PREVALENCE OF AUDITORY HALLUCINATIONS, AND QUALITY OF LIFE OF INDIVIDUAL WITH HEARING LOSS REPORTED TO AIISH

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This Dissertation is submitted as part

fulfilment for the Degree of Master of Science in Audiology

University of Mysore, Mysuru

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September, 2021

CERTIFICATE

This is to certify that this dissertation entitled **'Prevalence of Auditory Hallucinations, and quality of life of individual with hearing loss reported to AIISH'** is a bonafide work submitted as a part for the fulfilment for the degree of Master of Science (Audiology) of the student Registration Number: 19AUD025. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **'Prevalence of Auditory Hallucinations, and quality of life of individual with hearing loss reported to AIISH'** is the result of my own study under the guidance of Dr. Sreeraj Konadath, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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September 2021

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Abstract

Auditory hallucinations (AH) are conscious perception of sound in the form of meaningful environmental sound, voice or music in the absence of external stimulus. AHs have been linked to schizophrenia and other psychotic disorders for a long time. Recent evidence suggests that AHs are common in non-psychotic people and are sometimes linked to hearing loss. Estimating the prevalence of AHs in the hearing impaired population and assessing their impact are both necessary. The role of an audiologist will be required to investigate this area, identify the pathophysiological mechanism, and develop effective intervention strategies based on the estimated prevalence rates and their impact.

Aim: *This study aims to estimate the prevalence of AH's and their impact on hearing impaired individuals. The objectives include; estimating prevalence of AH's across age ranges, identifying the type and content of hallucinations, assess a relationship between severity of hearing loss and AH's, estimate an association between configuration of hearing loss and AH's, and finally compare quality of life outcomes between hallucinating and non-hallucinating individuals.*

Method: *Spontaneous Acoustic Phenomena was used to identify presence and content of hallucinations in 500 individuals age ranging between 18-65 years reported to AIISH in 2019. WHOQOL-BREF, a quality of life measure was administered on 30 hallucinating individuals and the scores were compared to 30 age, gender and diagnosis matched non-hallucinating individuals.*

Results: *The overall prevalence of hallucinations was 8.8%, with higher prevalence in hearing impaired and individuals between the age range of 31-50 years (11.04%). Majority of individuals experienced meaningful environmental sounds and 16% and 11% of hallucinating individuals experienced voice and music, respectively. No correlation was established between severity and AH's. A significant association between configuration of hearing loss and AH's was found. No significant difference was found between hallucinating and non-hallucinating hearing impaired individuals. Hallucinating normal hearing individuals scored significantly lower than non-hallucinating counterparts.*

Conclusion: *Higher prevalence in hearing impaired participants indicates the role of auditory pathways in the occurrence of AH's. Hallucinations adversely impact the quality of life of hallucinating individuals. This necessitates the involvement of an audiologist in the assessment, intervention and future scientific studies on AH's.*

Keywords: Auditory hallucinations, hearing impairment, non-psychotic, psychosis, quality of life, WHOQOL-BREF, prevalence

Chapter 1

Introduction

Hearing sounds, speech or music and interpreting the incoming sound wave is a unique ability bestowed upon humans. Hearing sounds or speech in the absence of sound producing substance or medium is a matter of concern. It has been reported that people can hear certain sounds in the absence of a sound source in the environment. They are able to perceive sounds that range from simple tonal sounds to complex speech.

For a long time now hearing simple tones or noises in the absence of an external source is termed as tinnitus. Tinnitus is phantom perception of pure-tones and noise like signal continuously or intermittently (Jastreboff, 1990). The prevalence of tinnitus among the adult population with or without hearing impairment varies between 5.1% to 42.7% (McCormack et al., 2016). Tinnitus is strongly linked to hearing impairment, the prevalence of tinnitus increases by two folds in hearing impaired population (Oosterloo et al., 2020). Thus, tinnitus is present irrespective of presence or absence of hearing loss. Tinnitus hearers usually do not associate the sounds heard to something meaningful in the environment (Baguley et al., 2013).

On the other hand, hearing voices or music or environmental sounds without an external generator is defined as auditory hallucinations. These perceptions are thought to be real and have meaningful association to an object or person not present in the environment during the hallucinatory incident. Auditory hallucinations for long a time now has been associated to mental illness. The presence of AH's is of diagnostic significance according to DSM-IV for Schizophrenia. However, hallucinations have also been associated to various other psychotic disorders; mood, affective and

personality disorders (Daalman et al., 2012). Recent literature suggests prevalence of auditory hallucinations in non-psychotic individuals (Kråkvik et al., 2015).

Since hallucinating patients perceive sound, it can be hypothesised that some activation in the peripheral or central auditory system may occur. Early neuro-stimulation experiments performed by Penfield and Perot (1963) concluded that electrical stimulation of temporal lobes resulted in AH in patients who suffered from seizures of temporal lobe. Electrodes positioned near the primary auditory cortex (Heschl's gyrus) resulted in the perception of wind or whistling like sounds, whilst stimulation towards Wernicke 's region resulted in the perception of voice or music. With the advent of newer imaging techniques like PET scans and functional imaging confirm the activation of Anterior cingulate cortex along with bilateral temporal lobes in schizophrenic patients with AH (Shergill et al., 2000). In a study, a young adult with AH performed poorly on central auditory processing tests (Musiek et al., 2007). These findings support the involvement of central auditory pathway along with few non-auditory structures in patients with AH's.

Investigations of peripheral auditory pathways in patients experiencing hallucinations were reported to be impaired (Teunisse & Rikkert, 2012). Audiological assessment of schizophrenic patients with AH's revealed fluctuating pure tone averages (Gordon, 2003). Abnormal ABR findings in hallucinating group than non-hallucinating, associates peripheral or brainstem deficit with AH (Lindstrom et al.,1987). It is reported that prolonged periods of sensory deprivation alter functioning of the brain. The brain attempts to compensate for reduced sensory inputs. The brain adapts or mal-adapts to reduced inputs by either increasing excitation or interfering in the inhibitory functions. This leads to generation of auditory hallucinations (Marschall et al., 2020; Mohan & Vanneste, 2017). Hearing loss is a significant cause of sensory

deprivation, affecting at least 50% of the population by 6th decade of life (NIDCD, 2010).

Hearing impairment can result in social isolation, and these individuals are likely to hallucinate (Marschall et al., 2020). Single case reports of patients with otosclerosis and unilateral hearing loss have documented auditory hallucinations and the hallucinations disappeared after Surgical management (Marneros et al., 1997). The subject initially experienced tinnitus and, over a duration of time, music and voices were perceived (Marneros et al., 1997). AH's may be associated with conductive or sensorineural hearing loss (Musiek et al., 2007). The occurrence of tinnitus can precede the occurrence of AH's. However, not all patients with AH's develop tinnitus initially. A large prevalence study on hearing impaired subjects indicated 16.2% experienced AH's. Fifty-one percent of subjects with hallucinations experienced verbal type of hallucinations (Linszen et al., 2019). Increased prevalence of Hearing impairment, in turn, increases probability of experiencing AH's. The role of the audiologist in dealing with this sensitive issue and understanding of this phenomenon has therefore become essential.

Auditory hallucinations have varying effects across countries and across culture. The content of AH's is comparable to the cultural context of the subject (Kent & Wahass, 1996). The impact of AH's on patients is influenced by cultural variation. The non-western countries did not find the voice to be intrusive, instead they were associated to godly advices (Luhrmann et al., 2015). In India, hearing voices are generally associated to playfulness and sex, and thus many people may not strongly associate a negative emotion to the voice (Luhrmann et al., 2015). A study compared the differences in impact of hallucinations on schizophrenic patients across three cultures, India, Ghana, and USA. This study concluded that AH caused more

disruptions to Americans than Indians or Ghanaians (Luhrmann et al., 2015). This offers insights into the heterogeneity of AH's across individuals and cultures. The impact of AH's is studied in schizophrenic patients (Luhrmann et al., 2015), but their impact on hearing impaired population is not very clear.

1.2 Need for the study

Auditory hallucinations have long been associated with psychiatric illness, but recent research indicates their occurrence in non-psychiatric individuals, too (Kråkvik et al., 2015). Sensory deprivation could result in experiencing hallucinations. Hence, hearing impaired individuals pose a risk of developing AH's. The increasing prevalence of hearing impairment paves the way for higher risk of witnessing or suffering from auditory hallucination. Hearing loss has a higher prevalence in old individuals, and they undergo physical and psychological transformations. They are the most vulnerable group and likely to suffer from hearing loss, and perhaps AH is expected to handicap them even more. The impact of AH may not be any lesser in the middle-aged and paediatric population. Middle-aged individuals are the working force of society, and children are the future working force. There is a need to explore how AH impacts the middle aged and pediatric population. Sporadic proof exists, but the picture is not very clear. It is, therefore, important for an audiologist to understand this phenomenon and provide an audiological perspective about the pathophysiology of AH's.

The prevalence of AH's in individuals with hearing impairment is variable across studies and is dependent on the definitions considered. We are not aware of how many people with hearing loss are suffering from AH. Only if we identify them, we will be able to establish a better rehabilitation for them. Thus, it is necessary to determine the prevalence of AH in hearing impaired individuals. AH's disrupt the well-being of individuals but, the effect of AH differs across cultures needs to be examined

to understand this phenomenon. However, the prevalence of auditory hallucinations and their impact on hearing impaired patients in the Indian scenario has not been documented to the best of our knowledge.

1.3 Aim

To estimate the prevalence of auditory hallucinations and their impact on quality of life in individuals with hearing impairment.

1.4 Objectives

1. To identify the prevalence of hearing impaired individuals suffering from auditory hallucinations across age groups.
2. To identify the type of AH (verbal, musical or environmental) perceived in individuals with hearing impairment.
3. To assess the relationship between the degree of hearing loss and prevalence of AH.
4. To assess the relationship between the prevalence of AH across unilateral, symmetrical and asymmetrical hearing loss.
5. To compare the overall quality of life between individuals with and without auditory hallucinations.

