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## A Call for Hearing Loss Prevention Programs in College Music Education Programs

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RUNNING HEAD: A CALL FOR HEARING LOSS PREVENTION PROGRAMS IN  
COLLEGE MUSIC EDUCATION PROGRAMS

A CALL FOR HEARING LOSS PREVENTION PROGRAMS  
IN COLLEGE MUSIC EDUCATION PROGRAMS

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An Honors Thesis

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Abstract

Music educators, ensemble conductors, and students who participate in musical ensembles are exposed to sound pressure levels which exceed the criteria for NIOSH. As such, this population should be enrolled in hearing loss prevention programs. Ensemble directors (many music educators fall into this category) have a direct role in influencing the sound pressure levels produced in rehearsals. Music educators have a role in influencing the knowledge, skills, attitudes, and behaviors of their students. Because of the health risks of noise exposure, and the role music educators (and ensemble directors in general) have in influencing their students, hearing loss prevention should be taught in college music education programs.

I suggest that this instruction should include hearing loss prevention materials from the National Association of Schools of Music (NASM); information on current hearing loss prevention programs for school-age students; information on sound pressure levels in ensemble classes and the hearing and health risks associated with it; and information on ways to reduce sound exposure, including the use of personal hearing protection devices. Future research should further study sound pressure levels in rehearsals and classrooms; how the design of classrooms impacts sound pressure levels; the role of music educators in developing the knowledge, skills, attitudes, and behaviors of their students; the effect of hearing loss prevention programs on the long-term behaviors of students; and the levels of use of personal hearing protection devices by music educators and students.

## **A Call for Hearing Loss Prevention Programs in College Music Education Programs**

### **Introduction**

#### **The Anatomy of Hearing**

Before discussing hearing loss prevention, it is worth discussing how hearing works and how hearing loss can occur. I will start with a simplified version of the anatomy of the ear, and how hearing works. The ear can be divided into three parts: the outer ear, which consists of the fleshy pinna at the surface of the head which is visible and the ear canal; the middle ear, which consists of the tympanic membrane (eardrum), ossicles (three small bones), and the Tensor Tympani and Stapedius (two small muscles); and the inner ear, which includes the cochlea and the vestibular system (the latter affects balance rather than hearing).<sup>1</sup> It is the inner ear that is of most importance to this paper. The cochlea is a small, snail-shaped organ which consists of three fluid-filled chambers.<sup>2</sup> One of these chambers, known as the scala media, contains the basilar membrane and the organ of Corti.<sup>3</sup> The basilar membrane, which makes up the floor of the scala media, is stiffer at one end (the basal end) than at the other (the apex).<sup>4</sup> The organ of Corti lies along this membrane, and contains hair cells.<sup>5</sup>

Sound can be described as an oscillating pressure wave which acts through a medium, such as air.<sup>6</sup> Typically, sounds travel through the air and into the ear canal.<sup>7</sup> The waves cause the tympanic membrane (eardrum) to vibrate in response to the sound. In the middle ear, the sound is transferred from the eardrum to the ossicles, which help transfer the sound from the medium of air outside the ear to the fluid of the cochlea and along the basilar membrane.<sup>8</sup> The hair cells in the organ of Corti convert the vibrations of the basilar membrane into the signal which is sent along the auditory nerve and into the brain for processing.<sup>9</sup> Because of the gradient of stiffness between the basal end and apex of the basilar membrane, sounds of different frequencies

stimulate different locations on the organ of Corti. This is what allows humans to distinguish stimulus frequency. Sound can also be transmitted to the cochlea via conduction through the bones of the head.<sup>10</sup>

