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Can Your Hear Me?: Assessing College Students' Knowledge of Noise Induced Hearing Loss

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Abstract

Noise Induced Hearing Loss (NIHL) is an irreversible condition in which the cells of the inner ear are destroyed by strong sound signals and are no longer capable of relaying said signals to the brain for comprehension. Previous studies found that college students are most at risk for NIHL. Several organizations have created Hearing Conservation Programs; however, their efforts to change students' behaviors have proven unsuccessful as noted by several research studies. These studies explain that Hearing Conservation Programs and initiatives have not worked because college students do not believe they are susceptible to NIHL. The purpose of this study was to assess the knowledge that the average college student has regarding Noise Induced Hearing Loss in order to design a custom Hearing Conservation Program that can be created to meet college students' needs. To assess college students' knowledge of NIHL, an online quiz was administered to current college students via social media. Fifteen quantitative questions were asked. Data suggest that average college students know very little about the prevalence of Noise Induced Hearing Loss and its implications.

Introduction

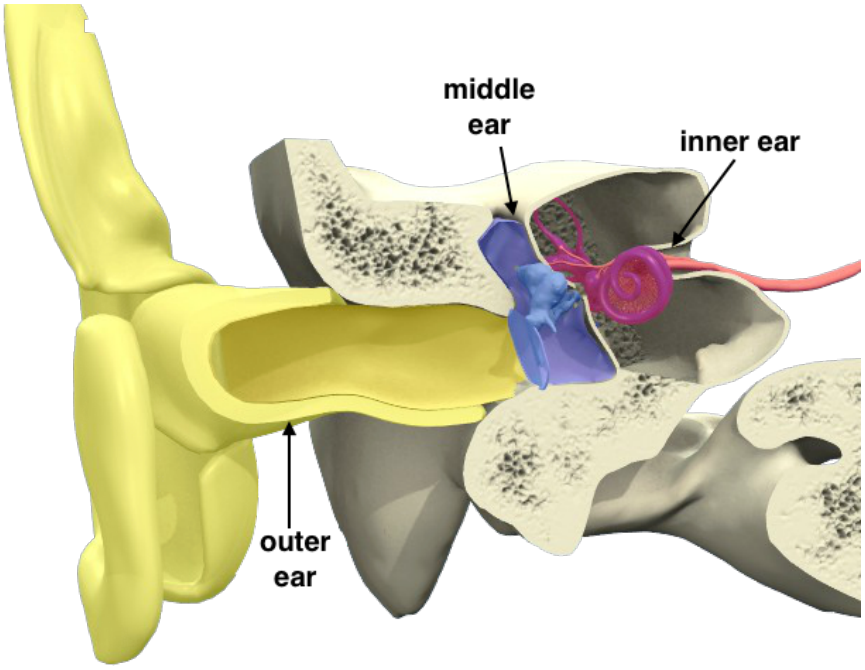
Imagine this: you are walking across campus to your next class. It's a long walk, so you decide to put your headphones in to make it less boring. Your favorite song comes on; you turn up the volume. The people walking in front of you are talking loudly; you turn the volume up even more. Distractions like these keep coming up all across campus

and by the time you get to your class, the music is almost at the maximum volume. Each time you walk around campus this scenario plays out. Later that night you are out at a bar. Music is playing, sporting events are on the televisions, and almost everyone is talking. You spend an hour or so here before heading out to a concert. The musicians have the amplifiers at maximum volume. At first you notice how loud the music is, but eventually you get used to it and enjoy the concert more. You begin to sing along to the songs with some friends that are there with you. Once the concert ends you head home. You are full of energy from the concert and your ears are ringing from all the great music you just heard. Over the next few days and weeks, people have to repeat what they said to you more often than before. Eventually your friends and family become accustomed to speaking to you at a louder volume – would you notice? Or would you care?

This is a classic example of noise induced hearing loss. As more and more sounds are rushing into your ears at louder and louder volumes, your hearing becomes damaged. This is especially true for college students; approximately 26 million adults aged 20+ have impaired hearing due to noise overexposure (Balanay & Kearney, 2015). Much of this is related to the youth culture of today. College students frequent rock concerts, sporting events, and nightclubs more than any other events (Balanay & Kearney, 2015). Noise Induced Hearing Loss is a common outcome of attending these events without the use of hearing protection.