Chapter 2

Review of Literature

This chapter reports the extensive research done in the area of auditory hallucinations, attempting to find a link between non-psychotic illness and hallucinations. Also, this chapter will try to evaluate and understand the research studies done to speculate a relationship between hearing impairment and auditory hallucinations. Finally, impact of auditory hallucinations on the quality of life of individuals suffering from it will be noted. This chapter will be discussed under the following subsections;

1. Definition and characteristics of Auditory Hallucinations
2. Difference between Auditory hallucinations and Tinnitus
3. Relation between Auditory Hallucinations, Schizophrenia, other psychiatric and non-psychiatric disorders
4. Association between Auditory Hallucinations and Hearing Impairment
5. Impact of auditory hallucinations on quality of life of individuals

2.1 Definition and characteristics of Auditory Hallucinations

Auditory Hallucinations (AH) are a conscious perception of auditory (sensory) stimuli in the absence of an external auditory object. The perceptions vary in type, form and content; ranging from simple (buzzing, clicking) to complex (verbal, music) acoustic phenomena. The perception of various auditory stimuli classified as AH is determined by the definition. The lax definition includes all sensory (auditory) perceptions ranging from buzzing to complex acoustic phenomena, whereas the stricter definition includes only complex auditory phenomena like hearing voices or music as hallucinations (Johns et al., 2014).

Auditory hallucinations can also be categorized into formed and unformed types. Formed auditory hallucinations includes hearing voices, noises or cries and in rare cases, perception of musical melodies (Wengel et al., 1989). Unformed hallucinations refer to the perception of noises, buzzing sounds or any other environmental sounds containing meaning.

Auditory hallucinations are characterized by a strong sense of belief that sound exists in the environment and is real. Likewise, individuals experiencing verbal hallucinations are more likely to identify the source of origin and clarity of the message. They are less likely to identify the "speaker" during the hallucinating incident. The findings also suggest that the length of utterances in verbal hallucinations are mostly limited to one word and rarely short sentences. In people with schizophrenia, these hallucinations tend to repeat themselves and become stereotyped (Oulis et al., 1995).

Several individuals with hallucinations also experience music perception. It can be heard as musical melodies, instrumental music or sometimes even lyrics. The volume of musical hallucinations varies across situations; ranging from very soft to very loud. However, the most typical quality across musical hallucinations is the searching of an external source. The subject realizes that the source must be within themselves after experiencing repetitive perceptions of sound without a reference in the external environment (Sacks & Blom, 2011). Musical hallucinations are the rarest type and usually associated with psychiatric illness or sometimes in hearing impaired population (Wengel et al., 1989).

2.2 Difference between Auditory Hallucinations and Tinnitus

Auditory hallucinations and tinnitus share some common characteristics; perception of sound in the absence of external acoustic stimulation. However, the two

conditions can be differentiated based on the type of sound perceived. Tinnitus is usually described as humming, hissing, tonal variety or noise-like which is non-meaningful. Sometimes pulsating or click like sound is also associated with tinnitus (Jastreboff, 1990). It is usually subjective and can be objective at times. On the other hand, auditory hallucinations are complex acoustic perceptions; it varies from environmental to musical to verbal types (Wengel et al., 1989).

Auditory hallucinations are most commonly found concomitant to psychiatric, neurologic, otologic, and other medical conditions, but subjective tinnitus, on the other hand, is usually some form of tonal perception. Auditory hallucinations can be experienced by people with sleep or disorders other than psychiatric in origin. 10-15 percent of people who experience AH's do not have an associated mental illness or even tinnitus, complicating the distinction between tinnitus and hallucinations. It is also reported that continuous and troublesome tinnitus may increase the risk of auditory hallucinations, particularly in people who are depressed (Traynor, 2018). An estimated 7.5-9.3 percentage of people suffer from debilitating tinnitus. The thin line that separates tinnitus from auditory hallucinations often becomes blurred within this small percentage (Traynor, 2018).

2.3 Relation between Auditory Hallucinations, Schizophrenia, other psychiatric and non-psychiatric disorders

Auditory hallucinations are considered to be classic psychotic symptom and are usually associated with Schizophrenia. AH’s are a cardinal feature of Schizophrenia and forms the basis to diagnose this condition according to DSM-IV. AH’s also occur in other psychotic conditions which are not typically associated with hallucinations like mood, affective or personality disorders (Daalman et al., 2012). AH’s usually indicates

a mental illness; however, they are not necessarily associated with psychotic conditions. It is also prevalent in non-psychotic individuals (Kråkvik et al., 2015).

AVH is also prevalent in individuals from the general population who do not suffer from a concomitant psychiatric or neurological disorder. The prevalence of AVH in this population varies widely according to the definition considered (strict or lax) (Beavan et al., 2011). Literature suggests that AVH may serve as an antecedent to clinical disorders in combination with negative emotional states, familial history of psychosis, and environmental exposures such as childhood adversity. However, the effect of these predisposing factors on the occurrence of AVH is not entirely clear (Johns et al., 2014).

The prevalence of auditory hallucinations reported in individuals who are "normal" (without psychological basis) is probably not as pathologic as they are typically considered, or that less-than-hallucinatory experiences maybe sometimes mislabelled as AH. Such hallucinations with conversion disorder, trauma or sensory deprivation indicate a strong association between AH and psychopathology but suggest limited diagnostic specificity and relevance (Pierre, 2010). There is no proven treatment, but many patients will benefit from knowing that their hallucinations are not a result of mental illness (Teunisse et al., 1996).

2.4 Association between Auditory Hallucinations and Hearing Impairment

Auditory hallucinations can be characterized as complex auditory hallucinations (environmental, verbal and musical) and simple hallucinations (usually unformed like tinnitus). The exact mechanism underlying hallucinations is unclear to date. However, perception of sound during the incidence of AH's might indicate activation or involvement of either central or peripheral auditory system. A study was done by

Wengel et al. (1989) on individuals with complex hallucinations (musical), who perceived instrumental melodies, have typically been associated with significant hearing loss, old age, female sex, lack of response to treatment, and general lack of associated psychopathology.

Rossell & Boundy (2005) investigated whether the presence of auditory–verbal hallucinations (AVH) was associated with impaired auditory affect perception. They compared Schizophrenic patients with hallucinations to schizophrenic patients with no history of hallucinations. The assessment consisted of four auditory perception tasks; non-verbal/non-semantic or verbal/semantic stimuli were utilized. AVH patients showed significant impairments on a non-verbal task requiring the recognition of environmental sounds. Thus, confirming auditory affect deficits in AVH patients. AVH patients also showed reduced right ear performance on a dichotic listening task. Additionally, both groups showed impairments on auditory affect tasks that used verbal/semantic stimuli, as these tasks require proficient semantic processing, which was affected in schizophrenic patients. The overall results support the notion that patients with AVH have increased liability for auditory affect perception deficits.

2.4.1 Involvement of central auditory system in perception of Auditory hallucinations

Early neuro-stimulation experiments performed by Penfield and Perot (1963) concluded that electrical stimulation of the Temporal lobes resulted in AH in patients who suffered from seizures of the temporal lobe. Electrodes positioned near the primary auditory cortex (Heschl's gyrus) resulted in the perception of wind or whistling like sounds, whilst stimulation towards Wernicke's region resulted in the perception of voice or music.

An fMRI study on patients with Schizophrenia experiencing frequent auditory hallucinations was assessed. The main aim of this study was to identify the areas in the brain responsible for the manifestation of hallucinations. The fMRI recording was compared between two incidents in the same patient; while hallucinating and not experiencing hallucinations. There was a clear difference between the activities in the brain areas during the two incidents. During hallucinations, increased activity was recorded in the insular, anterior cingulate gyrus, bilateral temporal lobes, and the left hippocampus and para-hippocampal regions (Shergill et al., 2000). However, this study was done in schizophrenic patients, so it is still unclear whether the increased activity in certain areas was solely due to hallucinations or as a co-factor of psychiatric abnormality.

Marschall et al. (2021) aimed to explain the phenomenology behind the occurrence of complex hallucinations. He theorized that increased spontaneous brain activity following de-afferentation could manifest hallucinations. In this study, individuals with complex, simple, and no hallucinations had their resting-state fMRI recorded and compared. The group with complex hallucinations had increased activity in the bilateral temporal cortex, including Wernicke's area, whereas the group with simple hallucinations had more spontaneous activity in the cerebellum. Increased activity in the language area only in individuals with complex hallucinations explains the involvement of the central system in the phenomenology of hallucinations (Marschall et al., 2021).

Most studies compared auditory processing skills in Schizophrenia with AH versus Schizophrenia without AH. According to the dichotic listening test, there were differences in performances between AH and non-AH groups and abnormal asymmetry (Løberg et al., 2004). Poor speech in noise scores in individuals with AH compared to

non-AH schizophrenics is another indication towards central auditory processing deficits rather than just cognitive or attentional deficits (Hoffman et al., 1999). A young adult with AH performed poorly on central auditory processing tests (Musiek et al., 2007). Electrophysiological tests like Auditory brainstem response and Late latency potentials showed abnormal findings compared to the control group (Ford et al., 2001; Nam, 2005).

These brain imaging, behavioural and electrophysiological tests of the brainstem and auditory cortex have revealed a significant involvement of the central auditory pathways in the generation of auditory hallucinations. Although most studies have focused on people with schizophrenia and their central processing, there is a need to assess central processing in non-psychotics with AH's. The findings discussed above support the involvement of the central auditory pathway along with few non-auditory structures in patients with AH's. Because of the involvement of the central pathway, the role of an audiologist becomes significant in understanding this phenomenon.

2.4.2 Involvement of peripheral system in the perception of Auditory hallucinations

Investigations of peripheral auditory pathways in patients experiencing hallucinations were reported to be impaired (Teunisse & Rikkert, 2012). Audiological assessment of schizophrenic patients with AH's revealed fluctuating pure tone averages (Gordon, 2003). Abnormal ABR findings in the hallucinating group than non-hallucinating associates peripheral or brainstem deficit with AH (Lindstrom et al., 1987).

2.4.2.1Auditory Hallucinations and conductive hearing loss. The link between ear disease and hallucinations was suspected long back by Bryant (1906). He came across three patients experiencing auditory hallucinations and tinnitus. One of

them was suffering from catarrhal otitis media and hallucinations. Once the middle ear infection was treated, the hallucinations and tinnitus disappeared. He found evidences that ear dysfunction is linked to auditory hallucinations. He concluded that when ear treatment was applied, it relieved/cured hallucinations. He also theorized that peripheral tinnitus might stimulate the auditory centres, resulting in auditory hallucinations. Ear disease, tinnitus, or deafness is found in a surprising number of cases with auditory hallucinations (Gordon, 2003).

Another study reported the case of a 35-year-old man suffering from otosclerosis and auditory hallucinations in the same ear and other psychotic symptoms. The patient initially experienced tinnitus which transformed to music and to voice perception four months later. However, the transformation from one form to another occurred during an alcohol withdrawal syndrome. These hallucinations disappeared completely after otosclerosis surgery (Marneros et al., 1997).