### **How Hearing Loss Can Occur**

There are many factors that can cause hearing loss in individuals. Conditions which affect transmission of sound to the cochlea can cause hearing loss.<sup>11</sup> These can include impacted earwax, birth defects, fluid in the middle ear, and damage to the outer or middle ear caused by trauma. Of interest to this paper is hearing loss associated with harm to the structures of the cochlea, which normally results from damage to the hair cells inside the cochlea. This can be caused by aging, certain drugs, and from disease, as well as excess sound exposure. Hearing loss caused by sound exposure is called noise induced hearing loss (NIHL).<sup>12</sup> This can take the form of a temporary threshold shift, in which hearing eventually returns to normal; or in a permanent threshold shift, in which some hearing ability is permanently lost. NIHL is the main type of hearing loss addressed in this paper. Hearing loss can impact the ability to understand speech.<sup>13</sup> It may also be accompanied by tinnitus, which is the perception of ringing or roaring in the ears; or hyperacusis, which causes sensitivity to certain sounds.<sup>14</sup>

### **NIOSH and Occupational NIHL**

Since the passage of the Occupational Safety and Health Act of 1970, and the subsequent creation of the National Institute of Occupational Safety and Health (NIOSH),<sup>15</sup> a growing body of research has demonstrated that millions of workers are at risk for hearing loss due to exposure to noise in the workplace.<sup>16</sup> NIOSH developed standards which defined the recommended exposure limit (REL) as the equivalent of 85 dB, A-weighted, over an eight hour equivalent.<sup>17</sup> Workers who are exposed to sounds of this level or higher face an increased risk for developing

a significant or material occupational noise-induced hearing loss (NIHL).<sup>18</sup> In 1998, NIOSH made a recommendation to revise the hearing conservation amendment to the Occupational Safety and Health Act to define the eight-hour equivalent in terms of 3 dB increases in sound, which is also known as a 3 dB exchange rate. This means that for every increase in the level of sound exposure, the permissible exposure time is halved (see Fig. 1).<sup>19</sup> Under the NIOSH recommended standard, the daily noise dose should not exceed 100% of the 85 dBA eight hour time weighted average (TWA).<sup>20</sup> The standard also defines 140 dBA as the ceiling limit, or maximum instantaneous level of sound to which any worker can be exposed.<sup>21</sup>

**Figure 1. Table 85 dBA Eight Hour TWA<sup>19</sup>**

<b>Sound Exposure Level</b>	<b>Time to reach REL</b>	<b>Daily Dose (if exposed for eight hours)</b>
85 dBA	8 Hours	100%
88 dBA	4 Hours	200%
91 dBA	2 Hours	400%
94 dBA	1 Hour	800%
97 dBA	30 Minutes	1,600%
100 dBA	15 Minutes	3,200%
103 dBA	7 Minutes and 30 Seconds	6,400%
106 dBA	3 Minutes and 45 Seconds	12,800%
109 dBA	1 Minute and 53 Seconds	25,600%
112 dBA	56 Seconds	51,200%

Under the NIOSH recommendations, employers must develop a hearing loss prevention program (HLPP) once any of their employees receives a dose exceeding the 85 dBA eight hour TWA.<sup>21</sup> These programs involve noise measurement, noise controls, the use of hearing protection, hearing level monitoring, worker training, record keeping, and program evaluation. The noise measurement, or noise exposure assessment, is designed to regularly evaluate workplace noise levels, and to identify workers whose dose exceeds the 85 dBA eight hour TWA.<sup>22</sup> Noise controls are designed to reduce the level of sound to which workers are exposed.<sup>23</sup> Engineering controls are designed to reduce sound exposure by modifications to the sound

source (for example, by replacing machines with quieter versions), sound path, or the environment in which the sound receiver resides. Administrative controls (for example, the rotation of workers) also reduce sound exposure. In the event that feasible engineering or administrative controls are not available, employers are required to provide hearing protection at no charge to the employee.<sup>24</sup> Furthermore, employers are responsible for ensuring that the hearing protectors fit and are effective.<sup>24</sup> If sound levels exceed 100 dBA eight hour TWA, the employee must use double protection (for example, wearing both earplugs and earmuffs). Hazard notifications must be present in areas which require workers to use hearing protection.<sup>25</sup> Hearing level monitoring, in the form of an audiogram, is designed to measure employee hearing at the time of employment, and how it changes over time.<sup>26</sup> If significant hearing loss is measured, further steps can be taken to prevent further hearing loss. Employers must also educate their workers in how noise can impact their physical and psychological health; how to properly use hearing protection equipment; how their hearing will be monitored; and in how they and their employer will be responsible for hearing loss prevention.<sup>27</sup> The employer must keep records and annually evaluate the effectiveness of the HLPP.