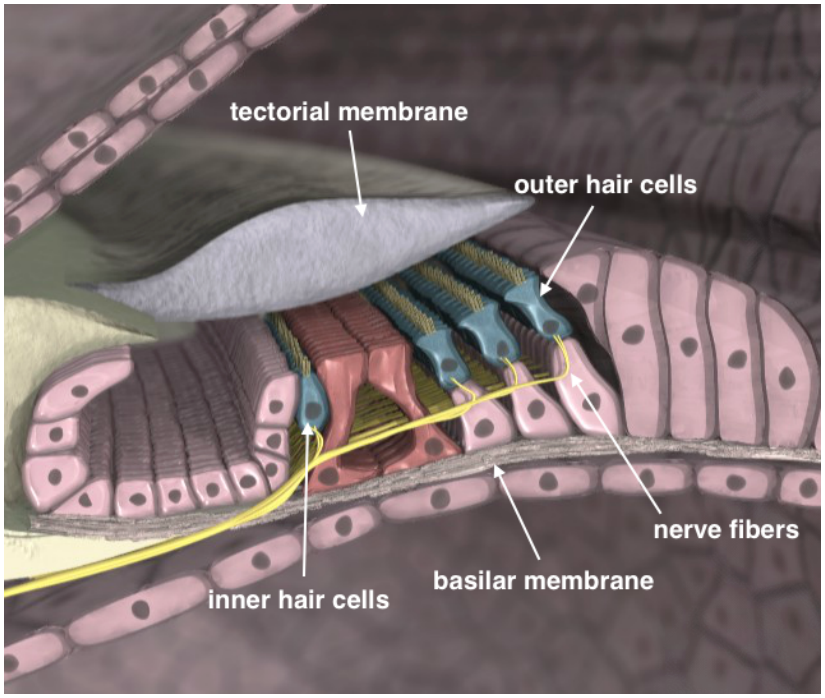
Anatomy of the Ear

There are three main sections of the ear – outer, middle and inner. The outer ear is landmarked by the ear lobe and the ear canal. The ear lobe has several crevices and curves that all serve a common purpose – to redirect and funnel sound waves into the ear canal from many directions. The sound waves, in the form of acoustic energy, travel down the ear canal to the tympanic membrane, also known as the eardrum. This is where the middle ear begins.



At the tympanic membrane the energy changes from acoustic energy into mechanical energy. The tympanic membrane acts like a drum – as you hit the surface, the energy is transferred to the space beyond it. When the tympanic membrane is displaced by the acoustic energy, it transfers the energy to the malleus (hammer), incus (anvil), and stapes (stirrup) – the bones of the middle ear. Because the three tiny bones are attached to the tympanic membrane, they move in and out with the membrane in accordance with the frequency of the acoustic energy. The malleus, incus, and stapes pivot back and forth together in order to transfer the mechanical energy to the inner ear via the stapes pushing against the oval window (Darrow, 2015).

The landmark feature of the inner ear is the cochlea, which is shaped like a snail shell. The cochlea is filled with fluid. Displacement of the oval window by the stapes causes a wave to form. Now the mechanical energy witnessed in the middle ear is converted to hydraulic energy. The cochlea contains the organ of Corti, which is the sensory organ that receives sound energy. The organ of Corti sits on top of the basilar membrane. It is continuous from the base to the apex of the cochlea. Inside the cochlea is the organ of Corti, which is organized like a piano keyboard – high frequency sounds cause a wave that peaks at the base, and low frequency sounds cause a wave that peaks at the apex. Inside the organ of Corti are three rows of outer hair cells (OHC) and one row of inner hair cells (IHC). Both types of hair cells perform specific tasks when they are activated, but are activated in a similar manner.



The OHC and IHC have stereocilia at the top. Stereocilia are like little hairs sticking out of the cells. The tallest of the OHC stereocilia are embedded into the tectorial membrane, a gelatinous arm that extends out over the inner hair cells. As the basilar membrane lifts, the OHC and IHC bend. The shearing of the OHC stereocilia against the tectorial membrane causes the OHC to bend. The fluid turbulence that results from the

lift of the basilar membrane causes the IHC to bend (Pickles, 2012). This causes potassium and calcium to rush into the cell which increases its voltage, and causes an electrochemical signal to travel down the hair cells to nerve fibers. The nerve fibers carry the signal to the central auditory nervous system, allowing us to perceive and comprehend sound and speech.

Why It Matters

Hearing is a very delicate function; several processes are occurring almost simultaneously. The suggested maximum amount of time listening to personal music players is one hour daily at a volume of no more than 89 dB, about as loud as a lawn mower ("Noise Level Chart", n.d.). College age students have been found to listen at 75-80 dB for up to eight hours daily (Sliwinska-Kowalska & Davis, 2012). This has a significant effect on the hair cells of the cochlea. Following noise overexposure, the organ of Corti enters an acute phase of noise damage – a state of degeneration and repair. In this phase, the cells of the inner ear begin to swell and degenerate; the OHC are more often affected by noise exposure than the IHC. With increased noise exposure and degeneration, the organ of Corti is unable to repair hair cells (Bohne & Harding, 1999). The OHC allow us to hear sounds that are less than 60 dB. This threshold will begin to increase as the cells continue to be overexposed to noise, meaning that the hair cells will become less sensitive to lower amplitude (softer) sounds coming into the cochlea. As the OHC become damaged, they cannot amplify the sounds coming into the ear, causing the hair cells to be unable to register lower levels of sound energy. This would not allow the hair cells to transmit electrochemical signals to the central auditory nervous system. Without the transmission of this signal, hearing is impaired.

Secondary problems can result from hearing loss, such as communication competency. Not only does the person affected with hearing loss have trouble communicating, but their communication partner may also suffer. Communication partners may have to repeat words/phrases or talk more loudly or slowly. In this regard, it is important to educate people on hearing conservation. Understanding how to preserve hearing is just as important as understanding why to preserve hearing. College students, especially, participate in louder activities. In a survey published in *Noise and Health*, it was revealed that college students are most exposed to dangerous noise levels when listening to personal music players, car stereo systems, and attending music events/concerts and nightclubs (Rawool & Colligon-Wayne, 2008). As a college student, I can confirm these results – in my free time I am most often found doing any of those things. As technology advances and the potential for the volume to be amplified further increases, it is possible that NIHL may become more prevalent. My research looked into college students' knowledge of hearing loss and effective hearing conservation programs.

Literature Review

Almost 500 million people across the world are at risk of or are experiencing noise induced hearing loss (hereafter NIHL). This estimate has nearly tripled throughout the past few decades, especially in youth populations. In 1980, approximately 6.7% of young people experienced social noise overexposure. In the 2000s, this estimate increased exponentially to 18.5% (Sliwinska-Kowalska & Davis, 2012). Because this condition is pervasive, it is important to look into college students' knowledge of NIHL in order to create effective hearing conservation programs.

