Modern-Day Hearing Impairment: The Role of Environmental Factors and Lifestyle Choices

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Modern-Day Hearing Impairment:

The Role of Environmental Factors and Lifestyle Choices

A Thesis Presented

by

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ABSTRACT

This thesis explores the increasingly prevalent issue of hearing impairments in the context of modern environmental factors and lifestyle choices. The intricate workings of the human auditory system are first examined, emphasizing its complexity and sensitivity. The study delves into the categories of hearing impairments - conductive and sensorineural - highlighting their distinct characteristics, causes, and impacts on individuals' lives. A key focus of the research is the influence of environmental factors, particularly the escalating problem of noise pollution in urban and industrial settings. Studies show that prolonged exposure to high decibel levels significantly deteriorates hearing acuity. Other environmental risks, like air pollution and chemical exposures, are also examined for their auditory impacts. The thesis then transitions to lifestyle choices affecting auditory health, such as the widespread use of personal audio devices and exposure to social and recreational noise. The ubiquity of headphones and the popularity of loud entertainment venues among the youth pose significant risks for noise-induced hearing loss. Furthermore, the effects of certain medications and chemicals with ototoxic properties are explored. A comparative analysis reveals a marked increase in hearing impairments over recent decades, attributed to factors such as industrialization, urbanization, and technological advances. The study concludes with a call for heightened public awareness and policy interventions to mitigate these risks. The urgent need for preventive measures and further research into solutions is underscored to preserve auditory health in the face of modern challenges.
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Introduction

In the intricate tapestry of human senses, hearing stands out as a vital component that weaves together the sounds of our environment into meaningful patterns of communication and experience. Through this auditory channel, we not only perceive the subtle nuances in a loved one's voice or the melodious complexities of music but also gain essential cues that navigate our daily interactions and ensure our safety. However, this crucial sense, which is often taken for granted, remains vulnerable.

In an era where technological advancements are progressing at an unprecedented rate, there is a growing concern regarding the unintended consequences of noise exposure on this sensory mechanism. This thesis seeks to explore the intricate relationship between modern environmental factors, lifestyle choices/habits and the increasing prevalence of hearing impairments. Modern-day hearing impairment is significantly exacerbated by environmental factors such as noise pollution and by lifestyle choices including the use of personal audio devices and exposure to chemicals, necessitating a comprehensive approach to prevention and awareness.

This exploration is crucial in the context of our rapidly evolving society in which the auditory health risks associated with common and unseemly harmless conditions are often overlooked. Through a systematic review of current literature, this thesis will highlight the extent of these risks while underscoring the need for increased public awareness in order to preserve hearing health in the modern world.
Basics of Hearing

The human auditory system is a marvel of biological engineering, allowing us to navigate and interact with our environment through the dimension of sound. This section delves into the foundational aspects of hearing, exploring the intricate structures and sophisticated processes that enable this critical sense. The human ear is divided into three main sections: the outer ear, middle ear, and inner ear, each with distinct structures and functions. The outer ear consists of the auricle and the ear canal. The auricle, with its unique folds and ridges, serves as a natural acoustic gatherer as it directs sound waves into the ear canal. This canal, a tube running from the outer ear to the eardrum, not only channels sound waves towards the middle ear but also provides a measure of protection for the more delicate structures deeper inside the ear. The middle ear houses the eardrum, a thin membrane that vibrates in response to sound waves. Attached to the eardrum are three tiny bones collectively known as the ossicles — the malleus (hammer), incus (anvil), and stapes (stirrup). These ossicles form a mechanical chain that amplifies and transmits vibrations from the eardrum to the inner ear. The inner ear contains the cochlea, a snail-shaped, fluid-filled structure where the mechanical vibrations are transformed into nerve impulses. It also includes the vestibular system, integral for maintaining balance and spatial orientation. Together, these components work in concert to not only make hearing possible but also to aid in the complex process of sound localization and balance maintenance (de Nava and Lasrado et al, 2023).