### **NASM Accreditation Standards**

The National Association of Schools of Music (NASM) is the national accrediting organization for college programs in music and related fields.<sup>28</sup> Schools that wish to be accredited by the organization are subject to the standards set in the NASM Handbook.<sup>29</sup> Archived versions of the handbook prior to the 2011-2012 version do not include standards relating to hearing health.<sup>30</sup> In its latest version (2014-2015), Section II.F.i of its Standards for Accreditation defines the health and safety standards accredited schools must meet:

*“Students enrolled in music unit programs and faculty and staff with employment status in the music unit must be provided basic information about the maintenance of health and safety within the contexts of practice, performance, teaching, and listening.*

*For music majors and music faculty and staff, general topics include, but are not limited to, basic information regarding the maintenance of hearing, vocal, and musculoskeletal health and injury prevention. They also include instruction on the use, proper handling, and operation of potentially dangerous materials, equipment, and technology as applicable to specific program offerings or experiences. Beyond the provision of basic general information, and the identification of available resources, decisions regarding topic areas and breadth and depth are made by the institution, and normally are correlated with the nature, content, and requirements of specific areas of specialization or specific courses of study.*

*For non-majors enrolled in courses offered by the music unit, including performing ensembles, or other curricular offerings of the music unit, topics chosen in addition to the maintenance of hearing health are directly related to health and safety issues associated with their specific area of study or activity in music.*

*Music program policies, protocols, and operations must reflect attention to maintenance of health and injury prevention and to the relationships among: the health and safety of musicians; suitable choices of equipment and technology for various specific purposes; appropriate and safe operation of equipment and technology; and the acoustic and other conditions associated with health and safety in practice, rehearsal, performance, and facilities.*

*Specific methods of providing information and addressing injury prevention, technology, and facilities are the prerogative and responsibility of the institution. (65)”<sup>31</sup>*

Because of these standards, institutions which desire to remain accredited by NASM must take steps to maintain the hearing health of their students. These requirements give flexibility for institutions to choose “the topic areas and breadth and depth” of information and resources given, and to customize their materials to match “the nature, content, and requirements of specific areas of specialization or specific courses of study.”<sup>32</sup>

### **The Need for Hearing Loss Prevention Programs Designed for Music Educators**

#### **Exposure Levels and Health Effects**

Music educators (and musicians in general) require a high degree of hearing ability for the entire length of their career.<sup>33</sup> “Hearing acuity allows musicians to match pitch, rhythm,

loudness level, and to be able to blend within an ensemble.”<sup>34</sup> However, many music educators are exposed to sound levels high enough to damage their hearing.<sup>35</sup> Further research needs to be done into the prevalence of hearing loss among musicians in general, and music educators specifically. A study by Chesky and Henoch found that 21.7% of musicians self-reported hearing loss. Of the music educators who responded to this survey, 22.3% reported some degree of hearing loss. Studies of classical musicians give a range of 42-69% of musicians who have some degree of hearing loss, and about 74% of rock and jazz musicians had some form of hearing disorder. Seventy-eight percent of respondents to a survey indicated they do not wear hearing protection while playing instruments. Of those who did use hearing protection, none of them used it 100% of the time, and only one participant reported using earplugs designed for musicians.<sup>38</sup> However, these musicians received from 1,600% to 17,000% doses during the study.

