

**CHARACTERISTICS OF TINNITUS IN INDIVIDUALS WITH NOISE  
INDUCED HEARING LOSS (NIHL) - A SYSTEMATIC REVIEW**

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A Dissertation Submitted in Part Fulfilment of Degree of  
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University of Mysore



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AUGUST, 2022

## **CERTIFICATE**

This is to certify that this dissertation entitled '**Characteristics of Tinnitus in Individuals with Noise Induced Hearing Loss (NIHL) - A Systematic Review**' is a bonafide work submitted in part fulfilment for degree of Master of Science (Audiology) of the student Registration Number: 20AUD037. This has been carried out under the guidance of a 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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## **CERTIFICATE**

This is to certify that this dissertation entitled '**Characteristics of Tinnitus in Individuals with Noise Induced Hearing Loss (NIHL) - A Systematic Review**' has been prepared under my supervision and guidance. It is also been certified that this dissertation 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 '**Characteristics of Tinnitus in Individuals with Noise Induced Hearing Loss (NIHL) - A Systematic Review**' is the result of my own study under the guidance a faculty at All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru,  
August, 2022

**Registration No. 20AUD037**

## **Dedication**

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*I whole heartedly dedicate this dissertation to my hero my papa Mr. A. Govindaraju and to my lovely amma Ms. Meena. K you both are my strength and support always.*

*I love you papa and mumma.*

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### **Dedication Note to my parents**

*Papa and Amma I am proud & blessed to be born as your daughter. You both are the reasons for who I am today, u guys have taught me how to lead a better life in all the ups and downs.*

*Papa your memories have made me still alive today I am living with it. I wish I had more time to spend with you, I can always feel your presence in my heart. I wish you were here next to me to see your daughter's growth from a kid to becoming an Audiologist and SLP.*

*Amma you are my world you mean everything to me. I feel so blessed to have a mother like you. You have never let me down; you have been my best friend who is always understanding and supportive. I am happy and proud to say that I have got the best mom and papa. Thank you for everything love you Amma and Papa.*

*I hope I have made you both proud and I promise to continue to so in the future as well.*

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*Hardships often prepare ordinary people for an extraordinary destiny – C.S Lewis*

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## ABSTRACT

**Background:** Exposure to noise at the workplace, as well as personal listening devices, is a significant risk factor for hearing loss or tinnitus in young adults and adolescents. Noise exposure causes not just hearing loss but also tinnitus and its associated co-morbidities which is permanent, causing damage to hearing cells within the inner ear resulting in decreased quality of life. Tinnitus is much more common (24%) among noise-exposed workers than in the general population (14%). Recent studies have reported more severe hearing loss and severe subjective tinnitus in individuals with noise induced hearing loss (NIHL) (Kang et al., 2021). There is a need for a systematic study on this subject because there hasn't been a current update on all of the major and minor tinnitus features in cases with NIHL.

**Objective:** The present study aims to review the significant studies conducted in the past ten years (2010-2020) reporting the characteristics of tinnitus in individuals with noise induced hearing loss (NIHL).

**Method:** A systematic search in the electronic databases like Google Scholar, PubMed, JSTOR, AJOL, COCHRANE & Science direct was carried out using the appropriate key Words. Following the PRISMA guidelines and based on inclusion and exclusion criteria 12 research articles were finalized and reviewed which included data collected on subjective tinnitus in individuals with noise induced hearing loss (NIHL). Only research articles containing studies on adult subjects were included in the review.

**Results:** This systematic review throw light on the 10 different tinnitus characteristics in individuals with noise induced hearing loss (NIHL). Based on that the major characteristics were tinnitus loudness and pitch, laterality, severity and discomfort, duration, type and sex differences which was report by most of the articles whereas

minor characteristics include frequency of occurrence of tinnitus, tinnitus onset, tinnitus subjective quality and loudness grading which was reported in very few publications. Finding suggested that tinnitus was mostly bilateral, followed by left-sided, and described as buzzing or high-pitched in individuals who had NIHL. There was a correlation between age, length of tinnitus, and hearing loss. Tinnitus onsets ranges from acute (within one month) to more than a year. The severity of tinnitus reflects the level of hearing loss. The intensity of tinnitus is affected by the degree of NIHL. No significant ear and gender difference was noticed. Tinnitus or hearing loss affects about one-fifth of young adults ( $\leq 40$  years old), indicating that future hearing difficulties are on the rise.

**Conclusion:** Exposure to noise in the workplace, as well as personal listening devices, is a significant risk factor for hearing loss or tinnitus in young adults and adolescents. Rock musicians are at an increased risk of developing chronic tinnitus. Overexposure to noise causes not just hearing loss but also tinnitus and its associated co-morbidities, which results in deterioration of quality of life. Noise induced tinnitus affects a substantial proportion of young adults, yet they do not use hearing protection as a result, probably due to a lack of information about the consequences of loud music. Young adults should see tinnitus as a warning sign rather than a natural result of listening to loud music. This basic research gives us the better understanding of various characteristics of tinnitus encountered in people with NIHL.

**Key words:** Tinnitus; Noise Induced Hearing Loss (NIHL); Noise Exposure.

## **Chapter 1**

### **Introduction**

Tinnitus is the perception of sound in the absence of an external acoustic stimulus. The word tinnitus is derived from the Latin word ‘tinnire’, which means ‘to ring’. According to McFadden (1982), “Tinnitus is the conscious expression of a sound that originates in an involuntary manner in the head of its owner, or may appear to him to do so”. It is estimated that it has a prevalence of about 10-15% in adults (Schaette et al., 2010). In younger adults, the prevalence of tinnitus is increasing which is associated with noisy environment and high volume of music exposure (Khilnani et al., 2018). Tinnitus arises more frequently in people between the ages of 40 and 50 years (Savastano, 2004). It is one of the most common complaints and distressing otological problem, which is a common hearing symptom affecting a majority of patients with hearing impairment (Henry et al., 2005).

People have described the perception of tinnitus as buzzing, roaring, ringing, hissing, and sizzling in nature, which may persist continuously or maybe be present intermittently (Baguley et al., 2013a). Tinnitus could be due to abnormal neuronal activity seen at a subcortical level of the auditory pathway (Han et al., 2009). It maybe localized, being heard in one or both ears or centrally within the head. The Most common type of tinnitus can be subjective as heard by the individual alone, and less frequently seen is the objective type of tinnitus wherein the observer can hear it (Baguley et al., 2013a).

