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Adaptation of the Dangerous Decibels Program to Youth in Farming

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ADAPTATION OF THE DANGEROUS DECIBELS® PROGRAM TO YOUTH IN FARMING

A Doctoral Scholarly Project Submitted in Partial Fulfillment
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has been approved as meeting the requirement for the Degree of Doctor of Audiology in the College of Natural and Health Sciences in the Department of Communication Sciences and Disorders, Program of Audiology.

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ABSTRACT

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The prevalence of noise-induced hearing loss (NIHL) among youth in farming communities is a pressing issue, primarily due to prolonged exposure to loud farm environments. Effective health communication techniques that focus on education and NIHL prevention are essential to convey critical health messages to young individuals in agricultural communities. The Dangerous Decibels program employs these techniques, emphasizing the identification of hazardous noises, understanding the consequences of noise overexposure, and promoting hearing protection measures. It is crucial to acknowledge that the effectiveness of health communication messages can vary among different social groups, necessitating a tailored program to effectively inform young individuals in agriculture about the risks of loud noise exposure and protective measures. This customized approach draws parallels with successful adaptations of the program for youth firearm users and military families and holds significant potential for the well-being of farm youth.

The adaptations to the Dangerous Decibels program for youth in farming communities have been thoughtfully crafted to retain the program's core content, module structure, and associated learning activities. The modified Dangerous Decibels program for farm youth incorporates several alterations throughout its modules, including the emphasis on presenters with ties to the farming community, the introduction of the concept of acoustic trauma relevant

to firearm use, simulation of high-frequency hearing loss using additional farm-related sounds, addressing noise exposure risks specific to agriculture, providing information on electronic hearing protection devices, and adapting scenarios to better relate to the social pressures and stigma faced by young individuals engaged in farming. These adaptations are strategically implemented to align with the needs and experiences of youth in the farming community while upholding the core objectives of the program.

The adapted Dangerous Decibels program necessitates a strategic approach to dissemination, with a focus on reaching young individuals in farming communities through agricultural organizations and events. Overcoming challenges, such as establishing connections with relevant organizations and addressing potential reluctance to endorse hearing health initiatives, is crucial. Future directions involve evaluating the program's effectiveness through questionnaires to assess its impact on knowledge, attitudes, and behaviors, thereby providing insights into its potential success among youth in farming communities.

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I would like to thank my family for always believing in me and reminding me I can do anything I set my mind to. Thank you to my parents who cultivated kindness, responsibility, and resilience into my character. Special thank you to my mother, who encouraged me to pursue continued education, and understands my love for learning.

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LIST OF ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
dB	Decibel
dBA	A-weighted decibel
dBHL	Decibels Hearing Level
FFA	Future Farmers of America
FUHPS	Farmer's Use of Hearing Protection Scale
HCP	Hearing conservation programs
HI	Hearing impairment
HLPP	Hearing loss prevention program
HPA-5	Hearing Protection Assessment
HPD	Hearing protection device
JEM	Job exposure matrix
kHz	Kilohertz
MSHA	Mine Safety and Health Administration
NHANES	National Health and Nutrition Examination Survey
NHES	National Health Examination Survey
NIHL	Noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
NITS	Noise-induce threshold shift

OSHA	Occupational Safety and Health Administration
PBC	Perceived behavior control
PEL	Permissible exposure limit
PPE	Personal protective equipment
PTA	Pure tone average
PTS	Permanent threshold shift
REL	Recommended exposure limit
SLM	Sound level meter
SNHL	Sensorineural hearing loss
TTS	Temporary threshold shift
TWA	Time weighted average
U.S.	United States

CHAPTER I

REVIEW OF THE LITERATURE

Noise-Induced Hearing Loss

Hearing loss is divided into two primary groups, conductive and sensorineural. Conductive hearing loss involves the outer and/or middle ear structures. The simplified outer and middle ear structures are the pinna, ear canal (external auditory meatus), eardrum (tympanic membrane), and the three ossicles identified as malleus, incus, and stapes. Common etiologies of conductive hearing loss are wax (cerumen) impaction, middle ear infections (otitis media), and perforations of the eardrum (Hong et al., 2013). Sensorineural hearing loss (SNHL) involves the inner ear and/or the auditory nerve. The auditory nerve is the link between the cochlea and the brainstem. Location of the sensorineural hearing loss is classified as sensory at the level of the cochlea, and neural at the location of the auditory nerve. An SNHL can be congenital (present at birth or hereditary), a result of aging (presbycusis), noise exposure, ototoxicity, or caused by pathology (Isaacson & Vora, 2003). Mixed hearing loss is categorized when a combination of sensory, neural, and conductive occurs in the same ear (Hong et al., 2013).

What is Noise-Induced Hearing Loss?

Noise-induced hearing loss (NIHL) is a result of exposure to hazardous noise. Exposure to high-level noise can result in permanent damage to the hair cells in the cochlea resulting in SNHL. A study by Sliwinska-Kowalska and Davis (2012) estimated that 500 million individuals are susceptible to developing a NIHL. Roughly one-third of all hearing loss can be attributed to exposure to hazardous sound levels (Bethesda, 1990). A study by Carroll et al. (2017) reported approximately one in four adults had audiometric notches indicating evidence of NIHL. An audiometric notch, or noise-notch, is characterized as increased (worse) hearing thresholds at 3-, 4-, and/or 6 kHz due to noise damage of the higher frequencies. Lower (better) thresholds at 0.5- to 1 kHz are noted, and a characteristic recovery of hearing at 8 kHz is present on the audiogram (Rabinowitz et al., 2006). Roughly one in four of the adults who categorized their hearing as “excellent” or “good" hearing had hearing losses revealed by the presence of audiometric notches on audiograms. Indicating that individuals with NIHL often are not aware they have hearing loss.

Etiology of Noise-Induced Hearing Loss

A consequence of over-exposure to hazardous sound levels is NIHL. Harmful levels of noise can exhaust or destroy hair cells located in the cochlea. Damage to the hair cells initiates noise-induced hearing loss that is temporary or permanent (Graydon et al., 2019). Temporary threshold shift (TTS) or permanent threshold shift (PTS) are two possible outcomes of overexposure to hazardous sound levels. Temporary threshold shift is considered less critical than PTS (Kurabi et al., 2017). An individual experiencing TTS typically recovers their hearing within 24-48 hours after the reduction of hearing sensitivity. Reclamation of hearing sensitivity after TTS occurs when the stereocilia of hair cells in the cochlea return to their initial orientation and return to their initial orientation and position in relation to the tectorial membrane. Synaptopathy can also occur during TTS resulting in a disconnect of the inner hair cells to afferent neurons (Kurabi et al., 2017). In the case of PTS, continued exposure to hazardous noise results in the cochlea being unable to recover, and hearing sensitivity is permanently reduced.

Hearing loss due to PTS is a result of permanent damage to hair cells in the cochlea. Overexposure to hazardous noise, chronic exposure, or sudden blast exposure, results in mutilation of the stereocilia of the hair cells and apoptosis/necrosis of outer and inner hair cells. Destruction of the stereocilia inhibits or eliminates cellular function. Researchers report during intense exposure, harmful stimulation of the cochlea can also disturb supporting cells located in the epithelium (Kurabi et al., 2017). Cochlear damage as a byproduct of hazardous noise exposure results in NIHL and can accelerate the onset of hearing loss due to aging (Graydon et al., 2019).

Prevalence of Noise-Induced Hearing Loss in Adults

In a study by Nelson et al. (2005), occupational noise exposure is responsible for 16% of hearing loss in adults worldwide. The Centers for Disease Control and Prevention (CDC) reviewed data obtained from surveys and audiometric tests of 3,583 adults aged 20-69 from the 2011-2012 cycle of the National Health and Nutrition Examination Survey (NHANES) (Carroll et al., 2017). Researchers revaluated the data for evidence of audiometric notches revealing NIHL. The prevalence of audiometric notches suggestive of NIHL was reviewed unilaterally and bilaterally. Noise-notches were defined as present when the hearing thresholds at 3-, 4-, and/or 6 kHz surpassed the thresholds of 0.5 kHz and 1 kHz greater or equal to 15 dB HL. The threshold and there was at least a 5 dB improvement at 8 kHz from the poorest threshold at 3, 4, or 6 kHz. Participant’s social influences, demographic factors, and self-report of hazardous noise exposure were accounted for in the analysis. Results indicated that approximately 24% of U.S. adults have audiometric notches. The incidence of notches was higher in the male population. The rate of occurrence for young adults aged 20-29 was one in five (Carroll et al., 2017). This suggests that NIHL may have an onset in childhood/adolescence.

Prevalence in Noise-Induced Hearing Loss in Youth

Niskar et al. (2001) evaluated U.S. children and the prevalence of noise-induced hearing threshold shifts (NITS). The authors noted that NITS can be a progressive issue with further exposure to dangerous noise resulting in reduced high-frequency sound identification over time. A total of 5,249 children (6-19 years) completed the Third National Health and Nutrition Examination Survey (NHANES III) consisting of an interview, audiometric testing of frequencies 0.5 – 8 kHz, and middle ear compliance testing for both ears. A child was categorized as having NITS when the following three conditions were true for at least one ear: threshold values at 0.5 and 1 kHz in one ear was ≤ 15 dB, maximum thresholds at 3-, 4-, or 6 kHz were at least 15 dB higher than the highest threshold for 0.5 and 1 kHz, and the threshold value at 8 kHz is 10 dB lower than the maximum threshold at 3-, 4-, or 6 kHz All participants passed middle ear compliance criteria, which ruled out middle ear pathologies. Results gathered from the NHANES III indicated approximately 12.5% of U.S. children (6-19 years) have NITS in one or both ears. Findings from data analysis of NHANES III suggest that children are over-exposed to dangerous levels of noise placing children's hearing at risk of NITS. Niskar et al., (2001) concluded that there is a need for hearing conservation programs and for NITS hearing screening programs for youth.

A retrospective study by Su and Chan (2017) further exemplified the occurrence of hearing loss and noise exposure in the U.S. pediatric population. This study included 7,036 survey participants from NHANES III 1988-1994, NHANES 2005-2006*,* NHANES 2007-2008, and NHANES 2009-2010 cycles. Participant audiometric data was available for youth ranging in age from 12 to 19 years. Data were grouped into two-year age categories (12-13, 14-15, 16-17, and 18-19 years of age). The interview survey responses provided information about past ear infections, noise exposure, firearm use, and hearing protection use. Hearing sensitivity was measured by pure-tone audiometry from 0.5 to 8 kHz. Noise-induced threshold shifts were characterized by a noise-notch audiometric configuration. The NHANES III data analysis reported that 17% of the study population had hearing loss indicated by a pure-tone average of 15 dB or greater from NHANES III. A pure tone average (PTA) is the sum of pure-tone thresholds obtained at 0.5, 1, and 2 kHz, divided by three. The prevalence of hearing loss increased to 22.5% using a PTA 15 dB or more when referencing NHANES 2007-2008. The prevalence of hearing loss decreased to 15.2 % for the NHANES 2009-2010 cycle. Changes in NITS indicated an increase in occurrence from NHANES III to NHANES 2007-2008 of 15.8% to 17.5%. Then the incidence of NITS decreased to 12.8% by the NHANES 2009-2010 cycle period (Su & Chan, 2017). The prevalence of NITS reported by Su and Chan (2017) from NHANES 2009-2010 of 12.8% indicates a decrease in affected youth. Applying the 12.8% incidence to the 2018 U.S youth census data indicates approximately 5.9 million adolescents between 9 and 19 years demonstrate evidence of early NIHL on audiometric evaluation (Meinke, 2021). Su and Chan (2017) concluded that the pediatric population is at risk for developing noise-induced threshold shifts as evidenced by audiometric data from longitudinal data gathered by NHANES hearing testing and surveys from 1998-2010.

A cross-sectional study by Hoffman et al. (2019) examined the factors related to hearing impairment (HI) in youths between 1966-2010. The audiometric data set included hearing thresholds from adolescents age ranging from 12-17 years who participated in the National Health Examination Survey (NHES Cycle 3) from 1966 to 1970 (n=6,768) and a separate group of youths 12-19 years of age who participated in the NHANES III (1988-1994; n=3,057) or NHANES (2005-2010; n=4,374). The occurrence of HI was characterized as a PTA of ≥ 20 dB

HL in the speech frequencies (0.5,1, 2, and 4 kHz) and high frequencies (3, 4, and 6 kHz) (Hoffman et al., 2019). Factors considered in the analysis included demographic variables, recreational noise, occupational noise, smoking, otitis media, meningitis, viral infection, congenital hearing loss, and perinatal illness. The incidence of HI in the speech frequencies was 10.6% in the NHES, 3.9% in NHANES III, and 4.5% in the NHANES 2005-2010. The prevalence of HI in the high frequencies was 32.8% (NHES), 7.3% (NHANES III), and 7.9% (NHANES 2005-2010) (Hoffman et al., 2019). The authors noted the decline in HI in the high frequencies can attributed to a reduction of risk factors including smoking, occupational noise exposure, and firearm noise (Hoffman et al., 2019).

It is clear that NIHL is prevalent in both adults (Carroll et al., 2017; Nelson et al., 2005) and youth (Hoffman et al., 2019; Niskar et al., 2001; Su & Chan, 2017) in the U.S. Many of these individuals work or live on farms that expose them to high levels of agricultural sounds and put them at risk of NIHL.

Noise Exposure and Production Agriculture

The Centers for Disease Control and Prevention (CDC) estimates over 2.1 million individuals were employed in full-time agriculture production in 2019 (most recent data available) (CDC, 2023). In 2014, it was estimated that 3,000 youth under 20 years of age lived on farms. Roughly 454,000 youth who do not reside on farmland were hired as farm employees in 2014 (CDC, 2021).

Noise Exposure Limits

In general, noise is considered hazardous to hearing when the noise intensity reaches an average of 85 A-weighted decibels (dBA) and an agricultural worker is repeatedly exposed for 8 hours a day, which is termed a time-weighted average (TWA) over a 40-year period. The allowable daily duration of exposure decreases as the intensity of the sound increases. A discussion of the various noise exposure limits are addressed in more detail in the following sections entitled “Occupational Safety and Health Administration” and “National Institute for Occupational Safety and Health”.

Occupational Safety and Health Administration

The Occupational Safety and Health Administration (OSHA) 29 CFR 1910.95 “Occupational Noise Exposure” establishes legal restrictions on noise exposure in work environments in the U.S. The permissible exposure limit (PEL) is 90 dBA averaged for an 8-hour workday (time-weighted average; TWA) and employees that exceed this exposure are required to utilize hearing protection devices (HPDs) and employers are required to implement feasible engineering noise controls (OSHA,1983). Standards for occupational workers are quantified into daily noise dose percentages. A worker who is exposed to sound at 90 dBA for 8 hours equates to a daily noise dose of 100% per OSHA regulations. An individual exposed to 85 dBA over the 8-hour workday equals 50% of the maximum daily noise dose. All employees exposed at or above 50% dose (84 dBA TWA) are then required to be enrolled in a hearing conservation program (HCP) (OSHA, 1983; Moore & Lusk, 1997). Components of the HCP include noise measurement, control of noise, hearing protection, audiometric monitoring, hearing loss prevention education, recordkeeping, and assessment of the HCP (Wells, 2022). Both the TWA and noise dose account for both the duration and the intensity of the noise. OSHA integrates noise exposures using a 5 dB exchange rate, meaning that for each 5 dB increase in sound level, the allowable time of exposure is halved. For example, exposure at 90 dBA is allowed for 8 hours, whereas exposure at 95 dBA is allowed for 4 hours and both are equivalent to 100% noise dose.

Hearing conservation programs are designed to prevent NIHL caused by over-exposure to occupational noise. The primary goals of HCPs are to proactively avoid the occurrence of hearing loss, preserve the remaining hearing of employees with auditory impairment, offer educational strategies to empower workers in safeguarding their hearing, and furnish effective HPDs (OSHA, 1983). Employers are required to measure the noise level of the work environment, implement noise controls, and offer complementary annual hearing evaluations, HPDs, and educational hearing protection training. According to OSHA (1983), HPDs are evaluated to ensure acceptable attenuation for the amount of noise exposure. Not every industry is mandated by OSHA to implement HCPs oil and gas; and construction industries are explicitly exempt. Small farming operations are exempt from all rules, regulations, and standards or orders under the OSHA (including 29 CFR 1910.95) when they employ 10 or fewer employees (family members do not count as employees) and do not maintain a temporary labor camp (OSHA, 2007). The exemption of small-family farming agriculture from OSHA noise regulations (OSHA, 1983) places a large number of farmers at risk of NIHL due to the lack of regulation for these workers exposed to hazardous levels of agricultural noise. This is concerning since there are an estimated 2.1 million farms in the U.S. and an estimated 97% of these are family-owned farms (USDA, 2015).