Owens cites a study which found that directors of high school concert bands can be exposed to sounds between 99 and 105 dBA.<sup>39</sup> Under NIOSH standards, exposure time should be limited to between 7 and 15 minutes; however, many music educators teach much longer than this each day. Owens’ study found a link between small room size and poor acoustical treatments in classrooms and increased sound pressure levels.<sup>40</sup> His doctoral dissertation found that the average sound level in a high school concert band rehearsal was 90 dBAL<sub>eq</sub>, and in high school jazz bands the average sound level was 91 dBAL<sub>eq</sub>.<sup>41</sup> Peak sounds in concert bands reached 115 dBA, and in jazz bands, they reached 112 dBA.<sup>42</sup> The mean daily dose for all band directors in the study was 143.6%. Projected over an eight-hour duration, the average dose was 369.3%, with peaks as high as 600%!<sup>43</sup> Measurements of sound levels in an indoor high school marching band rehearsal exceeded the NIOSH REL, with max levels of 110 dBA.<sup>44</sup> In the same study, sound

levels in a fifth and sixth grade music class ranged from about 80 to 100 dBA, and exceeded 100 dBA briefly.<sup>45</sup> Also, sound levels reached about 90 dBA in a fifth grade band class and a sixth grade band class.<sup>46</sup>

A study of kindergarten through twelfth grade teachers (N=26) including music teachers (N=11) found that music teachers were exposed to the highest equivalent noise levels (normalized to eight-hour durations) of all teachers studied, with a mean of 87.7 dBL<sub>eqA,8</sub>.<sup>47</sup> At the 25<sup>th</sup> percentile, exposure levels were 85.74 dBL<sub>eqA,8</sub>, and the levels at the 75<sup>th</sup> percentile were 90.77 dBL<sub>eqA,8</sub>. The levels of exposure faced by music teachers was consistently about 10 dBL<sub>eqA,8</sub> higher than for classroom teachers.<sup>48</sup> The daily dose for music teachers (mean of 235.24%) was almost ten times as high as for classroom teachers (mean of 23.51%). At the 25<sup>th</sup> percentile, the dose was still above 100% (p25=118.59%), and at the 75<sup>th</sup> percentile, the dose was 377% (p75=377.39%). Levels above 65 dB can cause adverse effects to health, and at 75 dB, adverse hearing effects can occur.<sup>49</sup> Individuals exposed over a 40-year period to the 85 dBA REL have an increased risk of NIHL of 8%.<sup>50</sup> Levels in excess of the REL can increase the risk of NIHL. Because of the increased risk of developing NIHL, music teachers should be enrolled in hearing loss prevention programs.

Flamme noted that “prolonged or excessive exposure to harmful noise” can, in addition to causing hearing loss, lead to physical and psychological problems, including “vocal strain, increased heart rate, fatigue, stress, tension, irritability, difficulties in concentration, sleep disturbances, and tinnitus.”<sup>51</sup> Teachers need to speak at least 15 dB louder than background noise to be understood in classrooms.<sup>52</sup> This causes teachers to need to speak loudly, which can lead to “hoarseness, discomfort in vocal use, fatigue in vocal ability, and a change in voice quality.”<sup>53</sup> Studies have found that teachers are facing more work-related voice problems than the general

population, with 90% of teachers surveyed reporting “hoarseness and/or a persistent cough.”<sup>54</sup>

According to the NIOSH REL, “adverse effects to hearing and shifts in auditory thresholds can start to occur at 75 dBA.”<sup>55</sup> Although threshold shifts are not necessarily permanent, they can lead to long-term hearing loss.

Noisy classroom environments can also have a negative effect on learning. Flamme notes that noise above 55 dB “becomes annoying in rooms intended for theoretic work.”<sup>56</sup> The World Health Organization recommends that classroom background noise levels should not be above 35 dBL<sub>eqA</sub>. Noise can interfere with “learning, concentration, and attention.”<sup>57</sup> For teachers, this effect can continue at home, interrupting sleep and restorative time, which may affect cardiovascular health. Both long-term and acute noise exposure can cause “elevated blood pressure, increased heart rate, and vasoconstriction.”<sup>58</sup> Flamme suggests that further research needs to measure noise levels in classrooms, and assess the health effects of noise on both teachers and students.