Tinnitus is more often closely related to hearing loss although it can exist without hearing loss (Savastano, 2008). Tinnitus can be one of the symptoms of otological diseases such as ototoxicity, noise-induced hearing loss (NIHL), Meniere's

disease and presbycusis. NIHL and presbycusis are the two most common type of hearing loss associated with tinnitus. Therefore, tinnitus is a serious health problem that is exacerbated by co-existing hearing loss (Segun-Busari et al., 2021). The causes of tinnitus include sudden hearing loss, presbycusis, administration of ototoxic drugs, noise trauma and traumatic head injury (Langguth, 2013). Hearing loss, ototoxic medicine, head injury, and depression are all risk factors that are associated with it (Baguley et al., 2013b).

NIHL is a serious problem in many workplaces and throughout society. According to the National Institute for Occupational Safety and Health, more than 30 million workers (almost one in ten) are exposed to hazardous noise levels at work (McReynolds, 2005). It is an irreversible impairment caused by continuous exposure to excessive noise levels, which damages and destroys hearing cells within the ear (Lusk, 1997). It is found that prevalence of tinnitus is slightly more in men associated with or without hearing loss than women this could be because they are more exposed to industrial noise than women are and as it is well known that chronic exposure to noise is a leading cause of tinnitus (Savastano, 2008).

Long-term exposure to noise can also cause persistent apoptosis of hair cells and degeneration of spiral ganglion neurons, which can lead to irreversible hearing loss by gradually lowering speech recognition and increasing hearing thresholds (Wang et al., 2020). Noise induced permanent tinnitus in general is tonal and high-pitched. On pitch matching, the most common frequency of tinnitus is the same as the poorest frequency for hearing (Axelsson & Prasher, 2000). The sensation level of Noise induced permanent tinnitus is usually low and sometimes negative. Usually, the time gap between the beginning of noisy work and the appearance of tinnitus is long (Axelsson & Prasher, 2000).

Studies have shown that tinnitus was most common at the high frequencies and the majority of the patients described their tinnitus as moderate to severe. The intensity of tinnitus perception corresponded to the pure tone hearing threshold, and symmetrical hearing loss was observed in patients who had a history of noise trauma, even though there was no difference seen in terms of lateralization of tinnitus perception. Significant correlation was reported between the history of noise trauma, presence of high-pitched whistling type of tinnitus with high frequency hearing loss (Nicolas-Puel et al., 2006). Noise and stress were found to be key factors in the development of tinnitus. Stress proved to be especially crucial during the transition from mild to severe degree tinnitus (Baigi et al., 2011). Maximum levels of noise exposure, daily and total noise exposure time, and continuous noise exposure are all important elements that affects the quality of life. Occupational noise-induced tinnitus is more likely to produce emotional distress than physical distress. Tinnitus-related psychological issues may be the cause of emotionally poor quality of life (Muluk, 2008).

Tinnitus caused by noise can be acute or chronic. Acute tinnitus can continue anywhere from a few minutes to several weeks after being exposed to loud noise. Tinnitus can have a gradual onset in certain circumstances, and it can take several years for an intermittent, low-intensity tinnitus to become troublesome. More than three-quarters of victims obtain spontaneous remission due to natural habituation. The central nervous system (CNS) is involved in habituation, whereas a peripheral sensory organ is involved in adaptation. For those in whom the condition progresses, the tinnitus severity increases over time, but the pitch of tinnitus tends to remain steady. If tinnitus persists for more than two years, it is considered persistent and irreversible. However, chronicity is not correlated with a better response to treatment (Han et al., 2009).

There is a need to understand the major characteristics features of tinnitus in individuals with NIHL because recent studies have shown more severe hearing loss and severe subjective tinnitus in patient with NIHL (Kang et al., 2021). Although tinnitus is more of a subjective phenomenon, audiological test finding carried out on patients with NIHL have revealed that the individuals with tinnitus had considerably higher Pure Tone Audiometry (PTA) thresholds from 2 to 8 kHz. Despite the fact that the tinnitus group had longer wave I, III, and V delay on ABR testing, the differences were not statistically significant. At 3 and 4 kHz, Distortion product otoacoustic emissions (DPOAE) showed more anomalies than at 1 and 2 kHz. In both ears, Transient otoacoustic emission (TEOAE) revealed abnormal findings (Kang et al., 2021).

### **1.1 Need for the study**

Tinnitus is much more common (24%) among noise-exposed workers than in the general population (14 %). Tinnitus was reported to be mostly bilateral, and it was buzzing or high pitch as described by the patients (Ralli et al., 2017). Studies have reported that noise induced tinnitus negatively affects the quality of life of an individual (Kang et al., 2021). As it is more frequently reported symptoms in individuals with noise exposure, studies have shown a significant correlation between the history of exposure to noise trauma and the existence of a high-pitched "whistling" tinnitus (Puel et al., 2006). Studies have also shown that ears with tinnitus have a significantly higher hearing threshold which is usually present at high frequency bilaterally in cases of NIHL (Phoon et al., 1993). A vast amount of literature is available on the same. Hence, it is necessary to consolidate the literature and carry out a systematic review to reveal the major and minor tinnitus characteristics in cases with NIHL. To better understand the pathophysiology of tinnitus due to noise exposure, the basic research establishes a

better understanding of the various characteristics features like severity, type, laterality, and duration of tinnitus in individuals with NIHL.

## **1.2 Aim of the study**

The present study aims to review the significant studies conducted in the past ten years (2010-2020) reporting the characteristics of tinnitus in NIHL.

## **1.3 Objectives of the study**

- To gather the most recent information on the characteristics of tinnitus in individuals with NIHL from the literature that was published between the years of 2010 and 2020.
- Compilation of selected articles using appropriate data extraction methods.
- Evaluation of the quality of the articles extracted from the database using an appropriate quality analysis tool.
- Interpretation to understand the characteristics of tinnitus in case of NIHL.

## **1.4 Research questions**

The following questions are addressed in this review:

1. What are the characteristics of tinnitus found in individuals with NIHL?
2. What are the findings of each characteristics of tinnitus reported in NIHL?



## **Chapter 2**

### **Methods**

To study the characteristics of tinnitus in individuals with NIHL a systematic search was conducted in the following electronic databases: Google Scholar, Science direct, JSTOR, AJOL, COCHRANE & PubMed for English language articles published in peer-reviewed journals. This advanced search was conducted using Key words and Boolean operations. Key words used are: tinnitus, noise induced hearing loss, noise exposure along with the Boolean operations such as ‘AND,’ ‘OR,’ and ‘NOT’ were used for extracting the data from all the above-mentioned databases.

PRISMA guidelines (Page et al., 2021) was used to screen the articles. Title and abstract screening were conducted for identifying the relevant observational studies for full-text review, as per the inclusion and exclusion criteria. The articles published in the peer-reviewed journals from the past ten years (2010 to 2020) were considered in the systematic review.