NIHL is a condition where overexposure to noise destroys the hair cells in the ear, followed by degeneration of the auditory nerve (Kujawa, 2012). Both of these components play an integral role in relaying sound information to the brain. However, as hearing thresholds (the lowest volume of sound that is heard two-thirds of the time) increase, less sound information is relayed to the brain. As a result, only sounds that are above that hearing threshold are heard, leading to difficulties with communication.

History of the Effects of Noise

The United States Environmental Protection Agency takes precautions against noise and its effect on the environment. Each year billions of dollars are spent in an attempt to reduce noise in the environment. Not only is noise pollution distracting and unpleasant, but it can also contribute to NIHL. In 1967, William F. Rintelman, of the University of Pennsylvania School of Medicine, conducted the first long-term study of NIHL in rock musicians. It was found that long-term exposure to loud noise did have an effect on hearing (Leepson, 1980).

In the following years, efforts were made to protect people from the harmful effects of long-term exposure to noise. The Noise Control Act of 1972 was created to decrease and regulate noise in the environment. This act applies to construction equipment, air traffic, labels on noisy products, and efforts to control noise. Similarly, the Quiet Communities Act of 1978 worked to provide funds to communities that experienced above average noise levels. These funds were used to run noise control programs (Leepson, 1980). In 2015, the Quiet Communities Act was reevaluated. Funds were given to communities to assess noise in the environment, for research on the health

impacts of noise, and to develop effective educational materials for noise control programs ("Text – H.R. 3384", n.d.).

Government agencies are also concerned with the effects of noise. The Occupational Safety and Health Administration (OSHA) has controls in place to regulate exposure to occupational noise. Currently, the noise standard is 90 decibels (dB) in any work environment. If the 90 dB limit is exceeded, appropriate preventions must be practiced to protect workers' hearing. Many of these precautions established by OSHA, such as the use of earplugs, can be applied to other settings as well (Leepson, 1980).

As noise builds in the environment, things like iPods/MP3 players, conversations, or TV shows/movies may not be heard as well. To make up for this, people may turn up the volumes on their devices or speak at louder volumes. This can be hazardous to hearing and a precursor to NIHL if it becomes habitual.

Who is Most at Risk?

While people of all ages are susceptible to NIHL, researchers disagree on which factors are related to its development. When we are first born, our hearing mechanism is completely developed; as we age, our hearing subtly declines naturally. Part of this decline is a result of noise exposure. Many studies have tried to identify the type of people who are most at risk for NIHL. In a recent study, researchers found that NIHL is commonly found in college students, particularly those who are 21 years old (Balanay & Kearney, 2015). Other studies have found similar results. In a survey of 238 college students in the United States, Rawool and Colligon-Wayne (2008) found that 76% of participants experienced symptoms related to NIHL, such as a chronic ringing noise in one's ears known as *tinnitus*. Similar studies narrow this down even further, stating that

music majors in particular are at greater risk of NIHL than the general college student population (Callahan et al., 2011). This can be caused by the countless hours these students spend listening to music and playing instruments for their studies.

While many researchers are in agreement about college students being most at-risk for NIHL, some researchers suggest otherwise. Basner et al. (2015) note that the odds of experiencing NIHL are much greater if you are older, male, and a smoker. This study also notes that the greatest risk of NIHL is from occupational noise exposure, particularly the mining and wood products industry, as well as construction. Other studies suggest that the risk is greatest before college. According to audiologists at Colorado University, pre-university teens not only blast music louder than the average adult, but also are unaware of how excessive the volume is (Naik, Kiran, & Pai, 2014).

While many studies find that college students have the highest prevalence of NIHL, some studies have found different results. Because all of these studies note that NIHL does occur in college students, though at varying rates, it is important to look further into this population in order to make conclusions about their knowledge of hearing and hearing loss.

Youth Culture

Much of the NIHL that is seen in college students is attributable to behaviors related to participation in youth culture. Youth, more than any other age group, engage in activities with excessive levels of noise. This exposure mainly comes from iPods/MP3 players, car stereo systems, and attendance at clubs and concerts (Rawool & Colligon-Wayne, 2008). Collegiate sporting events are also a popular activity for students, especially in the southern United States. Spectators and workers of these sporting events,

mainly football games, are exposed to extreme levels of noise. Events such as football games are considered to be the most significantly hazardous exposure to noise (Balanay & Kearney, 2015). Many of the leisure activities that youth participate in are known to be loud, which has been true for generations in the past. Portnuff, Fligor, and Arehart (2011) report that adolescents today are not at a greater risk of NIHL than those who used older technologies. However, this study states that graduate-level students today listen at lower levels than adolescents using similar technologies. This evidence suggests a discrepancy between the knowledge of adolescents and of graduate students regarding NIHL. While there is no difference between past and present generations, there is a difference between ages and experiences of listeners that cause graduate students to listen to music at safer levels.

The use of iPods/MP3 players is particularly important to the study of NIHL. As technology advances, iPods/MP3 players are becoming more and more ubiquitous. New types of devices are being rapidly introduced. With the advancement of technology comes an increase in qualities of the devices, such as sound. New technologies allow for increased volumes that do not distort the sound. Headphone advances, too, allow for listeners to use these devices at louder volumes. Because there is minimal sound leakage from the headphones, listeners can turn up the volume without disturbing those around them (Naik, Kiran, & Pai, 2014).

The most popular genres of music among young people today are Pop and Rock (Marron et al., 2015). These genres of music have been found to produce the highest sound pressure level (SPL), producing sound in the highest octave levels, ranging from 250 Hz – 2000 Hz (Marron et al., 2015). Producing sounds at these levels means that

there is extraordinary pressure on the hearing mechanism. This pressure created by the volume and frequencies of the sound damages the hair cells.