### **Student Exposure Levels**

An increasing body of literature suggests that those who participate in music in college and university ensembles are exposed to potentially dangerous levels of sound. Chesky notes that a study found college athletic band members received a 17,000% daily dose of noise.<sup>59</sup> A study of college music students found that while 74% of participants had knowledge of hearing conservation practices, just 22% of those surveyed used hearing protection.<sup>60</sup> Of those who used hearing protection, none used it 100% of the time, and only one participant used musician’s earplugs. Sixty-three percent of those surveyed experience tinnitus after exposure, and tinnitus can be an early sign of hearing damage. Daily doses of these students ranged from 1,600% to 17,000%.

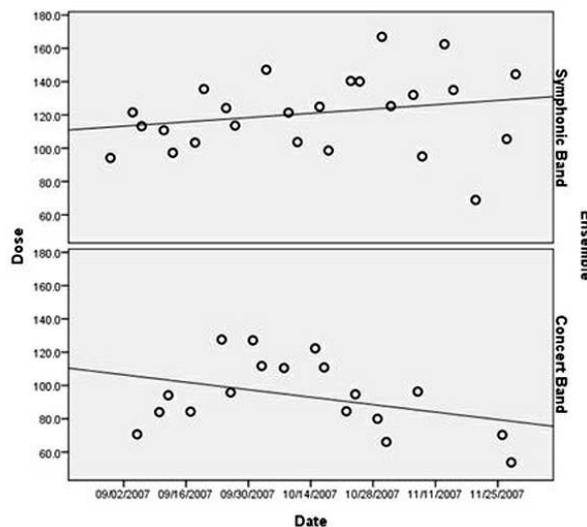
A study of college jazz band members recorded an average exposure of 92-100 dBA during a 50-minute rehearsal.<sup>61</sup> The highest level of exposure occurred in the trombone and saxophone sections. The lead players of these sections faced the highest exposure, with a 400% eight-hour dose equivalent under OSHA standards (of a REL of 90 dBAL<sub>eqA,8</sub>, with a 5 dB exchange rate).<sup>62</sup> Another study of college jazz band members found daily doses between 104 and 280%, based on NIOSH criteria.<sup>63</sup> Seventy-eight percent of musicians exceeded a 100% dose. This study also found the highest exposure level in the trombone and saxophone sections, followed by trumpet and drums.<sup>64</sup>

A study of college wind bands found the mean dose per event measured was 109.5%, and ranged from 53.8 to 166.9%.<sup>65</sup> The mean dose for the symphonic band was 121.0%, and the mean dose for the concert band was 93.6%. The symphonic band got louder over the course of the semester, and the concert band got quieter over the course of the semester (see Fig. 2).<sup>66</sup> While the average dose exceeded 100%, it varied over time (see Fig. 2).<sup>67</sup> Some of the differences in levels might be caused by hearing loss in instructors, whose acuity in hearing the relative loudness of the ensemble may be compromised.<sup>68</sup> On the other hand, pedagogical differences and literature selection may explain some of the differences. Despite the fact that the reasons for variability in exposure are not clear, what is clear is that members of college wind bands are at an increased risk for NIHL. Another study of college wind bands found that 52% of members received daily doses in excess of 100% during at least one rehearsal, and that 37% of members had an average daily dose greater than 100% for the duration of the study.<sup>69</sup> Brass players experienced a greater average dose than either woodwind or percussion players.<sup>70</sup> The sections with the highest average dose were the trumpets, trombones, and alto saxophones.<sup>71</sup>

However, just 2 of 44 participants who were surveyed said they used hearing protection while playing.<sup>72</sup>

A study of college marching band members found that the average daily dose received during band camp was 1,992%.<sup>73</sup> In this study, the median daily dose was 1,628%, which is equivalent to 97.1 dBL<sub>eqA,8</sub>. Music majors in this study received a significantly higher dose, at about 99 dBL<sub>eqA,8</sub> per day, versus 96 dBL<sub>eqA,8</sub> in non-majors.<sup>74</sup> About 84.59% of this exposure was directly related to music activities. Compared to a study of college music majors, this population receives a greater percentage of noise exposure from music activities.<sup>75</sup>