Musical hallucinations developed in a patient with otosclerosis who had a history of obsessive-compulsive disorder (OCD). This is the first reported case of musical hallucinations in a patient with otosclerosis-related hearing loss and an OCD history (Islam et al., 2014). Although the studies mentioned above do not conclusively link hallucinations to middle ear disease, it can be concluded that ear disease associated with psychotic illness is a risk factor for hallucinations.

These evidences directly correlate middle ear infection, in other words, a conductive pathology to auditory hallucinations. Nonetheless, these findings cannot be generalized to all individuals with conductive pathologies. A general predisposition factor for experiencing hallucinations is the presence of conductive pathology along with other psychotic or non-psychotic disorders.

2.4.2.2 Auditory Hallucinations and SNHL. Sensorineural losses are primarily the permanent type of hearing loss, unlike conductive hearing losses, which are temporary. Sensory losses cause prolonged periods of sensory deprivation, and it is reported that this deprivation alters the brain's functioning. The brain attempts to compensate for reduced sensory inputs. It adapts or maladapts to reduced inputs because of brain plasticity. It is proposed that during sensory loss, the brain tries to compensate by bottom-up and top-down approaches; when the compensation becomes unsuccessful, phantoms precepts occur. In other words, maladaptive changes in the brain are instrumental in generating phantom percepts, that is, perception of sensory stimuli in the absence of an external source. The brain mal-adapts by either increasing the excitatory function of neurons or interferes in the inhibitory processes. This mechanism possibly leads to the generation of auditory hallucinations (Marschall et al., 2020; Mohan & Vanneste, 2017) and explain why sensorineural hearing loss is associated with auditory hallucinations.

Hearing loss is a significant cause of sensory deprivation, affecting at least 50% of the population by the 6^{th} decade of life (NIDCD, 2010). Hearing impairment can result in social isolation, and these individuals are likely to hallucinate. AH, 's may be associated with conductive or sensorineural hearing loss. The occurrence of tinnitus can precede the occurrence of AH's. However, not all patients with AH's develop tinnitus initially. A large prevalence study on hearing impaired subjects indicated 16.2% experienced AH's. Fifty-one percent of subjects with hallucinations experienced a verbal type of hallucinations (Linszen et al., 2019). Increased prevalence of Hearing impairment, in turn, increases the probability of experiencing AH's. The audiologist's role in dealing with this sensitive issue and understanding of this phenomenon has therefore become essential.

2.5 Impact of auditory hallucinations on quality of life of individuals

2.5.1 Impact across patient groups

Auditory hallucinations have long been strongly associated with Schizophrenia. But the recent literature shows that hallucinations are also prevalent in other psychotic and non-psychotic disorders. The question arises whether the type and impact of hallucinations are similar across the psychotic and non-psychotic individuals? A study investigated the form and the effect of complex auditory hallucinations in three patient groups; patients with Schizophrenia, patients with dissociative disorder, and non-patient individuals experiencing auditory hallucinations. The results indicated that the three groups' hallucinatory experience was similar across the three groups. However, the impact of hallucinations significantly varied across groups; the hallucinations did not alarm the participants in the non-patient group, unlike the patient group. The non-patient group felt in control of the situation. This study emphasizes that hallucinations are similar regardless of diagnosis, but the impact varies across groups. Voices are associated with more negative feelings and negative emotions in the patient group with psychotic illness (Choong et al., 2007; Honig et al., 1998).

In a study, a comprehensive structured interview was conducted to study 199 subjects who had experienced AHs. They assessed the overall impact of hallucinations and the affective direction i.e., positive or negative. AHs that were more frequent, lasted longer, and were louder were experienced more negatively than others (Copolov et al., 2004). However, the individuals recruited for the study were diagnosed with psychiatric condition and thus the impact of hallucinations cannot be generalised to non-psychiatric individuals.

2.5.2 Cross-cultural impact of AH

The presence of auditory hallucinations in some can be positive experience while in others negative experience. The emotional valence of hallucinations varies depending on the content and form heard. The content of auditory verbal hallucinations is influenced by the individual's exposure to language and culture, which varies across countries (Kent & Wahass, 1996). A study compared the differences in the impact of hallucinations across three cultures, India, Ghana, and the USA. They recruited 20 schizophrenic individuals from each country (India, Ghana and the USA). According to this study, Americans were more affected by AH than Indians or Ghanaians (Luhrmann et al., 2015). The Indians and Ghanaians reported a strong connection with their voices. Hearing voices is generally associated with playfulness and sex in India, so many people may not strongly associate the voice with a negative emotion. This sheds light on the diversity of AHs across individuals and cultures. Despite the fact that this study added to our understanding of AH, its findings should be interpreted with caution due to the small sample size. The effects of AHs are being studied in schizophrenic patients (Luhrmann et al., 2015), but their effects on the hearing impaired population are unclear.

Chapter 3

Methods

A retrospective case study design was used to recruit participants for the current study. The patients who reported to the All India Institute of Speech & Hearing (AIISH), Mysuru, between 1st January 2019 to 31st December 2019 and met the eligibility criteria were considered for the study. To determine the eligibility, the case files of the patients were analysed.

3.1 Participant Selection

Patients who visited AIISH in the year 2019 were considered for the study. The following subsections explain the inclusion and exclusion criteria of the participants.

3.1.1 Inclusion Criteria/ Eligibility Criteria

The eligibility criteria of participants for this study are as follows;

1. Participants of any gender with age between 18-65 years.
2. Subjects with absence of conductive diseases.
3. Subjects diagnosed with hearing sensitivity within normal limits confirmed by the most recent audiological report.

   OR

   Unilateral, symmetrical or asymmetrical sensorineural hearing losses; degrees ranging between mild to severe degree in either ear confirmed by the most recent/latest audiological report.
4. Educational qualification should be 10th standard or above, and should be able to comprehend conversational English.

All the patients fulfilling the eligibility criteria and willing to provide informed consent will be considered for further study.

3.1.2 Exclusion criteria

Participants with middle ear disorders or diagnosed with conductive or mixed hearing losses were excluded from this study. Patients with known psychiatric symptoms or comorbidities which prevent them from answering the questions appropriately were omitted.

3.2 Instrumentation/Tests used for diagnosis

The participants who reported to AIISH with hearing or balance related complaints were evaluated by skilled student clinicians and the provisional diagnosis was labelled by the supervising Audiologists. Various tests were conducted to arrive at a diagnosis; which included Pure tone audiometry (PTA), Immittance evaluation, Oto -Acoustic emissions (OAE's) (only when required) and Auditory Brainstem Response (ABR) (only when required).

The instruments and environment of test is as given below.

3.2.1 Pure Tone Audiometry

Pure tone audiometry was conducted on all participants using a calibrated two-channel diagnostic audiometer in a sound-treated double room setup. The pure tone average (PTA) was calculated as an average of four frequencies (500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz). Subjects having pure tone averages of less than or equal to 25 dB HL were considered as having normal hearing. The PTA ranging between 26-40 dB HL, 41-70 dB HL, 71-90 dB HL were diagnosed as mild, moderate and severe hearing losses, respectively. Individuals with PTA beyond 90 dB HL and Air bone gap greater than 10 dB (indicating presence of middle ear pathology) were excluded from the study.

3.2.2 Immittance Evaluation

Middle ear status was assessed using middle ear analyzers (like Grason Stadler Inc- Tympstar V 2.0 and Otoflex). Immittance evaluation included both tympanometry and reflexometry. Tympanograms and acoustic reflexes were obtained at a probe frequency of 226 Hz. The acoustic reflex eliciting stimulus was presented ipsilaterally and contralaterally at various frequencies (500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz) to obtain acoustic reflex thresholds.

Patients with normal hearing sensitivity (i.e., less than or equal to 25 dB HL) underwent immittance evaluation. 'A/As' type of tympanogram with bilateral presence of acoustic reflexes were eligible for participation. The middle ear of patients with hearing losses ranging from mild to severe degree was examined. 'A/As' type of tympanogram with presence or absence of acoustic reflexes unilaterally or bilaterally were eligible.

3.2.3 Oto Acoustic emissions

Oto-acoustic emissions (OAE's) are a tool used to evaluate the function of outer hair cell. OAE's were not administered on all subjects, it was only administered when the status of outer hair cell function was questionable. Based on the degree of hearing loss, TEOAE or DPOAE was administered.

3.2.4 Auditory Brainstem Responses (ABR)

ABR threshold estimation was conducted only on few participants to correlate thresholds obtained from pure tone audiometry. ABR- site of lesion test was conducted on patients, in whom a retro-cochlear pathology was suspected.

3.3 Materials Used

The "Spontaneous Acoustic Phenomena" questionnaire was used to screen for the presence of auditory hallucinations, and the “World Health Organisation- Quality of Life (Brief Version) (WHOQOL-BREF) checklist was used to assess the quality of life of the participants.

3.3.1 Spontaneous Acoustic Phenomena

The presence of auditory hallucinations was assessed using, the screening form “Spontaneous Acoustic Phenomena” (Appendix A), a 14-item semi-structured questionnaire. It was adjusted from a comparable questionnaire used in a study with visual hallucinations (Teunisse et al., 1996). This adjusted questionnaire was used in previous studies to screen for auditory hallucinations (Linszen et al., 2019; Schakenraad et al., 2006). This questionnaire enables the experimenter to screen for the presence of hallucinations. It helps to differentiate between mental imagery and hallucinations, and between tinnitus, musical and verbal hallucinations. This questionnaire comes with background information for the interviewer to carefully understand and pick up signs of hallucinating hearing impaired patients. The respondent is expected to answer in yes/no mostly; however, a few questions are open-ended, providing respondents with a chance to describe their hallucinations. If question 1 until 8 has all been answered with 'no', the participant is considered not to have hallucinations. In that case, the interview is over. Suppose a participant answer to question 1 until 8 with 'yes' one or more times, or if the participant or researcher has any doubt. In that case, the researcher can decide to continue the interview with question 10 until 14. Question number 9 and 14 are for the interviewer to decide whether the respondent has hallucinations or not.

3.3.2 World Health Organisation - Quality of Life (WHOQOL-BREF)

The overall quality of life was assessed using the World Health Organisation Quality of Life -BREF (WHOQOL-BREF) (The WHOQOL Group, 1996) (Appendix C). It assesses the quality of life, health and other domains related to life. The respondents' culture, value systems in which they live in and their goals and concerns are also addressed. It is a 5-point rating checklist assessing four different domains in 26 questions. The rating scale ranges from very dissatisfied to very satisfied, not at all to an extreme amount and very poor to very good across domains. The scores of each domain are added in a particular fashion as recommended by WHO to obtain raw scores and transformed scores.