National Institute for Occupational Safety and Health

The National Institute for Occupational Safety and Health's (NIOSH) organizational goal is to develop and implement knowledge for improvements in safety and health for workers. One strategic plan of NIOSH is to diminish the prevalence of occupational noise-induced hearing loss (CDC, 2022). NIOSH (1998) has published the "Criteria for a Recommended Standard:

Occupational Noise Exposure Revised Criteria" which incorporates recommended exposure limits (REL) for worker noise exposures. The NIOSH REL is 85 dBA referencing an 8-hr TWA. Noise exposure at or exceeding this level is considered hazardous to hearing (NIOSH, 1998). NIOSH integrates noise exposures using a 3-dB exchange rate and is more conservative than OSHA in terms of allowable noise exposure in the workplace. Workers exposed above the REL are to be enrolled in a hearing loss prevention program. The NIOSH recommended exposure limits assume a working career of 5 days a week for 50 weeks a year for 40 years and do not consider non-occupational noise exposure. The NIOSH guidelines would be considered "best practice" guidelines for adults and adolescents working on farms.

Agricultural Noise Exposure

Average noise exposures for both male and female agricultural workers in Australia were similar (85.3 dBA) and L_{Aeq}'s ranged from 69-119 dB measured across a large number of activities. (Williams et al., 2015). In a study of noise exposures among three farm families in northwest Ohio, it is estimated that adult farmers are exposed to sound levels ranging from 46.1 to 89.6 dBA measured with OSHA (1983) hearing conservation program criteria and 62.6 to 92.1 dBA when measured with the NIOSH (1998) recommended exposure levels (Milz et al., 2008). Children exposed to farm noise had TWA exposures that ranged from 15.4 to 81.2 dBA using OSHA exposure criteria and 42.4 to 85.5 dBA using NIOSH REL sampling. Lander et al (2008) reported noise exposure assessments for 10 farm youths (10-18 years) and found that TWAs ranged from 79 dBA to 103 dBA when measured with OSHA exposure metrics. It is worth noting that the damage-risk criteria for youth may be different than for adults and these exposure levels may underestimate the risk of NIHL for youth (Roberts & Neitzel, 2019). Given the elevated risk of NIHL due to farm noise exposure, it is crucial to educate children about safe listening practices, the recognition of noisy environments to avoid, and the importance of using hearing protection in high-noise settings. Effective public health intervention programs such as Dangerous Decibels® have been established for this purpose (Roberts & Neitzel, 2019).

Sources of Hazardous Noise in Farming

Farmers are exposed to a variety of hazardous sounds throughout the workday. The Noise Job Exposure Matrix (noiseJEM) includes noise exposure measurements for a myriad of occupations (Cheng et al., 2018). Measurements included in noiseJEM are comprised of measurements from the OSHA, MSHA, and other published literature (Cheng et al., 2018). From 2002 to 2013 the noiseJEM estimates the mean OSHA PEL for farmers, ranchers, and other agricultural managers as 92.78 dBA (n=19). The 19 OSHA PEL measurements collected during this timeframe indicated that 73.7% exceeded the 90 dBA OSHA PEL (Neitzel et al., 2023). Franks et al. (1996) states NIOSH estimates noise is a health hazard to 84% of farmers.

Hazardous noise exposure for farmers can vary due to seasonal operations. Typical farming sound sources include tractors (74-112 dBA), combines (80-105 dBA), swine squeals (85-115 dBA), chainsaws (77-120 dBA), and riding lawn mowers (79-89 dBA). Approximately 84 to 90% of farmers report firearm (shotgun or rifle) use which can range from 143 to 173 dB peak sound pressure level (SPL) (Lankford & Meinke, 2006). Exposure to various sources of hazardous sounds places farmers at risk of developing NIHL.

Evidence of Noise-Induced Hearing Loss in Agriculture Workers

A ten-year cross-sectional study examined the hearing sensitivity of adult males (n=2,695) residing in farming communities from 34 states and 4 foreign countries (Lankford & Meinke, 2006). Lankford and Meinke (2006) noted farmers between the ages of 20 and 60 years of age displayed more advanced high-frequency hearing loss in relation to individuals who were not exposed to hazardous noise and hearing loss progressed as the farmers aged.

Plakke and Dare (1992) reported hazardous noise exposures for farmers included tractors, combines, livestock, and power tools. These authors conducted a study comparing the hearing sensitivity between individuals exposed exclusively to agricultural noise and a control group comprised of individuals who were not subjected to noise at their jobs. Farmers were matched with a control group member by age. A total of 60 individuals participated and were grouped by age by decade; 30s, 40s, and 50s. Pure-tone hearing thresholds were collected for each participant at 0.5-, 1-, 2-, 3-, 4-, 6-, and 8 kHz. For the 30-year-old age group, the hearing thresholds for farmers were poorer than the non-noise-exposed workers, but the differences were not significant statistically. For the 40-year-old group, thresholds were similar for .5 to 2 kHz, but individual test frequencies were significantly poorer ($p<.05$) for the farmers at 3-8 kHz. The older, 50-year-old group also demonstrated significantly poorer ($p<.05$) for the farmers, but across all the individual test frequencies .5 to 8 kHz. The researchers concluded that the hearing loss exhibited in farmers is suggestive of NIHL due to the loss being primarily confined to the high frequencies (Plakke & Dare, 1992) Audiometric data from the three age groups demonstrated that as individuals who are exposed to farm noise get older, the amount of hearing loss increases compared to the control group members. Plakke and Dare (1992) conclude farmers are at risk for NIHL. They further stated that guidelines are needed to improve safety and hearing conservation for farmers through hospital-based programs, county extension offices, and rural-based audiologists.

**Evidence of Noise-Induced
Hearing Loss in Farm Youth**

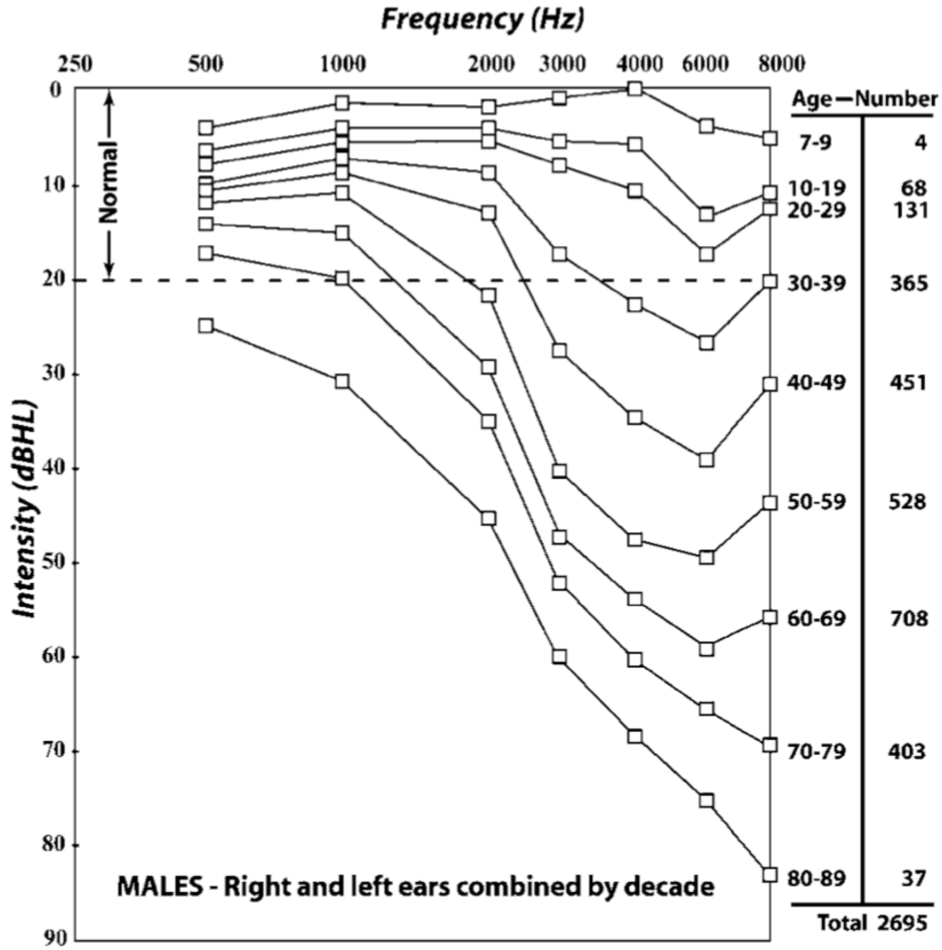
Hearing loss is common in adult farmers and evidence suggests onset could occur in childhood (Broste et al., 1989; Perry & May, 2005; Renick et al., 2009). Renick et al. (2009) obtained audiometric thresholds from youths (n= 212) who resided on farms in Ohio during the years 1994 to 1996. Follow-up audiometric evaluations were again performed from 2003 to 2004 to observe shifts in hearing thresholds in children ages 4 to 21 years (n=132). Participants were from agriculture families who were involved in the Ohio Farm Family Health and Hazard Study Review of the audiometric data suggests youths who live on farms had a higher occurrence of hearing loss in comparison to representative data for the same age group. A high-frequency hearing loss was observed in 50% of the experimental farm youth population (Renick et al., 2009). The occurrence of a NITS was twice as large as the representative sample and NITS was characterized using the audiometric notch definition described earlier by Sliwinska-Kowalska and Davis (2012). The data analyses suggest youth who reside and/or work on farms are at a higher risk of developing hearing loss than youth who do not live and/or work on farms (Renick et al., 2009).

Broste et al. (1989) also investigated the occurrence of hearing loss in teenage youth living on farms. Audiometric thresholds (0.25 -8 kHz) were obtained from a population of students residing on farms in Wisconsin (n=870). The students ranged in age from 12 to 19 years and participants attended 12 different high schools. Students completed surveys regarding their health, hearing history, exposure to farm machinery, and how often they are involved in farm work. Results obtained from the survey grouped students accordingly: students who lived and assisted on the farm (group A, n = 445), youth who did not live on a farm but were employed on a farm (group B, n=198), students who lived on the farm but had minimal involvement (group C, n=50), and students who did not live on a farm nor were involved with farm work (group D, n=177). Results from the analysis of the audiometric thresholds revealed hearing loss was present in both low and high frequencies for 71% of group A, 74% of group B, 39% of group C, and 46% of group D. Groups A and group B were most involved in farming and had a higher prevalence of NIHL (defined as thresholds less ≤ 10 dB HL at .5 and 1 kHz, and >10 dB HL at 4 or 6 kHz) when compared to students who were less involved in farming. These authors concluded that youth involved in farming are at a higher risk for developing hearing loss.

The previously mentioned study by Lankford and Meinke (2006) highlighted that an audiometric notch pattern at 3, 4, or 6 kHz serves as an indicator of NIHL. Figure 1 visually represents the recorded hearing sensitivity in both ears of 2,695 male farmers from the Midwestern United States, as part of a comprehensive 10-year cross-sectional study. This dataset systematically documents hearing thresholds by age decade, revealing the presence of a noise notch pattern that diminishes in individuals aged 70 and older, extending to encompass 8 kHz as hearing loss advances**.** These authors concluded that farmers exhibit a more pronounced high-frequency hearing loss when compared to their peers who have not been exposed to excessive noise (Lankford & Meinke, 2006). The documented decline in hearing sensitivity among farmers implies an elevated risk of developing NIIHL compared to their age-matched counterparts who have not been exposed to significant noise levels. This data implies that the susceptibility to NIHL emerges at an early stage in the lives of farmers and continues to escalate over the course of their lifespan. The heightened likelihood of farmers developing NIHL due to their exposure to noise underscores the necessity for the creation of an intervention aimed at educating farm youth about the dangers of hazardous noise exposure and preventing hearing loss.

Figure 1

Hearing Sensitivity of Males in Farming by Age Decade



Note. Advancement of noise-induced hearing loss in male farmers across the lifespan. From *Acoustic Injuries in Agriculture* (486) by J. E. Lankford and D. K. Meinke, 2006, Springer. Copyright 2006. Reproduced with permission from Springer Nature.

Perry and May’s (2005) review of the literature found exposure to noise and chemicals can increase the risk of hearing loss in young farmers. Sources of hazardous noise included farm equipment, machinery, and livestock sounds. Toxic chemicals like pesticides and other substances found on farms were also reviewed, and exposure to these substances may exacerbate the risk of NIHL for farm youth. Perry and May (2005) highlight the need for public and occupational health solutions to bring attention to the prevention of NIHL and ototoxicity from chemical exposure in youth farmers. In response to this need, efforts to prevent NIHL have been undertaken and different approaches can be implemented to address this public health issue in the context of farming.

Models of Hearing Loss Prevention

Preventative strategies are actions taken to reduce exposure to hazardous noise and limit an individual’s risk of NIHL. Meinke and Stephenson (2018) outline four models for preventing NIHL, including 1) regulatory model, 2) medical treatment model, 3) preventive medicine model, and 4) educational model. Each approach has application to adults and youth engaged in farming.

Regulatory Prevention Model

Regulatory prevention models depend on government agencies collecting scientific based evidence related to NIHL for the generation of legal requirements for employers to abide by regarding employees’ exposure to hazardous noise levels. The U.S. government also offers documents to model “best practices” to the public (Meinke & Stephenson, 2018). In this framework, audiologists utilize the regulatory model via the implementation of hearing conservation programs (HCPs) that are mandated by law for occupational noise exposure. It is imperative that HCPs be supervised by professionals. In this case, the audiologist follows the legal mandate for hearing conservation program components in state and federal regulations (Meinke & Stephenson, 2018).

Hearing Conservation Programs

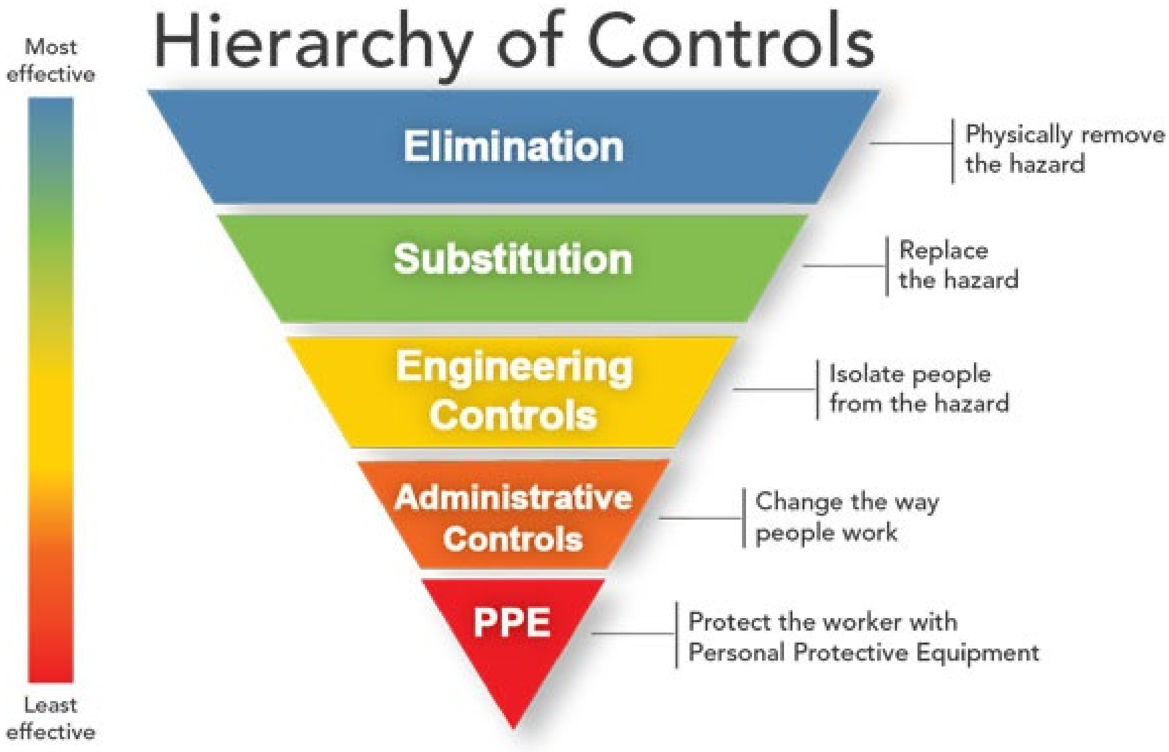
Hearing conservation programs (HPC) also termed, hearing loss prevention programs (HLPP) are comprised of essential components to effectively reduce hazardous noise and ototoxic exposures with tactical program implementation. A successful program limits the risk of employees being subjected to NIHL. The first component of an HCP/HLPP is noise measurement. The work area's sound levels and noise exposures are measured, analyzed, and documented. The next element of a program is noise control. When a noise hazard is recognized, a strategy to mitigate it is developed, employing a hierarchy of controls that includes various measures to eliminate or decrease noise levels in a given setting. Conducting a noise control survey aids in pinpointing sources of noise and selecting appropriate control measures based on the Hierarchy of Controls (Wells, The Noise Manual, 157).

Hierarchy of Controls

Occupational health and safety professionals utilize the hierarchy of control to establish how to carry out practical and successful controls. Actions are categorized according to predicted success in decreasing or eliminating hazardous noise (CDC, 2018). Figure 2 displays the different levels of the Hierarchy of Controls.

Figure 2

Hierarchy of Controls



Note. Retrieved from Center for Disease Control and Prevention.