Some studies have found relationships between club drugs (psychoactive drugs often used at clubs, bars, raves, etc.) and NIHL. One such study looked at the consumption of ecstasy, also known as MDMA, in cases of NIHL. MDMA is widely used for its stimulant effect; it also decreases the levels of serotonin and dopamine in the brain, which are imperative in the protection against acoustic trauma. Without proper levels of serotonin and dopamine, the brain is incapable of firing electrical signals to the muscle in the middle ear. The stapedius muscle contracts when it is exposed to noises over 70 dB, causing the bones of the middle ear to be unable to pivot as much. While MDMA alone does not cause any hearing loss, it does enhance any hearing loss that may occur while under the influence (Church, Zhang, Langford, & Perrine, 2013). When students attend clubs and concerts after consuming MDMA, the brain's capacity to protect the ears against loud volumes is impaired.

Many studies that have looked into the youth culture as the instigator of NIHL in young people have found similar results. NIHL is most often the result of leisure activities of college students, most of which are noisier than the every day environment. Many students are aware of their dangerous habits. In one survey, one third of participants reported being in noisy settings frequently/always, while one half of participants reported sometimes (Danhauer et al., 2009). In this regard, it is important to look into youth culture when discussing college student's knowledge of NIHL.

Possible Treatments and Interventions

Preventions and interventions, which can protect hearing both during noise exposure and after, for NIHL are available. Because some of these preventions and interventions are not widely known, it is important to consider them and their effectiveness when looking at college students' knowledge of NIHL.

Researchers and medical professionals debate whether or not NIHL is irreversible. More recently studies have shown that there are possible treatment options and interventions available. According to Le Prell, Yamashita, Minami, Yamasoba, & Miller (2007), dietary antioxidants, such as vitamin E, can protect hair cells from the damage caused by noise exposure. However, these interventions have only been found to work within a specific and critical window of administration. These antioxidants proved most therapeutic and effective when taken within the first three days post-noise exposure. These antioxidants prevent free radicals from forming in the cochlea. Free radicals are oxygen molecules that reduce cochlear blood flow and cause neural swelling, among other things that are obstacles in the pathway of noise.

Other biological interventions have been proved successful as well. Ginseng extracts and N-acetyl-cysteine (NAC) have antioxidant features, allowing them to protect against NIHL. Oral administration of these supplements was found to significantly reduce damage caused by noise exposure (Doosti et al., 2014). The results from the NAC group were shown to be more prominent than the ginseng group. Fausti, Wilmington, Helt, Helt, & Konrad-Martin (2005) have found that L-carnitine, a nutrient, is successful at limiting hair cell death in the inner ear. L-carnitine replenishes glutathione (an antioxidant) levels in the cochlea, thus preventing cellular damage.

Some manufacturers of personal music players are beginning to set volume limits on devices. Apple Computer Inc. did just that according to the *Wall Street Journal* (2006). iPods have bee found to produce sound levels exceeding 115 dB. Listening to sounds at this level can cause damage to hearing after just 28 seconds. As an attempt to decrease potential harm to listeners, Apple Computer Inc. introduced a software update allowing users to set their own volume limit.

Many sound companies are now making noise-cancelling headphones as a method of NIHL prevention. These headphones have miniature microphones in the earpieces that actively listen to the environment. A sound wave that is 180° out of phase with the ambient noise is sent out ("How do active", n.d.). When waves are out of phase, it means that their amplitudes do not line up. Being 180° out of phase would mean the amplitude of one wave is opposite the amplitude of another. When the amplitudes of waves are opposite each other, they cancel each other out. As the headphones send out these waves, the user is unable to hear the ambient noise around them. This means that music can be played at lower volumes while still being heard by the listener.

Musicians use electronic earplugs to protect their hearing while performing. These devices are capable of producing high-quality sound without attenuation, except for at the highest levels of volume (Basner et al., 2015). There are also many simpler options to preventing NIHL, such as earplugs and lowering volumes when possible.

Hearing Conservation Programs

Nearly all researchers advocate for the implementation of hearing conservation programs and education. Some researchers consider preventions and interventions, such as earplugs and limits on devices to be forms of hearing conservation.

Fausti et al. (2005) offers many possible conservation options. They state that the most effective way to prevent NIHL is to change behaviors related to hearing protection. While some devices may be difficult to use or uncomfortable to wear, it is important that listeners make the effort to get as much protection from the device as it offers. They also report that there are community-based education programs available. These programs include Dangerous Decibels®, run by the Oregon Hearing Research Center, and WISE EARS!®, run by the National Institute on Deafness and Other Communication Disorders. Each of these programs promotes the importance of hearing protection and education. This study found evidence that multimedia campaigns about preventing hearing loss can be effective when tailored to each target audience.

Other researchers, such as Alberti (1992), suggest that education is the key to hearing conservation. By labeling devices, such as power tools, as hazardous to hearing, users will begin to recognize when sound levels are becoming more dangerous. Through this practice, adults will be better able to educate their children about safe hearing practices.

A model that can help researchers better understand how young people perceive and behave towards NIHL is the Health Belief Model. This is often used as a preventative strategy in health fields. It consists of three elements: (1) individual thoughts based on perceived susceptibility, (2) perceived threat based on variables, such as gender or demographics, and (3) perceived benefits of preventative measures. For example, students may be aware of NIHL, but feel that they are not likely to experience it. As a result, hearing conservation programs can be fine-tuned to better reach the college student population (Rawool & Colligon-Wayne, 2008). Survey question can be

developed to gain an understanding of college students' knowledge and perceptions of NIHL. With this information, hearing conservation programs can target these perceptions, and resulting behaviors, in order to show susceptibility levels and benefits of prevention.