3.4 Procedure

This study was carried out in two phases; Phase 1- Identification of individuals with hallucinations, Phase 2- Assessing the quality of life in individuals with and without hallucinations. A detailed explanation of each of the steps followed in each phase is given below;

3.4.1 Phase 1 – Identification of individuals with hallucinations

In this phase, individuals passing the eligibility criteria were identified and screened for hallucinations. The steps followed in phase 1 are described below;

1. Selecting eligible participants
2. Conducting phone interview
3. Segregation into groups

3.4.1.1 Selecting eligible participants. The patients' detail who visited AIISH in 2019 was retrieved from the AIISH clinical services database with due permission from the department head. The details of patients provisionally diagnosed as hearing

sensitivity within normal limits or unilateral, symmetrical and asymmetrical sensorineural hearing loss were retrieved using an appropriate search criterion. The search criteria used are given in Table 3.1, Table 3.2 and Table 3.3.

Table 3.1

The demographic details of eligible participants

Demographic details		**Eligibility Criteria**
Dates	**From**	01/01/2019
	To	31/12/2019
Age	**Minimum**	18 years
	Maximum	65 years
Gender		Any

Table 3.2

Diagnostic criteria used to select eligible individuals

Diagnostic criteria	**Eligibility**
Complaint history	Any
Type of hearing loss	Sensorineural
Degree of hearing loss	Mild to severe
Configuration of hearing loss	Normal hearing sensitivity
	Unilateral hearing loss
	Symmetrical hearing loss
	Asymmetrical hearing loss

Table 3.3

Search criteria used to select participants based on degree and configuration of hearing loss

Configuration of hearing loss	Degree in right ear	Degree in left ear
Normal hearing sensitivity	Normal	Normal
Unilateral hearing loss	Normal	Mild Moderate Severe
	Mild Moderate Severe	Normal
Symmetrical hearing loss	Mild Moderate Severe	Mild Moderate Severe
Asymmetrical hearing loss	Mild	Moderate Severe
	Moderate Severe	Mild
	Moderate	Severe
	Severe	Moderate

The patient details retrieved from the software were exported in excel format and saved. The investigator referred to each case file and noted the patients' contact number and the educational level. The individuals with education lesser than secondary level were excluded at this stage.

3.4.1.2 Conducting Phone interview. The investigator conducted a phone interview because in-person data collection was not possible due to Covid-19 pandemic. The investigator used the google form software and created forms for "Spontaneous Acoustic Phenomena" (Appendix A) to enter data from interview.

During the initial session of the interview, consent was taken, and 500 eligible patients willing to participate were considered for further study. The interview was conducted in English. The comprehensiveness of the questionnaire was increased by providing examples in the native language to elicit appropriate responses. The screening form “Spontaneous Acoustic phenomena” consists of yes/no questions in the English language, and the participants were asked to respond appropriately and describe experiences wherever necessary. The importance of each question to identify presence of hallucinations is given in Appendix B. The investigator did not use words such as psychosis, hallucinations or psychiatric to avoid bias. This interview aided to identify patients suffering from auditory hallucinations (verbal, music or environmental). Tinnitus was differentiated from AH’s based on their characteristics. Non-meaningful pure tone like or narrowband noise like sounds were considered tinnitus, whereas complex auditory perception like environmental sounds, musical and verbal was categorised as AH's. This data was used for prevalence based analysis.

3.4.1.3 Segregation into groups. Based on the results from the interview and questionnaire, the participants were divided into 4 groups as follows:

a) Group 1 - Participants with unilateral, symmetrical or asymmetrical hearing loss ranging between mild to severe degree and no auditory hallucinations

b) Group 2 - Participants with unilateral, symmetrical or asymmetrical hearing loss ranging between mild to severe degree and experiencing auditory hallucinations.

c) Group 3 - Normal hearing individuals without hallucinations

d) Group 4 - Normal hearing individuals with hallucinations

The type of hallucinations perceived by Group 2 and 4 was analysed and categorised into verbal, musical, and environmental. The prevalence of each type of hallucinations was analysed.

3.4.2 Phase 2: Assessment of the quality of life in individuals with and without hallucinations

Overall quality of life was assessed using a World Health Organisation Quality of Life -BREF (WHOQOL-BREF). The google form version of "WHOQOL-BREF" (Appendix C) was sent to individuals who experienced hallucinations and their age, gender and diagnosis matched counter parts in the non-hallucinating group also underwent quality of life evaluation. This data was used to compare impact of hallucinations between hallucinating and non-hallucinating group.

Chapter 4

Results

The study aimed to identify the prevalence of auditory hallucinations in patients reported to the All India Institute of Speech and Hearing in Mysore in 2019. This chapter reports the findings of the study conducted on 500 individuals with and without hearing loss. Seven hundred forty-nine individuals met the eligibility criteria. However, only 500 individuals agreed to participate in the study and provide consent. Telephonic interviews were conducted with those selected participants. The other 249 individuals did not participate due to incorrect/outdated phone numbers (n = 140) an unwillingness to participate in the study (n = 109).

This study aims to answer the following five objectives:

1. To find the overall prevalence of auditory hallucinations and across age ranges,
2. To find the type of auditory hallucinations (verbal, musical, or environmental) perceived in individuals
3. To find the relationship between the degree of hearing loss and the presence of auditory hallucinations
4. To assess the association between the presence of auditory hallucinations across unilateral, symmetrical and asymmetrical hearing loss.
5. To compare the overall quality of life across hallucinating and non-hallucinating individuals.

The above five objectives were answered using data obtained from telephonic interviews on "Spontaneous Acoustic Phenomena" and google form surveys of WHOQOL-BREF. The data obtained from these questionnaires were tabulated and analysed using Statistical Package for the Social Sciences - Version 20 (SPSS v.20).

1. The prevalence analysis was performed on the "Spontaneous Acoustic Phenomena" data obtained via phone interview. The prevalence formula used is as follows;

$$\text{Prevalence rate (\%)} = \frac{\text{Total number of cases}}{\text{Total population size}} \quad \text{X } 100$$

Overall prevalence and prevalence rates across age ranges were calculated using the above formula.

2. The frequencies of form and content of different types of environmental, verbal and musical hallucinations were calculated based on the questionnaire data.
3. Spearman's rho correlation analysis was conducted to determine whether a relationship exists between the severity of hearing loss ranging from mild to severe and the presence of auditory hallucinations. If a relationship exists, then the degree and direction of correlation were noted.
4. Chi-square test of association was performed to assess an association between the configuration of hearing loss, i.e., unilateral, symmetrical and asymmetrical hearing loss with auditory hallucinations.
5. The data/scores of WHOQOL-BREF obtained from hallucinating and non-hallucinating age, gender and diagnosis matched groups were tabulated in SPSS v.20. Firstly, normality was assessed using Shapiro Wilk's test for each of the four domains of WHOQOL-BREF. The data followed normal distribution for domains 1 and 2, and parametric analysis was done. An independent t-test was performed to compare scores across hallucinating and non-hallucinating individuals. While domains 3 and 4 followed non-normal distribution, non-parametric analysis was performed. Mann Whitney U test was conducted to compare scores across hallucinating and non-hallucinating individuals in

domains 3 and 4. Effect sizes were calculated when a significant difference was found between hallucinating and non-hallucinating individuals.

4.1 The overall prevalence of auditory hallucinations and across age ranges

This section addresses the first objective of the study. "Spontaneous Acoustic Phenomena" is a 14 item questionnaire used to identify the presence of auditory hallucinations and was administered on the selected 500 (N = 500, M = 322, F = 178) individuals. Among them 272 (M = 191, F = 81) individuals had hearing impairment and 228 (M = 131, F = 97) had hearing sensitivity within normal limits. In total 44 (M = 27, F = 17) individuals were identified to have experienced auditory hallucinations. As a result, the overall prevalence of auditory hallucinations is 8.8%. It was observed that 27 out of 44 individuals had hearing impairment while the rest (n = 17) had normal hearing sensitivity. Hearing impairment was present in 61% of hallucinating individuals, while normal hearing levels were present in 39%. The prevalence of auditory hallucinations in hearing impaired individuals (n = 272) and normal hearing individuals (n = 228) is 9.9% and 7.45%, respectively. Figure 4.1 represents the prevalence of hallucinations in hearing impaired and normal hearing individuals. Table 4.1 shows the overall prevalence rates of auditory hallucinations in hearing impaired and normally hearing individuals.

Figure 4.1

Prevalence rates across presence and absence of hearing impairment

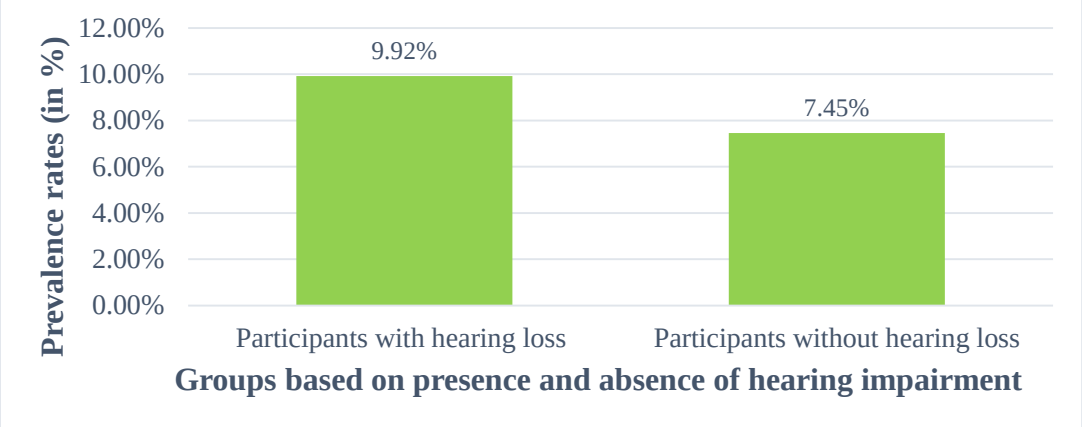


Table 4.1

Overall prevalence rates of auditory hallucinations across individuals with hearing loss and normal hearing

Group	Participants with hallucination	Participants without hallucination	Total participants	Prevalence rates (in %)
Participants with hearing loss	27	245	272	9.92%
Participants without hearing loss	17	211	228	7.45%
Total	44	456	500	8.80%

The participants' ages ranged between 18-65 years, and their mean age was 42.78 years. The participants were segregated into three groups based on age ranges; 18-30 years, 31-50 years, and 51-65 years and their mean age ranges were 25.30 years, 40.22 years and 57.80 years, respectively. The prevalence analysis was performed separately across each group and revealed that prevalence rates vary across groups. The prevalence rates of 9.49%, 11.04% and 6.04% were found in 18-30 years, 31-50 years and 51-65 years, respectively, and the same is represented in Figure 4.2. The prevalence rates across age groups are shown in Table 4.2 below.