The journey of sound is an intricate process of conversion from air vibrations into neural signals, illustrating the remarkable capabilities of the ear's inner workings,
particularly within the cochlea and its hair cells. Once sound waves traverse the outer and middle ear, they reach the cochlea: a spiral-shaped, fluid-filled organ that plays a crucial role in auditory perception. Inside the cochlea, sound vibrations cause the fluid to ripple, a movement that is detected by the organ of Corti, a structure situated on the basilar membrane. This structure houses thousands of tiny hair cells; the true sensory receptors of hearing. As the fluid waves move the basilar membrane, these hair cells bend to create a mechanical stimulus that triggers the release of neurotransmitters (Nobili et al, 1998). These neurotransmitters then activate the auditory nerve fibers, converting the mechanical energy of sound waves into electrical impulses. The cochlea not only transduces sound but also helps in differentiating the pitch of sounds. High-frequency sounds primarily stimulate the hair cells at the base of the cochlea, while low-frequency sounds travel further along the cochlea's spiral to stimulate cells closer to its apex (Martin and Hudspeth, 2021).

Moreover, the human ear exhibits remarkable sensitivity and a wide range of hearing that enable it to detect sounds across a broad spectrum of frequencies. Typically, the healthy human ear can perceive sounds ranging from 20 Hz to 20,000 Hz (Purves et al, 2001), though this range can vary among individuals and changes with age. Sensitivity to sound, or auditory threshold, is the minimum sound level that an individual can detect, and it's commonly measured in decibels (dB). This sensitivity is not uniform across all frequencies; humans are most sensitive to frequencies between 500 and 4,000 Hz (Dobie and Van Hemel, 2004), which coincides with the frequency range of human speech. It's
within this range that the ear's ability to discern sounds is most acute, a feature that is thought to have evolved to optimize the processing of speech and communication sounds.

The human auditory system, with its intricate anatomy and sophisticated processing capabilities, represents a remarkable integration of biological and neurological functions, crucial for our interaction with the world. The range and sensitivity of hearing, finely attuned to the needs of human communication, highlight the delicate balance maintained within this system. However, this balance can be disrupted, leading to various forms of hearing impairments. As we transition from understanding the normal functioning of the auditory system, it becomes imperative to explore the types of hearing impairments that can occur. These impairments, varying in cause, severity, and impact, not only alter an individual's ability to perceive sound but also have broader implications for communication, social interaction, and quality of life.

**Hearing Impairments**

Hearing impairments, encompassing a diverse range of conditions affecting one's ability to hear, are not only prevalent but also carry significant individual and societal implications. This section delves into the intricate world of hearing impairments, providing a detailed exploration of their various types, causes, and consequences. Hearing impairments can be broadly classified based on several factors. The primary categories include conductive hearing loss, which occurs when sound is hindered in its path to the inner ear; sensorineural hearing loss, resulting from damage to the inner ear or
auditory nerve; and mixed hearing loss, a combination of both conductive and sensorineural elements.

Understanding these distinctions is not merely an academic exercise but is critical for accurate diagnosis, effective treatment planning, and comprehensive patient care. Each type of hearing impairment presents its unique set of challenges and impacts on an individual's communication abilities, social interactions, and overall quality of life. By examining the characteristics, etiology, and treatment options for each type, this section aims to provide a thorough understanding of the complexities surrounding hearing impairments. Such knowledge is essential not only for healthcare professionals but also for educators, policymakers, and, crucially, for individuals and families directly affected by these conditions.

Conductive hearing loss is characterized by a reduction in sound level or the inability to hear faint sounds, primarily caused by an obstruction or damage to the outer or middle ear. This type of hearing impairment can result from a variety of conditions that interfere with the efficient conduction of sound waves to the inner ear. Common causes include blockages in the ear canal, such as earwax buildup, foreign objects, or swelling due to infections (Narayanan et al, 2019). Infections or inflammation of the middle ear, such as otitis media, can also lead to conductive hearing loss, with otitis media with effusion being one of the leading causes for acquired hearing loss in children (Coleman and Cervin, 2019). Consequently, conductive hearing loss is more common for younger patients. A study on primary school children in Malaysia noted that of the 15% of the
school population suffering with hearing loss, 88.9% of them had conductive hearing loss (Daud et al, 2010).

Additionally, abnormalities or damage to the ossicles themselves, such as from trauma or otosclerosis – a condition where abnormal bone growth around the stapes bone hampers its movement – can impede sound transmission (Quesnel et al, 2018). A study conducted in 2008 on 16 individuals who had trauma-induced hearing loss went through exploratory tympanotomy; of which 12 of the patients showed an improvement through their respective audiographs (Basson and van Lierop, 2008).

Unlike sensorineural hearing loss, which is often permanent, conductive hearing loss can be temporary and may be resolved with medical treatment or minor surgery, depending on the cause. Early diagnosis and intervention are crucial in these cases, as prolonged conductive hearing loss can sometimes lead to secondary complications, including social withdrawal or speech delays in children (Tomblin et al, 2014).

Sensorineural hearing loss (SNHL), distinct from conductive hearing loss, primarily results from damage to the hair cells in the cochlea or the auditory nerve pathways leading to the brain (Patuzzi and Robertson, 1988). This type of hearing impairment is often more permanent and can range from mild to profound. The key characteristic of SNHL is not just a reduction in sound intensity but also a decline in sound clarity, especially in understanding speech amidst background noise. Common causes of SNHL include age-related changes (presbycusis), prolonged exposure to loud
noises (noise-induced hearing loss), certain medications (ototoxic drugs), viral infections, and genetic predispositions (Lin et al, 2021).

It should come at no surprise that hearing loss trends upwards with age. A population-based cross-sectional analysis in the United States discovered that the annual incidence of sudden sensorineural hearing loss (SSNHL) was 27 per 100,000; upwards of 66,000 new cases annually (Alexander and Harris, 2013). However, age is not the only contributing factor but also noise-induced hearing loss (NIHL). A study from 2 decades ago demonstrated that 16% of disabling hearing loss in adults (over 4 million disability-adjusted life years) is attributed to occupational noise which, in theory, can be very easily minimized (Nelson et al, 2005). A more recent study identifies NIHL as the second leading cause of sensorineural hearing loss, affecting 5% of the world’s population (Natarajan et al, 2023).

In summary, the realm of hearing impairments encompasses a diverse spectrum of conditions, each with its unique set of causes, characteristics, and challenges. From conductive hearing loss, often reversible with appropriate medical intervention, to sensorineural hearing loss, typically permanent and managed with assistive devices, and the complexities of mixed hearing loss, understanding the nuances of these impairments is critical. Having understood the foundation to this field of hearing and hearing impairments, this thesis will develop by looking at the underlying causes for such impairments. From the effects of modern day environmental factors like noise pollution
in urban areas to the lifestyle habits of using personal audio devices, this thesis will uncover the contributing factors of this underlying global issue.

**Methodology**

The primary objective of the research for this thesis is to gather information from previously conducted studies and research articles that contribute to the understanding of hearing loss. The use of the databases Web of Science and Google Scholar with the use of specific key terms as simple as “hearing loss” to “ototoxic chemicals” to narrow down the infinite supply of sources to the select few that provide the most contextual relevance. Most of the sources used tend to be from the more recent decade, although some sources may date back to the 1990s, given that they accentuate the overarching point.

A huge emphasis has been placed on the criteria of the studies, more specifically the sample size used respective to the ages and gender where appropriate. Sources used must also follow the necessary scientific requirement of being peer-reviewed and verified which was largely attributed to the use of PubMed. Any discrepancies in findings would be addressed yet there seemed to be a common agreement between all sources. However, one limitation to this methodology arises in the Comparative Analysis section, in which there were limited sources for a direct comparison across historical and modern data so a more lenient approach would be taken in the analysis made.
Section 1: Environmental Factors