A common trend found in the results of studies is that there is a great need for hearing conservation programs. Chung, Roches, Meunier, & Eavey (2005) found that just 8% of participants labeled NIHL as "a very big problem". In comparison to this, 18% of participants labeled acne in the same way. This study notes an extreme lack of concern towards hearing health. Studies such as these are helpful in gauging the attitude towards NIHL college students have so that effective conservation programs can be established.

My research focused primarily on assessing college students' knowledge of NIHL, as well as evaluating the need for hearing conservation programs. The literature that has been reviewed has proven that there is a relaxed attitude about NIHL across all populations. In particular, I think it is important to study the college student population, since many of the activities they engage in are loud. The literature also shows that there is a real need for effective hearing conservation programs. Information collected from college students is vital for creating a working model of such a program.

Methodology

A quiz designed to gain information regarding college students' knowledge of NIHL was administered to 100 current college students. Participants were students at a variety of colleges and universities in a variety of programs. It was thought that this would provide more accurate information, since it generalizes the college student

population. Being a current college student was the only commonality among participants to ensure that the quiz polled from all walks of life.

The quiz was accessed via Facebook. The primary researcher posted a link to the online quiz on her wall, where only their friends were able to see it. The post encouraged participants to share the quiz on their walls, since only friends of the researcher would see it due to privacy settings. Several Facebook members from different states, colleges and universities shared the researcher's post, allowing their friends access to the quiz.

It was decided that students would take the quiz online, rather than on paper, because it would allow for anonymity and flexibility in regards to time. Several online quiz templates were consulted, such as SurveyMonkey, Survey Gizmo, and SoGo Survey, before deciding on Google Forms, which offered the ability to provide students with immediate feedback regarding their answers, and the ability to provide researchers with statistics on an individual basis and an overall summary.

A variety of topics having to do with NIHL were covered – anatomy and physiology of the ear and hearing mechanism, awareness of noise levels in every day situations, at-risk populations, prevalence, risk factors, hearing protection/intervention strategies, and current Hearing Conservation programs – in order to understand what knowledge and awareness current college students have of NIHL. All answers were collected anonymously, with the participant's year of graduation being the only identifying factor. By knowing the year of graduation, the researcher could conclude whether or not there was a significant difference in the students' knowledge based on their level of education.

Out of concern that students would get bored or careless with a long quiz, it was be decided that 15 quantitative questions would suffice to get a solid understanding of college students' knowledge of NIHL. Each question had exactly one correct answer and was worth one point, giving each student the opportunity to earn a total of 15 points. All questions held the same amount of importance, so there were no questions that were worth more than others. It was also a simple way to show students their scores with the immediate feedback provided by the researchers who created the quiz.

Data were analyzed quantitatively in order to gain insight into the knowledge that college students have regarding NIHL. Descriptive statistics (average and range) were used to interpret the results, as researchers combed through the data question by question. This information is to be used in the creation of a model Hearing Conservation Program designed to serve the college student population.

Results

The highest possible score on this quiz was 15. On average, participants scored 8.15, or 54%, which is a failing grade. The average score for each graduation year was reported, as well. The class of 2017 averaged 8.3, or 55%. The class of 2018 reported an average of 9.7, or 64%. The class of 2019 scored an average of 8.15, or 54%, while the class of 2020 averaged at 7.5, or 50%. As the highest average grade among the classes was a 64%, each class failed the quiz, suggesting a lack of knowledge surrounding NIHL.

The lowest score reported on this quiz was 5, or 33%, while the highest score was 13, or 86%. Each class year reported wide ranges of scores. The class of 2017 ranged

from 5 to 13. The class of 2018 ranged from 5 to 11, with the class of 2019 reporting a smaller range of 7 to 10. The class of 2020 reported a range of 5 to 10.

More participants scored toward the lower end of the range than the higher end. Only one participant scored 13, whereas five students scored 5. Ninety percent of participants scored 10 or lower, leaving just 10% of participants scoring above a 66%. This suggests, again, that there is a lack of knowledge surrounding NIHL.

A copy of the quiz and results can be found below.

1) Noise Induced Hearing Loss occurs when the hair cells of the inner ear are destroyed by strong sound signals.
   - **a. Fact** *(81)*
   - b. Myth *(19)*

2) Using a snowmobile for 30 minutes is more damaging to hearing than using a lawn mower for 30 minutes.
   - a. Fact *(31)*
   - **b. Myth** *(69)*

3) Males and females between the ages of 20-25 are most at risk for Noise Induced Hearing Loss.
   - **a. Fact** *(77)*
   - b. Myth *(23)*

4) Which of the following is the most damaging to hearing?
   - a. Snowmobile/ 30 minutes *(30)*
   - b. Lawn Mower/ 30 minutes *(48)*
   - c. Vacuum/ 30 minutes *(17)*
   - **d. Remote control airplane/ 30 minutes** *(5)*

5) Some noise regulations regarding the environment apply to:
   - a. Construction equipment *(7)*
   - b. Air traffic *(3)*
   - c. Labels on machinery *(2)*
   - **d. All of the above** *(88)*

6) Noise Induced Hearing Loss is irreversible.
   - **a. Fact** *(76)*
   - b. Myth *(24)*

7) Nearly 2 million people worldwide are experiencing Noise Induced Hearing Loss.
    a. Fact *(95)*
    b. Myth *(5)*

8) Which chemicals in the brain are imperative in protection against acoustic trauma?
    a. Dopamine and serotonin *(17)*
    b. Serotonin and oxytocin *(20)*
    c. Dopamine and endorphins *(31)*
    d. Oxytocin and endorphins *(32)*