Figure 4.2

Prevalence of auditory hallucinations across three age groups (18-30 years, 31-50 years and 51-65 years)

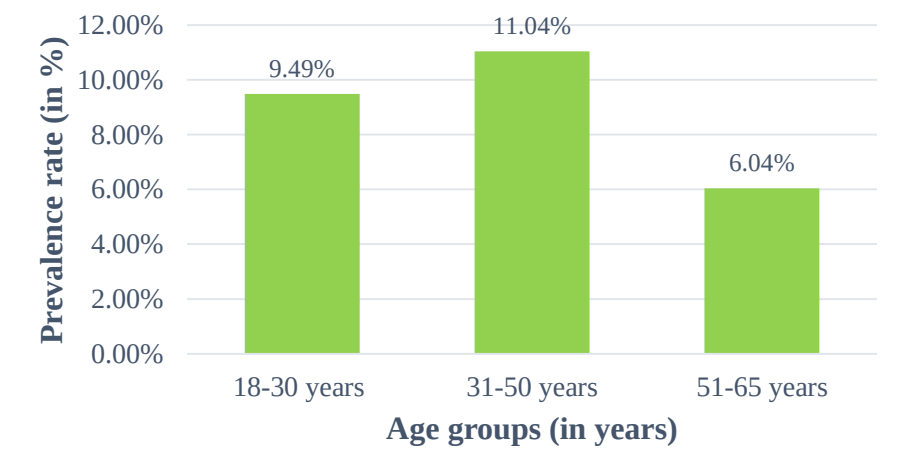


Table 4.2

Prevalence rates of auditory hallucinations across the age groups

Age groups	Individuals with hallucination	Individuals without hallucination	Total individuals in each age group	Prevalence rates in each age group (in %)
18-30 years	13	124	137	9.49%
31-50 years	20	161	181	11.04%
51-65 years	11	171	182	6.04%
Total	44	456	500	8.80%

4.2 Type of auditory hallucinations (verbal, musical or environmental) perceived in individuals

The content and type of auditory hallucinations experienced were found to be variable across individuals. They experience verbal, musical, environmental or a combination of these types. Table 4.3 contains information about the type and content of auditory hallucinations experienced by all hallucinating individuals (n = 44). Majority of individuals experienced some form of environmental sound (90%, n = 40) while others heard voices (16%, n = 7) or music (11%, n = 5). Eight individuals experienced a combination of voice or music with environmental sounds.

Table 4.3

Categorisation of content and type of hallucinations across all individuals (n=44)

Category	Sounds	Number of individuals	% of total
Environment	Dripping water from a tap	9	90% (n = 40)
	Cricket/ honey bee buzzing	9	
	Water flowing	7	
	Gushing of wind	5	
	Forest	5	
	Cooker whistle	2	
	Moving train	2	
	Birds chirping	2	
	Falling vessels	1	
	Turning on and off of tube-light	1	
	Cloud thundering	1	
	Drilling machine	1	
	Handloom weaving	1	
	Door knock	1	
	Car/Bus engine	3	
Voices	Indistinctive voice calling	6	16% (n = 7)
	Murmuring crowd	1	
Music	Melody	2	11% (n = 5)
	Harmonium	2	
	Anklet	1	

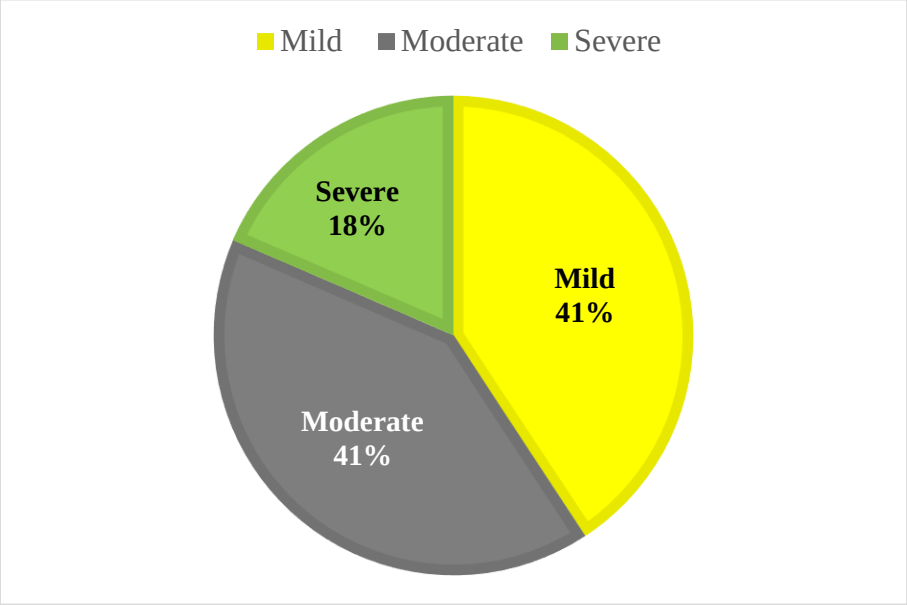
4.3 Relationship between the degree of hearing loss and presence of Auditory Hallucinations

The relationship between severity of hearing loss and presence of auditory hallucinations was assessed using spearman's rho correlation. A very weak negative correlation was found between them, but the significance level was greater than 0.05 ($p>0.05$, $\rho = -0.005$, $n = 272$).

A total of 27 individuals with hallucinations were identified who had hearing loss of degrees ranging from mild to severe. Out of 27 hallucinating individuals, 11, 11, and 5 individuals had mild, moderate and severe hearing losses, respectively, in their poorer ears. Figure 4.3 represents the percentages of individuals with hallucinations belonging to different degrees.

Figure 4.3

Percentages of hallucinating individuals with hearing loss ranging from mild to severe degree in their poorer ears



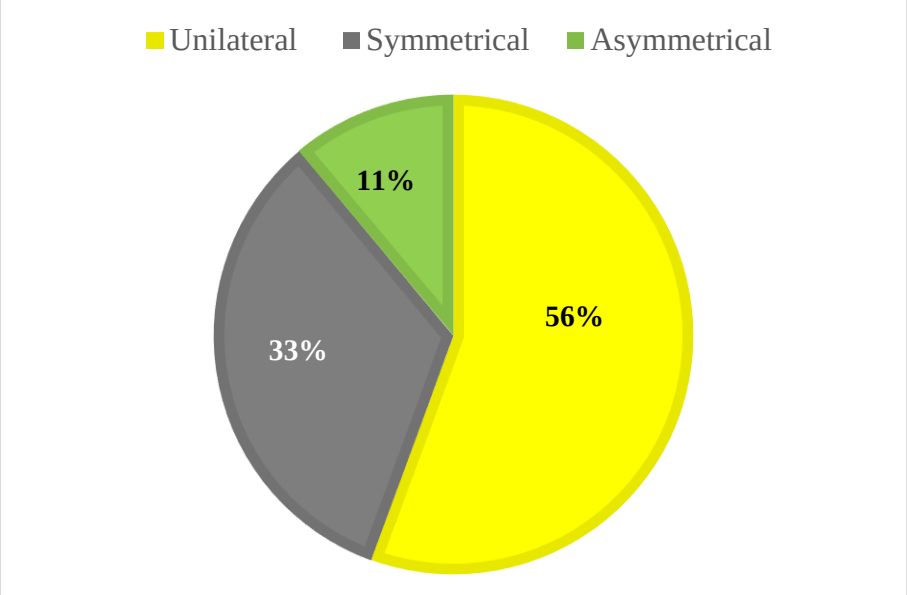
4.4. Association between the presence of Auditory Hallucinations across unilateral, symmetrical and asymmetrical hearing loss

A Chi-square test was performed to assess an association between different configurations of hearing loss (unilateral, symmetrical and asymmetrical) and the presence of auditory hallucinations ($p < 0.05$, chi-square = 11.572, df = 2). A significant association was found between the presence of hallucinations and configuration of hearing loss.

In the non-hallucinating group with hearing loss (n = 245), 67, 163, and 15 individuals had unilateral, symmetrical and asymmetrical hearing losses, respectively. In the hallucinating group with hearing loss, 15 individuals had unilateral hearing loss, while 9 and 3 individuals had symmetrical and asymmetrical hearing losses. Figure 4.4 represents the percentages of hallucinating individuals with different configurations of hearing loss.

Figure 4.4

Percentages of hallucinating individuals belonging to unilateral, symmetrical and asymmetrical configurations of hearing loss



4.5 Comparison of overall quality of life across hallucinating and non-hallucinating individuals.

Thirty individuals out of 44 hallucinating individuals consented to fill WHOQOL-BREF. Thirty age, gender and diagnosis matched non-hallucinating individuals were selected to answer WHOQOL-BREF. Out of the thirty hallucinating individuals, nineteen had hearing impairment, and eleven had normal hearing sensitivity. The raw scores obtained from each domain of four domains (Physical health, Psychological, Social relationships and Environment) of WHOQOL-BREF were transformed to scores ranging between 4-20, as mentioned in the WHOQOL-BREF manual. These transformed scores allow us to compare the brief version of WHOQOL to the full-length WHOQOL, which has 100 questions. The Shapiro-Wilk test of normality was administered on each domain of WHOQOL scores to assess whether the data were normally distributed or not.

