hearing from potentially damaging noise levels.**	
Activity: Hearing Protection Trivia	The teacher displayed possible hearing protection methods on PowerPoint slides. Students held up signs to either "agree" or "disagree" that each method would provide adequate hearing protection. Discussion regarding each protective methods ensued.	
	Hearing protection options included:	Turn down the volume of music (agree)
		Limit listening time (agree)
		Use headphones rather than ear buds (agree)
		Walk away from the loud sound (agree)
		Put cotton or Kleenex in your ears (disagree)
		Make yourself listen to the loud sound for longer periods of time (disagree)
		Spend less time around loud sounds (agree)
		Use earplugs or ear muffs when around loud sound (agree)
Section 4:	**Students identified sounds in the environment to which they enjoyed listening.**	
Activity: Drawing	Students drew a picture to represent something to which they enjoyed listening (e.g., birds singing, piano playing, breeze through the trees, music, mother's voice). During class discussion, students offered to share their chosen sounds.	
	Class discussion addressed this question:	How would you feel if you could not hear your favorite sound(s)?

Chapter Three

Discussion

Prevalence and Impact of Hearing Loss

The World Health Organization (WHO) (2013a) estimates that approximately 32 million children worldwide have disabling hearing loss. In 2005-2006 the prevalence of childhood hearing loss in the United States, was estimated to be approximately 19.5% (Shargorodosky et al., 2010). The WHO (2015b; 2013b) reports that hearing loss among low- and middle-income nations is much greater than that of high-income nations. Yet, through a review of the literature, it is evident that much less is known about hearing loss in developing nations.

Young people around the world are exposed to potentially damaging noise levels regularly from personal listening devices and recreational noise exposure (WHO, 2015a). Damaging noise exposure can lead to hearing loss. Hearing loss caused by noise is typically minimal to mild; however, it is of particular concern among younger individuals because it has potentially far-reaching consequences. Minimal to mild hearing loss has shown to negatively impact children's speech and language development, academic achievement, and psychosocial/social-emotional wellbeing (ASHA, 2015b). An important consideration of NIHL is that it is often difficult to detect because (a) the symptoms are not necessarily associated with hearing loss, (b) children may initially compensate for related issues (c) the early symptoms vary and are often confused with distractibility and in attention (Pakulski, DeVantier, Thompson, & Hendershot, 2011). Due to the grave impact of NIHL, education can be provided to reduce damaging noise exposure and prevent resultant hearing loss.

Hearing Conservation

Hearing conservation programs (HCPs) in the United States have resulted in positive changes in young individuals understanding of and behaviors related to hearing loss prevention in many high income nations (Addison & Gilliver, 2012; Bennett & English, 1999; Chermak & Peters-McCarthy, 1991; Gilles & Paul, 2014; Griest, Folmer, & Martin, 2007; Keppler, Ingeborg, Sofie, & Bart, 2015; Knobel & Lima, 2014; Martin, Griest, Sobel, & Howarth 2013; Taljaard, Leishman, & Eikelboom, 2013; Weichbold & Zorowaka, 2007). Yet, HCPs are still not included as part of students' education regularly, often due to the demanding curriculum. Legislation to incorporate hearing conservation education in the curriculum as part of health, math, or science education may help to reduce the barrier of the curriculum within schools.

In the meantime, collaboration among professionals, specifically speech-language pathologists (SLPs) and audiologists, and universities can help to bring hearing conservation programs to young children in schools to meet the gap in education. According to the ASHA Scope of Practice (2016), SLPs play a critical role in hearing loss education and prevention. Given their existing role on the educational team, coursework and clinical training, SLPs, along with educational audiologists, are well positioned to collaborate with teachers to develop and implement HCPs. To reduce the burden on professionals, graduate and undergraduate students in speech-language pathology and audiology university programs can help to educate students and communities on hearing loss and hearing loss prevention.

Parents/guardians and educators play a significant role in changing children's everyday behaviors (Punch et al., 2011); however, many adults are at risk for hearing loss

due to potentially damaging noise exposure. Approximately 15% of adults in the United States have some hearing loss related to noise exposure (NIDCD, 2014). As a result, partnerships with parents/guardians and professionals may create changes in parents' concepts of noise exposure to reduce children's noise exposure as well (Martin et al., 2006; Pakulski et al., 2011; Punch et al., 2011). With adequate information parents/guardians and educators can help to guide the everyday practice of healthy listening behaviors among young children. More research is necessary to identify successful methods to provide parents/guardians education related to noise exposure.

Legislation and public health campaigns can also help to reduce hearing loss on a larger scale. Legislation to monitor and reduce noise levels in entertainment venues and with personal listening devices can reduce the amount of potentially damaging noise exposure among young children. Overall, public health campaigns can increase the public's awareness of the negative impact of loud noise exposure.

International Impact

Successful hearing conservation programs from high-income nations may provide examples for hearing conservation programs in developing nations; however, more research is required to identify necessary components of hearing conservation programs in low- and middle-income nations. Collaboration among professionals is crucial for the development and implementation of hearing conservation programs to areas around the world where the consequences of loud noise exposure may not be fully understood. In addition, advocating for policy change in low- and middle-income nations is necessary.

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