**Figure 2. Scatter plots of dose received by date, by ensemble<sup>66</sup>**



A study of undergraduate music majors found the average daily dose received by this population was 242% (with an interquartile range of 112 to 685%).<sup>76</sup> Men received greater exposure than women.<sup>77</sup> There were significant differences based on the primary instrument of the participant. Saxophone, percussion, trumpet, and trombone students had the highest exposure, usually over 400% daily doses, while string instruments had significantly less exposure, at around 40%. This study measured exposure related to the academic requirements of music majors (rehearsals and classes, for example), and additional exposure outside the

classroom.<sup>78</sup> Music activities accounted for about 50% of total exposure, and most of the rest was associated with non-music and non-occupational exposure.

These exposure levels suggest that music majors would have about a 5 to 55% excess risk of NIHL by age 45, exceeding the limit of 8% excess risk under the NIOSH REL.<sup>79</sup> This assumes that the musician was not exposed to any hazardous level of sound prior to the age of 18, and that such levels continue for 10 years. However, it is typical for musicians to begin studying much earlier in life. Those on the 90<sup>th</sup> percentile and above in the study could expect 20 to 60% greater risk by age 30, with exposure for just 5 to 10 years. This means that musicians face the risk of developing hearing loss from an early age, jeopardizing career potential. Estimates from the 1990s suggest that 12.5% of children aged 6-19 had NIHL.<sup>80</sup> The same paper cited studies that have shown that most children are exposed to dangerous levels of sound by the third grade, and that teens are using headphones at dangerous volumes. This suggests that students are exposed to dangerous levels of sound prior to college. Future research should measure sound levels in elementary, middle, and high school ensembles, including bands, choirs, orchestras, and chamber ensembles in order to assess the risks accumulated by exposure prior to age 18.

### **Why Music Educators?**

One of the major responsibilities of music educators in schools is to lead ensembles. Here they make artistic choices, such as volume, blend and balance, and literature selection, all of which can make a direct impact on sound levels in rehearsal.<sup>81</sup> Students in these ensembles depend on conductors to make these decisions. Therefore, as an important factor in sound exposure in rehearsals, directors “have a primary role in controlling and managing the sound levels of education-based ensembles.”<sup>82</sup> To safely lead their ensembles, music educators must be

educated on the risks associated with noise, hearing health promotion skills, and how hazardous ensemble-based activities can be.<sup>83</sup>

Another argument for the role of music educators in promoting hearing health is their effect on the knowledge, skills, attitudes, and behaviors of their students. A search of peer-reviewed literature did not return studies which prove that music educators influence these areas in their students. However, it seems reasonable to assume that music educators affect the knowledge, skills, attitudes, and behaviors of their students. One of the major theories behind current hearing loss prevention programs aimed at students (see below) is the importance of knowledge and attitudes relating to hearing loss, and whether this influences behaviors which promote hearing health.<sup>84</sup> Music educators could use their teaching to instill healthy hearing habits early, mitigating risk from ensemble participation. Therefore, the roles of music educators as ensemble decision makers; their influence on the knowledge, skills, attitudes, and behaviors of their students; and the risks of noise exposure to both educators and students that makes this population excellent candidates for becoming hearing health promoters.

### **Current Hearing Loss Prevention Programs for Students**

There are several hearing health awareness programs, offered for students ranging in age from primary school through college. One example is the Dangerous Decibels program, which is aimed at school-age children. It is designed to change the knowledge, attitudes, and intended behaviors students hold related to hearing loss prevention.<sup>85</sup> This program offers a curriculum and teaching guide online. Adopt-a-Band, developed by Etymotic Research, is designed to increase the use of hearing protection devices in a band program.<sup>86</sup> The materials included with the program teach about how the ear works, how loud sounds affect hearing, and how personal hearing protection devices can prevent hearing loss. Each student receives a pamphlet. Many

materials are given for the teacher to choose from, including a PowerPoint presentation and a DVD. Another example is the Listen to Your Buds program, which offers research, resources for educators, and events to raise awareness of hearing protection for children.<sup>87</sup> Others include Cheers for Ears and Sound Sense.<sup>88</sup> Many of these programs operate under the assumptions of the Theory of Planned Behavior, which states that actions are influenced by attitudes toward behaviors, the perceived normalcy of behaviors, and the perceived control subjects have toward a behavior.<sup>88</sup>