4.5.1 Hearing loss without and with hallucinations (Group 1 and Group 2)

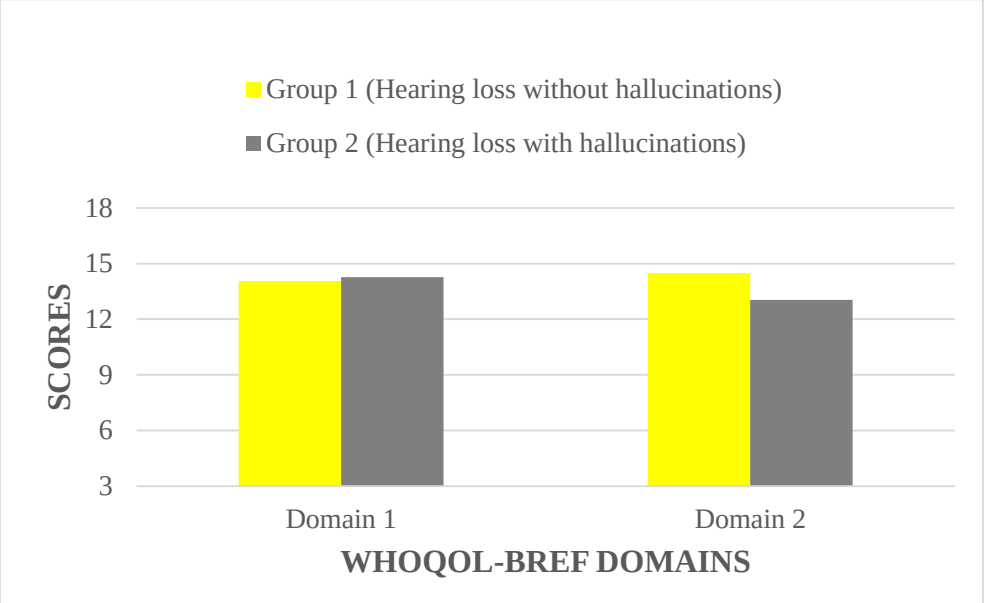
The level of significance on the Shapiro Wilks test (p) was greater than 0.05 for domains 1 and 2; thus parametric test was chosen for analysis. While the significance level was lesser than 0.05 for domains 3 and 4, thus non-parametric test was used for their analysis.

The mean WHOQOL scores for group 1 (hearing loss without hallucinations) participants on domains 1 and 2 were 14.06 and 14.5, respectively. The mean scores for group 2 (hearing loss with hallucinations) participants on domains 1 and 2 were 13.26 and 14.05, respectively. Independent sample t-test was administered to identify any significant differences in scores between group 1 (non-hallucinating) and group 2 (hallucinating) in domain 1 ($t = 1.367$, $df = 35$, $\alpha > 0.05$) and domain 2 ($t = 0.663$, $df =$

35, α > 0.05) scores. No significant difference was observed in the scores between the groups across both domains and is represented in Figure 4.5.

Figure 4.5

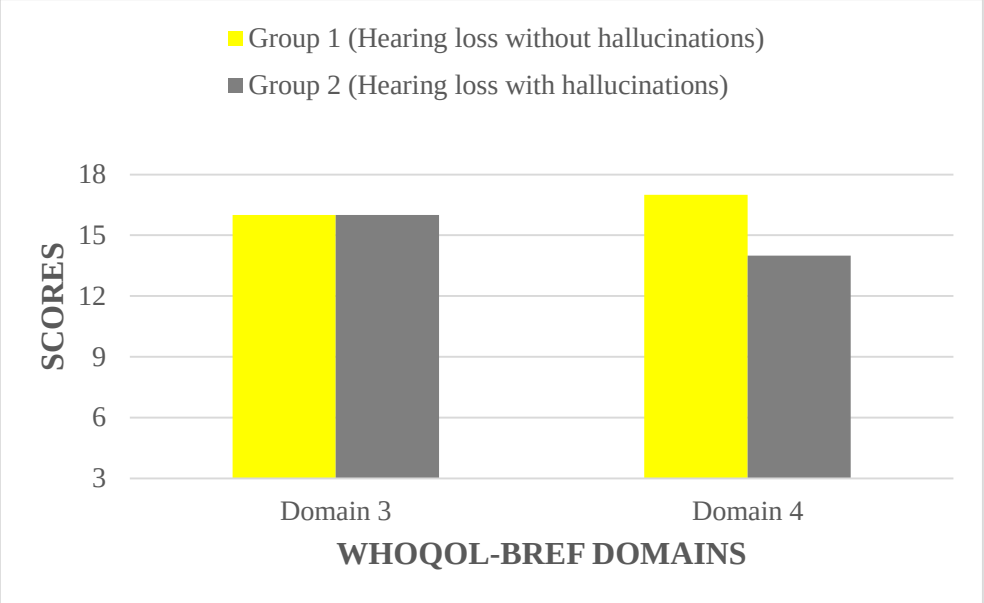
Comparison of WHOQOL-BREF scores (Domain 1 and Domain 2) between Group 1 and Group 2



The median WHOQOL scores for group 1 participants on domains 3 and 4 were 16 and 17, respectively. The median scores for group 2 participants on domains 3 and 4 were 16 and 14, respectively. Mann Whitney U test was utilised to compare scores across domain 3 (U = 166, Z = 0.155, α > 0.05) and domain 4 (U = 110, Z = 1.872, α > 0.05) between groups 1 and 2. No significant difference was observed between the groups in both domains and is represented in Figure 4.6.

Figure 4.6

Comparison of WHOQOL-BREF scores (Domain 3 and Domain 4) between Group 1 and Group 2



4.5.2 Normal hearing individuals with and without hallucinations (Group 3 and Group 4)

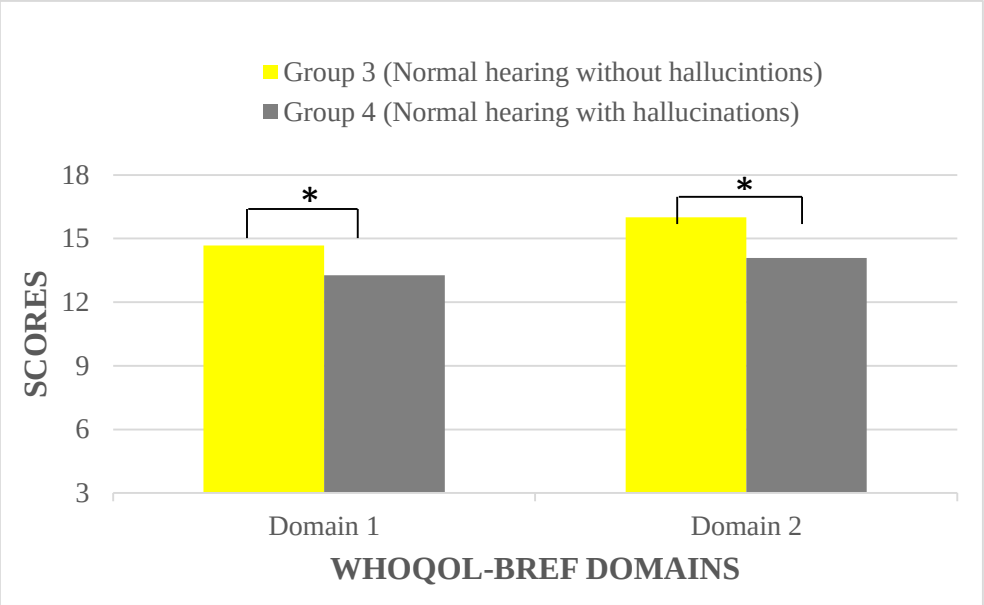
The level of significance on the Shapiro Wilks test (p) was greater than 0.05 for domains 1 and 2; thus parametric test was chosen for analysis. While the significance level was less than 0.05 for domains 3 and 4, thus non-parametric test was used for their analysis.

The mean WHOQOL scores for group 3 (normal without hallucinations) on domains 1 and 2 were 14.67 and 16, respectively. The mean scores for group 4 (normal with hallucinations) on domains 1 and 2 were 13.27 and 14.09, respectively. Independent sample t-test (t-test for Equality of means) was administered to identify any significant differences in scores between group 3 (non-hallucinating) and group 4 (hallucinating) across domain 1 ($t = 2.67$, $df = 21$, $\alpha < 0.05$, $r = 0.50$) and domain 2 ($t = 2.39$, $df = 21$, $\alpha < 0.05$, $r = 0.46$) scores. The test results suggest a significant difference between non-hallucinating and hallucinating normal hearing individuals

with large effect sizes in domain 1 and medium effect sizes in domain 2 (Cohen, 1992). Figure 4.7 below provides a representation of the comparison of scores between group 3 and group 4.

Figure 4.7

Comparison of WHOQOL-BREF scores (Domain 1 and Domain 2) between Group 3 and Group 4

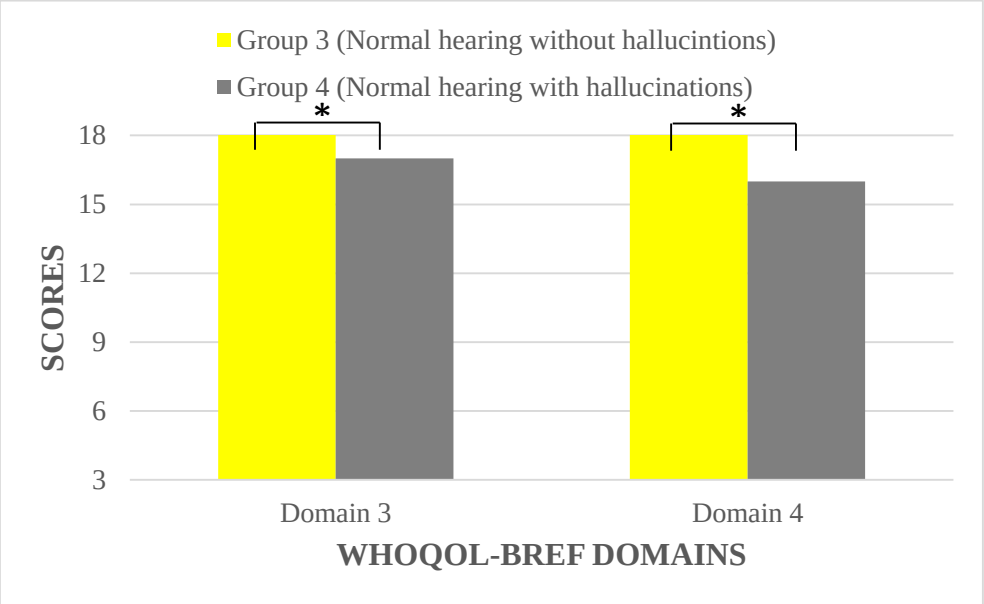


** denotes p < 0.05 for comparison of WHOQOL scores between hallucinating and non-hallucinating individuals.*

The median WHOQOL scores for group 3 participants on domains 3 and 4 were 19.5 and 19, respectively. The median scores for group 4 participants on domains 3 and 4 were 17 and 16, respectively. Mann Whitney U test was utilised to compare scores across domain 3 ($U = 26$, $Z = 2.55$, $\alpha < 0.05$, $r = 0.532$) and domain 4 ($U = 3.5$, $Z = 3.956$, $\alpha < 0.05$, $r = 0.825$) between groups 3 and 4. The results indicate a significant difference in the WHOQOL-BREF scores between non-hallucinating (group 3) and hallucinating (group 4) normal hearing individuals across domains 3 and 4 with large effect sizes (Cohen, 1992). A comparison of scores between group 3 and group 4 is graphically represented in Figure 4.8.