In the modern era, the impact of environmental elements on hearing health has become increasingly significant. This section aims to thoroughly examine how various factors in everyday surroundings are influencing the incidence and intensity of hearing loss. The rapid pace of urban and industrial development, though beneficial in many respects, has brought about a range of auditory challenges, most notably, the pervasive issue of noise pollution (Tong and Kang, 2020). The constant exposure to high-decibel sounds from traffic, industrial machinery, and construction is a growing concern in daily life, leading to an alarming rise in harmful sound level exposure (Singh et al, 2018). This section will also shed light on less apparent environmental variables contributing to auditory damage, such as specific chemical exposures and air quality issues, which recent research has pinpointed as new risks to our hearing health (Ju et al, 2022). This section’s aim is to provide a detailed exploration of how environmental shifts are influencing the state of auditory well-being, emphasizing the importance of increased awareness and preventive actions against these evolving risks.

Section 1.1: Noise Pollution

This subsection zeroes in on the escalating issue of noise pollution, a predominant environmental concern with far-reaching implications for auditory health (European Environmental Agency, 2020). As cities expand and industrial activities intensify, the omnipresence of noise from various sources has become a staple of modern living. The incessant hum of urban traffic, the rhythmic pounding of construction sites, and the
relentless roar of factory machinery not only disrupt daily life but also pose a serious threat to our hearing capabilities.

Studies have shown that prolonged exposure to such high-decibel environments is a key contributor to the deterioration of hearing acuity in populations worldwide (Chepesiuk, 2005). Oguntende et al. (2019), aimed to analyze the noise pollution levels in major areas across the Ota metropolis in Nigeria. This data recorded the noise level in 41 major areas in the Ota metropolis ranging from industrial areas to busy roads and junctions. The results showed that the mean noise level in the morning, afternoon and evening clocked in at 90.78, 90.6 and 90.72 respectively. Given this, a compendium of WHO and other UN guidance on health and environment, recommends that average noise exposure should not surpass 53 dB for road traffic noise (Compendium of WHO and Other UN Guidance on Health and Environment 2022 Update). Even to a non-statistician, the sheer difference from what was recorded in Nigeria and the recommended figure, a huge cause for concern must be raised, all of which generated on a typical day in a metropolitan area.

Furthermore, a more recent paper (Wang et al, 2021) conducted a case-control study on the association between exposure to road traffic noise and hearing impairment. With urban areas becoming increasingly infested with traffic, and consequently traffic noise pollution, this study involved a total of 80 subjects, 41 of which had pre-existing hearing impairments and after detailed otologic evaluations, the case group with binaural hearing loss had a significantly higher mean exposure level of road traffic noise
In short, Wang et al showed that by exposing to road traffic noise greater than 70 dB, there was an increased risk of damage to the auditory system.

Section 1.2: Other Environmental Factors

In addition to the well-documented issue of noise pollution, there are other environmental factors that are often overlooked. This subsection aims to uncover these less discussed yet impactful elements. From the chemicals we encounter in our daily lives to the quality of the air we breathe, various environmental exposures contribute to the risk of hearing impairment. We will explore how these factors, often subtle and unnoticed, can have lasting effects on our auditory system. Through examining recent studies and environmental reports, this section seeks to broaden our understanding of the complex relationship between our environment and hearing health, highlighting the importance of a holistic approach to preventing hearing impairment.

In a recent study, researchers tested for a relationship between an exposure to air pollution and an increased risk of sensorineural hearing loss (Chang et al, 2020). A cohort of 75,767 subjects older than 20 with no prior history of sensorineural hearing (SHL) were observed from 1998 to 2010, evenly divided based on exposure to low-/mid-/high-levels of carbon monoxide (CO) and nitrogen dioxide (NO\(_2\)). Their findings showed significant evidence that subjects who were chronically exposed to air pollution were at a significantly increased risk of developing SHL. It is also relevant to mention, the same researchers had used this longitudinal data set previously to demonstrate a correlation to other diseases such as AMD (Chang et al, 2019) and parkinson’s disease (Chen et al, 2017). Although it is no new discovery that air pollution
is a serious contributor to health risks (Landrigan, 2017), the risks to hearing have only been recently unraveled.