9) Your genetics can increase your risk of Noise Induced Hearing Loss.
    a. Fact *(55)*
    b. Myth *(45)*

10) Which of the following does NOT protect your hearing from damaging noise levels?
    a. 1 baby aspirin each day *(65)*
    b. Wearing ear plugs in noisy environments *(4)*
    c. Taking dietary antioxidant supplements before attending noisy events *(21)*
    d. Using noise-cancelling headphones *(10)*

11) The recommended level of daily noise exposure is 89 dB for one hour. It is estimated that college students experience up to 7 hours of noise overexposure each day.
    a. Fact *(83)*
    b. Myth *(17)*

12) There is an extreme lack of concern for Noise-Induced Hearing Loss. Hearing conservation programs work to educate the population about the dangers of noise overexposure. Which of the following is an organization with a hearing conservation program?
    a. Safe Sounds *(59)*
    b. How to Hear *(12)*
    c. Dangerous Decibels *(19)*
    d. Cochlear Caution *(10)*

13) The organ of Corti is our sensory organ for hearing. It is located in the:
    a. Middle Ear *(34)*
    b. Brain *(2)*
    c. Cochlea *(47)*
    d. Ear Canal *(17)*

14) Hearing can be restored to normal capabilities through the use of a hearing aid.
    a. Fact *(50)*
    b. Myth *(50)*

15) Noise Induced Hearing Loss is 100% preventable.
    a. **Fact** *(78)*
    b. Myth *(22)*

Frequently missed questions include numbers 4, 7, 8, 12, and 13. Question numbers 4, 7, and 12 focus on students' awareness of NIHL. These questions use every day situations and public information in an effort to see how many students are familiar with the information. Less that one quarter of participants answered these questions correctly. Questions 8 and 13 focus on knowledge of ear anatomy as it relates to NIHL. Less than half of participants answered question 13 correctly. Fewer than 20% of participants answered question 8 correctly, which went into greater detail than question 13.

Discussion

The results of this survey indicate that the college students sampled know very little about NIHL. This is demonstrated by analyzing the average score of the quiz, and by looking at answers to each question individually. Several of the questions asked were frequently missed, or provided interesting findings that the researcher did not expect – information that may be helpful in creating a model Hearing Conservation program tailored to college students.

Question number four was the first question that was frequently missed. The question aimed to assess college students' level of understanding and awareness of decibels and frequencies of sounds. Students were asked to pick which device was most damaging to hearing after 30 minutes of exposure, giving the following options: snowmobile, lawn mower, vacuum, and remote control airplane. Of the 100 participants, only 5 answered this question correctly – remote control airplane.

In order to answer this question correctly, participants had to be familiar with these devices and be able to rank them in order of loudness – the loudest being the correct answer. Most often, participants chose to answer with lawn mower, which is not a bad choice, just not the correct one. According to "Noise Level Chart: DB levels of Common Sounds" (n.d.), a lawn mower produces 90 dB; however, a remote control airplane produces 93 dB ("Model Aircraft Engine Noise…", 2013). While this may seem like a small difference – only 3 dB – it is actually a large difference, since decibels are not linear.

A superficial analysis of this question leads to the conclusion that college students are not knowledgeable about decibels as they relate to noise levels in the environment and every day situations. It is crucial that students are knowledgeable about decibels and understand when noise levels become dangerous. Once the hair cells of the inner ear are destroyed, they cannot regenerate without taking precautions within 3 days of noise overexposure (Le Prell, Yamashita, Minami, Yamasoba, & Miller, 2007). Students' awareness and judgment of noise levels is crucial in the success of protecting the fragile hair cells that are transmit sound waves, allowing us to hear.

The second question that was frequently missed was number seven. A true/false statement, question seven told students 'Nearly 2 million people worldwide are experiencing Noise Induced Hearing Loss.' Of the 100 participants, only five answered correctly – false. Ninety-five participants felt that 2 million, of the 7+ billion people in the world, was an accurate estimate of the amount of people experiencing NIHL. This estimate is tremendously low, as Naik, Kiran, & Pai (2014) report that an estimated 20 – 30 million people worldwide are experiencing negative effects of NIHL.

While 20 – 30 million people are actually experiencing NIHL, almost 500 million people are at risk of NIHL. This estimate has risen exponentially since 1980, increasing from 6.7% of the youth population to 18.5% (Sliwinska-Kowalska & Davis, 2012). Based on the results of this quiz, college students are dangerously unaware of the looming potential of NIHL. This finding is not surprising, as a previous study found that just 8% of participants labeled NIHL as "a very big problem", as 18% of participants labeled acne in the same way (Chung, Roches, Meunier, & Eavey, 2005).

If students are to become aware of NIHL and its effects, they need to understand its prevalence. Chung, Roches, Meunier, & Eavey (2005) report an extreme lack of concern for NIHL in young people. A Hearing Conservation program aimed toward college students would need to include a component addressing the reality of NIHL. If students are aware of the potential of NIHL, perhaps they will pay more attention to prevention strategies and hearing protection.

The goal of question number eight was to assess the knowledge that college students have of ear physiology as it pertains to NIHL prevention. When asked to identify the chemicals in the brain that help to protect against acoustic trauma, only 17 participants answered correctly with dopamine and serotonin. In order to answer this question correctly, participants would need knowledge of what chemicals are found in the brain, and what each of them do.

Knowing that dopamine and serotonin play a role in hearing protection is not common knowledge. Specifically, dopamine and serotonin allow the stapedius muscle to function properly. The stapedius acts as a built-in hearing protection device. When noise levels exceed 70 dB, the muscle contracts, preventing the bones of the middle ear from

pivoting normally. Consequently, the sound transmitted by the middle ear is dampened, thus protecting the inner ear from harmful levels of sound energy. Should there be a deficit of either chemical, the brain is unable to signal the muscles in the middle ear (Church, Zhang, Langford, & Perrine, 2013).