The favored strategy is to eliminate the source of the hazardous noise. Exchange of equipment for a quieter model is preferred when elimination of sound is not an option. The next step is engineering controls involving the process of redesigning the equipment. This strategy is utilized to reduce the intensity of noise to a safe level. Another example of engineering controls is to implement a barrier to reduce hazardous noise exposure. The following control is to reduce contact with dangerous noise levels using administrative controls. An example of administrative control is altering work schedules to reduce the time an employee is in the presence of hazardous noise. The final strategy for reducing exposure to hazardous noise is personal protective equipment (PPE). Examples of PPE include earplugs, earmuffs, and other varieties of hearing protection. The use of PPE is considered the least effective technique due to reliance on human efforts to reduce noise exposure. Personal protective equipment can be used in conjunction with engineering or administrative controls to improve the effectiveness of hazardous noise reduction. NIOSH encourages the implementation of the Hierarchy of Controls for occupational safety, health professionals, employers, and employees to educate on preventative strategies for hazardous noise level exposures (CDC, 2018).

The third component of an HCP/HLPP is hearing protection. The use of HPDs are another strategy to protect against NIHL. Hearing protective devices are implemented when other noise control efforts are not able to efficiently reduce noise exposure to safe regulatory limits (Wells, 2022*).* There are many styles of HPDs including earplugs, earmuffs, and canal caps. The authors recognize that HPDs are only effective when worn properly. Failure to ensure proper insertion or placement of HPD is a contributing factor to NIHL (Meinke & Stephenson, 2018).

The next component of an HCP/HLPP is hearing health surveillance also known as audiometric monitoring. Regular audiometric testing is utilized to detect small changes to employee hearing thresholds. Baseline audiograms are obtained and compared to tests performed at routine intervals. Thresholds that increase (worsen) at frequencies at risk for NIHL are important for recognizing a need for an intervention. Monitoring hearing thresholds aids in identifying at-risk employees (Wells, 2022).

Education and motivation are additional components of an HCP/HLPP. Regulatory agencies require concepts of the hearing program to be taught to employees. Concepts include the effects of noise, how to properly use HPDs, the need and methods of audiometric testing, and how to follow company HCP/HLPPs. The motivational component inspires individuals to care for their hearing health and promotes behaviors and attitudes toward protecting hearing outside of the workplace (Wells, 2022).

Recordkeeping is an integral element of HCP/HLPPs for the purpose of upholding records which provide proof of compliance to regulatory agencies. Accurate records provide information to guide HLPP decisions and lower liability claims (Wells, 2022).

The last component is the HLPP evaluation which instructs the employer to apply an effective program. The success of the HLPP is up to the discretion of the employer to determine whether the program is effective at preventing NIHL in employees. Types of records include noise surveys, noise control designs, audiometric evaluations, HPD information, and HLPP training documentation for employees. Quality of recordkeeping can indicate the reliability of the HLPP (Wells, 2022). Each element of the HLPP is important to ensure the effectiveness in preventing NIHL in employees.

Medical Treatment Model

The medical treatment model takes the stance that medical treatments can prevent and/or cure NIHL (Meinke & Stephenson, 2018). Scientific advancements have brought insight into the pathologic damage hazardous noise can have on the auditory system. Improvements in molecular biology, biochemistry, and histopathology provide resources to explore possible medical treatments for NIHL. Damage to the organ of Corti and metabolic stress are recognized as two mechanisms for NIHL. Knowledge of these mechanisms allows for proactive treatments before damage from hazardous sounds or prevents increased deterioration of hearing from NIHL (Meinke & Stephenson, 2018). Otoprotectants are an example of this growing field of research and emerging clinical applications (Le Prell, 2019).

Preventive Medicine

The preventive medicine model combines clinical and public health knowledge to diminish the possibility of developing a disorder or disability. The ideology of the model is to take precautions to abstain from acquiring an ailment initially rather than to treat a developed disorder. There are three levels to the preventive health model. The primary level involves actions made to limit the risk of disease or disorder for an individual who could potentially acquire the illness. An example of primary prevention is vaccines. Secondary prevention entails recognizing and caring for an asymptomatic individual who possesses risk factors which are not easily recognized by the person (Meinke & Stephenson, 2018). An example of a secondary prevention would be a COVID test taken by an individual exposed to the virus but not displaying symptoms. The tertiary prevention entails the management of symptomatic individuals with the goal of reducing the effects of the disease or illness. Monitoring sugar levels in a diabetic individual is an example of tertiary prevention. Meinke & Stephenson, 2018)

Educational Prevention Model

Audiologists can provide educational presentations in multiple forms. Training and information can be administered through programs to employees, newsletters, and websites. Audiologists can assist in the changes in behavior regarding hearing health. Typical topics included in formal training include how humans hear, the harmful effects of noise, consequences of hearing loss, techniques to lessen noise exposure, the selection of proper HPDs, and the importance of audiometric testing (Meinke & Stephenson, 2018).

Health education models are typically administered through the school environment for youth. Three components of health promotions in the education system include a formal health curriculum which provides information for students to make decisions to limit the risk of developing NIHL. The next element is the school environment pertaining to the health services and policies upheld by the facility. School and community interaction is the third factor of health promotion in school environments. Parents and community members trust that sound pressure levels at school are at safe listening levels for students (Meinke & Stephenson, 2018).

The Need for Hearing Loss Prevention in Farming

Ehlers and Graydon, 2011

Ehlers and Graydon (2011) explain how NIOSH collaborated with other organizations to advocate for the use of hearing protection by farmers. Their target population was comprised of farmers 14-35 years old. A participatory, community-based public health approach was used to familiarize farmers with NIHL. Participation entailed a partnership between NIOSH and groups associated with farmers to deliver hearing conservation material. Organizations NIOSH is affiliated with include the National Association of Agricultural Educators, Progressive Agriculture Foundation®, Farm Safety 4-Just Kids, Farm Bureau®, and cooperative extension programs (Ehlers & Graydon, 2011). In 2007, NIOSH held a meeting for the National Institute for Farm Safety for individuals interested in hearing loss prevention. Farmer attendees reviewed brochures developed by NIOSH about NIHL prevention. Hearing loss prevention events were held in 43 states and sponsored by a participating organization. Two NIOSH hearing conservation brochures were created in collaboration with farmers and health promotion experts. The brochures are entitled. *They're your ears- Protect them (#2007-175)* and *Have you Heard? Hearing Loss Caused by Farm Noise is Preventable (#2007-176).* NIOSH filled 500 requests for the brochures equaling 330,000 copies of each brochure. Requests for 3,400 brochures were filled at eight workshops for National Association of Agricultural Educators conventions between 2008 and 2009 (Ehlers & Graydon, 2011). The request of agricultural brochures regarding hearing loss prevention by the identified key organizations indicates an interest in protecting hearing from noise induced hearing loss in the farming population.

Sliwinska-Kowalska and Davis, 2012

A review by Sliwinska-Kowalska and Davis (2012) evaluated improvements made in communicating the consequences of dangerous noise exposure to hearing. The paper focused on "hard to control" occupations including construction and farming. Farmers are at a higher risk for developing NIHL because of not using hearing protection. Hearing loss is common in the farming community and audiometric data from youth living on farms suggests hearing loss can start in childhood.

McCullagh, 2011

It has been determined farmers are exposed to hazardous noise putting them at an increased risk of NIHL (McCullagh, 2011; Sliwinska-Kowalska & Davis, 2012). McCullagh (2011) conducted a single group pre- and post-test study on 32 members of a farming organization to test the effectiveness of a short intervention to increase proper use of hearing protection. Participants were at least 18 years of age, involved in farming production, and agreed to complete a post-test. The mean age of the sample was 50 years (standard deviation of 10 years) with an average of 27 years of farming experience. The pre-test included a demographic survey and the Farmers' Use of Hearing Protection Scale (FUHPS) questionnaire. The demographic survey entailed information regarding individuals, main farm products produced, years involved in farming, occupational role, age, and gender. The FUHPS questionnaire asked about history of HPD use, hearing health information sources, and the participant's functional hearing. Participants were provided multiple styles of hearing protectors via mail with instructions on proper insertion. The post-test was administered via telephone two months after the pre-test. The post-test contained the FUHPS and the Comfort and Convenience Questionnaire.

Results obtained from pre- and post-tests indicated a 44% increase in the use of hearing protection by participants. Pre-test responses indicated farming participants wore hearing protection 22% of the time when exposed to hazardous noise. Use of hearing protection significantly increased to 66% according to post-test responses ($p < 0.001$). Twenty-eight participants completed the post-test and 24 increased their hearing protection use. McCullagh (2011) indicates participants shared positive remarks about their experience. These remarks included an increased knowledge of hearing protection styles, the need to protect residual hearing, and an increased use of hearing protection.

Health Communication Science

Health communication science can be defined as the analysis and utilization of communication plans to educate and bring about change in both personal and community health behaviors. This encompasses actions and beliefs that improve health (National Institutes of Health, 2002). Health communication plans are designed to share principles at all levels of communication resources. Brochures, websites, and campaigns are materials utilized to convey health messages. Successful health communication programs implement developed research strategies to determine which tool to present to the target audience (National Institutes of Health, 2002).

Health Communication Campaigns and Programs

A health communication campaign is classified as a purposeful effort to educate and change behaviors in target audiences. Health communication campaigns add to the development of public health awareness. Communication campaigns are important elements in interventions such as tobacco use (Zhao, 2020). The National Institutes of Health (2002) outlines attributes effective health communication campaigns strive to obtain. First, the goal of the health communication program should be clearly defined. Secondly, the program should identify the aspect of the goal the communication program specifically seeks to target. Next, the objectives of the health communication plan are clearly identified. The intended audience is determined, including subgroups who would benefit from the health message. Beliefs, behaviors, attitudes, social and psychosocial environments of the intended audience should be researched prior to executing a health campaign. Next, the message and goal of the communication campaign is curated specifically for the target audience. Administrators of the health study determine channels of communication deemed trustworthy by the intended audience. Delivery of the campaign is determined by identifying the optimal time to present to the intended audience. Materials are pretested within the financial means and time restrictions of the health communication plan. Pre-test message materials are presented to a population similar in qualities to the target audience. Adjustments to the message and presentation materials should be made based on pretesting results and suggestions provided by the sample audience. Implementation of a health communication plan is then presented to the intended audience by following a developed plan, efficient communication with additional contributors, and evaluating the campaign once presented (National Institutes of Health, 2002).

Theoretical Basis of Hearing Health Promotion

Sobel and Meikle (2008) examined effective health research programs which could be implemented into hearing health promotion programs. Health communication programs monitor changes in knowledge, awareness, attitudes, and behaviors. Theories are categorized by their application to the individual, relationships between the individual and others, or the connections between people and their communities (Sobel & Meikle, 2008). Intrapersonal theories indicate how an individual’s knowledge, attitude, and beliefs influence health behaviors. Interpersonal theories evaluate how one’s relationships shape social identity, and norms, and affect health behaviors. Community level theories involve how regulations and policies impact health behaviors. (Sobel & Meikle, 2008). Intrapersonal theories include the Transtheoretical Model, the Theory of Planned Behavior, Theory of Reason Action, and The Health Belief Model.

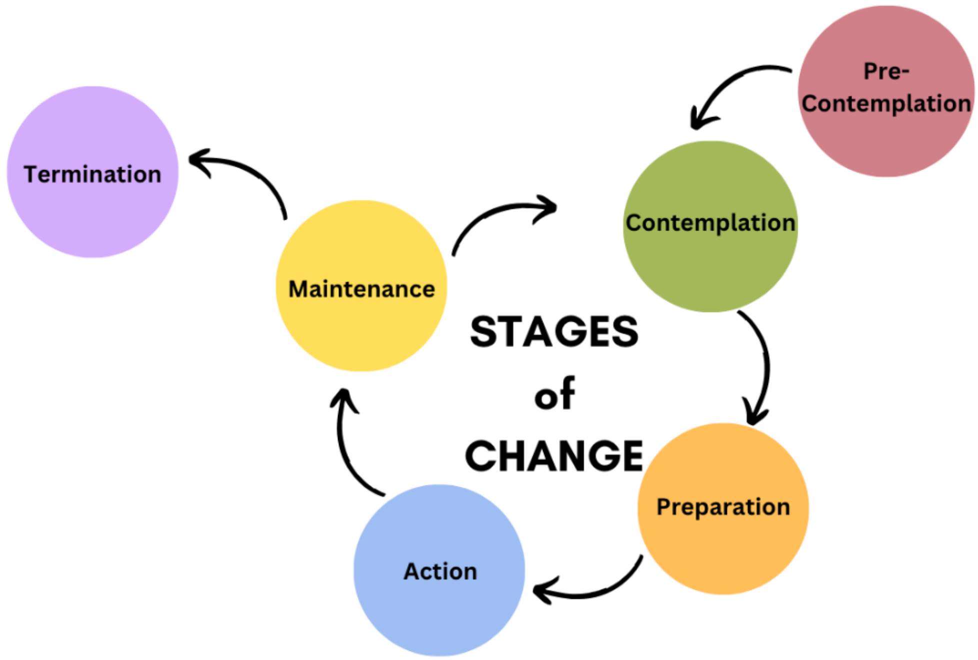
The Stages of Change

The Transtheoretical Model, also labeled The Stages of Change (Prochaska et al., 1994) is utilized to analyze an individual’s willingness to adjust their behavior. Figure 3 illustrates each stage of the model. The stages include precontemplation, contemplation, preparatory actions, action stage, maintenance stage, and termination stage. The precontemplation phase is a state of contentedness with the undesired behavior and the individual is not considering making a behavioral change. The contemplation stage occurs when the individual recognizes the risks of their behavior and plans to adjust. Preparatory actions are steps taken to change the behavior. Maintenance phase is the time the individual maintains the new behavior. The termination state occurs when the new behavior is habitual, and the former risk behavior is eliminated (Sobel & Meikle, 2008).

At that time, Sobel and Meikle (2008) suggested the public was in the precontemplation phase regarding the use of hearing protection and noise-induced hearing loss because individuals are not aware of the risks associated with exposure to excessive levels of noise. A qualitative study by Hunter (2018) examined a focus group of 28 adults ranging from 18-35 years old with no diagnosed hearing issues. Attitudes towards high noise activities, hearing protection devices and perceived risk of noise-induced hearing loss were collected and recorded in an interview format. Answers collected indicated participants perceived hearing loss as not a serious concern, hearing loss is a problem for older individuals, and there are other health risks participants place a higher priority on such as alcohol use (Hunter, 2018). This study indicates a continued need for awareness regarding noise-induced hearing loss.

Figure 3

Stages of Change



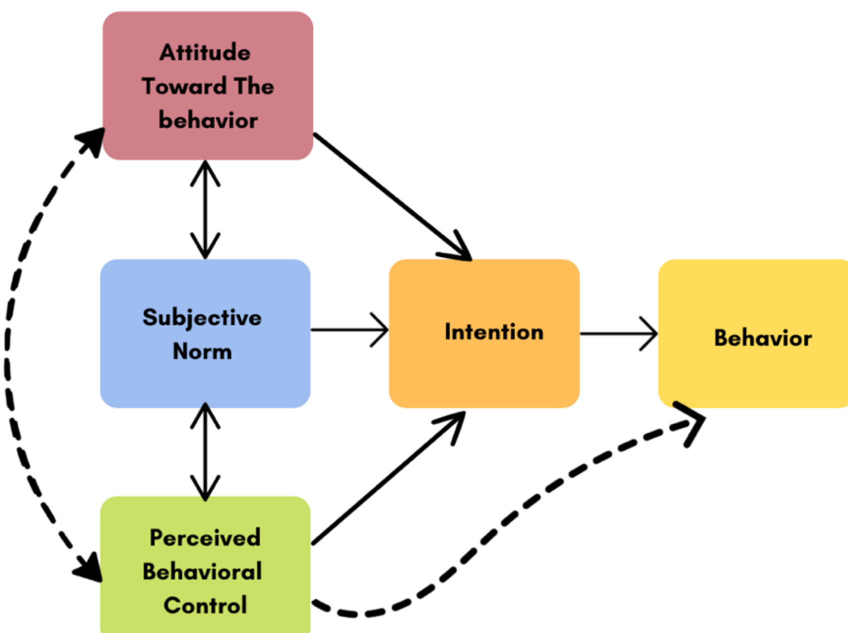
Note. Adapted from "Cycle of Change: Change promoter or benevolent fiction?", Davies. and Ashton (n.d.). Theory of Planned Behavior

Theory of Planned Behavior

The Theory of Planned Behavior is rooted in the Theory of Reasoned Action originally developed by Fishbein and Ajzen (1977). The authors identified three factors critical to planned change of risky behaviors. These constructs include the individual's attitude regarding the behavior, the perceived control the individual has over the behavior, and the perception of how peers view the behavior in question. This theory recognizes the importance of social norms and their influence on an individual's attitudes (Fishbein & Ajzen, 1977). Ajzen (1991) notes an individual's intentions are a key part of the Theory of Planned Behavior. Intentions affect the amount of effort an individual will allocate to performing a change in behavior (Ajzen, 1991). Figure 4 outlines the Theory of Planned Behavior.

Figure 4

Theory of Planned Behavior



Note. Adapted from "The theory of planned behavior", by I. Ajzen, 1991, *Organizational behavior and human decision processes*, *50*(2), 179-211.