A study on Korean adults was investigated in 2022 to assess the long-term exposure to ambient air pollutants and its consequences on hearing loss (Ju et al, 2022). This study looked into PM$_{10}$, NO$_2$, CO and SO$_2$ pollution and provided sufficient evidence for hearing loss at speech-frequency as well as high frequencies. It is these same particles that share a cellular mechanism that promotes oxidative stress which may be a contributor to the discovered hearing loss (Kampa and Castanas, 2008).

Section 2: Lifestyle Choices

While our ever-worsening environment is nothing short of a hindering factor to hearing, lifestyle choices stand as another culprit to this increasingly concerning global issue (Davis and Hoffman, 2019). Dictated by habits and daily activities that we partake in, these lifestyle choices can either protect or endanger our auditory capabilities. From the seemingly innocuous use of personal headphones (Catalano and Levin, 1985) to the social habit of attending loud music concerts (Pienkowski, 2021), these choices have significant implications towards our hearing. In addition, this section will touch on the effects of certain medication and dietary decisions that are recognized as factors to influence auditory health (Gopinath et al, 2013). By examining these lifestyle choices through the lens of recent research and health studies, we can shed light on the profound implications these daily activities may have and consequently bring light to foster new habits and a culture aware of such implications and possibly more engaged in the prevention so that individuals make informed decisions regarding their health.
Section 2.1: Personal Audio Devices

In this subsection, we will delve into the ubiquitous use of personal audio devices and the consequent effect on auditory health. In our increasingly digitally connected world, the use of headphones, smartphones and other gadgets has made it easier than ever to access music and audio content (Daniel, 2007). However this convenience has also increased the access to auditory health risks, especially from a prolonged exposure to high volumes through headphones as well as earbuds. This part will explore how, when used inappropriately, these devices can lead to noise-induced hearing loss, a condition that is becoming increasingly prevalent across younger generations (Świerczek et al, 2020). Through the examination of health studies and research papers, this section will unravel the mystery of the balance between enjoying this innovative audio technology and a healthy maintenance of healthy hearing practices that many of the juvenile population have struggled to decipher.

In 2013, Dobrucki conducted a preliminary study on the influence of headphones on hearing loss on young people (Dobrucki et al, 2013). The study involved 81 young adults aged from 16-25 years who had all declared to be frequent high volume listeners that felt no effect on their hearing ability. The results suggested that if the music was played at a level of approximately 100 db, an irreversible hearing damage will occur after no more than 4 years of using such devices. This is increasingly concerning as shown when subjects exposed to sounds exceeding 87 db, 60% of the 700 adolescents reported this to not be too loud (Mercier and Hohmann, 2002). So not only does this show there is
an increase of high volume noise exposure, but there is also a lack of awareness of the negative effects of such usage.

Section 2.2: Social and Recreational Noise Exposure

This subsection will address the often overlooked aspect of hearing health: the impact of social and recreational noise exposure on our hearing health. In a world where a lot of socializing and entertainment revolves around an exposure to high levels of noise through nightclubs, concerts, and various sporting events, the risk these functions have can be a pressing concern (Jokitulppo et al, 2006). We will explore how these leisure activities contribute to cumulative noise exposure, and consequently hearing damage, despite being enjoyable and culturally significant. Through the scope of recent studies and surveys, this section will break down the relationship between our social activities and auditory health, with intentions of developing strategies to enjoy our leisure activities with respect to our hearing health.

In 2015, the World Health Organisation (WHO) had estimated that approximately 1.1 billion young people could be at risk of developing hearing loss due to unsafe hearing practices with a 40% of this estimate attributed to exposure to damaging levels of sound at nightclubs, discotheques and bars (World Health Organization, 2015). In a sample taken from young adults in England, 18.8% of them had been exposed to significant noise from social activities in comparison to the 3.5% from occupational noise (Smith et al, 2000). A lot of this can be attributed to the lifestyle of adolescents once they start attending university and engage in the social culture.
A more recent study on 34 female university students from their enrolment for 3 years had their hearing evaluated with pure-tone audiometry and questionnaires regarding their exposure and attitudes towards noise and hearing loss (Degeest et al, 2022). Results show that there was a significant deterioration in hearing as well as an increase in noise exposure related to visiting nightclubs and music venues. Although the sample size was too small to draw generalisable conclusions, there was enough significance to at least draw some correlation between exposure to noise from social and recreational activities and hearing impairment.