A successful Hearing Conservation program would need to include a variety of prevention strategies that would catch the attention of college students. There are several substances, foods, and activities that affect the chemicals in the brain. Analysis of this question draws the conclusion that college students are not knowledgeable of brain chemicals and their physiology. In order to counteract this, successful programs should include the consequences of club drugs, unhealthy foods, and noisy activities on the hearing mechanism.

Question number 12 was also frequently missed. The aim of this question was to see whether or not college students had heard of any Hearing Conservation programs that are readily available to the public. Just 19 participants chose Dangerous Decibels, which was the correct option. The most popular choice was Safe Sounds, a fake organization that was created using the researcher's imagination. Brief analysis of this question suggests that students are unaware of current education efforts in regard to NIHL.

Literature suggests that Hearing Conservation programs are largely unsuccessful, proving the reliability and validity of this question. Over 80% of participants did not recognize that Dangerous Decibels was an organization that promoted hearing conservation and education. The key to successful hearing conservation is education (Alberti, 1992). If current efforts are not reaching college students, then college administration should provide on-campus efforts to protect hearing.

Undergraduate institutions, such as Assumption College, require all incoming students to pass an online course about alcohol education. In a similar manner, institutions could create online courses regarding NIHL, as the youth culture thrives in noisy environments (Rawool & Colligon-Wayne, 2008). Implementation of Hearing Conservation programs on college campuses could help to prevent or further progress NIHL.

The final question that was frequently missed was question number 13, which assessed students' knowledge of ear anatomy. When asked to provide the location of the organ of Corti, the main sensory organ for hearing, 47 participants correctly answered cochlea. While the cochlea was the most-chosen option, less than half of the participants chose it. Other popular choices include the ear canal and the middle ear.

Knowing the location of the organ of Corti is important for understanding NIHL. Inside the cochlea, the organ of Corti sits on the basilar membrane, and is continuous from base to apex of the cochlea. Within the organ of Corti are all of the hair cells necessary for transmitting sound signals to the brain for comprehension. Without the knowledge of the structures in the ear, students cannot be expected to be able to prevent NIHL.

Efforts to educate students on ear anatomy should be included in any hearing Conservation program. Each part of the ear can be explained simply, emphasizing important structures, such as the organ of Corti. Should students know what part of the ear is most impacted by noise overexposure and how it is impacted, perhaps they will become motivated to take measures to protect it. This can be done easily through the incorporation of animated images with labels next to each structure.

A few questions yielded very interesting results. The first, question number 14, asked students to decide whether the statement 'hearing can be restored to normal capabilities through the use of a hearing aid' is true or false. The correct answer, false, was chosen by 50 participants, which is exactly half. It was not expected that there would be a tie between the two options. In an attempt to understand what students know about compensating for lost hearing, there are no overall conclusions that can be made. Based on the results, it is possible that students have a very basic understanding of hearing aids, in that they can help compensate for lost hearing; however, it is unclear whether or not students fully understand the purpose and capabilities of hearing aids since participants are divided half and half.

As noted in "Myths and Facts about Hearing Aids" (n.d.), hearing cannot be fully restored through the use of hearing aids in the same way one corrects their vision through the use of glasses. Rather, hearing aids aide in binaural hearing, or hearing with two ears. This helps us with sound localization, as well as sound clarity, particularly in noisy environments. Though hearing aids cannot restore hearing to its full potential, they help in easing communication for someone with hearing loss.

While no conclusions can be made about the knowledge that college students have regarding techniques to improve hearing, components of a Hearing Conservation program can be made to address it. To do this, a basic overview of hearing aid technology should be included. A myth/fact section could follow, having students apply their learned knowledge along with their reasoning skills to answer questions.

The next question that resulted in an interesting finding is question number 11. Participants performed well on this question, with 83 participants correctly answering

true to the statement ‘the recommended level of daily noise exposure is 89 dB for one hour. It is estimated that college students experience up to seven hours of noise overexposure each day.’ These results suggest that college students are aware of noise overexposure. Danhauer et al. (2009) found the same results when half of their participants reported being in noisy settings frequently. The results do not, however, suggest what types of noise students are overexposed to, or whether or not students are concerned about it.

Organizations should consider this when making improvements to their Hearing Conservation programs. Ideally, a program tailored to college students should include the types of noise overexposure that are common among youth, such as concerts, iPods/MP3 players, and car stereos (Rawool & Colligon-Wayne, 2008). Since it is unfair to ask students to stop participating in youth culture, the program should also include several strategies for hearing protection and interventions. While a number of strategies involve dietary supplements and chemical balances in the body, there are many simple improvements students can make to protect their hearing, such as using earplugs or noise-cancelling headphones, and being mindful about volume settings (“How do active”, n.d.) (Basner et al., 2015).

Question number three asked participants to identify the population that is most at-risk for NIHL. Of the 100 participants, 77 answered correctly, saying that males and females ages 20-25 are most at-risk. Not only do college students recognize that they experience noise overexposure daily, but also that they are the population that is most at-risk for NIHL.

Even though college students fall within the range of who is most at-risk for NIHL, it is crucial to stress the importance of lifelong hearing protection practices. Our hearing naturally declines as we age. Age-related hearing loss combined with NIHL would make for increasingly difficult communication as someone goes through life. Frustration that this might cause would most definitely decrease the quality of one's life, as communication is such a large part of daily living. In promoting healthy hearing habits, hearing loss and any consequences it brings can be kept to a minimum.