The Theory of Planned Behavior is an expansion of the Theory of Reasoned Action. Bandura et al. (1999) theorized an individual's belief in their perceived control of the behavior played a significant factor in adjusting a behavior. Their research indicated people avoid tasks they perceive as being out of scope and gravitate towards situations in which they deem themselves capable (Bandura et al., 1999). Perceived behavior control (PBC) is a new aspect of the Theory of Planned Behavior. Authors La Barbera and Ajzen (2020) investigate the role of PBC as a mediator of attitude and subjective norms. The authors utilized three studies involving different behaviors (voting, decreasing waste, and energy use) which suggested larger PBC leads to increased importance of attitude in the estimation of the intention to change behavior. A strong PBC results in a decreased significance in subjective norms (La Barbera & Ajzen, 2020).

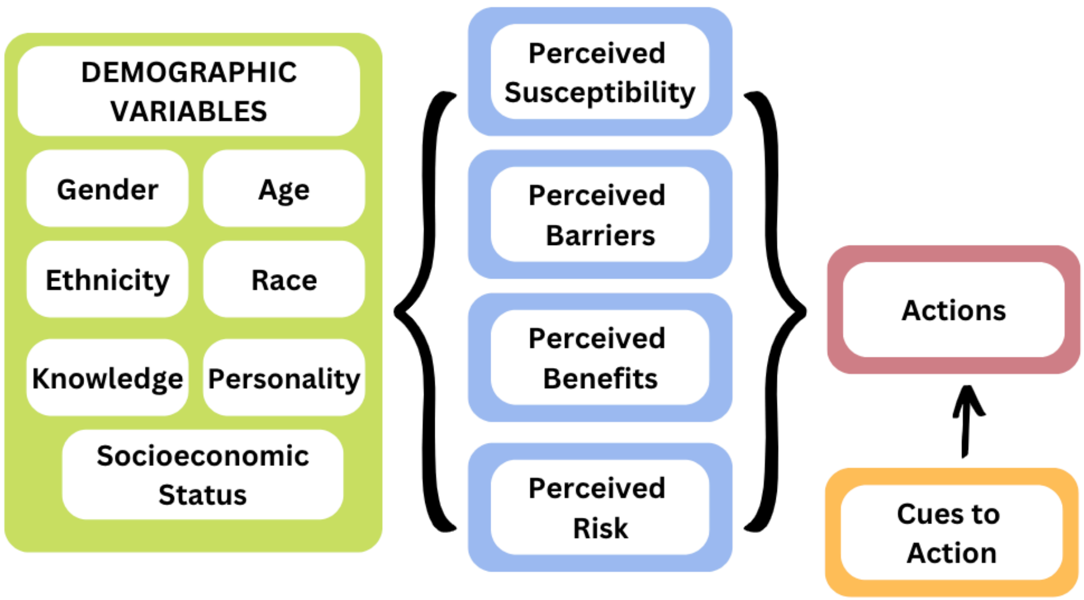
Individuals who perceive their ability to prevent noise-induced hearing loss as out of their control may be less willing to explore options to help preserve residual hearing. Self-efficacy can be strengthened when individuals share the importance of refraining from dangerous behaviors with their peers. Learning how to present avoidance techniques and practicing strategies to avoid undesirable behaviors can increase the likelihood the individual will refrain from the behavior. Success in presenting risk avoidance to peers and their adaptation of abstaining from the activity results in an increase in communication skills and the probability the social norm regarding the behavior will change (Sobel & Meikle, 2008).

Health Belief Model

The Health Belief Model capitalizes on an individual's consciousness of behaviors that put their health at risk, these beliefs potentially influence their acceptance of health promotion programs. The Health Belief Model is depicted in Figure 5. In the model, Janz and Becker (1984) address five factors that impact a person's choice to implement a health practice. The first element is perceived barriers to adapting the suggested behavior. Second, is the perception of the potential benefits which are acquired from implementing the new behavior. Next, the individual's perceived vulnerability to the risk. Fourth, the possible adverse consequences that could occur if the risk is not avoided and self-efficacy. Finally, cues from their peers and environment mold their opinion if a change of behavior is needed (Janz & Becker, 1984).

Figure 5

Health Belief Model



Note. Adapted from "The health belief model: A decade later" by Janz and Becker (1984), from Health *education quarterly*, *11*(1), 1-47.

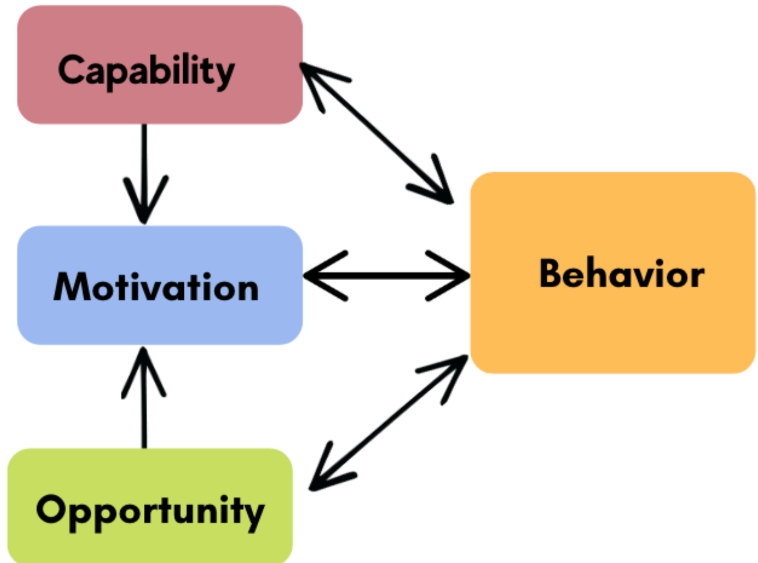
The Health Belief Model identifies topics that need to be highlighted in hearing health communication plans targeted toward youth. Media messages are designed to educate adults and children about the risks of noise exposure. (Sobel & Meikle, 2008). The Health Belief module is commonly utilized by assessing the five factors individually. Rather than examining all constructs, a single factor such as barriers to implementing the recommended behavior is investigated (Sobel & Meikle, 2008).

COM-B Theory

COM-B Theory is a model for behavior change. Behavior change interventions are described as organized activities constructed to modify a behavior routine. Behavioral interventions are utilized to endorse healthy behaviors (Michie et al., 2011). The three elements of the COM-B model that influence behavior (B) are capability (C), opportunity (O), and motivation (M). Figure 6 depicts the COM-B Theory. Capability describes a person's psychological and physical ability to participate in the activity of interest. Opportunity describes external factors which stimulate a behavior from an individual. Motivation is described as the brain activities that guide behavior (Michie et al., 2011). Capability and opportunity can both affect motivation. Performing a behavior can influence capability, opportunity, and motivation (Michie et al., 2011). West and Michie (2020) summarize the COM-B theory by stating for an individual to participate in a behavior, a person must be mentally and physically capable, be presented with the opportunity to demonstrate the behavior and feel motivated to exhibit the behavior. The COM-B model is successful because it addresses which factor needs to be altered for the intervention to be effective (West & Michie, 2020)

Figure 6

COM-B Theory



Note. Adapted from "The behaviour change wheel: A new method for 31characterizing and designing behaviour change interventions," by Michie et al., 2011 *Implementation Science*

Loughran et al. (2021) performed a study investigating targets for intervention for a population exposed to hazardous noise in recreational environments. The population consisted of 185 adults with a mean age of 36.79 who wore hearing protection and those who elected not to wear protection in the presence of recreational noise. A Chi-square, Analysis of variance, and Multivariate analysis of variance were performed to examine differences in sociodemographic factors and key factors of COM-B. Results indicated both groups felt capable and had comparable opportunities to wear hearing protective devices. Non-hearing protection users were significantly deficient in motivation ($p < 0.001$) compared to the individuals who elected to use hearing protection (Loughran et al., 2021). These results depict how motivation can influence the resulting behavior.

Social Cognitive Theory

According to Bandura (1986), the Social Cognitive Theory anticipates behavior by observing interactions occurring in the individual's social environment. The theory suggests individuals learn by observing, anticipating outcomes of behavior, practicing skills, and becoming more confident in the skills they practice. Their experiences in relation to a behavior are reinforced and the act will be strengthened. The Social Cognitive Theory stresses the need to recognize social pressures which refute the importance of health behavior (Bandura, 1986).

A study by Southall et al. (2011) recognized circumstances which prompt individuals to hide or reveal their hearing loss in the workplace. Authors identify the interaction of a social cognitive perspective and decision to inform a coworker of their hearing loss. Communication regarding how individuals learn about, understand, and choose a variety of approaches to identity management (Southall et al., 2011).

Ecological Theory

The Ecological Theory of Health Promotion evaluates health behavior at many levels including interpersonal, intrapersonal, organizational, community, and policy. In an article by McLeroy et al., (1988) these levels are discussed in depth (Figure 7). Interpersonal factors include attributes of the individual including their knowledge, viewpoints, and how they conduct themselves. The interpersonal level is comprised of social structures including family, coworkers, and friendships. Institutional factors include social institutions and the regulations of these organizations. The community element involves interactions between organizations, institutions, and networks. Finally, public policy includes laws of the local area, state, and nation (McLeroy et al., 1988).

Figure 7

Socio-Ecological Model of Hearing Health Promotion

Source. Figure 16.1 – Socio-Ecological Model of Hearing Health Promotion. By Sobel J, Martin WH. (2022). Beyond the workplace. In: *The Noise Manual,* 6th edition, edited by Meinke DK, Berger EH, Driscoll DP, Neitzel RL, Bright. Reprinted with permission from AIHA.

A study by Reddy (2014) investigated the individual and ecological influences affecting hearing protection use in manufacturing workers and how to endorse hearing protection use. The population consisted of twenty-five individuals aged 19 and 60 years old. The Ecological Model for Health Promotion was used to detect and determine behavioral manipulates throughout different areas of an individual's social surroundings. Data was collected through interviews, surveys, and an intervention. The interview distinguished barriers and promotions for the use of hearing protection. The survey was given to the entire group and included topics that coincided with questions from the interview phase. The intervention was directed by the Ecological Model and other behavior models. Results from the interview and survey revealed factors that affect behaviors of hearing protection use. Findings suggest barriers and supports of hearing protection use are influenced by intrapersonal, interpersonal, and organizational determinants according to the Ecological theory. The identified supports and barriers were used to curate an intervention curriculum. Outcomes of the intervention were successful in targeting influences affecting the use of hearing protection (Reddy, 2014). The Ecological theory can be used to create an intervention for promoting hearing protection use is effective.

Each level of the Ecological Model theory is applicable to hearing health promotion. The individual level assumes individuals hold personal beliefs, attitudes, behaviors, and level of knowledge regarding hearing health behaviors, these factors can formulate thinking on topics like preventing NIHL. The interpersonal level involves interactions between the individual and their family, friends, and other individuals in their environment. Individuals develop attitudes and behaviors based on their observations of other persons. Welch et al., (2016) explored interpersonal involvement by having high school-aged students (14-17 years) present the Dangerous Decibels program to 8- to 12-year-old students. The researchers discovered an increase in the young students' knowledge, self-reported behavior, and perceived supports surrounding hearing protection (Welch et al., 2016). The organizational level encompasses organized groups such as schools, businesses, healthcare organizations, military groups, and more. A workplace environment with noise levels above the allowed exposure limit will employ a hearing conservationist to provide solutions to bring sound levels to acceptable exposure limits (Sobel & Martin, 2022). Community Level of influence focuses on the interactions amongst organizations that collaborate to foster awareness and impact ideals at a community level. A community can be defined geographically, online, or as people who hold the same interests and values. An individual with a large social media following can utilize their online platform to share the hazards of NIHL (Sobel & Martin, 2022). The final level of the Ecological model is Public Policy which refers to laws and regulations. OSHA regulates how to prevent the risk of NIHL in the workplace and this would be an example that represents the Policy Level (Sobel & Martin, 2022).

Health communication is a consideration when developing, adapting, or delivering any public health intervention. In terms of hearing health, Dangerous Decibels is an evidence-based interactive program theoretically based in health communication science.

Dangerous Decibels® Program

The Dangerous Decibels program is an interactive, in-person program delivered to the public with the goal of decreasing the incidence of noise-induced hearing loss and tinnitus (Martin et al., 2008). Meinke et al. (2008) describe Dangerous Decibels as a unique health promotion because the goal of the program is to not only educate participants about hazardous noise and NIHL but to also alter opinions, and actions, and positively change behaviors toward promoting hearing health. Health communication sciences are implemented into the Dangerous Decibels program design (Meinke et al., 2008).

Health Communication Science Applied to the Dangerous Decibels Program

Dangerous Decibels utilizes multiple health communication theories for the purpose of educating young individuals about NIHL. A goal of the program is to change adolescent attitudes toward hearing loss prevention. The program addresses beliefs regarding avoiding hazardous noise and educates participants on how to practice healthy listening behaviors (Griest et al., 2007). Communication theories incorporated into the Dangerous Decibels program include the

Stages of Change (Transtheoretical Theory), Theory of Reasoned Action, Theory of Planned Behavior, Health Belief Model, and Social Cognitive Theory. Dangerous Decibels integrates concepts from the mentioned theories to develop a hearing loss prevention program suitable for adolescents. Components of each model contribute to the effectiveness of the Dangerous Decibels program as a hearing health intervention (Martin et al., 2008).

The program is distributed in an educational manner, utilizing research to study its effects on participants hearing health. The activities included in the Dangerous Decibels program are utilized to convey three educational messages regarding noise and hearing loss prevention. These messages include educating participants on what sources produced dangerous sound, the repercussions of being exposed to high levels of noise, and techniques for protecting oneself from excessive levels of noise (Martin et al., 2008).

The Dangerous Decibels program educates participants on sources of dangerous sounds by expanding their knowledge regarding situations which put them in proximity to high levels of sound which increases their risk of noise-induced hearing loss (Martin et al., 2008). Next, participants will recognize the worth of normal hearing sensitivity. They will be informed of the determinants of hearing loss such as the decrease in ease of communication and other enjoyable activities, such as listening to music. Finally, the program aims to educate and grow self-efficacy in strategies for protecting their hearing. These skills include turning the level of hazardous sound down, moving away from a source of dangerous sound, and the proper utilization of hearing protective devices when the prior protective techniques are not applicable (Martin et al., 2008).

Program Design

The Dangerous Decibels program is an approximately 50-minute interactive program. Dangerous Decibels is organized by eight modules designed to sequentially and effectively administer the messages of the program which include; what are the sources of dangerous sounds, what are the consequences of exposure to dangerous sounds and how do I protect myself from dangerous sounds.

Module 1: Introduction

The first module is titled "Introduction" The presenter is referred to as the Dangerous Decibel Educator. The presenter introduces themselves and shares what organization they are affiliated with. The Dangerous Decibel Educator can share an interesting personal fact and informing the purpose they are there. The three goals of the module are to define a dangerous decibel, identify the three techniques to fight dangerous decibels and provide behavioral expectations to the participants. Materials used are the Dangerous Decibels logo sign, "Decibels = Measurement of Sound" sign, a pair of earmuffs, and three caution signs signaling "Turn it Down", "Walk Away", and "Protect Your Ears". The signs should be visible to the participants and each objective discussed by the Dangerous Decibel educator.

Module 2: What is Sound?

The second module is labeled "What is Sound? The educator explains sound is energy, sound occurs when an object vibrates, and sound propagates through air molecules. Tuning fork and ping pong ball activities are utilized to demonstrate how sound is a result of vibrations and how sound is energy. The tuning fork activity allows participants to strike the tuning fork on the sole of their shoe and observe the sound and vibrations of the tines. This experiment enforces the message that sound is vibrations. The second activity demonstrates sound vibration energy can move objects. The still tuning fork has no effect when placed near a ping-pong ball on a string. Next, the participants strike the tuning fork and hold it near the ping pong ball. The sound waves cause the ball to move which demonstrates the force of sound energy.

Module 3: How Do We Hear?

The third module is entitled "How Do We Hear?" the objective of this section is to provide a basic understanding of how sound travels through the different structures in the ear to allow hearing. Educators utilize an ear anatomy poster to facilitate the explanation of the different parts of the ear and explain how humans hear.

Module 4: How Do We Damage Our Hearing?

The fourth module is "How Do We Damage Our Hearing?" The intention of this module is for participants to understand how intense sounds can produce vibrations capable of permanently destroying the hair cells of the cochlea. Materials used in this segment include a photograph of one hair cell, healthy and damaged hair cell bundle pictures, and pipe cleaners for the model of a hair cell activity. The participants are distributed 4-5 pipe cleaners to hold in their fists to resemble a healthy hair cell. Sound vibrations are enacted by the opposite hand brushing over the tops of the "hair cells". Safe sounds are modeled by gently brushing the tops of the pipe cleaners and the pipe cleaners return to their resting position without changing shape. Loud sound waves contacting the hair cells are demonstrated by rough brushing, leaving the pipe cleaners bent and damaged. The damaged pipe cleaners are then compared to the image of the damaged hair cell bundle to further illustrate loud sound can damage tiny fragile structures within the cochlea.

Module 5: What's that Sound?

The fifth module is titled "What's that Sound?" the objectives of the section are to inform participants of the effects of hazardous noise levels and experience listening with a simulated high-frequency hearing loss. Materials used in the module include a computer with internet access, speakers, projector, screen monitor, and the Dangerous Decibels -dB Zone! "What's That Sound?" application. The "What's that Sound?" activity depicts the challenge of hearing with high-frequency hearing loss. A sound is played, and a group of pictures is visible on the screen. The listeners hear the sound as if they have high-frequency hearing loss. The participants attempt to match the sound with the corresponding image. Once the correct image is identified, the sound is then toggled between the simulation of "with" and "without" hearing loss to further reinforce the differences in audibility.

Module 6: How Loud is Too Loud?

The sixth module is "How Loud is Too Loud?". The module has three objectives for the participants. The first goal is for participants to be able to identify the decibel levels of different sounds. The second objective is for participants to determine what method of hearing protection is most effective when subjected to dangerous decibels. The third topic is to address the social norms related to hearing protective techniques. Materials utilized include "How Loud is Too Loud" flashcards and an 85 dBA sign. The educator informs participants that sound levels of 85 dBA for 8 hours are classified as a dangerous decibel level. Repeated exposure to sounds at this level of intensity can potentially damage the hair cells. Flashcards are incorporated to identify different sounds and their associated decibel levels. The flashcards have pictures of different sound sources with their decibel level and the exposure limits that could result in damage to hearing if exceeded. Participants are shown a sound source and determine if the sound is categorized as “safe” or “dangerous” and identify how best to protect their hearing (walk away, turn it down, wear earplugs or earmuffs). Flashcard pictures include motorized vehicles, factories, lawnmowers, firearms, and power tools.

Module 7 A-C: Protecting Our Hearing

The seventh module is “Protecting Our Hearing” The module targets the three strategies for protecting hearing; “Turn It Down”,” Walk Away”, and “Protect Your Ears”.

Module 7A. The first technique to protect hearing is “Turn it Down” The objective of the segment is to inform the risks of listening to high-level sounds through headphones and provide guidelines for safe listening. Materials used are the “How Loud” flash card for headphones and the “Turn It Down” caution sign. The educator informs the audience that turning down music played through headphones will protect hearing and increase listening time without changing their listening enjoyment.

Module 7B. The second strategy is “Walk Away”. Participants will measure sound pressure levels with sound level meters and learn how walking away from a sound source can prevent hearing damage from dangerous decibel levels. Items needed for the module are a blender and a sound level meter (SLM). The blender and SLM activity demonstrate the concept of changing the distance from the sound sources results in a change of decibel level. When the SLM is approximately 1 inch from the blender the decibel level is hazardous to hearing (> 85 dBA). Increasing the distance between the blender and SLM results in lower decibel levels, and it can become a “safe” level (< 85 dBA). The activity demonstrates walking away from a sound source producing dangerous decibel levels can prevent harm to hearing.

Module 7C. The third technique to protect hearing is “Protect Your Ears” Objectives of this module include educating participants on correct insertion and fitting of pre-formed earplugs.

Materials needed include pre-formed earplugs for the Dangerous Decibel educator and participants, the “Protect Your Ears” caution sign, and earmuffs. The educator will inform participants to be prepared for loud sounds by having earplugs handy. The educator will demonstrate how to properly insert the earplugs. Participants will have the opportunity to practice correctly inserting the earplugs and thereby increase self-confidence and self-efficacy.

Module 8: Rock Your World: Time to Act!

The eighth module is “Rock Your World”. This section aims to discuss peer pressure associated with following safe hearing practices. Materials required include “Rock Your World” response cards and the rock concert flash card. The “Rock Your World” activity asks participants to pretend they are at a rock concert. The educator reads a scenario of a peer questioning their use of earplugs at a concert. Participants will select how they would respond from three options; (A) put the earplugs in, (B) not wear the earplugs, (C) give their peer an extra set of earplugs and explain they protect hearing. The educator will review answers with the participants while respecting all choices.

Individuals who seek to present the Dangerous Decibels program complete a two-day in-person educator workshop. The first day of training provides education on the physics of sound and hearing, physiology of the cochlea, hearing loss, standard limits for noise exposure, information on noise-induced hearing loss in youth, hearing protection devices, and strategies to avoid hearing loss caused by hazardous sound levels. The participant is also briefed on health communication theory as it applies to hearing, classroom management techniques, and an overview of the classroom program. During the second day, participants practice presenting the classroom program to small groups. This is an opportunity for the participants to practice the material and check for understanding. A course syllabus, comprehensive program guide, and educator kit complete with necessary materials, graphics, and other tools required when performing the program (Meinke et al., 2008). When an individual successfully completes the Dangerous Decibels Educator Training, they receive a Dangerous Decibel Educator certificate which allows them to identify themselves as formally trained in the program delivery. The Dangerous Decibels Educator Training is designed for teachers, nurses, high school students, audiologists, scientists, safety managers, industrial hygienists, and other individuals who desire to deliver the Dangerous Decibel program (Meinke et al., 2008). Trained Dangerous Decibel educators are equipped with the knowledge and skills to effectively present the program to students or adults.

Effectiveness of the Dangerous Decibels Program in Youth

Since its inception, several researchers, in several countries, have evaluated the effectiveness of the Dangerous Decibels program in various age groups and populations. This section will focus on the effectiveness of the program when delivered to youth.

Griest et al., 2007

Griest et al., (2007) conducted research evaluating the effectiveness the of Dangerous Decibels program in growing students understanding regarding NIHL and positively impacting their attitudes and behaviors towards hearing loss prevention. Researchers assessed 478 fourth-grade students and 550 seventh-grade students attending schools in Oregon and Washington. Classrooms participating in the study were divided into groups that received the Dangerous Decibels program, and a comparison group that did not receive the hearing loss prevention training. Study groups were comprised of 223 fourth-grade students and 284 seventh-grade students. The remaining 255 fourth grade students and 266 seventh-grade students were a part of the comparison group. Questionnaires were developed for the students in each grade and were utilized to collect baseline, post-presentation, retained knowledge, and attitudes about NIHL. Questionnaires contained themes regarding student's recent hearing health behavior and the three main messages of the Dangerous Decibels program: how loud is too loud, how hearing gets damaged, and how to protect hearing. The questionnaire includes topics on attitudes about hearing and loss prevention strategies, experiences with potentially hazardous sound exposures in the past year, and future hearing health behaviors. Students in both the study and comparison groups completed baseline questionnaires prior to the presentation of the Dangerous Decibels program to the study group. After the program had been presented to the study group students, the students completed a post-presentation questionnaire. The comparison group was not administered the post-presentation questionnaire due to not receiving the training. Three months after the baseline questionnaire, all students completed a follow-up questionnaire.

Immediate effectiveness of the Dangerous Decibels program was examined by comparing the scores of the baseline test to the post-presentation scores using paired *t*-tests. Baseline scores and 3-month post-presentation scores of the study and comparison group were analyzed to distinguish if changes in scores could be attributed to the hearing loss prevention program using independent *t*-tests and the Mann – Whitney *U* test. The long-term effectiveness of the Dangerous Decibels program was evaluated by comparing correct responses from the study baseline and 3-month post-presentation using paired *t*-tests (Griest et al., 2007).

Reports from students collected with the baseline questionnaire revealed that 80% and 90% of fourth and seventh-grade students used stereo headphones in the past year, respectively. Other sources of hazardous noise exposures included lawnmowers, concerts, motorized vehicles, and firearm use. Answers collected from the baseline questionnaire indicated that 60% of both fourth and seventh graders who participated in the study did not wear hearing protective devices when exposed to potentially hazardous sounds. Only 3% of all students reported always utilizing hearing protection in the presence of excessive noise (Griest et al., 2007).

The researchers further examined differences in responses between pre- and post-participation regarding their knowledge of hearing and hearing loss prevention in fourth and seventh graders receiving the Dangerous Decibels program and those in the comparison group. Scores from the baseline questionnaire suggest no significant differences in knowledge of hearing loss and hearing loss prevention between the study and the comparison group of fourth graders. Post-presentation and baseline responses were analyzed with paired t-tests and indicated a significant improvement $(p \leq .01)$in knowledge regarding the three educational messages. The messages include sources of dangerous sound, repercussions of exposure to excessive noise, and protective actions to avoid hearing damage. Three months post-training, fourth graders belonging to the study group retained 85.7% of the information from the presentation (Griest et al., 2007). The ability of fourth-grade students to recollect knowledge of hearing, hearing loss prevention, and sources of dangerous sounds demonstrates Dangerous Decibels as an effective tool in educating youth about dangerous sources of noise.

Baseline results from the 7th grade study and comparison group were also compared to evaluate the student's knowledge of hearing and hearing loss prevention. Results from the baseline questionnaire indicated initial knowledge of hearing and hearing loss prevention were not equivalent between the 7th grade study group and comparison group. Data collected from the study group at the post-presentation and three-month follow-up indicate growth in knowledge regarding hearing and hearing loss prevention. A difference noted by the seventh-grade student population compared to the 4th grade students was their baseline understanding of Item 6, suggesting seventh graders understand people of all ages are at risk of NIHL. Like the fourth-grade students in the study group, seventh-graders who received the Dangerous Decibels program grew in their knowledge of the three educational messages and were better able to identify sources of dangerous noise. Prior to completing the classroom training, baseline questionnaire responses of seventh graders indicated that 65.9% identified the eardrum as the structure of the ear damaged by sound, and 1.3% correctly answered damage from hazardous noise occurs at the level of the cochlea in hair cells. In the post-presentation questionnaire, 78.4% of the seventh-grade study group correctly identified hair cells as the anatomical structure damaged when overexposed to dangerous levels of sound (Griest et al., 2007). The Dangerous Decibels program is an effective resource for teaching young individuals the anatomy of the ear and how exposure to high sound levels can damage the mechanism.

Attitudes and intended behavior regarding hearing loss prevention were also examined by these researchers for all of the students participating in the research study. The researchers noted growth in knowledge and understanding does not always result in positive hearing health behavior change. In the fourth-grade student population, individuals in the study group displayed improvement in desired behaviors and attitudes towards hearing loss and noise exposure on both the post-presentation and 3-month follow-up questionnaires compared to the study group baseline responses. The fourth-grade students in the comparison group did not exhibit an improvement in desired hearing health behaviors in comparison to the baseline results (Griest et al., 2007) The improvement of attitudes towards hearing loss and noise exposure for the study group who received the training program suggests Dangerous Decibels has a positive effect on fourth-grade students' attitudes towards hearing conservation.

The seventh-grade students assigned to the study population only demonstrated an improvement in desired attitude regarding concern towards hearing loss. This finding was exhibited in the post-presentation questionnaire results. In contrast to what the researchers noted in the fourth-grade study population, attitude improvement evident on the post-presentation questionnaire was no longer observed in the 3-month follow-up, and these responses resembled the baseline results. A statement regarding whether a student would wear hearing protection to a concert was asked and 15.1% responded "yes" during the baseline questionnaire. In the post-presentation questionnaire, this response increased to 44% of the study population and lessened to 16.2% by the 3-month follow-up (Griest et al., 2007). Dangerous Decibels is effective at informing seventh-grade students about the risks of hearing loss; however, the longevity of positive attitude and behavioral changes is not the same as younger fourth grade students.

Martin et al., 2013

A randomized trial by Martin et al. (2013) examined the effects of four NIHL interventions influences on growing knowledge, attitudes, and intended behaviors concerning sound exposure and hearing protection strategies in 1,120 fourth-grade students. The four interventions included (1) Dangerous Decibels program given by high school students, (2) Dangerous Decibels program presented by the school nurse, (3) interactive on-site NIHL and tinnitus museum exhibit, and (4) virtual online museum activities. A control group received no intervention. All interventions aimed to convey educational messages (1) identify sources of dangerous sounds, (2) understand effects of exposure to hazardous levels of sound, and (3) recognize strategies to protect oneself from dangerous sounds (Martin et al., 2013).

Questionnaires were administered at baseline, post-intervention, and three months post-intervention. Questionnaires evaluated retained knowledge, attitudes, and intended behaviors pertaining to noise exposure and implementation of hearing protective tactics. The four intervention groups completed the three questionnaires. The control group completed the baseline and 3-month follow-up questionnaires. Student's answers from the baseline questionnaire revealed no significant differences in correct answers for intervention groups and the control group based on Wilcoxon signed ranked test (Martin et al., 2013).

Effectiveness of each intervention was determined based on correct answers to questions associated with to use of hearing protection. The Dangerous Decibels program presented by a school nurse resulted in positive improvements (p-values ranged from $<.001$ to $<.05$) observed between baseline and post-intervention correct questionnaire answers for all 11 knowledge-based questions. At the 3-month follow-up 9 of the 11 correct answers were maintained (p-values ranged from $<.01$ to $<.05$). Similar results were observed when the classroom presentation was delivered by high school students with significant improvements (p-values ranged from $<.001$ to <0.5) observed in 10 of 11 questions. Results were maintained at a 3-month follow-up for 8 of the 11 questions. Positive improvements were noted when the classroom program was presented by a school nurse ($p= <.01$) and when administered by the high school student (p-values ranged from $<.001$ to $<.01$). Correct answers for intended behavior questions were maintained for 1 of 2 questions with the school nurse ($p=<.01$) and 2 out of 2 questions when the high school student educator ($p= <.01$). The museum exhibit was found to be the least effective intervention compared to the other methods and only knowledge-related correct answers were observed at the 3-moth follow-up. Immediate improvement in knowledge and intended behaviors was observed for the virtual online exhibit. A significant positive change in attitude ($p= <.01$) was noted for 1 of the 2 related questions but was not maintained at the follow-up. None of the 3 constructs were maintained at the 3-month follow-up after the virtual exhibit intervention (Martin et al., 2013).

The authors concluded classroom presentations integrate interactive dialog between students and educators and demonstration, rather than self-lead learning. The classroom interventions guaranteed the three educational messages were delivered to students. These researchers note that while classrooms were the more successful method of intervention, the level of impact they have on a population is limited to the individuals in the classroom. The museum site reported approximately 600,000 visitors yearly making the potential impact larger. Internet education activities can introduce hearing health messages to individuals but requires advertising to direct participants (Martin et al., 2013).

Interventions are effective in educating elementary students on dangerous noise exposure and proper use of hearing protection, specifically classrooms delivered by older peers compared to a museum exhibit or an online educational activity at post and 3-month follow-up (Martin et al., 2013)

Welch et al., 2016

The Dangerous Decibels program delivered by teenagers to an audience of younger children was evaluated in a quantitative study by Welch et al., (2016). The researchers hypothesized teenagers trained in the Dangerous Decibels program would adopt the messages delivered and better their own hearing health behaviors. Participants consisted of 44 teenagers 14-17 years old. Teenagers completed the two-day Dangerous Decibel Educator training administered by university-educated individuals with experience in audiology, hearing science, health promotion, and occupational health safety. The second training day entailed participants presenting the classroom program to the researchers and other participants. Researchers were interested in teenager retention and application of hearing-health messages from presenting the Dangerous Decibels program. Participants completed questionnaires before the training, directly after, and three months later after the student had presented the Dangerous Decibels program. The initial questionnaire was administered during the first day of ‘Educator’ training.

Questionnaires were comprised of 21 questions, measuring five subscales associated with NIHL. Topics of questions related to knowledge, behavior, attitude, supports for utilization of hearing protective devices, and barriers related to hearing protection. Questions pertaining to exposure to noise in the past year was included. Questions relating to behavior were adapted in the post-training questionnaire due to participants not being subjected to noise exposure during the training. Baseline and 3-month follow-up questionnaires inquired about participants' behavior in the presence of hazardous noise. The post-training measurement questioned their anticipated behavior.

Teenage participants visited local primary and intermediate schools to present the Dangerous Decibels program to 8–12-year-old students. The teenage educators typically presented the program with a partner. A focus group comprised of six of the participants occurred three months after the program training to collect qualitative data. Responses were collected to obtain perceptions of teenage participants. Questions directed towards the focus group were used as prompts for the group discussion:

- What aspects of the program training did you find enjoyable?
- Is there anything you found unclear or felt could have been approached differently?
- In what ways do you believe your awareness of NIHL has developed?
- Do you utilize HPDs or employ other strategies to protect your hearing?
- What were your experiences delivering the program to younger students?

Responses to questions were recorded via digital voice recorder, transcribed, and coded for data analysis. Data was analyzed ANOVAs for the five measures: knowledge, attitudes, behaviors, supports, and barriers. The scores from pre-training, post-training, and three-month follow up were recorded and handled as repeated measures. Data from the focus group were reviewed and assigned qualitative coding to denote themes within responses (Welch et al., 2016).

Results from the pre-training survey revealed prevalent exposure to possible dangerous noise in the year before. Forty-five percent of the 44 teenage participants reported exposure to loud sounds resulting in ear ringing or pain. 23% indicated they had not been exposed to harmful noise. 32% said they were unsure of exposure to dangerous noise (Welch et al., 2016).

Knowledge scores collected after the training showed improvement compared to pre-training knowledge scores (p=.005). The growth in knowledge was maintained at the three-month follow-up. Data collected from the three questionnaires at pre-training, post-training, and three-month follow-up concerning attitude towards noise and hearing protection device use showed no significant improvement ($p = 0.518$). Self-reported behavior scores improved at post-training and were maintained in results from the three-month follow-up questionnaire ($p < 0.001$). Supports to practice safe hearing-health behaviors increased in post-training results. The increase in mean score for perceived supports was also sustained at three-month follow-up ($p < 0.001$). No change was observed for barriers related to practicing safe hearing-health behaviors after the completion of the Dangerous Decibels program ($p = 0.428$) (Welch et al., 2016).

Responses obtained from the focus group discussion recognized five themes and were connected to the four levels of the ecological model. Training and personal development were connected to the intrapersonal level of the ecological model. Delivering the Dangerous Decibels program linked to the interpersonal level. Organization of the program related to the organizational level and community and social pressures associated with the community level of the model.

Being Trained

Teenage participants of the focus group reported enjoying partaking in the training and learning about NIHL and practicing good hearing health behaviors. The focus group reported presenting the program to other participants and staff during the second day of training increased their confidence to present at schools. The focus group noted the training is comprehensive and a large amount of detail is presented in a short amount of time (Welch et al., 2016).

Personal Development

Participants indicated their attitude concerning noise exposure and NIHL had been affected as an outcome of participating in the Dangerous Decibels program. A focus group member stated, "I'm more worried about losing my hearing" after participating in the training (Welch et al., 2016).

Delivering Training

Teenage Dangerous Decibel Educators were recommended to present the program in partners or small groups to increase confidence and provide support. Discussion revealed some participants enjoyed working as a team, while other members reported their partner did not know the material. Resource packs were provided with module cue cards to remind presenters what to discuss and demonstrate in each module. Focus group discussions agreed the cue cards were helpful resources. Teenage Educators stated intermediate students (ages 11-12) were not as engaged as primary students (8-10) in terms of their questions and interest (Welch et al., 2016).

Organization of the Program

Scheduling difficulties were noted in arranging for teen Educators to present to primary school students. Difficulties in organization resulted in unsatisfactory experiences for the presenters. Remarks included students suggesting going to present to schools quicker and others stated they forgot they were required to present the program to primary and intermediate students (Welch et al., 2016)

Community/Social Pressure

Discussion of focus groups suggested participants encourage others to practice healthy hearing behaviors. Teenagers indicated telling parents to wear hearing protection when using loud equipment and to turn down loud music. Wearing hearing protection at a concert was noted as a social barrier to protecting hearing due to not wanting to appear different (Welch et al., 2016).

Quantitative data from the pre-training, post-training, and three-month follow-up questionnaire showed statistically significant and maintained improvements in teenagers' knowledge, behavior, and observed supports for protecting hearing. No significant differences were reported in attitudes or barriers to hearing protection use. Qualitative data collected from the focus group revealed the training was recognized as being helpful and a positive experience. Improvements in the presentation of the training material and organization of primary school presentations were noted (Welch et al., 2016). The study suggests teenagers retain healthy hearing behaviors when they participate in the Dangerous Decibel program training and present the material to younger school-age students.

Effectiveness of the Dangerous Decibels Program in Adults

Reddy et al., 2017

A study by Reddy et al. (2017) examined the adaptation of the Dangerous Decibels program for 56 adult manufacturing employees. The objective was to adapt a hearing health promotion program directed by an ecological model and evaluate the effectiveness of fostering hearing health practices in a workplace environment (Reddy et al., 2017).

Adaptation of the program included modifying school-based components, objectives, activities, and manuals to accommodate the workplace setting. Nine modules were integrated into the adaptation. Adaptations of Module 1 included information specific to the industry including the prevalence of NIIHL in manufacturing workers. Importance of workplace techniques for managing noise exposure including engineering, managerial, and hearing protection device use was incorporated. Additional key messages to “walk away”, “protect your ears”, and “turn it down” included “eliminate”, “isolate”, and “minimize” noise exposure. Three additional caution signs were incorporated to communicate the three new key messages. No adaptations were made to modules 2 or 3 which highlighted the physics of sound and energy and the hearing process. Module 5 discusses the effects of hearing loss and uses hearing loss simulation software to exhibit the results of hearing loss. The workplace adaptation recognized emotional factors associated with hearing loss and quality of life. Employees shared family and friend involvement and the simulator determined how communication can be affected by hearing loss. Module 6 focused on the decibel levels of the work environment. The 85 dBA level for safe sound and lowering contact with noise were highlighted. Workers participated in the flash card activity depicting decibel levels of tools and other machinery industry employees operate. Module 7 covers sound measurement and utilizes an SLM and power drill to display dangerous noise levels. Further conversation included machinery producing different levels of noise when operated on various substances like wood or metal. Module 8 focuses on the proper application and use of HPDs. The school-based design of practicing correct insertion of HPDs was performed amongst the workers. Additional direction utilizing earmuffs with hats and long hair was given to maintain integrity of HPD. Workers were motivated to ask employers for quality HPDs. Module 9 promotes demonstrating hearing-health behaviors in the workplace.

Adaptations included employees evaluating personal and coworker behaviors concerning wearing hearing protection in the presence of hazardous noise levels. Workers completed a hearing protection questionnaire to evaluate supports, barriers, knowledge, attitudes, and behaviors toward hearing protection (Reddy et al., 2017).

Results collected from the questionnaire indicated the adapted Dangerous Decibels program for workers led to significant improvements in worker knowledge ($p < 0.001$), attitudes ($p = 0.002$), and behaviors ($p = 0.00$)1 for the hearing-health program, The adapted Dangerous Decibels program was received by the study population and proved successful in advancing hearing-health practice in the workplace. The ratio of supports for hearing protection increased and barriers were reduced after participating in the Dangerous Decibels program ($p = 0.01$) (Reddy et al., 2017). These results indicate the Dangerous Decibel program is effective in promoting hearing-health behaviors when adaptations to the program are implemented for workers.

Welch et al., 2019

The Dangerous Decibel program was adapted to recreational activities. A leisure environment that subjects both participants and employees to potentially hazardous levels of noise are nightclubs. Welch et al. (2019) evaluated 20 individuals employed as bar staff, DJs, and security in New Zealand nightclubs. Participants were assessed using the Hearing Protection Assessment (HPA-5) evaluating supports and barriers to practicing safe hearing health, knowledge, attitudes, and behaviors regarding hearing and hazardous sound exposure. Participants were presented the Dangerous Decibels workplace program (Reddy et al., 2017). Administration of the HPA-5 occurred before the participants completed the adapted program, a week after completion, and three months post-presentation. Responses obtained from the questionnaire indicated that supports-to-barriers of hearing protection improved at the one-week evaluation and proceeded to improve at the three-month follow-up. Knowledge of hearing, hearing loss, and noise exposure grew in both post-presentation questionnaires. Participant attitudes and self-reported behaviors toward hearing loss and noise exposures did not change (Welch et al., 2019). The workplace adaptation of the Dangerous Decibels program suggests improvements in knowledge and support to barriers to practicing good hearing health. However, there was an absence of change in attitudes and more investigation needs to occur to address this component.

Nosa et al., 2021

The effects of recreational noise and NIHL on the youth population were further examined by Nosa et al., (2021). An adapted version of the Dangerous Decibels program was delivered to Pasifika University students. The goal of the study was to improve the student's knowledge, attitudes, and behaviors toward hearing, loud sounds, and hearing conservation. A sample of 25 students participated in the study. Participants completed the adapted Dangerous Decibels program and pre and post-test questionnaires. A distribution test was performed on the data collected from the pre-and post-questionnaires. A Wilcoxon signed-ranks test was utilized to assess the null hypotheses due to no difference between the post and pre-training questionnaire scores. Post-test results indicated the Dangerous Decibels program training helped improve the Pasifika student's knowledge, attitudes, and behaviors. Nosa et al. (2021) recognize further studies on hearing conservation in the Pasifika youth population are needed. The research supports the effectiveness of adapting Dangerous Decibels programs to specific populations.

Lacerda et al., 2021

The ecological model was used to assess the effectiveness of the Brazilian version of the Dangers Decibels program when administered to noise-exposed meat packing employees. Participants were separated into two groups. Group one consisted of 132 participants divided into 6 subgroups who received Dangerous Decibels educational intervention adapted to workers (Reddy et al., 2017). Group two had 138 participants separated into 5 groups who completed a conventional educational intervention (Lacerda et al., 2021). The HPA-5 was administered pre- and post-interventions. The five dimensions (attitudes, behavior, knowledge, supports, and barriers) were evaluated using the *t*-test for paired data (<0.05).

Results from HPA-5 indicated improvements in perceived barriers, supports, knowledge, attitudes, and behaviors. Responses from post-intervention questionnaires revealed Dangerous Decibels educational intervention participants had greater improvements in knowledge, attitudes, and behaviors compared to conventional educational intervention participants (Lacerda et al., 2021) Improvements in the five dimensions shows the Brazilian version of the Dangerous Decibels program is effective when administered to workers at risk of noise-exposure.

Effectiveness of Dangerous Decibels Program Co-Administered to Adults and Youth

Researchers have investigated if parental involvement in the Dangerous Decibels presentation affects the hearing health program. This approach provides an opportunity to reach a broader audience and influence the hearing health behaviors of family members.

Clark, 2013

Clark (2013) studied the effectiveness of Dangerous Decibels program when administered to both children and parents in a study group. The author utilized baseline, post-presentation, and 3-month follow-up questionnaires to determine the effectiveness of the

Dangerous Decibels program. The results from the surveys were analyzed to compare responses from students who received the Dangerous Decibels program with or without parental engagement (Clark, 2013).

Participants were 45 pairs of parents and children between 8-12 years of age. Twenty-two of the pairs were in the experimental group (parent and child received Dangerous Decibels program) and the remaining 23 were in the control group (child only received Dangerous Decibels program without a parent present). Parents and children of both groups completed the baseline questionaries. Children in both groups completed the post-program questionnaire as well as parents in the experimental group. At the 3-month follow-up, both the parent and child in the control group and experimental groups completed the survey. The surveys assessed the participants' knowledge, attitudes, and behaviors regarding hearing loss prevention and NIHL and was adapted from Martin et al., (2013).

Results indicated differences between knowledge attitudes and intended behaviors of the experimental and control groups. Responses obtained from parents and children who both received the Dangerous Decibels program benefitted from the hearing health promotion program. Statistical significance $p \leq .05$ was observed for questions like "I will use hearing protection when I use a lawn mower" which was not observed in the control group. Results from surveys indicate parents in the experimental group maintained desired behavioral changes at the 3-month follow-up time point (Clark, 2013). The Dangerous Decibels program can be successfully delivered to students and their parents and can have positive effects on their knowledge, attitudes, and intended behaviors regarding NIHL and hearing loss prevention.

Bramati et al., 2020

An intervention study utilized the Dangerous Decibels program to present to eight refrigeration company employees and their 16 children (Bramati et al., 2020). The Dangerous Decibel program intervention material was appropriate for parent and child understanding. The Dangerous Decibel program was presented to the company's corporate team including managers, an audiologist, a nurse, and an engineer. Participants were selected by leadership role and work area. Participants were asked to promote the program to their children. The event included a conversation meeting with children and parents, the children learned about the work environment, noise and NIHL, a production tour, a presentation of the Dangerous Decibel program, a management speech on the importance of hearing health, a snack, and a closing. The intervention used educational material from the Dangerous Decibel program. Conversation during the meeting revealed children had little knowledge of the parent work environment. The conversation indicated children and parents of the refrigeration company had limited knowledge of NIHL and the effects of occupational and leisure noise including toys, music, and use of headphones. Participants expressed inadequate knowledge about hearing protection.

Bramati et al. (2020) reported the program was effectively received by participants. The production tour allowed participants to experience noise exposure in the workplace and preventative protocols were implemented. The Dangerous Decibel program was an interactive way for participants to receive educational information. Participants stated to the manager they would share knowledge about hearing health to other co-workers, friends, and family members. Bramati et al. (2020) concluded the Dangerous Decibel program is an effective intervention strategy for promoting hearing health when jointly presented to workers and their children.

Health Communication and Dangerous Decibels

The Dangerous Decibels program utilizes health communication models to effectively deliver information to individuals about how to prevent the development of noise-induced hearing loss and tinnitus (Martin et al., 2008). Rimal and Lapinski (2009) acknowledge information from health communication models do not fit every social group. Meaning gleaned from health communication messages is done at an individual level (past experiences, beliefs, knowledge, etc.) and the group level (cultural patterns, social norms, etc.) It is noted that incorrect interpretations of the information can occur when not directed towards a specific target audience resulting in discrepancies (Rimal & Lapinski, 2009). An adaptation of the Dangerous Decibels program is needed to effectively communicate to youth in farming the dangers of hazardous noise and how to protect their ears from noise-induced hearing loss.

Summary

Sensorineural hearing loss can result from prolonged exposure to excessively loud sounds, causing damage to the cochlear hair cells. Youth residing or working on farms face an increased risk of noise-induced hearing loss due to their exposure to loud farm-related noises like agricultural machinery and livestock. To mitigate this risk, health communication sciences can be employed to disseminate vital health messages to young individuals in the agricultural community, focusing on education and prevention of hearing loss. Health communication science encompasses various strategies and tools such as brochures, websites, and campaigns, with effective programs being research-driven, aiming to tailor their approach to specific target audiences. The Dangerous Decibels program is grounded in health communication theories and seeks to reduce noise-induced hearing loss and tinnitus by educating the public and promoting positive hearing health behaviors. The program emphasizes three key educational messages: informing participants about the sources of dangerous sounds, highlighting the consequences of high noise exposure, and educating individuals on hearing protection techniques, including adjusting sound levels, distancing from noisy sources, and using hearing protective devices (Martin et al., 2008). This program has proven effective in educating youth about noise-induced hearing loss and promoting healthier hearing practices in adults and youth.

The Dangerous Decibels program effectively imparts knowledge on preventing noise-induced hearing loss and tinnitus by employing health communication models (Martin et al., 2008). Nevertheless, health communication messages may not universally resonate with all social groups due to the influence of individual and group-level factors, such as past experiences, beliefs, and cultural norms (Rimal & Lapinski, 2009). Therefore, it becomes crucial to customize an adapted version of the Dangerous Decibels program to effectively raise awareness among young individuals in agriculture, addressing their specific risks associated with exposure to loud noises and educating them on hearing protection measures.

CHAPTER II

ADAPTATION OF THE DANGEROUS DECIBELS PROGRAM

Rationale for Program Adaptations

Health communication is most effective when the message is tailored to a specific target audience. Overlooking an audience's individual experiences, beliefs, knowledge, cultural patterns, and social norms can result in the intended message of the health communication being misinterpreted (Rimal & Lapinski, 2009). The message of a health communication program needs to be tailored to yield desired behavioral changes. The Dangerous Decibels program has previously been adapted for relevancy to target audiences to effectively inform individuals of a specific group about preventing noise-induced hearing program (O'Dorisio, 2018; Wise, 2016). There is a need to tailor the Dangerous Decibels program to youth in a farming community due to their unique sources of sound exposure in their community and living environments.

Previous Adaptations of the Dangerous Decibels Program for Target Populations

Based upon the successful results observed from the general Dangerous Decibels program in educating youth and adults about hearing health promotion and prevention of noise-induced hearing loss has led to modifications of the program for specific audiences. The Dangerous Decibels program has been adapted to unique youth populations including youth firearm users (Wise, 2016) and children from military families (O'Dorisio, 2018).

Youth Firearms Users

A capstone completed by Wise (2016) incorporated firearm-specific content to the Dangerous Decibels program and investigated the effectiveness of the adapted program in changing the knowledge, attitudes, and intended behaviors regarding recreational firearm sound exposure in youth participants of recreational shooting. Adaptations made accounted for maintaining overall program length and preserving the core content of the original program (Wise, 2016).

Modifications to the Dangerous Decibels program included changes to the program and materials utilized. Adaptations that were made for this specific target population included changes in the areas of firearm-specific sound pressure levels, increased risk of hearing loss from firearms, and integration of personal recreational firearm shooting experiences. The goal of the adapted program was to change knowledge, attitudes, and intended behaviors about dangerous firearm sound exposure and the proper choice and utilization of hearing protectors. (Wise, 2016).

The first adaptation to the program for recreational firearm users included an additional activity to section four which recognizes how hazardous noise can damage hearing. The original modeling of hazardous sound damaging hair cells represented by pipe cleaners was kept. In the adapted program the educator demonstrates how the impact of unprotected exposure to a high-impact noise like a gunshot can permanently damage ears. This acoustic trauma caused by a hazardous noise was modeled by hair cells (pipe cleaners) being completely sheared off by an impact noise (gunshot). A microscopic photo was presented to further help participants visualize the permanent damage of high-level exposure (Wise, 2016).

The second adaptation occurred in section six “How Loud is Too Loud”. Three additional sound source flashcards were incorporated including a pistol, rifle, and shotgun. The peak SPL for each firearm was labeled on the back of the card. The traditional Dangerous Decibels program only included a shotgun flashcard which may or may not be used in the classroom program depending on the culture of the school community concerning discussing recreational firearms. The goal of adding a variety of firearms was to communicate that all types of firearms can cause NIIHL (Wise, 2016).

Adaptations to section seven communicated to participants that only scientists with specialized equipment can accurately measure the noise emitted by a firearm (Wise, 2016) Section eight reviews the selection and proper wear of HPDs. Adaptations were made to educate participants on electronic and passive HPDs for shooting sports. Students were provided hands-on experience with electronic earmuffs with microphones that automatically shut off when a high-impact noise is present. Passive earmuffs and earplugs were also passed around. The goal of discussing different types of HPDs was to increase use rates and prevent NIHL in the target population (Wise, 2016)

Section nine in the Dangerous Decibels program is a scenario activity called “Rock Your World” where participants think about how they would behave at a concert. The scenario was changed to a shooting range outing with friends to better apply to the target population. Changes to this section were intended to address social pressures and promote HPD use in recreational shooting sports. (Wise, 2016).

Participants (10-15 years of age) were members of youth organizations with recreational shooting activities Effectiveness of the adapted Dangerous Decibel program was determined by evaluating baseline, post, and three-month follow-up questionnaires. The questionnaires monitored changes in knowledge, attitudes, and intended behaviors of youth recreational shooters concerning NIHL and tinnitus. Questions included history of hazardous noise exposure, knowledge of hearing, identifying noise risks, and choosing hearing protection. Adapted questions for the target population included HPD use while hunting and or target shooting, knowledge, and use of electronic HPDs, and attitudes and intended behaviors regarding HPD use in the presence of recreational firearms (Wise, 2016).

Military Youth

O'Dorisio (2018) investigated the effectiveness of a modified Dangerous Decibels program presented to fourth-grade children from military and non-military families. The study population included fifty-three fourth graders from four separate classrooms recruited from a school located near an Air Force base. Adaptations to the original Dangerous Decibels program were implemented to tailor the information to the population of children from military families. Adaptations included sound pressure levels and exposure time for military noise sources were added into the flashcard activity, differentiating acoustic trauma from gunfire, and including a demonstration of electronic HPDs. The adaptations were made with consideration of the overall length of the program to maintain the 50-minute time course. Therefore, this researcher found it necessary to substitute or replace minor components of the program and strived to maintain the overall intent of the program. The research study was designed to investigate the effectiveness of the modified Dangerous Decibels program.

An online web-based survey was used to collect questionnaire responses regarding the student's knowledge, attitudes, and intended behaviors related to the prevention of NIHL. Students were surveyed at three time points; pre-presentation, post-presentation, and at 3-months (O'Dorisio, 2018). The students' responses to questions regarding knowledge, attitude, and intended behaviors regarding hearing health were combined to formulate an overall score to quantify the effectiveness of the Dangerous Decibels program. A score of 37 was the lowest possible score and 111 was the highest score that could be awarded. A higher cumulative score suggested greater effectiveness of the program.

Fifty-three students from fourth-grade classrooms were recruited to participate in the study. The researcher separated the students into two experimental groups of military-family students (21 %, n=11) and non-military family students (79%, n=42). All students received the adapted Dangerous Decibels classroom program. For program delivery, participants were combined within their usual 4^{th}-grade classroom. Pre- (baseline) and post-surveys were completed immediately before and after the delivery of the classroom program using school computers. The 3-month surveys were also completed in the classroom setting.

Data analysis compared survey responses for each participant from baseline to post, baseline to follow-up and post to follow-up. No significant differences were found between children from military families and those from non-military families when comparing overall scores, or changes within each construct; knowledge, attitudes, and intended behaviors. After combining the groups of children, a post-hoc- t-test was applied to evaluate the variations in scores between the pre-, post-, and 3-month follow-up questionnaires. Results revealed statistically significant differences amongst the means from baseline test (89.8 ± 8.1) to post (105.2 ± 6.1), baseline (89.2 ± 8.5) to follow-up (97.7 ± 9.1), and post (104.5 ± 6.3) to 3-month follow-up(97.7 ± 9.1). Significance for each comparison was attained with $p<.05$. The mean scores of the post-test and 3-month follow-up test were greater than the baseline. Results indicate improved scores between baseline and 3-month follow-ups are significantly different, however, there was a decrease from the improvement of average scores seen in baseline to post-test. Outcomes from all three measures indicate that the adapted Dangerous Decibels program is effective for both military and non-military fourth-grade students. The Dangerous Decibels program modifications for O'Dorisio (2018) and Wise (2016) are summarized in Table 1.

Table 1

Summary of Dangerous Decibel Program Adaptations

Module Number	Dangerous Decibels Program Module		Adaptation for Youth from Military Families	Adaptation for Youth Firearm Users
1	Introduction		No Adaptation	No Adaptation
2	What is Sound?		No Adaptation	No Adaptation
3	How Do We Hear?		No Adaptation	No Adaptation
4	How Do We Damage Our Hearing?		Acoustic Trauma: unprotected firearm and explosions	Added Acoustic Trauma using pipe cleaners & scissors to shear off the hair bundles
5	What's that Sound?		No Adaptation	No Adaptation
6	How Loud is Too Loud?		Added Military Noise flashcards	Added Pistol, Rifle, and Shotgun flashcards
7	How Loud is Too Loud?	7A: Turn It Down	No Adaptation	Specialized Equipment for Measurement
		7B: Walk Away	No Adaptation	No Adaptation
		7C: Protect Your Ears	Electronic & combat arms ear plugs	Electronic & Passive HPDs
8	Rock Your World: Time to Act!		No Adaptation	Shooting range scenario

Note. Dangerous Decibel adaptations from O'Dorisio (2018) and Wise (2016).

Dangerous Decibels Adaptations for Youth on Farms

As mentioned previously, there is a need to adapt the Dangerous Decibels program to youth in farming and provide a hearing health communication program tailored to this specific target population. Adaptations incorporated into the Dangerous Decibels program were made in consideration of the original time length of the program (45-50 minutes) with and intent to limit any additional time being added to the overall program length. The adaptations that are suggested stive to preserve the integrity of the original program, keep specific content areas included in modules, and maintain related learning activities.

Changes to the Dangerous Decibels Program and Materials

Module 1: Introduction

Ideally, the program will be delivered to youth in the farming community by someone with direct ties to that community. The first adaptation to the Dangerous Decibel program for youth in farming will occur in module 1, “Introduction”. The program will maintain the initial greeting from the Dangerous Decibel Educator with the addition of how the individual is connected to the farming community. This can be achieved by the Dangerous Decibels educator sharing ties to agriculture including growing up on a farm, working on a farm, raising livestock, or past involvements in agricultural organizations. Informing the audience of the educator’s connection to the farming community develops the credibility of the educator in informing youth in farming about the dangers of hazardous noise exposures.

Module 2: What is Sound?

No adaptations will be made to Module 2, “What is Sound?”. The module lesson will teach youth in farming that sound is energy which is made when objects vibrate. No alterations are needed to this module as the physical principles of sound do not change. An in-depth description of Module 2: What is Sound can be found on page 36.

Module 3: How Do We Hear?

Similarly, no adaptations will be made to Module 3 “How Do We Hear?” for the farm youth population. The information within this module will remain unaltered because the process of sound transmission through the auditory system remains consistent regardless of the audience to which the material is presented. A detailed description of the contents of the module can be found on page 37.

Module 4: How Do We Damage Our Hearing?

The addition of acoustic trauma will be implemented into Module 4 “How Do We Damage Our Hearing?” similar to the Wise (2016) adaptation. The purpose is to inform students very high-level noise, like that from firearms, can damage hair cell bundles instantly. This is important because many rural youths use firearms for hunting or controlling livestock predators on the farm. The educator will begin the module by showing the farm youth an image of a hair cell body and hair bundle. Students will learn damage caused to hair cells by sound vibrations is irreparable. The model hair cell activity will be maintained. The students will use their fists to represent the body of a hair cell and pipe cleaners to represent the hair bundles. Youth will learn that straight pipe cleaners represent healthy hair cells. The educator will tell a story of a typical day with farm noise exposure and instruct farm youth to run their hands over the top of the pipe cleaners to represent sound vibrations shearing the hair bundles. Students will lightly run hand over pipe cleaners for safe levels of noise such as feeding the barn cats. The rate the student brushes the pipe cleaners will increase when the level of noise depicted in the story becomes more intense like a lawnmower. The students visually see the pipe cleaners are no longer straight and cannot return to their original state. This model represents how hair cells behave when damaged by hazardous noise. The addition of acoustic trauma will include an image representing acoustic trauma and additional modeling using the hair cell models. The educator explains the possible effect one unprotected exposure to high-level impulse noise from an object like a firearm can have on the hair cells. The acoustic trauma will be demonstrated by the educator holding pipe cleaners (hair cell bundle) and showing with scissors (gunshot) how the pipe cleaners can be broken and sheared off by a single gunshot. A microscopic image of sheared-off inner hair cells assists in students visualizing damage that could result from high-level impulse noise.

Module 5: What's that Sound?

Module 5 "What's that Sound?" will maintain the activity from the dBZone! available on the Dangerous Decibels website (http://dangerousdecibels.org/exhibit/virtual-exhibit/). The purpose of this module is to allow students to experience how difficult it is like to identify different sounds with high-frequency hearing loss. In addition, a hearing loss simulator was used to create additional farm-related sounds, including cattle, chickens, and pigs. Heavy farm equipment will be incorporated (e.g., tractors, combines, mowers, and safety phrases including "Watch out!", "Get out of the way!" and "Close the gate". Additional farm theme phrases including "Why did the chicken cross the road?" and "Till the cows come home" and "Old McDonald Had a Farm" will be included during the segment. These .wav files were recorded with and without high-frequency filtering and can be played on a computer coupled to a speaker system.

Module 6: How Loud is Too Loud?

Module 6 entitled "How Loud is Too Loud?" will maintain educational objectives by having students associate different sounds with their respective decibel levels via the flashcard activity. Students will be reminded of the definition of a decibel and informed they can listen to a sound with a level of 85 dBA for 8 hours. Students will learn sound levels greater than 85dBA are considered dangerous decibel levels. Pre-existing flashcards included in the Dangerous Decibels flashcard deck will be used during the activity. Table 2 displays the pre-existing Dangerous Decibels flashcards that are agricultural-related noise exposure sources, the associated noise level (dBA), and the length of safe exposure according to NIOSH (1998).

Table 2

Existing Dangerous Decibels Farm Noise Flashcards

Noise Source	Noise Levels (dBA)	Length of permissible exposure
All-Terrain Vehicle	105	5 minutes
Chainsaw	110	1 minute 30 seconds
Generator	98	24 minutes
Jack Hammer	120	5 seconds
Jack Hammer Drill	113	44 seconds
Lawn Mower	91	2 hours
Leaf Blower	100	15 minutes
Power Tools	100	15 minutes
Sawing Wood	85	8 hours
Sheep Sheering	97	30 minutes
Shotgun	150-165	Immediate Damage
Squealing Pigs	115	30 seconds
Tractor with cab	85	8 hours
Tractor without cab	100	15 minutes
Wheel loaders	98	23 minutes 42 seconds

Source. Dangerous Decibels Program which references NIOSH RELs.

Adaptations made to Module 6 include the addition of farm-related sound sources. New flashcards will feature images of farm noise sources, decibel levels, and safe exposure limits without HPDs. The additional flashcards will include a combine harvester, crop dusting aircraft, grain dryer (Lankford & Meinke, 2006), semi-trucks (Seshagiri, 1998), forklifts (Depczynski et al., 2005), cattle (Weeks et al., 2009). Table 3 displays the proposed additional Dangerous Decibels flashcards that are agricultural-related noise exposure sources, the associated noise level (dBA), and the length of safe exposure according to NIOSH (1998). The additional agricultural-related Dangerous Decibels flashcards are included in appendix A.

Table 3

Proposed Additional Dangerous Decibels Farm Noise Flashcards

Noise Source	**Noise Levels (dBA)**	**Length of permissible exposure**
Auger	98	30 minutes
Cattle	90	2 hours
Combine Harvester	105	5 minutes
Crop Dusting Aircraft	116	22 seconds
Forklift	84	Unlimited
Grain Dryer	102	9 minutes 25 seconds
Semi-Truck	89	3 hours 11 minutes

Sources. Noise levels and permissible exposure collected for each source from forklift, Depczynski et al., (2005); combine harvester, crop dusting aircraft, and grain dryer, Lankford & Meinke, (2006); semi-trucks, Seshagiri,(1998); cattle, Weeks et al., (2009); auger, Williams et al., (2015)

Module 7A: Turn it Down

No modifications for youth in farming will be made to Module 7A “Protecting Our Hearing: Turn it Down”. Participants will learn listening to music through headphones at the loudest volume can be a source of dangerous decibels utilizing the headphone flashcard. The educator will inform students that turning the volume down when listening to music will allow them to listen to their favorite songs longer. The educator should inform the farm youth about the importance of being mindful of the volume when listening to music while operating farm equipment. It's crucial to emphasize that increasing the volume to overcome the noise from loud equipment like tractors and combines can be hazardous. Listening to music at high levels can also impede the listener’s ability to communicate with other individuals and impact their safety. The message will be reinforced by displaying the Turn it Down sign.

Module 7B: Walk Away

No adaptations will be made to Module 7B “Walk Away”. Volunteers will be selected from the audience and measure the level of sound from a kitchen blender utilizing a sound level meter at different distances. Students will learn walking away from a source of hazardous noise can decrease their exposure to dangerous sound levels. The educator can illustrate this by suggesting stepping away from a grain bin when the fans are in operation to reduce the risk of unnecessary hearing damage from fan noise exposure.

Module 7C: Protect Your Ears

Adaptations to Module 7C “Protect Your Ears” will include information on electronic hearing protective devices. This portion of the program is modified to inform youth involved in farming of hearing protection that can provide audibility when being utilized. The module will maintain teaching participants about the appropriate fitting technique of pre-formed ear plugs.

Participants will practice inserting the earplugs properly and learn the correct way to remove the earplugs. Once students have removed all earplugs from their ears the educator will introduce electronic hearing protective devices. The educator will differentiate passive types of hearing protection from electrotonic hearing protection. The educator will explain how to operate the electronic hearing protection by turning the device on, instructing how to adjust the volume, and explain the function of the microphones located on the electronic earmuffs. The educator explains the microphones shut off in the presence of dangerous decibels protecting the wearers' ears. The intent of this adaptation is to inform youth of hearing protection devices that allow wearers to protect their ears from hazardous noise such as firearms without compromising their safety and ability to communicate with others.

Module 8: Rock Your World: Time to Act!

In the original program Module 8: "Rock Your World" provides participants the opportunity to think about how they would respond amongst their friends in a real-life scenario. The original program has participants imagine they are going to a rock concert with their friends. The rock concert flash card is used from Module 6: "How Loud is Too Loud?". The scenario is changed to a country concert/tractor pull event at a county fair to better replicate a situation that may occur for the target audience. The flashcard used will include a graphic of a country concert scene. Figure 8 depicts the Country Music Jam flashcard. Participants will be asked to imagine they are going to the country concert at their county fair with their peers. The youth are asked how they would respond if they were teased by their friends for wearing hearing protection.

Figure 8

Country Music Jam Flashcard

Note. Country Music Jam is the adaptation of the Module 8: "Rock Your World: Time to Act!" flashcard. Image courtesy of Deanna Meinke, Ph.D. (2024).

The adaptation for this segment of the program addresses social pressures and stigma around hearing protection at recreational events in a situation more common for youth involved in farming. Table 3 summarizes the adaptations of the original Dangerous Decibels program for youth engaged in farming activities or living on farms.

Table 4

Dangerous Decibels Adaptation to Youth in Farming

Module Number	Program Module Title	Adaptation for Farm Youth
1	Introduction	Connection to Farming Community
2	What is Sound?	No Adaptations
3	How Do We Hear?	No Adaptations
4	How Do We Damage Our Hearing?	Added Acoustic Trauma Damage
5	What's that Sound?	Incorporate farm noise to dBZone!
6	How Loud is Too Loud?	Incorporate flash cards related to agriculture and farming noise sources.
7	Protecting Our Ears	
	A. Turn it Down	No adaptation
	B. Walk Away	No Adaptation
	C. Protect Your Ears	Special Electronic hearing protection for firearms and communication/safety
8	Rock Your World: Time to Act	County Fair Country Concert Scenario

Dissemination

The adapted Dangerous Decibels program will need to be shared with related agricultural organizations and presented at events associated with agriculture to reach the target population of youth involved in farming. Multiple organizations and conventions share information with farm youth via meetings and event presentations. Possible organizations for presenting the adapted Dangerous Decibels program to farm youth include school Future Farmers of America (FFA) programs, county 4-H clubs, and conventions such as state farm shows.

Organizations

The National Future Farmers of America Organization

The National Future Farmers of America Organization (FFA) is a student organization for youth interested in agriculture and leadership, education, science, business, and more. National FFA is dedicated to assisting individual members with leadership skills, personal development, and future careers through agricultural education (National FFA Organization, 2019). The organization currently reports 850,823 members in 8,995 chapters across all 50 states in addition to Puerto Rico, and the U.S. Virgin Islands. Members of FFA range from 12 - 21 years of age and are enrolled in grades 7-12 or college. Student members of FFA are required to be enrolled in a minimum of one agricultural education course, attend chapter meetings, and participate in chapter activities (National FFA Organization, 2023).

FFA Chapters would be appropriate distributors of the adapted Dangerous Decibels program to youth in farming due to the organization's access to the target population. The adapted program could be delivered at school chapter meetings with club members or at the state and national conventions. School FFA chapters have regular meetings with student leadership, the advisor, and chapter members in attendance. Chapter meetings would be an ideal opportunity to have a Dangerous Decibels Educator deliver the adapted program to youth interested in agriculture. There are larger state-wide and a national FFA convention in addition to smaller school chapter meetings. The Colorado FFA Convention is a three-day event held annually in the summer. The state convention involves student competitions, an exhibit hall, a career show, a talent show, and sessions with keynote speakers (Colorado FFA, n.d.). Similarly, the National FFA Convention and Expo is held during the fall in Indianapolis, Indiana. The four-day convention is comprised of multiple general sessions, an expo, a shopping mall, delegate events, teacher and student workshops, a concert, and multiple rodeos (National FFA Organization, n.d.). Students can attend numerous events and participate in many activities throughout the conventions. The adapted Dangerous Decibels program could be featured as an exhibition at the expos of these large conferences. The expo at the state and national conference would provide an opportunity to connect with many FFA members from many different schools and/or states. The FFA organization brings thousands of youths interested in agriculture together through meetings, competitions, and conferences. Implementing the Dangerous Decibels program into these events will provide students the opportunity to learn about hazardous noise and how to protect their hearing. Another opportunity may be for FFA to offer educator training to their older youth members who in turn would deliver the program to younger youth (Welch et al., 2016).

4-H

The largest youth organization in America is 4-H. This organization is provided by state-level Cooperative Extension Services and promotes hands-on learning. Programs exist in every county of every state in the United States The term 4-H originates from the 4-H pledge which states: “I pledge my head to clearer thinking, my heart to greater loyalty, my hands to larger service, and my health to better living, for my club, my community, my country, and my world” Dangerous Decibels content would directly support the service and health aspects of the pledge. Youth members of 4-H participate in projects related to agriculture, health, science, and civic engagement. Members of 4-H are youth and teens aged 8-18 years. The Cloverbud program is offered for children 5 to 7 years old. Programs are offered through in-person clubs, virtual 4-H clubs, 4-H Camps, in-school, and after-school programs. All 4-H programs include a mentor and incorporate career preparedness into learning (National 4-H Council, 2023a). Additional curriculum and learning activities are available through the CLOVER online learning platform. The CLOVER platform contains over 190 interactive activities related to agriculture, science, health, and civic engagement (National 4-H Council, 2023b). Members of 4-H enter projects in local county fairs and can qualify for state fair competitions. Projects members can participate in cover a wide variety including livestock shows, woodworking, shooting sports, baking, cake decorating, ceramics, fashion design, photography, and more.

Monthly Meetings. Local clubs meet regularly once a month for in-person meetings. Meetings consist of the club advisor, members, and parents of 4-H members. During meetings, youth members have opportunities to present demonstrations of their projects to fellow members. Local community members also attend monthly meetings and give presentations on various careers or civic engagement opportunities.

Many members of 4-H are interested or involved in agriculture. The youth participating in these programs make up the target audience the adapted Dangerous Decibel program is tailored for. Monthly 4-H meetings would provide an ideal opportunity for presenting the adapted Dangerous Decibels program to youth in farming and their parents. Dangerous Decibels Educators would be able to present the program during a meeting and utilize members of 4-H to participate in the activities throughout the modules. The adapted program material and the inclusion of farm-related sound flashcards will inform both youth members and their parents of the importance of protecting their ears from dangerous sounds. The 4-H organizational structure may also provide an opportunity for older 4-H members to become Dangerous Decibels educators through the online educator training program and then deliver the program to the younger 4-H members (8-12 years) (Welch et al., 2016).

Colorado Farm Show

A third opportunity to disseminate the adapted Dangerous Decibels program is through farm exhibitions like the Colorado Farm Show. The Colorado Farm Show is the largest and longest-standing farm show that takes place annually in Greeley, Colorado. The three-day exhibition features roughly 350 agricultural-related exhibits and attracts approximately 30,000 spectators (Colorado Farm Show, 2020). Visitors come to gain information about new agricultural products, different companies, services, and machinery through exhibit booths and presentations. Exhibitors come from multiple states including Colorado, Kansas, Nebraska, Wyoming, and Montana. The farm show is put on by volunteers involved with agriculture daily, or those who have past connections with agriculture (Colorado Farm Show, 2020). The Colorado Farm Show gathers individuals of all ages who are interested in agriculture in one location.

The Colorado Farm Show has many exhibits comprised of agriculture-related booths and vendors which are selected by invitation only. Prospective exhibitors are required to complete an application for the Booth Sales Committee to review. The application entails the candidate describing the product or service they are delivering, inquiries about the innovative nature of the booth, and how the product or service relates to agriculture. The adapted Dangerous Decibel program would be an appropriate addition to the Colorado Farm Show because of the addition of farm and agricultural content and would provide a centralized venue to reach rural farm youth. Individuals attending the farm show vary in age, adults involved in agriculture bring their children to the event and local FFA chapters bring members to explore the booths, and vendors, and participate in seminars. The attendance of youth involved in farming provides the target audience the adapted program is tailored for. The presence of the adapted Dangerous Decibel program at the Colorado Farm Show will reach youth in farming and inform young individuals of the dangers of hazardous noise and how to protect their hearing.

The adapted Dangerous Decibels program for youth in farming will be a useful tool for educating young individuals about what sound is, how the auditory system works, identifying dangerous sound levels, and how to strategies to protect their hearing. For the adapted Dangerous Decibels program to have the desired impact it will be imperative to present the adapted program to the target audience. Agriculturally based organizations such as school FFA chapters and local 4-H clubs provide opportunities for Educators to attend annual conventions or monthly chapter or club meetings to present the adapted program to youth members. Large exhibitions like the Colorado Farm Show provide opportunities for Educators to share the message of the adapted program with many youth attendees through their participation in the adapted Dangerous Decibels presentation. Eventually, these initiatives could be further expanded to additional states and even national levels.

Planning For Dissemination

The educator will need to consider how to effectively reach farm youth to successfully disseminate the adapted version of the Dangerous Decibels program to the target audience. Multiple steps must be considered when disseminating the adapted program. The educator should utilize informative promotional materials including a brochure and flyer to promote and advertise the adapted Dangerous Decibels program to youth in farming. Next, the educator must establish contact with and representative or advisor of an organization whose members are comprised of farm youth members. It is crucial for the educator to convey to the advisor the importance of educating young individuals in the farming community about noise-induced hearing loss and the measures for prevention. They should also explain why members of the farming population are particularly susceptible to noise-related hearing damage. A time must be scheduled to present the adapted 50-minute adapted program and the educator and advisor must decide on an appropriate location. The chosen venue should be conducive to allowing active student participation in the module activities and have internet access and electrical power. The goal of presenting the adapted program to the target population is to make a positive impact by informing farm youth about the risks of noise exposure, the consequences of noise-induced hearing loss, and the importance of protecting their hearing.

CHAPTER III

CRITICAL APPRAISAL OF THE RESEARCH AND FUTURE DIRECTIONS

Gaps in Existing Literature

Health communication programs serve as deliberate efforts to educate and alter behaviors among specific target audiences. Within this context, hearing health communication programs play a crucial role in conveying knowledge, attitudes, and behaviors specific to promoting hearing health and prevention of NIHL. Tailoring such programs to specific demographics is essential for their effectiveness. While various health communication theories have been applied to educate youth about noise-induced hearing loss (NIHL), particularly through initiatives like the Dangerous Decibels program, there remains a gap in addressing the risks within farming communities. Despite evidence indicating a heightened risk of NIHL among agricultural workers, existing regulations often do not extend to protect them. This presents an opportunity to adapt hearing health programs, like Dangerous Decibels, to meet the needs of youth involved in farming, thus positively influencing their knowledge, attitudes, and behaviors toward hearing health. However, implementing such programs poses challenges, including access to the target population and ideally, recruitment of educators from those with agricultural backgrounds. This chapter further explores the theoretical basis for health communication in hearing health, the challenges of implementing adapted programs for farming youth, and proposes future directions for evaluating and improving such initiatives.

Theoretical Basis

Health communication campaigns are defined as a deliberate endeavor to both educate and modify the behaviors of designated target audiences. Such campaigns play a role in enhancing public awareness of health issues (Zhao, 2020). Hearing health communication programs are used to convey and monitor changes in knowledge, awareness, attitudes, and behaviors toward hearing loss (Sobel & Meikle, 2008). Applying successful health behavior research initiatives to hearing-loss prevention programs can help combat the prevailing lack of knowledge and concern within the public regarding the hazards associated with hearing loss (Sobel & Meikle, 2008). The efforts of health communication programs are most effective in changing knowledge, attitudes, and behaviors when the programs are tailored to specific target audiences (Rimal & Lapinski, 2009). The Dangerous Decibels program employs various health communication theories to educate young individuals about NIHL (Griest et al., 2007). The program has previously undergone adaptations to effectively educate specific populations regarding the dangers of excessive noise exposure and NIHL to both firearm users and military youth (O'Dorisio, 2018; Wise, 2016). Health communication campaigns related to hearing loss prevention have been tailored to at-risk populations, however, no program has been adapted for the purpose of educating youth in farming regarding the effects of hazardous noise exposure and NIHL.

It may be beneficial to expand the evaluation of the Dangerous Decibels program to incorporate newer health communication science theories such as the Social Ecological Model of Health discussed on page 31. Since there are organizational structures beyond the school setting that serve agricultural youth, these structures may be especially useful for influencing hearing health on multiple levels such as community, policies, and culture which are typically more difficult to engage.

Noise Exposure Limits

Dangerous Decibels originated in 1999-2000, before the publication of the Roberts and Neitzel (2019) article suggesting lower noise exposure limits for children up to age 18 years. Dangerous Decibels could consider revising the Flash Card activity to reference these 8-hour exposure limits to 80 dBA rather than the current 85 dBA limit. Although, this may be debatable because the 85 dBA limit originates from a government entity (NIOSH) after public input and scientific review. Adopting the 80 dBA limit for youth from a single research article does not have the support of being adopted by a larger U.S. agency or government entity at this time. Damage risk criteria specific to youth need to be developed, however that is challenging since it is unethical to intentionally expose youth to hazardous noise in order to determine how much is tolerable for young ears. Additionally, the current occupational damage risk criteria neglect consideration of a lifetime of noise exposure

Evaluation of the Adapted Program in Farm Youth

Researchers examining the relationship between noise damage and farming have shown that individuals who reside or work on farms are at an increased risk for developing NIHL due to their exposure to hazardous noise from various sources such as machinery or livestock compared to individuals who are not involved in agriculture activities (Lankford & Meinke, 2006; Plakke & Dare, 1992). Hearing impairment is prevalent among adult farmers, and there is evidence to suggest its onset could occur during childhood (Broste et al., 1989; Perry & May, 2005; Renick et al., 2009). Despite evidence of an increased risk of the development of NIHL, agricultural workers are not mandated to adhere to OSHA regulations concerning noise level exposure. They were exempted from the initial legal requirements outlined in OSHA 29 CFR 1910.95 (Moore & Lusk, 1997). The lack of inclusion of agriculture under OSHA requirements has called for the need for hearing loss prevention in farming (Ehlers & Graydon, 2011; McCullagh, 2011; Sliwinska-Kowalska & Davis, 2012). An initiative such as Dangerous Decibels could serve as a valuable tool for educating young individuals involved in farming who are at risk of developing noise-induced hearing loss. This could be achieved by adapting the program to the specific needs of the target population, with the aim of positively changing their knowledge, awareness, attitudes, and behaviors regarding the risks of hazardous noise exposure and the importance of hearing loss prevention. Research is needed to evaluate the effectiveness of the adapted program in youth from farming communities to further inform the usefulness of the changes to the program and the ability of the modified program to influence knowledge, attitudes, beliefs, and intended behaviors related to hearing health. The need for booster activities should also be investigated.

Challenges

Gaining access to the student population poses a significant hurdle when implementing a Dangerous Decibels program tailored for young individuals involved in farming, especially when youth are rural and geographically distant. To deliver the Dangerous Decibels program effectively, an educator will reach out to key figures within relevant organizations, including FFA advisors, 4-H chapter advisors, and school administrators in agricultural communities, or submit an exhibitor application to be a feature at a farm show exhibition. The adapted program contains content specific to agriculture and the effectiveness of the modification hinges on the presentation being delivered to the target audience of youth in farming. It will be important for the educator to ensure they are presenting to members of the agricultural community for the program to be most effective in positively impacting youths' knowledge, behaviors, attitudes, and awareness towards preventing noise-induced hearing loss and protecting their ears from hazardous noise exposure. The receptiveness of such organizations towards promoting hearing health is unknown and more information is needed regarding how best to disseminate the program.

Another noteworthy challenge involves the ideal need for an educator who possesses a background in agriculture. This aspect holds significance because the educator will be encouraged to establish a connection to agriculture during their introduction in Module 1 if possible. The educator vocalizing their ties to the farming community will enhance their credibility when conveying information about hearing loss prevention and NIHL. It may be worthwhile to establish an avenue for older (high school) farming youth to become Dangerous Decibels educators by completing the online educator training program. Perhaps this can be achieved through the organizational structures of FFA or 4-H.

Future Directions

The future trajectory of the adapted Dangerous Decibels program includes a necessity to assess how effectively the adapted Dangerous Decibels program educates youth in farming about the risks associated with hearing loss prevention and noise-induced hearing loss. The evaluation of the adapted program's effectiveness can be structured in a manner similar to previous adaptations of the Dangerous Decibels program, as demonstrated by Griest et al. (2007) and Martin et al. (2013). To gauge effectiveness, it will be essential for youth engaged in farming to participate in the adapted Dangerous Decibels program. Assessing alterations in their knowledge, attitudes, and intended behaviors concerning NIHL and hearing loss prevention can be accomplished through the administration of pre-program, post-program, and three-month follow-up questionnaires.

The questionnaires may need to be updated and tailored to the farming community. Responses to the initial questionnaire will offer valuable insights and data regarding the knowledge and perceptions of hearing loss prevention and NIHL among young individuals in farming before they undertake the adapted program. The surveys will also help determine whether there was a positive shift in the desired aspects immediately after program completion. The third questionnaire will determine whether positive changes in knowledge and behaviors were sustained three months after participating in the adapted Dangerous Decibels Program.

Summary

Noise-induced hearing loss (NIHL) is prevalent among youth in farming communities due to their prolonged exposure to loud farm environments. Health communication techniques, emphasizing education and prevention of hearing loss, are crucial in conveying essential health messages to young individuals in agriculture with a goal of positively influencing behavior when in the presence of hazardous noise. The Dangerous Decibels program employs these techniques, emphasizing the recognition of hazardous noises, comprehension of noise exposure consequences, and the promotion of hearing protection measures. It's important to recognize that effectiveness of health communication messages can vary among different social groups, necessitating a customized program to effectively inform young individuals in agriculture about the risks of loud noise exposure and protective measures. ach parallels successful adaptations of the program for youth firearm users (Wise, 2016), and military families (O'Dorisio, 2018), adults (Reddy et al., 2017), and other countries and cultures (Gomes et al., 2023; Knobel & Lima, 2014;

Ma, 2015; Reddy et al., 2017; Welch et al., 2016) and the modified program can likely benefit farm youth in the same manner.

The adaptations to the Dangerous Decibels program for youth in farming were crafted to retain the core content of the program, module structure, and associated learning activities. The adapted Dangerous Decibels program for farm youth includes several modifications throughout its modules, such as emphasizing the importance of a presenter with connections to the farming community, introducing the concept of acoustic trauma relevant to firearm use, simulating high-frequency hearing loss with additional farm-related sounds, addressing noise exposure risks specific to agriculture, providing information on electronic hearing protection devices, and adapting scenarios to better relate to the social pressures and stigma faced by young individuals involved in farming. These adaptations are strategically implemented to align with the needs and experiences of youth in the farming community while upholding the core objectives of the program.

The adapted Dangerous Decibels program requires a strategic approach to dissemination, targeting young individuals in farming communities through agricultural organizations and events. Overcoming challenges, such as connecting with relevant organizations and addressing potential reluctance to endorse hearing health initiatives, is essential. Future directions involve assessing the program's effectiveness through questionnaires to understand the immediate and long-term impact on knowledge, attitudes, and behaviors, thereby informing its potential for use among youth in farming communities.

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APPENDIX

AGRICULTURAL RELATED
DANGEROUS DECIBELS FLASHCARDS

Combine Harvester

105 dBA
5 minutes

Combine Harvester

Cattle

90 dBA
2 hours

Cattle

Semi-Truck

89 dBA
3 hours

Semi
Truck

Grain Dryer

102 dBA
9 minutes

Grain Dryer

Crop Dusting Aircraft

116 dBA
22 seconds

Crop Dusting Aircraft

Forklift

116 dBA
22 seconds

Forklift

Auger

98 dBA
30 minutes

Auger