Figure 4.8

Comparison of WHOQOL-BREF scores (Domain 3 and Domain 4) between Group 3 and Group 4



** denotes $p < 0.05$ for comparison of WHOQOL scores between hallucinating and non-hallucinating individuals.*

Chapter 5

Discussion

This study primarily aims to identify the prevalence of auditory hallucinations in the hearing impaired population. Additionally, the results of the five objectives of this study are discussed in this chapter. A quick recap of the five objectives;

1. To find the overall prevalence of auditory hallucinations and across age ranges.
2. To find the type of auditory hallucinations (verbal, musical, or environmental) perceived in individuals.
3. To find the relationship between the degree of hearing loss and the presence of auditory hallucinations.
4. To check the association between the presence of auditory hallucinations across unilateral, symmetrical and asymmetrical hearing loss.
5. To compare the overall quality of life across hallucinating and non-hallucinating individuals.

The discussion of these objectives will follow the same order.

5.1 The overall prevalence of auditory hallucinations and across age ranges

This study estimated the prevalence of auditory hallucinations to be 8.8% in individuals reporting to AIISH in 2019. This population consisted of both hearing impaired and normal hearing individuals. Maijer et al. (2018) conducted a systematic review and meta-analysis of 25 research papers which included 84711 individuals and estimated an overall 9.6% prevalence of auditory hallucinations in the general population. The prevalence rates of auditory hallucinations in the general population varies from 0.6% to 84% (Beavan et al., 2011). This large variability is attributed to the difference in definitions considered and ethnic and environmental differences. Linszen et al. (2019) estimated a lifetime prevalence of 20.8% (n = 1007) in the population

reported to their clinic. Psychiatric comorbidity was not the basis of their exclusion, and the study was conducted in a different cultural setting (Netherlands) than India.

The prevalence rates of 7.45% and 9.9% were found in hallucinating normal hearing individuals and hearing impaired individuals. These results indicate that the prevalence of hallucinations is higher in hearing impaired individuals than normal hearing individuals. The increased prevalence rate in the hearing impaired group suggests an involvement of the auditory pathway in the generation of hallucinations. Marschall et al. (2020) and Mohan & Vanneste (2017) suggested that prolonged periods of sensory deprivation, as in sensorineural hearing loss, causes de-afferentation. The brain attempts to compensate for reduced sensory inputs, which results in the generation of auditory hallucinations.

The first objective of this study was to estimate the prevalence of auditory hallucinations across three age ranges. Prevalence rates of 9.49%, 11.04% and 6.04% were estimated in the age ranges 18-30 years, 31-50 years and 51-65 years, respectively. These findings indicate that the prevalence of hallucinations is higher in the middle-aged population (31-50 years). 61% of hallucinating individuals were males. Tien (1991) and Kråkvik et al. (2015) reported that the prevalence of auditory hallucinations peaked between 25-30 years in males and a little later in females.

Contrastingly, a study conducted by Maijer et al. (2018) reported a higher prevalence (approximately 12%) of auditory hallucinations in children and adolescents when compared to adults or old aged individuals. They hypothesized that the language areas continue to mature around puberty, which causes transient vulnerability resulting in the generation of auditory hallucinations. Abnormal synaptic pruning during early adolescence and early adulthood could result in hallucinations (de Leede-Smith &

Barkus, 2013). Another study reported that the prevalence of auditory hallucinations in non-clinical adults is similar to children and adolescence (de Leede-Smith & Barkus, 2013). However, our study did not include participants under 18 years of age.

5.2 Type of auditory hallucinations perceived by the general population

Auditory hallucinations can be broadly categorized into environmental, verbal and musical hallucinations based on content. In this study, we estimated the frequency of occurrence of each one of these types. We found that 90% of hallucinating individuals perceived environmental sounds, and the most common among them were water dripping or flowing of water, gushing of wind and bees buzzing. 16% of hallucinating individuals heard indistinctive voices or crowd murmurs (Table 4.3). The least type of reported hallucinations was musical, which is in line with the literature (Linszen et al., 2019; Wengel et al., 1989). Linszen et al. (2019a) reported that approximately 50% of the hallucinating individuals heard voices. Nevertheless, prevalence research by Cole et al. (2002) revealed a higher prevalence of simple hallucinations like buzzing, shushing, beating, tapping, and ringing sounds. However, this study was conducted on cognitively sound geriatric population irrespective of the type of hearing loss.

Cole et al. (2002) and Marschall et al. (2020) have reported that tinnitus and auditory hallucinations lie on a continuum. They have hypothesized that perception of random noises over time could transform into a perception of simple to complex auditory hallucinations in few individuals. In our study, we have found that most of the individuals perceived simple auditory hallucinations, and it can be speculated that a portion of these individuals could experience complex hallucinations like voices or music in the future. However, our study does not directly prove the existence of such a continuum and requires further longitudinal studies.

5.3 Correlation between degree of hearing loss and presence of auditory hallucinations

No correlation was found between degrees of hearing loss (mild, moderate and severe) and the presence of hallucinations in the present study. Additionally, in our study, more individuals with a mild or moderate degree of sensorineural hearing loss experienced hallucinations than severe degrees of hearing loss. Teunisse and Rikkert (2012) did not find any direct relationship between severity of hearing loss and presence of complex hallucinations. However, Linszen et al. (2019) calculated the prevalence of auditory hallucinations across the severity of hearing loss. A direct relationship was found between them, i.e., as the degree of hearing loss increased, the prevalence rate of auditory hallucinations also increased from 6% to 24%. However, our study did not establish such a relationship due to the small sample size of hallucinating individuals.

5.4 Association between auditory hallucinations and configuration of hearing loss

A significant association between configurations of hearing loss (unilateral, symmetrical and asymmetrical) and the presence of hallucinations was found. More than 50% of hallucinating individuals belonged to the unilateral group, indicating that hallucinations are found more in this group. It can be speculated that unilateral hearing loss could be a factor for the generation of hallucinations and requires further study. Cole et al. (2002) reported a significant association between asymmetrical hearing loss and prevalence of hallucinations. Cole et al. (2002) grouped unilateral losses under asymmetrical loss and thus found a higher prevalence in the asymmetrical group than the symmetrical group. Teunisse and Rikkert (2012) also reported that most hallucinating individuals had asymmetric hearing loss and a higher degree in the left ear. The pathophysiological basis for this phenomenon still needs further exploration.

5.5 Effect of auditory hallucinations on quality of life

The current study results indicate that auditory hallucinations do not have a significant impact on hearing impaired individuals. A multitude of research shows that hearing impairment significantly affects the quality of life of adults and the elderly (Ciorba et al., 2012; Gopinath et al., 2012; Hawkins et al., 2011), especially on social, emotional and communicative domains (Mulrow et al., 1990). Individuals with hearing loss have reduced communication and withdraw from social situations. Hearing impairment negatively affects their quality of life; perhaps the additional presence of hallucinations may not be further disabling. Furthermore, hallucinations in the general population tend to be positive and non-threatening (Choong et al., 2007). The overall scores for the group of hearing impairment were lesser than normally hearing individuals in our study. Hence, hearing impairment along with or without hallucinations have similar outcomes on quality of life measures.

The outcomes of quality of life measurement significantly varied between hallucinating and non-hallucinating normally hearing individuals in the present study. The hallucinating group scores were significantly lower than the non-hallucinating group, implicating that auditory hallucinations negatively affected the quality of life across physical health, psychological, social relationships, and environment domains. The additional presence of hallucinations without comorbidities might be disabling and is reflected in the quality of life outcome measures. However, this is a preliminary study investigating the effect of auditory hallucinations in the general population with and without hearing loss. Further experiments and research are required with other quality of life measures.

Chapter 6

Summary and Conclusion

The present study aimed at estimating the prevalence of auditory hallucinations (environmental, verbal and musical) in the patients reported to AIISH in 2019 with or without hearing loss. Objectives included estimating prevalence rates across three age groups (18-30 years, 31-50 years and 51-60 years), identifying and categorising the type (environmental, verbal and musical) and content of hallucinations. Additional objectives included assessing a relationship between the degree of hearing loss (mild, moderate and severe) and auditory hallucinations, assessing an association between the configuration of hearing loss (unilateral, symmetrical and asymmetrical) and the presence of auditory hallucinations. The final objective is to compare the WHOQOL-BREF scores between hallucinating and non-hallucinating individuals.

In order to address these aims and objectives, the data collection was carried out in two phases. In the first phase, "Spontaneous Acoustic Phenomena", a questionnaire used to identify the presence of hallucinations was administered to 500 consented individuals. Based on the outcomes of this questionnaire, the subjects were divided into four groups;

a. Group 1: Hearing impaired individuals without hallucinations
b. Group 2: Hearing impaired individuals with hallucinations
c. Group 3: Normal hearing individuals without hallucinations
d. Group 4: Normal hearing individuals with hallucinations

In the second phase, WHOQOL-BREF was administered to 30 individuals with hallucinations. Later 30 age, gender and diagnosis matched controls were asked to fill WHOQOL-BREF.

The data obtained from these questionnaire and checklists were tabulated in SPSS v.20. Prevalence analysis was conducted, and descriptive analysis of type and form of hallucination was done. Spearman's rho correlation test was performed to assess the relationship between severity of hearing loss and presence of hallucinations. A Chi-square test of association was administered to assess the association between the configuration of hearing loss and the presence of auditory hallucinations. Finally, normality was assessed using Shapiro Wilk's test. Independent t-test and Mann Whitney U test were utilised to analyse significant differences between hallucinating and non-hallucinating individuals.

The estimated prevalence of auditory hallucinations was 8.8%. The prevalence of hallucinations in the hearing impaired population was 9.6%, and in normal hearing individuals was 7.45%. Individuals with hearing impairment have a higher prevalence than normal hearing, indicating the involvement of auditory pathways in hallucinations. Most of the participants perceived environmental sounds like water dripping, water flowing, gushing wind, train moving sounds. Only 16% and 11% of hallucinating individuals experienced verbal and musical hallucinations, respectively.