It is also interesting to note that 76 participants correctly answered true on question number 6, which asked if NIHL is irreversible. Question number 15 was also met with overwhelming success as 78 participants stated that 'NIHL is 100% preventable' was a true fact. College students accurately identified NIHL as a permanent condition that can be prevented.

Although it is clear that students are aware that NIHL is irreversible and preventable, it is still important to include it in a Hearing Conservation program. These facts would not play a large role in the program so that students do not become bored if they think it will be information that they already know. Noise Induced Hearing Loss is a real condition and needs to be addressed seriously. Rather than bombarding students with information that they already know, they should be given lesser-known information so that they can make smart decisions regarding noise exposure going forward.

College campuses should be implementing Hearing Conservation programs to protect the hearing health of their students, who are not knowledgeable enough on their own to do so. While the quiz was anonymous, participants were asked to provide their year of graduation. Given this information, researchers could identify any differences in

the knowledge college students have based on their class year. The findings reported no significant difference in class year. First year students need to be educated on NIHL and healthy hearing habits just as much as the students who are about to graduate, and all of the students in between.

This quiz confirmed the fact that college students know very little about NIHL. A total of 15 questions were presented to each participant, though, only ten were addressed. These ten questions revealed the most information about college students' awareness and knowledge of NIHL. From these ten questions, data was collected that can be used in the creation of a Hearing Conservation program that is tailored to college students. The other five questions, while still providing important information, do not need to play a large role in the Hearing Conservation program as participants performed well on them. It is important to include the information that students know the least in order to maintain interest and attention.

Limitations

This research is limited by its sample of college students. Due to privacy settings on Facebook, participants were limited to students who were friends with the researcher, or students who were friends of friends with the researcher. This prevents the survey from being administered nationally and randomly. As a consequence, all results reflect the college students sampled rather than the average college student.

This research was also limited by the survey's relevancy to each participant. Some questions assume that participants are familiar with all of the answer choices or the information provided in the question. In future studies, survey questions will involve

events that are relevant to the youth culture, such as concerts and athletic events. This will increase the reliability and validity of the data collected.

Conclusion

Previous studies have shown that current Hearing Conservation programs are largely unsuccessful. This survey attempted to identify topics that are of utmost importance in a Hearing Conservation program that is tailored for college students.

Data collected through this survey confirmed that college students are not knowledgeable about NIHL. In order to increase knowledge and awareness, Hearing Conservation programs that specifically target the college student population need to be created. Information that was collected provided strong insight as to the topics that should be included in the program.

Of the topics covered in the survey, participants showed a strong understanding of what NIHL is and what population is most at-risk. Participants were also able to identify what products/equipment produce dangerous noise levels. Because participants are familiar with this information, it would play a smaller role in the Hearing Conservation program, so to maintain the attention and interest of college students.

Participants specifically struggled with anatomy and physiology of the ear and hearing mechanism. In an effort to change this, a Hearing Conservation program should include a brief, yet informative, overview of how sound travels through the ear.

A Hearing Conservation program not only needs to inform college students of NIHL, but also needs to motivate them to be proactive in protecting their hearing.

Increasing knowledge and awareness of NIHL is imperative in maintaining a high quality of life among college students.

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APPENDIX A

1) Noise Induced Hearing Loss occurs when the hair cells of the inner ear are destroyed by strong sound signals.
   - **a. Fact**
   - b. Myth

2) Using a snowmobile for 30 minutes is more damaging to hearing than using a lawn mower for 30 minutes.
   - c. Fact
   - **d. Myth**

3) Males and females between the ages of 20-25 are most at risk for Noise Induced Hearing Loss.
   - **a. Fact**
   - b. Myth

4) Which of the following is the most damaging to hearing?
   - a. Snowmobile/ 30 minutes
   - b. Lawn Mower/ 30 minutes
   - c. Vacuum/ 30 minutes
   - **d. Remote control airplane/ 30 minutes**

5) Some noise regulations regarding the environment apply to:
   - a. Construction equipment
   - b. Air traffic
   - c. Labels on machinery
   - **d. All of the above**

6) Noise Induced Hearing Loss is irreversible.
    a. Fact
    b. Myth

7) Nearly 2 million people worldwide are experiencing Noise Induced Hearing Loss.
    a. Fact
    b. Myth

8) Which chemicals in the brain are imperative in protection against acoustic trauma?
    a. Dopamine and serotonin
    b. Serotonin and oxytocin
    c. Dopamine and endorphins
    d. Oxytocin and endorphins

9) Your genetics can increase your risk of Noise Induced Hearing Loss.
    a. Fact
    b. Myth

10) Which of the following does NOT protect your hearing from damaging noise levels?
    a. 1 baby aspirin each day
    b. Wearing ear plugs in noisy environments
    c. Taking dietary antioxidant supplements before attending noisy events
    d. Using noise-cancelling headphones

11) The recommended level of daily noise exposure is 89 dB for one hour. It is estimated that college students experience up to 7 hours of noise overexposure each day.
    a. Fact
    b. Myth

12) There is an extreme lack of concern for Noise-Induced Hearing Loss. Hearing conservation programs work to educate the population about the dangers of noise overexposure. Which of the following is an organization with a hearing conservation program?
    a. Safe Sounds
    b. How to Hear
    c. Dangerous Decibels
    d. Cochlear Caution

13) The organ of Corti is our sensory organ for hearing. It is located in the:
    a. Middle Ear
    b. Brain
    c. Cochlea

d. Ear Canal

14) Hearing can be restored to normal capabilities through the use of a hearing aid.
   a. Fact
   b. Myth

15) Noise Induced Hearing Loss is 100% preventable.
   a. Fact
   b. Myth