**Section 2.3: Medications and Chemicals**

In this section, we’ll delve into a less obvious but equally essential aspect of modern lifestyle choices that affect hearing health: the use of certain drugs and chemical exposure. In the pursuit of health and wellness, one may frequently come into contact with a wide range of drugs and substances which possess ototoxic qualities, meaning they can hurt the ear. This part will also explore the various medications and chemicals that have been linked to auditory concerns. There have been studies that report the effect of heavy metals on hearing loss.

Lead has been recognized as a source for significant environmental pollution (Goldstein, 1992) but it has also been put forth as an ototoxic heavy metal with increased lead exposure being a contributing factor to degeneration of the inner ear receptor cell (Jones et al, 2007). A more recent study investigated the relationship between cumulative lead exposure and age-related hearing loss, with results suggesting that chronic low-level lead exposure may be an important risk factor for age-related hearing loss (Park et al, 2010).
Additionally, trace metals of cobalt and tin were also significantly associated with hearing loss (Zou et al, 2022). It is interesting to note that while some of these substances can be beneficial for some health aspects, they may also be potentially harmful to hearing (Cannas et al, 2020).

**Section 3: Comparative Analysis**

In the third and final section of this extensive literature review, this thesis presents a critical comparative analysis of the current state of hearing impairment due to environmental and lifestyle factors against historical data. Through the analysis of historical versus modern data, a more direct discern regarding the specific impacts of industrialization, urbanization and technological advancements can be made regarding the changes with respect to auditory health.

Although it seems like there is no directly comparable data available, the CDC have two publications with enough similarities to draw comparisons. The former of the two, conducted between 2000 and 2006, recorded that 37 million adults (Pleis and Lethbridge-Cejku, 2007) in the US had reported troubles with hearing compared to the 2000 figure of 31.5 million (Pleis et al, 2003). According to the most recent data from the National Health Interview Survey (NHIS), over 40 million of American adults have trouble hearing (National Center for Health Statistics).

In 2017, Goman et al projected an increase in hearing loss of 20 year olds from 44.11 million in 2020 to 73.5 million in 2060 (Goman et al, 2017), a serious concern for the future health of society. Goman et al, being the only researchers to have published
work regarding a projection of future hearing problems, reinforce a shift in attention to prevention strategies to avoid this catastrophic fate.

**Conclusion**

After exploring contributions from various studies and research, this thesis illuminates the profound impact of modern environmental factors and lifestyle choices on hearing health. Evident from the comprehensive analysis presented, the increase in hearing impairment is not a coincidental occurrence but a result of the world today and the choices made by its inhabitants. Noise pollution, which has stemmed from relentless urbanization, has emerged as a notorious enemy of auditory health. Similarly, lifestyle choices such as the extensive use of personal audio devices to the exposure to ototoxic substances has also been identified as contributing factors. Although there hasn’t been a direct measurement of this annually, the numbers do allude to an increase in auditory deterioration.

The finding of this thesis calls for an urgent and coordinated response. With projections that do not suggest any decline in this degradation, a need for heightened public awareness and robust policy intervention is imperative. Given the daily and regular occurrence for these factors, public health officials must prioritize auditory health as many of these exposures lead to irreversible damage. Unless modern biotechnology can keep up with the technology that hinders these issues, affirmative action should ideally begin before the turn of the decade. Moreover, the development of revitalizing technology could be a viable solution to this problem but may not be the most
economically sound solution. Further research could be conducted on the avenues of approach to this problem to ensure a future with a preservation of one of humans’ most vital senses.
Literature Cited


Compendium of WHO and Other UN Guidance on Health and Environment 2022 Update.


Hearing Loss due to Recreational Exposure to Loud Sounds a Review World Health Organization. 2015.