A study of fourth-grade students compared the effectiveness of programs presented by older students; presented by health professionals; presented at a museum; and presented online.<sup>89</sup> The presentations used Dangerous Decibels materials. The museum exhibit and online materials were also based on the Dangerous Decibels program. Survey results indicate that peers and parents influence their attitudes and behaviors related to hearing protection, but that students do not see their peers or parents model or discuss hearing protection.<sup>90</sup> All four interventions improved knowledge, attitudes, and intended behaviors, both in the short and long term, compared to a control group.<sup>91</sup> Of the four methods, the presentation by a health professional saw the greatest increase in correct answers on a survey, both after the presentation and after three months. A limitation of this study is that it did not measure actual behavior after the intervention, such as the use of earplugs. Another study of the Dangerous Decibels program found a similar long-term change in knowledge and attitudes in fourth grade students, but that the knowledge and attitudes of seventh grade students returned to baseline levels after three months.<sup>92</sup> This study did not measure intended behaviors.

The effectiveness of the Adopt-a-Band program is difficult to test because of the variety of materials offered, and the freedom teachers have to choose from these.<sup>93</sup> However, at least one

study has measured its effectiveness. Researchers offered a pre-intervention survey, a post-intervention survey, and another survey to members of high school marching bands three months post-intervention. The intervention included a discussion, a viewing of the DVD, and distribution of and training in use of musician's earplugs.<sup>94</sup> Fifty-four percent of participants reported increasing their use of earplugs in the long term.<sup>95</sup> It is unclear from this study whether this was as a result of increased availability of earplugs, or from the educational materials. Factors that influenced earplug use included director encouragement and seeing others use them. Factors that discouraged use included comfort and sound quality. There was also an increase in intended use after the end of the marching band season. After the intervention, 96% of participants felt they better understood hearing loss prevention. Responses to factual questions were not used to prove they actually had better knowledge. However, many students learned that military bands and Drum Corps International groups used earplugs. The increase in awareness of others who use earplugs while marching may influence the use by students.

At the collegiate level, the University of North Texas College of Music has a long history of exploring the problem of noise exposure among musicians and finding potential interventions to mitigate the exposure.<sup>96</sup> The course MUAG 1500 (Occupational Health – Lessons from Music) teaches “that music is a sound source capable of permanently harming human hearing, how hearing is permanently damaged from excessive sound exposures, health and safety standards and procedures related to noise exposure, and how music can be learned, taught, performed, and consumed in ways that are not risky to hearing.”<sup>97</sup> Students enrolled in the course are also encouraged to receive hearing exams, which are provided at no charge through the university.

Several studies have investigated the hearing health knowledge, attitudes, and behaviors of college students. One study found that University of North Texas music majors had healthier attitudes toward sound exposure when compared with non-majors.<sup>98</sup> This suggests that music majors perceive risky sounds as a negative thing, which may in turn influence their behavior. A study of a NIHL seminar for undergraduate and graduate music students concluded that their intervention led to more correct answers on a survey about hearing health and the use of hearing protection devices, and led to healthier attitudes about hearing exposure and greater intended use of hearing protection devices.<sup>99</sup> This survey supports the idea that presentations by professionals (in this case, audiologists) are more important to students than presentations by peers. Another study investigated the effectiveness of brochures in increasing hearing protection devices. While the brochures increased awareness of the risks of exposure and the efficacy of hearing protection devices, intended use of hearing protection devices did not change, and the intended use of over-the-ear headphones actually increased.<sup>100</sup>

### **Suggestions for Future Program Design**

Flamme, Roth, Smith, Deiters, and Needham suggest that sound level meters and personal noise dosimeters are becoming more accessible, and can be used to measure exposure.<sup>101</sup> Musicians should also have a professional audiologist monitor their hearing regularly. They also suggest the use of musician's earplugs, which can be custom fit by an audiologist. They note the limits of engineering and administrative controls, simply because of the nature of instruments and the need to practice, rehearse, and perform regularly. Hearing loss prevention programs should recognize the need for many hours of practice and rehearsal, and rely on enlightened self-interest over systems of reward and punishment. They suggest that post-secondary music programs "are the best place to establish hearing protection as the norm."<sup>102</sup>

Research suggests that there are several important factors which influence hearing health behaviors, including the knowledge and attitudes of individuals; how peers and family members view hearing health; and whether individuals believe they can control exposure.<sup>103</sup> It is suggested that interactive and age-appropriate programs can have a greater influence on these factors.<sup>104</sup> However, knowledge and attitudes are necessary but not sufficient conditions for behavior changes.

The NASM website includes materials which outline basic information on hearing health, with separate documents designed for administration and faculty, faculty and staff, and music students.<sup>105</sup> While use of these documents is voluntary and does not affect accreditation, they provide a starting point for design of hearing loss prevention programs for college music education students. There are three documents for music students. One is a packet designed to accompany an in-person orientation session; the second is a packet; and the third is a basic information sheet. All of these documents are in the public domain and free, and can be customized to meet the needs of each institution. These documents discuss the basic information about hearing loss, the risks specifically associated with music, and suggestions of healthy listening practices. The two packets also give tips on recognizing when situations are too loud (having to speak loudly to be heard, difficulty understanding speech during and after exposure, and tinnitus after exposure); and suggestions for maintaining hearing health (using musicians' earplugs, limiting exposure, taking breaks in rehearsals, and turning down the volume on listening devices).

In music education courses, this information could be provided, along with materials which specify the risks specific to ensemble rehearsals and individual practicing. Information on programs like Dangerous Decibels and Adopt-A-Band should be included to make future

educators aware of outside resources which could be used in their future classrooms. Music education students could be given an exercise to compile this information into materials appropriate for students of various ages (lower elementary, upper elementary, middle school, and high school), or to create unit plans designed to teach this information. In addition to learning the material, these assignments would serve to meet the objectives of music education courses (such as designing age-appropriate instructional activities and unit plans).

### **Call for Further Research**

Future research should continue measurements of sound pressure levels to which music educators and students are exposed in the classroom, and should be extended to learn about the effects it has on hearing and health. The effects of ensemble size, room size, and sound absorbing material should be studied to learn about how the room affects the sound pressure levels experienced in ensemble classes. Development of effective hearing loss prevention programs for music educators and students requires further research into the role of music educators in developing the knowledge, skills, attitudes, and behaviors of their students. Future programs need to prove that they influence the long-term behaviors of students. Further research should also explore levels of hearing protection device use by students and music educators.

### **Conclusion**

Music educators, ensemble conductors, and students who participate in musical ensembles are exposed to sound pressure levels which exceed the criteria for NIOSH. As such, this population should be enrolled in hearing loss prevention programs. Ensemble directors (many music educators fall into this category) have a direct role in influencing the sound pressure levels produced in rehearsals. Music educators have a role in influencing the knowledge, skills, attitudes, and behaviors of their students. Because of the health risks of noise

exposure, and the role music educators (and ensemble directors in general) have in influencing their students, hearing loss prevention should be taught in college music education programs.

This instruction should include hearing loss prevention materials from NASM; information on current hearing loss prevention programs for school-age students; information on sound pressure levels in ensemble classes and the hearing and health risks associated with it; and information on ways to reduce sound pressure exposure, including the use of personal hearing protection devices. Future research should further study sound pressure levels in rehearsals and classrooms; how the design of classrooms impacts sound pressure levels; the role of music educators in developing the knowledge, skills, attitudes, and behaviors of their students; the effect of hearing loss prevention programs on the long-term behaviors of students; and the levels of use of personal hearing protection devices by music educators and students.

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