Although no correlation was found between severity of hearing loss and presence of auditory hallucinations, most of the individuals had mild to moderate degree of sensorineural hearing loss. The sample size of hallucinations was small; thus, a correlation was not found. A significant association between the configuration of hearing loss and the presence of hearing loss was found. More than 50% of individuals had unilateral hearing loss, and thus speculation can be made that unilateral loss could be a factor for the occurrence of hallucinations. However, the pathophysiological basis of this is yet to be explored.

Auditory hallucinations had a significant effect on normal hearing individuals but not on hearing impaired individuals. Hearing impairment adversely affects the quality of life, and the additional presence of hallucinations may be more disabling. The presence of hallucinations adversely affects the quality of life in normal hearing as measured on WHOQOL-BREF.

6.1 Implications of the study

1. Knowing the prevalence of auditory hallucinations in individuals with hearing impairment and normal hearing will help us establish a relationship between hallucinations and the involvement of the auditory pathways.
2. The higher prevalence of hallucinations in hearing impaired individuals implicate adding counselling related to hallucinations in their effective management.
3. The presence of hallucinations in the general population (normal hearing and hearing impaired) and its adverse effects on quality of life necessitates the involvement of an audiologist in the evaluation and management of hallucinations.

6.2 Limitations of the study

1. The sample size was smaller and consisted of only 500 individuals, but our primary aim was to estimate prevalence rates in individuals reported to the audiology department of AIISH in 2019.
2. To collect data, telephonic interviews and Google form-based information were used. Face-to-face interviews may provide more reliable data and make it easier for Indians to talk about hallucinations. In-person data collection was not allowed due to the Covid-19 pandemic for safety reasons.

3. The sample size of hallucinating individuals was small. Thus, a correlation between the degree of hearing loss and the presence of hallucinations was not established.
4. Only one quality of life measure tool was utilised to evaluate the effect of hallucinations on individuals experiencing them. Nevertheless, WHOQOL-BREF is a standardised tool and the most commonly used tool for quality of life measures.

6.3 Future Directions

1. Further in-depth analysis and comparisons are required on a larger population to understand the prevalence rates better.
2. Electrophysiological tests or imaging studies should be carried out to understand the pathophysiology and the involvement of auditory pathways.
3. The effect of hallucinations should be measured using other quality of life measures that should be administered and compared.

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Appendices

Appendix A

Spontaneous Acoustic Phenomena. 14-item semi-structured interview, used for hallucination assessment.

English translation.

Screening form "Spontaneous Acoustic Phenomena"

Age:	Date of screening:
Gender:	Location:
Research number:	Interviewer:

ENT information

	Left ear	Right ear
Otological diagnosis:		
High Fletcher Index:		
Hearing aid:		

Short introduction: "Sir/madam, people with hearing illnesses are mostly bothered by the fact that they hear less than people with good hearing. Yet, they can sometimes hear things that other people cannot. These sounds can be humming, or squeaking, and can even consist of music, or spoken language. It is about those sounds that I wish to ask you some questions, within the context of scientific research. The questions will take about 10 minutes. Participation is voluntary. If you prefer not to participate, it will not have negative consequences for your treatment. May I ask you the questions?"

QUESTIONNAIRE

1. Have you ever heard sounds different from normal? Yes - No
   (e.g. with an echo, booming, or with a strange pitch?)
2. Do you experience tinnitus, peeping, or buzzing? Yes - No
   If so, did you experience that during the past 4 weeks? Yes - No

   Can you describe the sound?

3. Have you ever heard something wrong, i.e. that you thought you heard something, but it turned out to be something else? Yes - No
   If so, did you experience that during the past 4 weeks? Yes - No

   Can you give an example?

4. Have you heard sounds no-one else could hear? Yes - No

5. Have you heard song or other sorts of music, while nothing or nobody was making/playing that music? Yes - No

6. Have you heard voices speak while nobody was with you? Yes - No

7. Have you heard sounds, voices, or music that arose from inside your head? Yes - No

8. Have you experienced other special things related to hearing? Yes – No
   If so, can you describe your experience?

   .....

9. Is patient a possible case? Yes - No

   If no: end the interview. If yes: continue questionnaire.

10. Can you describe what you have heard?

    Are those sounds complex auditory phenomena? Yes - No

11. Did these sounds appear as real as actual sounds? Yes – No
    (or more like hearing in thoughts)

12. Could it have been a different sound that you heard wrong? Yes -No

13. When did you hear the sounds for the last time? _____

14. Are there complex auditory phenomena? Yes - No

Appendix B

Background information for interviewer using Appendix A.

Standardized additional information regarding screening form “Spontaneous acoustic phenomena”; can be used as a reference for trained interviewers. English translation, Dutch version upon request.

Question 1: this question regards *unformed* hallucinations. This is a phenomenon often pathognomic for certain diseases of hearing (e.g. hyperacusis). Complex auditory hallucinations are formed by definition.

Question 2: this question regards tinnitus. Tinnitus can be regarded as a *formed, non-complex* hallucination. Its cause has not yet been unravelled. Tinnitus can occur in both hallucinating and non-hallucinating patients. It is interesting to unravel the prevalence of tinnitus in the hallucinating group, in comparison to the prevalence of tinnitus in the entire study sample.

Question 3: this question regards the occurrence of illusions. In this way, one can distinguish a hallucination from an illusion.

Question 4-8: these questions closely resemble each other. They all have a slightly different angle to them, thereby enlarging the chance of potential cases bringing their hallucinations up than if only one of these questions would have been asked. Also, these questions distinguish between musical and verbal hallucinations.

Question 9: if question 1 until 8 have all been answered with ‘no’, the participant is considered to not have hallucinations. In that case, the interview is over. If a participant answers question 1 until 8 with ‘yes’ one or more times, or in case the participant or researcher has any doubt, the researcher can decide to continue the interview with question 10.

Question 10: be as complete as possible. There is a grey area between simple and complex hallucinations. Cases of doubt will always be reviewed in a later phase of the study. Therefore, it is important that anyone is able to reproduce the description given by the participant at any given time, and in full detail.

Question 11: this question regards the occurrence of mental imagery. Examples of mental imagery are so-called musical ‘ear worms’, a symptom that occurs frequently in mood disorders such as OCD, or depression. In this way, one is able to distinguish between the occurrence of hallucinations and mental imagery.

Question 12: this question regards the occurrence of illusions. In this way, one is able to distinguish between the occurrence of hallucinations and illusions.

Question 13: this question provides insight in the current presence of events.

Question 14: based on the information from the previous questions, the researcher is now able to judge whether or not spontaneous, complex hallucinations are present. A complex hallucination is a hallucination on which the participant bestows a certain amount of meaning; e.g.: participant continuously hears a gurgling stream of water. Ask in such cases: “do you hear sounds that only resemble a gurgling stream of water (…) ” (most likely tinnitus/non-complex), “(…), or do you actually hear a gurgling stream of water?” (most likely complex).

Appendix C

WHOQOL-BREF. A quality of life measure.

The following questions ask how you feel about your quality of life, health, or other areas of your life. I will read out each question to you, along with the response options. **Please choosethe answer that appears most appropriate.** If you are unsure about which response to give to a question, the first response you think of is often the best one.

Please keep in mind your standards, hopes, pleasures and concerns. We ask that you think about your life **in the last four weeks.**

		Very poor	Poor	Neither poor nor good	Good	Very good
1.	How would you rate your quality of life?	1	2	3	4	5

		Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
2.	How satisfied are you with yourhealth?	1	2	3	4	5

The following questions ask about how much you have experienced certain things in the lastfour weeks.

		Not at all	A little	A moderate amount	Very much	An extreme amount
3.	To what extent do you feel thatphysical pain prevents you from doing what you need to do?	5	4	3	2	1
4.	How much do you need any medical treatment to functionin your daily life?	5	4	3	2	1
5.	How much do you enjoy life?	1	2	3	4	5
6.	To what extent do you feel yourlife to be meaningful?	1	2	3	4	5
		Not at all	A little	A moderate amount	Very much	Extremely
7.	How well are you able toconcentrate?	1	2	3	4	5

8.	How safe do you feel in yourdaily life?	1	2	3	4	5
9.	How healthy is your physicalenvironment?	1	2	3	4	5

The following questions ask about how completely you experience or were able to do certain things in the last four weeks.

		Not at all	A little	Moderately	Mostly	Completely
10.	Do you have enough energy for everyday life?	1	2	3	4	5
11.	Are you able to accept your bodily appearance?	1	2	3	4	5
12.	Have you enough money to meet your needs?	1	2	3	4	5
13.	How available to you is the information that you need in your day-to-day life?	1	2	3	4	5
14.	To what extent do you have the opportunity for leisure activities?	1	2	3	4	5

		Very poor	Poor	Neither poor nor good	Good	Very good
15.	How well are you able to get around?	1	2	3	4	5

		Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
16.	How satisfied are you with yoursleep?	1	2	3	4	5
17.	How satisfied are you with your ability to perform yourdaily living activities?	1	2	3	4	5
18.	How satisfied are you withyour capacity for work?	1	2	3	4	5
19.	How satisfied are you withyourself?	1	2	3	4	5
.	How satisfied are you with yourpersonal relationships?	1	2	3	4	5

21.	How satisfied are you withyour sex life?	1	2	3	4	5
22.	How satisfied are you with thesupport you get from your friends?	1	2	3	4	5
23.	How satisfied are you with the conditions of your living place?	1	2	3	4	5
24.	How satisfied are you with youraccess to health services?	1	2	3	4	5
25.	How satisfied are you withyour transport?	1	2	3	4	5

The following question refers to how often you have felt or experienced certain things in thelast four weeks.

		Never	Seldom	Quite often	Very often	Always
26.	How often do you have negative feelings such as blue mood, despair, anxiety, depression?	5	4	3	2	1

Do you have any comments about the assessment?

[The following table should be completed after the interview is finished]

		Equations for computing domain scores	Raw score	Transformed scores*	
				4 to 20	0 to 100
27.	**Domain 1**	(6-Q3) + (6-Q4) + Q10 + Q15 + Q16 + Q17 + Q18	a. =	b:	c:
28.	**Domain 2**	Q5 + Q6 + Q7 + Q11 + Q19 + (6-Q26)	a. =	b:	c:
29.	**Domain 3**	Q20 + Q21 + Q22	a. =	b:	c:
30.	**Domain 4**	Q8 + Q9 + Q12 + Q13 + Q14 + Q23 + Q24 + Q25	a. =	b:	c: