Dangerous Decibels® I: Noise induced hearing loss and tinnitus prevention in children. Noise exposures, epidemiology, detection, interventions and resources

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INTRODUCTION

Youth of today participate in a variety of "noisy activities" and many accompany their parents or caregivers to loud events. Blair et al. (1996) noted that 97 % of 273 third graders surveyed had been exposed to hazardous sound levels. The World Health Organization (WHO) indicated that North American children "may receive more noise at school than workers from an 8-hour work day at a factory" (WHO 1997).

Developmentally, the risk of sound over-exposure for children begins at birth and continues through adolescence. The risk of noise induced hearing loss may increase with age as youth engage in both noisy activities and enter the workforce. Even in a neonatal intensive care unit (NICU) the sound levels may exceed acceptable levels (Busch-Vishniac et al. 2005). The risk of noise induced hearing loss has been demonstrated for youth engaged in farming (Broste et al. 1989), utilizing firearms (Clark 1991), playing with toys or fireworks (Axelsson & Jenson 1985; Gupta & Vishwakarma 1989; Hellstrom et al. 1992; Weber et al. 1967), or listening to amplified music (Clark 1991; Meyer-Bisch 1996, West & Evans 1990). In a study of 405 adolescents aged 12-17 years, meadian weekly L_{eq} was 85.1 dBA and 51 % of the subjects exceeded 85 dBA (Jokitulppo et al. 1997).

High sound levels can be encountered in the home, community, school and work environments. It is estimated that 1.5 million youth aged 16-19 years are engaged in work with noise-hazardous exposures (Hager 2006). Many of these jobs are seasonal or informal in nature and may not receive the full benefit of annual health and safety programs designed to protect the full-time workers from workplace injury.

Niskar et al. (2001) provided evidence of audiometric configurations suggestive of noise induced hearing loss in children aged 6 to 19 years. Extrapolating their 12.5 % of children with a "noise induced threshold shift or NITS" to 5.2 million children in the United States, the need for prevention and intervention becomes readily evident. Niskar et al. also noted that the older (12-19 years) children were more likely (15.5 %) to have NITS than the younger (6-11 years) group (8.5 %). Although the literature is lacking in terms of longitudinal studies, some cross-sectional studies suggest that the prevalence of NIHL among children is increasing (Chermak & Peters-McCarthy 1991; Montgomery & Fujikawa 1992). Rural youth engaged in farm work may be at twice the risk of NIHL as compared to their peers not involved in farm work (Broste et al. 1989). Additional insight into the prevalence of NIHL may be gained by reviewing the

ongoing results of the Dangerous Decibels® science museum exhibit which does public health research by measuring the hearing thresholds at 4 kHz of visitors aged 6 to 85 years. Results for 6 to 19 year old visitors revealed thresholds > 20 dBHL in 16 % of 23,183 children as of May 2008 (www.dangerousdecibels.org/resultshearing-loss.cfm).

It is encouraging to realize that the noise-related auditory damage and tinnitus is preventable. We have the opportunity in youth to instill the knowledge and mold the attitudes and behaviors that will enable them to minimize their risk and prevent noise induced hearing loss. This requires partnerships and the dissemination of effective educational resources such as those developed for the Dangerous Decibels® program.

METHODS

Hearing loss prevention materials, resources and programs are available from several sources (Folmer et al. 2002). The Dangerous Decibels program is a public health partnership involving hearing scientists, audiologists, physicians, teachers, museum exhibit designers and builders, education outreach specialists, health communication and public health experts and many others with the goal of reducing the incidence of noise induced hearing loss and related tinnitus (Martin 2008; Martin et al. 2006). The program uses various forms of educational outreach, museum exhibitry and research to promote and study hearing health. All Dangerous Decibels activities are intended to communicate the three educational messages:

- What are sources of dangerous sounds?
- What are the consequences of being exposed to dangerous sounds?
- How do I protect myself from dangerous sounds?

Developing health promotion resources represents a special challenge because the goal is to not only increase knowledge on a topic, but to also change attitudes and behaviors towards a specific health risk. Health communication theory was applied to the development of the Dangerous Decibels resources (Sobel & Meikle 2008) and included these principles:

Gear the program to the target audience. Schools are composed of a wide variety of students with varied backgrounds, cultures and knowledge bases. It is essential to know the characteristics of the population for a successful campaign. Urban and rural adolescents may respond differently to an educational program, even though they have similar knowledge bases prior to the intervention (MacDonald 1999). In some settings, it is advantageous to apply prevention interventions to an entire school rather than to just individual classes (Main et al. 1994). Gender assumptions may be false (Foshee et al. 1998). Researchers focusing on tobacco prevention in adolescents living in a tobacco-producing region recognized the need to provide a culturally relevant program, and were rewarded by lower smoking rates for those involved in raising tobacco than those who were not (Noland et al. 1998).

Use interactive, not passive instruction. Interactive peer-led interventions are statistically superior to non-interactive lecture programs led by teachers or researchers when working with middle school children (Black et al. 1998). Interactive programs were defined as those utilizing face-to-face peer interactions, role-plays, age-appropriate information, and feedback from peers to stimulate active participation. This is in contrast to non-interactive, teacher-led programs that involve passive exchanges between teachers and students. Chermak et al. (1996) reported that stu-

dents who received the hearing conservation message through an interactive style of instruction exhibited greater improvement on post-instruction tests than students who heard it in a more traditional lecture format. Results from a study by Bennett and English (1999) agree with this conclusion.

Incorporate skills-based learning. Self-efficacy at a healthy behavior is important. It is necessary to teach skills needed to accomplish a task requiring a student to refuse or avoid something, and allow time to practice the new skills in class (Black et al. 1998; Devries et al. 1992; Lukes & Johnson 1998; Main et al. 1994; Noland et al. 1998; Price et al. 1998; Reding et al. 1996). When a student has learned about the normal function of the body and the negative impact of a health behavior, they need to learn about how to prevent damage to themselves (Chermak & Peters-McCarthy 1991; Devries et al. 1992; Knobloch & Broste 1998; Lukes & Johnson 1998; MacDonald 1999; Reding et al. 1996).

Use multi-component programs and program repetitions. Successful programs include acquisition of skills and development of self-efficacy, but this requires adequate class time, activities beyond the classroom, and adequate teacher training (Main et al. 1994). Frequency and duration of the educational program can be important to the success of the outreach, but many programs have demonstrated significant knowledge gains in just a few sessions. Some programs have devoted large amounts of time to health topics (Main et al. 1994), and others have had relatively brief exposures (Reding et al. 1996), depending on need or availability of resources.

Select appropriate scientific content. Recommendations for hearing health promotion content has included recommended instruction about normal auditory mechanisms, types of hearing loss and their causes, noise and its effect on hearing, warning signs of noise-induced hearing loss, specific recommendations for preventing noise-induced hearing loss and the consequences of hearing loss and how it can affect life quality, and the types of noises or noisy activities are most dangerous to hearing (Anderson 1991; Folmer 2008; Lass et al. 1987; Martin 2008; Martin et al. 2006).

RESULTS

Museum Exhibition

A permanent Dangerous Decibels museum exhibition is at the Oregon Museum of Science and Industry (OMSI) and consists of 12 interactive, educational exhibit components (Figure 1). It is the only museum exhibition in the world dedicated to the prevention of noise-induced hearing loss and tinnitus. Exhibit components include presentations of the core science used throughout all Dangerous Decibels activities: the physics of sound, normal anatomy and physiology of hearing, simulations of noise-induced hearing loss and tinnitus, indicators of dangerous sound levels, interactive instruction on the selection of appropriate hearing protection, a “game show” style group interactive about hearing health facts and a computer game that educates, entertains, and performs data acquisition about the visitor’s noise exposure history while simultaneously performing hearing screening. The exhibit has been on display to approximately 670,000 visitors per year, including 72,000 K-8 students per year on school group field trips.

Figure 1: Students learn how to select appropriate hearing protection at the Dangerous Decibels museum exhibition at OMSI

Classroom Program

The Dangerous Decibels classroom program is a scripted, 50 minute interactive presentation that can be adapted for kindergarten though 12th grade students. The content was developed by Oregon Hearing Research Center (OHRC) hearing scientists and the format and delivery was developed by OMSI outreach educators with the assistance of three formative evaluation efforts in six counties across Oregon and Southwest Washington. The formative evaluations used student and teacher focus groups conducted by external evaluators, teacher consultants, and educational experts from OMSI for guidance in curriculum development. The classroom scientific content includes the physics of sound, normal anatomy and physiology of hearing, the pathophysiology of noise induced hearing loss, consequences of noise induced hearing loss and tinnitus, and instruction on methods of hearing loss prevention (Figure 2). The curriculum meets National Science Education Standards (www.nap.edu/readingroom/books/nses/html/) for Physical Science, Life Science, and Science in Personal and Social Perspectives. The classroom program is offered to elementary and middle schools throughout the Pacific Northwest through the OMSI Outreach Programs (www.omsi.edu/education/outreach/program.cfm?ProgramID=2). In addition, several individuals deliver the classroom program across the U.S. and Canada following participation in the educator training program.

Figure 2: Studying the physics of sound during the Dangerous Decibels classroom program

Educator Training Program

An intensive, two-day educator training program is available for those who wish to be fully equipped to teach the classroom program. The first day of training provides participants with essential background on the physics of sound and hearing, cochlear

physiology, hearing loss, standards for recommended limits for sound exposure, background on noise induced hearing loss in children and instruction on hearing loss protection devices and other means of hearing protection for children, health communication theory applied to hearing health, classroom management strategies and a walk through the classroom program. The second day, participants present the classroom program to small groups in order to refine presentation skills and clarify misunderstandings about the material. Each participant receives a course syllabus with a summary of the essential information, a detailed, step-by-step script of the entire classroom program and an educator kit with all of the essential materials, graphics and instrumentation needed to present the classroom program. Participants who complete the full training are certified as Dangerous Decibels Educators. The educator training program is intended for teachers, school nurses, high school students, audiologists, physicians, scientists, speech pathologists and other interested in presenting of the Dangerous Decibels curriculum.

Figure 3: High school students are trained to be Dangerous Decibels educators

Teacher's Resource Guide and DVD

The Dangerous Decibels Teacher's Resource Guide contains age-appropriate, hands-on science activities about the anatomy and physiology of hearing, the physics of sound, and health-related behaviors for prevention of noise-induced hearing loss that meet National Science Education Standards. It also includes a glossary of terms and diagrams and images that can be used in the classroom program. The activities were designed to either be included in the classroom program or to serve as pre- or post-classroom activities to facilitate learning of the educational messages. The Teacher's Resource Guide can be purchased as hard copy or downloaded for free from the Dangerous Decibels website (www.dangerousdecibels.org/teachers_guide.cfm).

The Dangerous Decibels DVD is complementary tool to the Teacher's Resource Guide. It contains visual demonstrations of many of the activities presented in the written guide and also has instructional presentations, demonstrations and interviews about hearing, hearing loss, tinnitus and hearing protection that are appropriate for teacher training or to be shown in classrooms. The DVD is available for order (www.dangerousdecibels.org/teachers_guide/DVD_TRG_Order_Form.pdf) with or without the Teacher's Resource Guide.

Science Festivals

Another mode of science outreach for OMSI is through Science Festivals at major events such as County or State Fairs. At these events, the museum presents several science-based, hands-on exhibits. Three of the Dangerous Decibels museum exhibits have been adapted into traveling versions that appear at Science Festivals. These

exhibits communicate the Dangerous Decibels educational messages to approximately 250,000 participants each year.

Televideo-conference Classroom Program

OHSU scientists and OMSI educators work together to conduct long-distance Dangerous Decibels classroom presentations using internet televideo-conferencing. Several schools can be connected via internet to a Portland-based studio for live interaction with the educators and with each other. Classroom materials and supplies for hands-on activities are forwarded to the schools in advance. The educators lead the students through activities just as if all were in the same classroom. This venue enables classrooms in rural and frontier areas to access hearing scientists and educators directly, engage in exchanges of questions and answers, and enable them to receive a complete version of the Dangerous Decibels classroom program.

Web-based Virtual Museum Exhibition

Eight of the OMSI museum exhibits have been translated into computer activities, demonstrations and games forming a virtual museum exhibition that communicate the fundamental educational messages of the project (www.dangerousdecibels.org/virtualexhibit.cfm). The Virtual Exhibit was developed as an experimental intervention for a research project and was found to promote improvements in knowledge, attitudes and behaviors regarding hearing health as a stand-alone activity and as a booster activity for students having received a presentation of the Dangerous Decibels classroom program. It is a resource that is used in National Institute of Occupational Safety and Health (NIOSH) young worker safety training and U.S. military educational programs for new recruits.

Jolene

Jolene is the product of a Dangerous Decibels student researcher's desire to design and construct an innovative, visually intriguing sound level measuring system, to be used in public places as part of an education program to alert young people about risks of noise-induced hearing loss and tinnitus resulting from listening to music at high levels through headphones. Constructed using a used mannequin, sound level meter and a wardrobe from a second-hand store, Jolene has made friends wherever she goes. The sound level meter microphone was coupled to a silicone ear. Participants are invited to set their personal stereo systems to their typical listening level and then allow Jolene to listen to it and measure the sound in dB (A-weighted, slow response). The transfer function of the outer ear (TFOE) was determined allowing decibel measures to be equated to national and international standards for recommended exposure levels. Jolene became so popular that many schools, organizations and individuals wanted information on how to make their own versions. In response, the National Hearing Conservation Association (www.hearingconservation.org) funded the production of the *Jolene Cookbook* (Martin & Martin 2007), a detailed instruction manual on how to make a Jolene for yourself. The cookbook has been downloaded across the United States and by groups in Canada, Japan, Mexico, New Zealand, Portugal, and Saipan. Jolene now has many siblings around the world and many have begun to send photos to the Jolene Family Album at the Dangerous Decibels website. A recent research study, using Jolene as a sound pressure measuring device, found that 16 % of 14-18 year olds sampled listened to their personal stereo systems at levels and durations that exceed NIOSH recommended exposure levels on a daily basis (Martin et al. 2008).

Figure 4: Jolene visiting Niagara Falls on a trip to Canada

The combined Dangerous Decibels activities, including the museum exhibition at OMSI, classroom presentations, OMSI Science Festivals at County Fairs and educational training sessions, reach nearly one million people annually.

CONCLUSIONS

Partnerships are the key to the success of any public health initiative. The challenges include conflicts in cultures, work patterns, terminology, priorities, institutional agendas, personalities, and time tables. The rewards of partnering include the ability to produce innovative, expansive and effective health promotion programs in ways that far exceed the ability of any individual contributor. Dangerous Decibels resources are still in development. Research is currently underway on applying these tools in specific communities at-risk for noise exposure. One such partnership is between the Dangerous Decibels group and the Northwest Portland Area Indian Health Board, representing the 43 Native American tribes and nations in the Pacific Northwest. Other initiatives with the Hispanic/Latino population in the Northwest are being developed.

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