#### **2.1 Study Selection**

The specific inclusion and exclusion criteria for selection of studies were as follows:

##### **2.1.1 Inclusion Criteria**

- Original articles containing human subjects with appropriate samples, practical treatment approaches, and relevant statistics.
- Articles that are published in the peer-reviewed journals which highlights the characteristics of tinnitus in NIHL were included.
- Review included only articles containing data collected from adult subjects.

- Articles reporting details about subjective tinnitus were only included.

### **2.1.2 Exclusion Criteria**

- The analysis omitted articles that used animals as subjects.
- Articles containing studies that are a single case studies, case series, short communications, letter to the editor, and systematic review.
- The study excluded pathologies other than noise-induced hearing loss.
- The review excluded articles with paediatric population as participants (under the age of 18).
- Articles with low methodological quality (having a higher risk of bias).
- Articles in languages other than English.

## **2.2 Data Extraction**

A systematic search was conducted in various databases. The articles were selected by performing title and abstract screening followed by full text screening which were based on predefined selection criteria, papers fulfilling the inclusion criteria were included in the study, and articles which are not fulfilling the inclusion criteria or which come under the exclusion criteria were excluded from the study after the duplicate removal. All these were performed using Rayyan QCRI (Qatar Computing Research Institute) software and Mendeley desktop reference manager system. The results of search are later represented through a PRISMA flow diagram (Page et al., 2021) as show in the table 3.1. “PRISMA” stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses. It is a minimum set of evidence-based elements that are reported in systematic reviews and meta-analyses. The PRISMA statement was developed to help authors publish systematic reviews and meta-analyses more effectively. It can also be used to report systematic reviews of other types of research, notably intervention evaluations. PRISMA could be useful for assessing

published systematic reviews as well. PRISMA is part of a larger initiative to enhance the reporting of many forms of health research, and thereby enhancing the quality of research used in healthcare decision-making (Page et al., 2020). The finalized articles are tabulated in two different tables, of which Table 3.1 depicts the basic details and quality analysis of the selected research articles. Another table 3.2 represents the detailed review of each article based on the objective of the study. The finding of each article that are reviewed is been discussed in this systematic review.

### **2.3 Quality analysis (Risk of bias)**

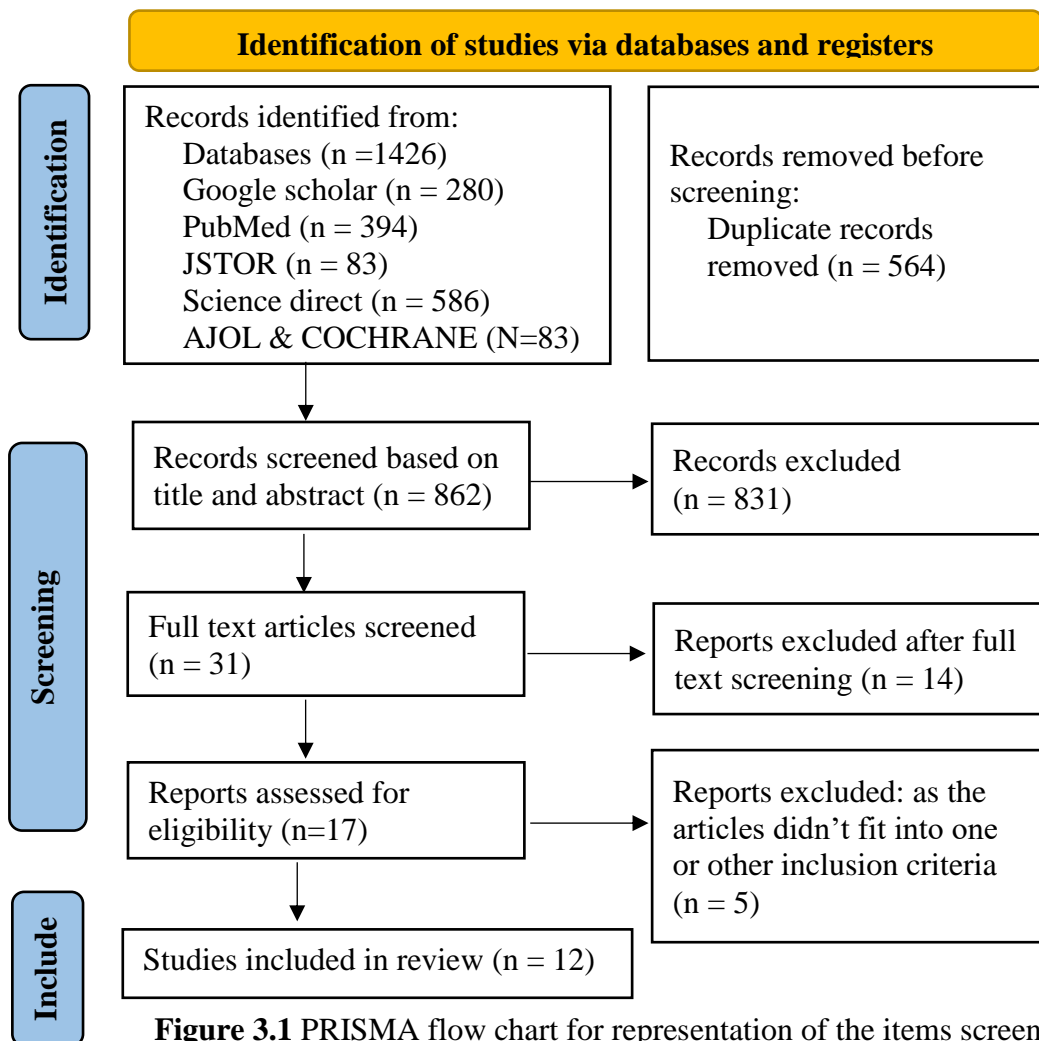
The National Institutes of Health (NIH) quality assessment tool was used to conduct a methodological quality assessment of the included studies. It was performed by two reviewers, to avoid the risk of bias. The detailed finding of each has been show in the results section. The NIH tool kit included individual tools for case-control studies, observational cohort and cross-sectional studies and before-after studies (pre-post) comparison without a control group.

After reading each article, the questions were presented with yes/no/other options to be answered. Each of the three tools listed above were used to analyse an article based on the kind of study it featured. Each reviewer was required to rate each article with a final rating of 'Good,' 'Fair,' or 'Poor,' and if there were any inconsistencies between the reviewers' results, a third reviewer was to be approached. However, since there were no significant differences in the evaluations of the first two reviewers, a third review for risk of bias was not necessary.

## Chapter 3

### Results

A total of 1426 Studies were obtained after conducting the searches in all the six mentioned databases and potentially relevant reference are shown in the Figure 3.1. Two reviewers independently carried out the title and abstract screening, out of which 564 Duplicates were removed. About 862 articles underwent title and abstract screening. In the full text screening, appropriate inclusion and exclusion criteria were assessed, and 12 articles were chosen for the review. Figure 3.1 depicts the article selection methods, from the results of the literature search to the finalisation of the articles for review.



**Figure 3.1** PRISMA flow chart for representation of the items screened, included and excluded in the systematic review.

### **3.1 Study Characteristics**

Out of the 12 articles finalized for the systematic review, three articles were published each in 2010, 2016 and 2017 respectively and one articles each in 2012, 2018 and 2019. Number of participants studied varied from 20 to 114411 across the articles. The research included in the articles which are reviewed have been carried out in various countries like Belgium (three articles), Brazil (two articles) and 1 each from Israel, Sweden, Norway, Italy, Germany, China, and Taiwan. The study design among the 12 review articles included seven cross-sectional study, two longitudinal studies, two cohort studies and one retrospective study. Characteristics of tinnitus in individuals with NIHL like laterality, ear difference, tinnitus pitch, tinnitus loudness, severity, duration, gender and age which has been studied in each article has been mentioned along with the basic details of each article in the Table 3.2.

### **3.2 Quality analysis**

Two reviewers carried out the quality analysis of which 10 articles were rated as 'good' and remaining two articles was rated as 'fair' in quality. Based on the quality analysis no articles were excluded. Quality analysis was carried out using NIH quality assessment tool in order to avoid the risk of bias. The NIH quality assessment tool kit had individual tools for the observational cohort and cross-sectional studies, case control studies, and pre vs post comparison studies without a control group. The former tool chosen was observational cohort and cross-sectional studies which had fourteen questions, whereas the latter two contained twelve questions each. After reviewing each item, the questions were supplied with yes/no/other alternatives such as cannot determine, not applicable, and not reported to be filled. Each of the three techniques listed above was used to analyse the article depending on the type of study stated in the article. Every article had to get a final evaluation from each reviewer, which might be

"Good," "Fair," or "Poor," providing it an overall grade. Quality was graded as poor for a score of 0-4 out of 14 questions, for 5-10 score out of 14 questions it was fair and good rating was given for a score of 11-14 out of 14 questions. So, among the 12 selected articles, 10 articles were rated as 'good' and remaining 2 articles was rated as 'fair' in quality. Based on the quality analysis no other articles were excluded as shown in table 3.1.

**Table 3.1***Quality analysis of the selected study*

Quality Analysis							
Sl. No	Author	Year	Country	Characteristics studied	No. Of subjects	Type of study	Quality analysis
1.	Nageris et al.	2010	Israel	Tinnitus pitch Tinnitus loudness Laterality	30	Longitudinal study	Good
2.	Hasson et al.	2010	Sweden	Frequency of occurrence of tinnitus Severity and discomfort of tinnitus Sex difference	114411	Cross-sectional survey	Good
3.	Stormer et al.	2017	Norway	Duration of tinnitus Degree of tinnitus Gender	111	Cross-sectional survey	Good
4.	Mazurek et al.	2010	Germany	Laterality Type of tinnitus Gender and ear Tinnitus pitch Tinnitus loudness	531	Retrospective study	Good
5.	Gilles et al.	2012	Belgium	Gender difference Loudness measure	145	Cross-sectional survey	Good
6.	Flores et al.	2016	Brazil	Laterality of tinnitus Tinnitus pitch Tinnitus loudness Gender & ear difference	33	Cohort study	Good
7.	Boger et al.	2017	Brazil	Laterality of tinnitus Frequency of occurrence of tinnitus	342	cross-sectional study	Good

8.	Chenqing et al.	2018	China	Tinnitus pitch Tinnitus across age groups	103	cross-sectional study	Fair
9.	Van Eynde et al.	2016	Belgium	Laterality of tinnitus Tinnitus onset Severity of tinnitus based on Tinnitus questionnaire (TQ) Severity of tinnitus based on Tinnitus handicap inventory (THI)	37	cross-sectional study	Good
10.	Ralli et al.	2017	Italy	Average duration of tinnitus Laterality of tinnitus Type of tinnitus sound Tinnitus pitch Tinnitus questionnaire scores	136	Cohort study	Good
11.	Yeh et al.	2019	Taiwan	Duration of tinnitus Tinnitus location Occurrence of tinnitus Tinnitus subjective quality Tinnitus pitch Tinnitus loudness THI- scores	20	Longitudinal study	Fair
12	Gilles et al.	2016	Belgium	Type of tinnitus Laterality of tinnitus Gender difference Tinnitus questionnaires: Tinnitus questionnaire (TQ) and visual analogue scale for loudness grading (VAS - L)	87	cross-sectional study	Good



Table 3.2 displays an insight into the research that was conducted highlighting the characteristics of tinnitus in patients with NIHL along with finding of each characteristic.

**Table 3.2**

*Study Characteristics of the selected articles*

<b>Sl. No</b>	<b>Author and year</b>	<b>Research question</b>	<b>Method</b>	<b>Findings of the study</b>	<b>Conclusion</b>
1	Nageris et al., 2010	The purpose of the study was to look into the test-retest value of tinnitus pitch and loudness in patients with tinnitus and NIHL.	<p><b>Mean age:</b> <math>35 \pm 6.7</math> years.</p> <p><b>Subjects:</b> total 30 patients with long-standing tinnitus, out of which 10 had unilateral tinnitus (7 individuals in left ear and 3 in ear ear) and 20 individuals had bilateral tinnitus.</p> <p>All patients had typical NIHL audiogram on the affected side.</p>	<p><b>Characteristics of tinnitus</b>  <b>Tinnitus Pitch average</b> (in kilohertz) in:</p> <p>Unilateral tinnitus patients on:            1<sup>st</sup> examination: <math>8.8 \pm 1.1</math>            2<sup>nd</sup> examination: <math>8.2 \pm 1.4</math></p> <p>Bilateral tinnitus patients on:            1<sup>st</sup> examination: <math>7.8 \pm 1.2</math>            2<sup>nd</sup> examination: <math>6.8 \pm 1.7</math></p> <p>Average tinnitus pitch (in kilohertz) of all the subjects on:            1<sup>st</sup> examination: <math>8.1 \pm 1.6</math>            2<sup>nd</sup> examination: <math>7.3 \pm 1.1</math></p> <p><b>Tinnitus loudness average</b> (in decibel sensation level):            In unilateral tinnitus patients on:            1<sup>st</sup> examination: <math>3.4 \pm 2.4</math></p>	<p>Subjective measurement of tinnitus loudness and pitch secondary to NIHL is accurate and reproducible, making it an important useful tool for diagnosis and follow-up.</p> <p>It suggests that both types of tinnitus may be treated similarly because there are no differences between people who have unilateral or bilateral tinnitus.</p>

				<p>2<sup>nd</sup> examination: <math>7.3 \pm 2.7</math></p> <p>In bilateral tinnitus patients on:  1<sup>st</sup> examination: <math>4.3 \pm 2.8</math>  2<sup>nd</sup> examination: <math>5.8 \pm 3.2</math></p> <p>Average tinnitus loudness (in decibel sensation level) of all the patients on:  1<sup>st</sup> examination: <math>4.0 \pm 2.6</math>  2<sup>nd</sup> examination: <math>6.3 \pm 2.1</math></p> <p><b>Results:</b>  For the entire group and individually for patients with unilateral or bilateral tinnitus, there was no statistically significant change in tinnitus with respect to pitch or loudness between the two tests.</p> <p>In all the groups, the severity of self-reported tinnitus was similar.</p> <p>The severity of hearing loss did not differ between the two groups.</p>	
2	Hasson et al., 2010	The goal of this study was to offer an up-to-date assessment of the prevalence of communication difficulties due to hearing loss and tinnitus in the general Swedish	<p><b>Age range:</b> 16 - 64 years</p> <p><b>Subjects:</b> a total 114411 Swedish working and non-working individuals participated in the study and 2 questionnaires were administered from</p>	<p><b>Characteristics of tinnitus</b></p> <p><b>Frequency of occurrence of tinnitus:</b></p> <p>Occasional tinnitus: 87 percent occasionally aren't worried by it at all or only a little.  Often experienced tinnitus: 47% are quite or severely disturbed by it.  Presence of tinnitus all the time: 60% are quite or severely distressed by it.</p>	<p>More than 30% of the Swedish population suffers from hearing loss and tinnitus. The prevalence of tinnitus or hearing loss was more than 20% among those aged 40 and younger.</p> <p>Noise exposure in the workplace, as well as</p>

		<p>working and non-working populations, as well as how they differed by gender, age, socioeconomic status, and noise exposure.</p>	<p>Swedish Longitudinal Occupational Survey of Health (SLOSH).</p> <p>Whereas 9756 individuals for working and 1685 participants for the non-workers group answered the questionnaire.</p> <p>Among the 120 questions there were 1 question assessed related to characteristics of tinnitus.</p> <p><b>Related to severity of tinnitus:</b> “How much do you feel that the tinnitus sounds worry, bother or upset you?” (Not at all, A little, Moderately, Severely).</p>	<p><b>Severity and discomfort of tinnitus:</b></p> <p>In working population:  Not at all – 530 (21%)  A little – 1285 (50%)  Moderate – 624 (24%)  Severe – 137 (5%)</p> <p>In non-working population:  Not at all – 103 (21%)  A little – 211 (42%)  Moderate – 143 (29%)  Severe – 39 (8%)</p> <p><b>Sex difference:</b></p> <p>In working population:  There was a significant gender difference. Tinnitus was reported by 4% of working respondents, with the frequency being higher in males than in women. Overall, 7% of people had tinnitus all the time; men had a prevalence of 10%, while women had a prevalence of 5%.</p> <p>In non-working population:  Non-workers had a higher prevalence of tinnitus than in the working population that is 6 percent (9% for men and 5% for women), and 9 percent (16 percent for men and 5 percent for women) were suffering from tinnitus all of the time. Hence, there was a significance difference between men and</p>	<p>personal listening devices, is a significant risk factor for developing hearing loss or tinnitus in young adults and adolescents.</p> <p>The study also added Tinnitus or hearing loss affects about one-fifth of young adults (<math>\leq 40</math> years old), indicating that future hearing difficulties are on the rise.</p>
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				women regarding the reporting of tinnitus in the non-working population as well.	
3	Stormer et al., 2017	This study sought to examine the distribution of anxiety and depressive symptoms among rock musicians with and without tinnitus, as well as how these mental health markers and internal locus of control influenced their concerns about tinnitus symptoms and the degree to which tinnitus affected their lives.	<p><b>Mean Age:</b> 30.4 years</p> <p><b>Subjects:</b> 111 active musicians from the Oslo area, as well as a control group of 40 non-musicians from the University of Tromso student population.</p> <p>The research consisted a questionnaire-based cross-sectional survey of individuals drawn from a group of rock musicians.</p> <p>Out of 85 items in the questionnaire, questions related to tinnitus included were duration, type of sound perceived and its degree.</p>	<p>Results showed that in the musician sample, 19.8% had permanent chronic tinnitus.</p> <p><b>Duration of tinnitus was:</b>  4.5 % - had never had tinnitus.  31.5 % - had it for less than two minutes.  36.9% - had it for one to two days.  6.3 % - for weeks, and 0.9 % for months.</p> <p><b>Gender:</b> males were more affected than females.  20.6% - male musicians.  14.3% - female musicians.  There was no significant gender difference being reported.</p> <p>The sound associated with chronic tinnitus subjects has been described as:  68.2% - Experienced a beep sound.  31.8% - Heard it as a murmur.  36.4% - Perceived it as monofrequency sound.  18.2% - Heard multiple frequencies, and 54% had bilateral symptoms.</p> <p>Studied also revealed the number of rock musicians with:  Temporary or permanent tinnitus:106  Musicians with permanent tinnitus: 22  Musicians with any duration of temporary tinnitus but no permanent tinnitus: 84</p>	<p>Rock musicians are at an increased risk of developing chronic tinnitus.</p> <p>In rock musicians, there is a relation between chronic tinnitus and depressed symptoms, but the evidence is ambiguous.</p> <p>Although rock musicians are exposed to loud noise on a regular basis, NIHL is not the only cause for the development of tinnitus.</p>

				<p>Control individuals with temporary tinnitus but no permanent tinnitus: 31.</p> <p><b>Degree was assessed based on its effect:</b>  22.7% - because of their hearing issues had terminated their musical career.  3.6% - indicated that their problems were an issue while performing.  40.9% - had consulted a doctor regarding their hearing disorders.  18.2% - had sought professional help for psychological issues.</p>	
4	Mazurek et al., 2010	To investigate whether there is a relationship between the degree of hearing loss and the severity of tinnitus.	<p><b>Age range:</b> 13 - 79 years  <b>Mean age:</b> 47 years</p> <p><b>Subject:</b> retrospective data obtained from 531 tinnitus patients with chronic tinnitus.</p> <p>The data was analysed from January 2008 to march 2010 on the day of admission. The subjects were admitted for 7 days multimodal tinnitus therapy.</p>	<p><b>Characteristics of tinnitus</b></p> <p>Finding of 441 tinnitus patients with NIHL-like audiogram</p> <p><b>Laterality:</b>  Unilateral tinnitus: 47%  Bilateral tinnitus: 53%</p> <p><b>Type of tinnitus:</b>  Pure tone tinnitus: 319 patients  Noise tinnitus: 122 patients</p> <p><b>Gender and ear:</b>  No differences were reported between males and females or between the right and left ears.</p> <p><b>Tinnitus frequency:</b>  Median value of pure tone tinnitus: 6.0 kHz</p>	This retrospective research showed that overexposure to noise causes not just hearing loss but also tinnitus and its associated co-morbidities, which results in deterioration of quality of life. The severity of tinnitus represents the level of hearing loss.

				<p><b>Tinnitus loudness:</b> Median value on right ear: 34.0 dB HL Median value on left ear: 37.0 dB HL</p> <p><b>Results:</b> On the right and left sides, they discovered a strong correlation between mean hearing loss and loudness of tinnitus (<math>p &lt; 0.0001</math>). The mean hearing loss and the loudness of the tinnitus on the right and left sides were shown to be closely correlated. The correlation between the tinnitus loudness and the hearing loss as evaluated at 6 kHz was strongest when considering individual frequencies.</p>	
5	Gilles et al., 2012	<p>To determine the prevalence of noise-induced tinnitus (NIT) in a young population as a risk factor for excessive noise exposure.</p> <p>To assess the impact of permanent/transient tinnitus caused by loud music, peer influence, attitudes toward noise and ability to manipulate Hearing</p>	<p><b>Age range:</b> from 19 to 26 years.</p> <p><b>Mean age:</b> 20.77 (<math>\pm 1.54</math>)</p> <p><b>Subject:</b> 145 students of a university completing their Bachelor or Master degree in medicine at the University of Antwerp responded to the survey questionnaire.</p> <p><b>Questionnaire:</b> included questions about the occurrence of</p>	<p><b>Characteristics findings of tinnitus</b></p> <p><b>Permanent tinnitus:</b> Permanent tinnitus in one or both ears was reported by 21 people, accounting for 14.8 percent of the total study participants.</p> <p><b>Transient tinnitus:</b> After being exposed to loud music, 89.5 percent of people experienced transient tinnitus at least once.</p> <p><b>Gender difference:</b> Permanent tinnitus: There were no significant sex differences in the prevalence of permanent tinnitus.</p>	<p>Noise induced Tinnitus affects a substantial proportion of young adults, yet they do not use HP as a result, probably due to a lack of information about the consequences of loud music.</p> <p>Tinnitus should be seen as a warning sign rather than a natural result of listening to loud music by young adults. This is a first step toward changing people's views towards noise in order to boost the use of HP in this group.</p>

		<p>Protection (HP) on the use of HP.</p>	<p>temporary tinnitus after listening to loud music, as well as the duration of tinnitus.</p> <p>A yes-no question was used to assess the presence of permanent tinnitus: “Do you experience tinnitus on a regular basis?”</p> <p><b>Loudness measure of tinnitus:</b> It was measured using a Visual Analogue Scale (VAS), which ranged from 0 (no tinnitus) to 10 (severe tinnitus) (extremely loud, unbearable tinnitus).</p>	<p>Transient tinnitus: Was significant difference higher in female students that is 92.9% compared to male students having 81.8%.</p> <p><b>Loudness measure:</b></p> <p>Permanent tinnitus: VAS scores of 21 students revealed that: The majority of students rated their tinnitus loudness as low on the VAS, with the mean score of 1.86 (<math>\pm 1.25</math>). 17 students rated their tinnitus as 1 - very silent, just detectable. 4 students assessed their tinnitus loudness as 3 or above, with one person scoring a 6 on the VAS.</p> <p>Transient tinnitus: Female students scored considerably higher on the VAS for transitory tinnitus than male students, with mean VAS ratings of 3.78 (<math>\pm 2.18</math>) and 2.98 (<math>\pm 2.34</math>) respectively.</p>	<p>The importance of hearing impairment in young people is also highlighted in this article.</p>
6	Flores, 2016	<p>To investigate the possible relationship between gender and tinnitus loudness and pitch, the degree of hearing loss, and the frequencies</p>	<p><b>Age range:</b> 42 to 76 years. Mean age range - 59.5<math>\pm</math> 9.4 years <b>Subjects:</b> 33 adult individuals out of which 11 females and 22 males, having unilateral or bilateral</p>	<p><b>Characteristics findings of tinnitus</b></p> <p><b>Laterality:</b> Average Unilateral tinnitus: 61.7 <math>\pm</math> 9.2 Average Bilateral tinnitus: 57.8 <math>\pm</math> 9.6 Unilateral tinnitus in males: 9 % Unilateral tinnitus in females: 6% Bilateral tinnitus in males: 13% Bilateral tinnitus in females: 5%</p>	<p>The greater the hearing loss, the lower the loudness of tinnitus in the evaluated individuals. Authors found no correlation between hearing loss and tinnitus pitch.</p>

		<p>affected in NIHL subjects.</p>	<p>tinnitus diagnosed with NIHL was considered.  <b>Characteristics measured:</b> tinnitus loudness and pitch with respect to gender and laterality of tinnitus.</p>	<p><b>Interpretation:</b> There was no significant difference between laterality of tinnitus with that of gender &amp; age.</p> <p><b>Ear difference:</b>  Right ear: 5 individuals (15.1%).  Left ear: 10 individuals (30.3%).</p> <p><b>Gender difference:</b>  Male with unilateral tinnitus: 9  Male with bilateral tinnitus: 13  Female with unilateral tinnitus: 6  Female with bilateral tinnitus: 5</p> <p><b>Tinnitus loudness in dB (median):</b>  Tinnitus loudness measure of female participates in right ear: 20 (6.3-30).  Tinnitus loudness measure of female participates in left ear: 15 (6.3-20).  Tinnitus loudness measure of male participates in right ear: 15 (0-20).  Tinnitus loudness measure of female participates in left ear: 7.5 (5-25).</p> <p><b>Tinnitus frequency in Hz (median):</b>  Tinnitus Pitch measure of female participates in right ear: 2500 (500-6000).  Tinnitus Pitch measure of female participates in left ear: 6000 (3000-7500).  Tinnitus Pitch measure of male participates in right ear: 4000 (4000-8000).</p>	
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				<p>Tinnitus Pitch measure of female participates in left ear: 4000 (2250-7500).</p> <p><b>Results:</b> There was no significant difference found between tinnitus pitch and the loudness of the left and the right ears.</p> <p>There was no significant relationship between gender and tinnitus pitch and loudness.</p> <p>The authors discovered an inverse relationship between tinnitus loudness and hearing threshold intensity, as well as the average of the thresholds and the grade of hearing loss. Pitch of tinnitus had no relationship with the higher frequency of hearing threshold.</p>	
7	Boger et al., 2017	To investigate the hearing and tinnitus of normal-hearing workers who have been exposed to occupational noise.	<p><b>Age range:</b> 18-55 years</p> <p><b>Subjects:</b> normal hearing male individuals who were working in metallurgical industries and are exposed to noise levels above 85 dB in Brazil were considered for the study. All male employees between the ages of 18 and 55 who have</p>	<p><b>Characteristics findings of tinnitus</b></p> <p><b>Frequency of occurrence of tinnitus:</b> Frequent: 41.5% Rarely: 58.5%</p> <p><b>Laterality:</b> Right ear: 28.3% Left ear: 30.2% Both ear: 41.5%</p> <p><b>Ear difference with respect to DPOAE:</b> Right ear: 45.3% failure of DPOAE Left ear: 43.3% failure of DPOAE</p>	The authors concluded that tinnitus and DPOAE failure are predictors of hearing loss; indicating that cochlear damage is present even with normal audiometric thresholds.

			<p>worked in the function for at least a year were examined.</p> <p>Evaluation carried out was otoscopy, PTA with acoustic rest of 14 hours, DPOAE on 342 individuals.</p>	<p><b>Interpretation</b> Between the ears, there was no statistically significant difference with respect to occurrence of tinnitus.</p> <p>There was no statistically significant relationship between ear laterality (right or left) and the presence of failure.</p> <p>The laterality of the ears and the evaluated frequency of DPOAE indicate that the amplitudes decrease as frequency increases.</p>	
8	Chenqing et al., 2018	To describe the audiological characteristics of a group of shipboard crew members who were exposed to noise.	<p><b>Age range:</b> 24-63 years</p> <p><b>Subject:</b> Tinnitus was evaluated on the group of crew members who were exposed to noise on board ships (exposure of more than 200 days in a year). Evaluation was also carried out across all age groups.</p> <p>Experimental group- 103 (206 ears) male subjects were included who were exposed to noise on board ships. Control group – 34 subjects consisting of 14 females and 20</p>	<p><b>Characteristics findings of tinnitus</b> A total of 112 out of 206 ears had tinnitus that is 54.4%.</p> <p><b>Tinnitus Frequency:</b> High pitched tinnitus: 96 ears accounts for 46.6%. Low pitched tinnitus: 16 ears accounts for 7.8%.</p> <p><b>Tinnitus across the age groups:</b> Tinnitus was assessed between 24-63 years of age.</p> <p>&lt; 50 years: 26/58 ears had tinnitus accounting for 44.8%. Between 50-55 years: 48 ears reported tinnitus accounting for 53.3%. &gt;55 years: 38/58 ears reported tinnitus accounting for 65.5%.</p> <p><b>Results:</b> Tinnitus pitch among ship noise exposed subjects did not significantly differ by age group.</p>	<p>Persistent and high-pitched tinnitus were reported by many tinnitus patients.</p> <p>However, tinnitus pitch among ship noise exposed subjects did not significantly differ by age group, according to the data.</p>

			males between the age of 27 to 59 years.		
9	Van Eynde et al., 2016	The severity and onset of the tinnitus complaint were evaluated in relation to the SRT scores in the study.	<p><b>Age range:</b> 18-44 years.</p> <p><b>Mean age:</b> 28 years.</p> <p><b>Subjects:</b> 37 subjects diagnosed with mild NIHL and tinnitus complaints were recruited for the study. Tinnitus analysis was performed, and most of the patients completed the tinnitus questionnaire (TQ) and tinnitus handicap inventory (THI) independently.</p>	<p><b>Characteristics findings of tinnitus</b></p> <p><b>Laterality of tinnitus:</b>  Left ear: 3 (8%).  Right ear: 8 (22%).  Bilateral: 12 (57%).  Unknown: 5 (13%).</p> <p><b>Tinnitus onset:</b>  &lt; 1 month: 9 (24%).  Between &gt;1 month to &lt; 12 months: 13 (35%).  ±12 months: 15 (41%).</p> <p><b>Severity of tinnitus:</b></p> <p><b>Based on tinnitus questionnaire (TQ) Score:</b>  Mild: 17 (46%).  Moderate: 5 (13.5%).  Severe: 2 (5.5%).  Unknown: 13 (35%).</p> <p><b>Based on tinnitus handicap inventory (THI):</b>  No handicap: 6 (16%).  Mild: 5 (13.5%).  Moderate: 5 (13.5%).  Severe: 1 (3%).  Unknown: 20 (54%).</p>	<p>Tinnitus onsets range from acute (within one month) to more than a year.</p> <p>Tinnitus severity (as measured by the TQ) was mild in the majority of subjects, and most subjects experienced no or only a minor handicap (as measured by the THI).</p> <p>There was a significant relationship between the TQ and the THI.</p>

10	Ralli et al., 2017	The aim of this study was to examine the characteristics of hearing loss, tinnitus, comorbidities, demographic factors, and a history of occupational noise exposure in individuals with chronic tinnitus and long-term noise exposure at work place.	<p><b>Age range:</b> 26–84 years.</p> <p><b>Mean age range:</b> 55.1 years</p> <p><b>Subjects:</b> 136 patients (86 females and 50 males) with chronic tinnitus</p>	<p><b>Characteristics findings of tinnitus</b></p> <p><b>Average Duration of tinnitus:</b>  In high-risk group: 10.9 years.  In Low-risk group: 9.2 years.</p> <p><b>Laterality of tinnitus:</b>  In high-risk group  Left: 18 individuals accounting for 26.5%.  Right: 04 individuals accounting for 5.9%.  Bilateral: 46 individuals accounting for 67.6%.   In Low-risk group  Left: 19 individuals accounting for 27.9%.  Right: 13 individuals accounting for 19.1%.  Bilateral: 36 individuals accounting for 52.9%.</p> <p><b>Type of tinnitus sound:</b>  In high-risk group  Buzzing type: 19 individuals accounting for 27.9%.  Whistle type: 17 individuals accounting for 25%.  Others: 7 individuals accounting for 10.3%.   In low-risk group  Buzzing type: 11 individuals accounting for 16.2%.  Whistle type: 29 individuals accounting for 42.6%.  Others: 12 individuals accounting for 17.6%.</p> <p><b>Tinnitus pitch:</b>  In low-risk group  High pitched tinnitus: 9 individuals accounting for 13.2%.</p>	Patients with tinnitus and a history of a profession linked with an increased exposure to occupationally-acquired NIHL differ from those without such a history. Tinnitus was predominantly bilateral, followed by left-sided, and was reported as buzzing or high-pitched in people working in high-risk jobs. There was a correlation between age, duration of tinnitus, and worse hearing.
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			<p>Low pitched tinnitus: 7 individuals accounting for 10.3%</p> <p>In high-risk group</p> <p>High pitched tinnitus: 17 individuals accounting for 25%.</p> <p>Low pitched tinnitus: 8 individuals accounting for 11.8%.</p> <p><b>Tinnitus questionnaire scores:</b></p> <p>In low-risk group</p> <p>Tinnitus Handicap Inventory (THI): 30.6 individuals accounting for 18.1%.</p> <p>In high-risk group</p> <p>Tinnitus Handicap Inventory (THI): 33.1 individuals accounting for 18.8%.</p> <p><b>Results:</b></p> <p>Bilateral tinnitus was seen in a considerably larger proportion of patients in the HIGH-RISK group, and that was followed by unilateral tinnitus in the left ear.</p> <p>Buzzing and "high-pitched" tinnitus sounds were more prominent in the HIGH-RISK group, whereas "whistle" sounds were more prevalent in the LOW-RISK group.</p> <p>The Hearing Handicap Inventory (HHI) questionnaire showed that patients in the HIGH-RISK group performed considerably worse than</p>	
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				<p>those in the LOW-RISK group; no significant differences were found for the THI.</p> <p>Duration of tinnitus was more in the HIGH-RISK group compared to LOW-RISK group but the difference was not significant.</p> <p>For both groups, the impact of age on tinnitus onset, and THI score was assessed. When compared to older participants (&gt;60 years), younger patients (45 years) in the LOW-RISK group had substantially reduced THI.</p>	
11	Yeh, 2019	To determine the effectiveness of zinc supplementation for the treatment of NIHL-related tinnitus.	<p><b>Age range:</b> 31-66 years.</p> <p><b>Mean age range:</b> 48.5 ± 11.3 years.</p> <p><b>Subject:</b> 20 patients with complaint of tinnitus and a typical NIHL audiogram (38 ears) were included in the experimental group.</p> <p>Control group – consist of 20 healthy subjects.</p> <p>Each subject was evaluated for tinnitus-match testing, THI. Mandarin-Chinese</p>	<p><b>Characteristics findings of tinnitus</b></p> <p><b>Duration of tinnitus:</b> Mean ± SD: 5.1 ± 6.3 years</p> <p><b>Tinnitus location:</b> Bilateral: 18 (90%) Unilateral: 2 (10%)</p> <p><b>Occurrence of tinnitus:</b> Persistent: 19 (95%) Intermittent: 1 (5%)</p> <p><b>Tinnitus subjective quality:</b> High pitch/hissing: 7 (35%). High pitch/Gee-Gee sound: 7 (35%). High-pitch/hissing + Gee-Gee sound:1 (5%) High-pitch/hissing + Chi-Chi sound:1 (5%) High pitch/ringing: 1 (5%) Low pitch/roaring: 3 (15%)</p>	After zinc treatment, THI scores improved significantly in NIHL patients associated with tinnitus.

			<p>version of THI questionnaire was used to evaluate subjective tinnitus.</p> <p>Apart from assessing for tinnitus, patient was also examined for otoscopic examination, basic audiologic evaluation, distortion product otoacoustic emissions (DPOAEs) and serum zinc level analyses.</p> <p>All these tests were repeated after 2 months of zinc treatment.</p>	<p><b>Before zinc treatment (mean ± SD):</b>  Tinnitus frequency (Hz): 5973.7 ± 1965.8  Tinnitus loudness (dB HL): 47.0 ± 18.3  THI-total scores: 38.3 ± 18.9</p> <p><b>After zinc treatment (mean ± SD):</b>  Tinnitus frequency (Hz): 6052.6 ± 2026.  Tinnitus loudness (dB HL): 46.7 ± 17.8  THI-total scores: 30.0 ± 18.6</p> <p><b>THI scores</b>  <b>Pre-treatment - THI scores across severity:</b></p> <p>Very mild (0-16 scores): 3 patients (15%).  Mild (18-36 scores): 9 patients (45%).  Moderate (38-56 scores): 4 patients (20%).  Severe (58- 76 scores): 3 patients (15%).  Very severe (78-100 scores): 1 patient (5%)</p> <p><b>Post-treatment - THI scores across severity:</b></p> <p>Very mild (0-16 scores): 5 patients (15%).  Mild (18-36 scores): 10 patients (50%).  Moderate (38-56 scores): 3 patients (15%).  Severe (58- 76 scores): 2 patients (10%).  Very severe (78-100 scores): 0 patient (0%)</p> <p><b>Results:</b>  Before and after therapy, there were no statistically significant variations in the results for tinnitus frequency and loudness.</p>	
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				Additionally, 17 patients (85%) had THI total scores that improved significantly post therapy, dropping from 38.3 to 30.	
12	Gilles et al., 2016	The aim of the study was to evaluate the differences in audiological characteristics between noise-exposed teenagers with and without noise-induced tinnitus (NIT).	<p><b>Age:</b> below 30 years</p> <p><b>Mean age of males:</b> 23.1±3.9</p> <p><b>Mean age of females:</b> 23.5±1.9</p> <p><b>Subjects:</b> they were medical students recruited through email from university Antwerp. Eighty-seven young adults who had a history of recreational noise exposure were evaluated using 2 tinnitus questionnaires; Dutch validated version of Tinnitus Questionnaire (TQ) for annoyance grading and a Visual Analogue Scale (VAS - L) for loudness grading. Due to recreational noise exposure, 19 students reported NIT. Students were only included if they</p>	<p><b>Characteristics findings of tinnitus</b></p> <p><b>Permanent tinnitus:</b> 19 subjects (22% of the sample).</p> <p><b>Gender difference:</b></p> <p><b>Male:</b> 11 individuals had tinnitus</p> <p><b>Female:</b> 8 individuals had tinnitus</p> <p><b>Type of tinnitus:</b></p> <p>Pure-tone: 13 subjects</p> <p>Noise: 6 subjects</p> <p>Polyphonic: 0 subjects</p> <p><b>Laterality:</b></p> <p>Unilateral: 2 subjects</p> <p>Bilateral: 16 subjects</p> <p>Central: 1 subject</p> <p><b>Tinnitus questionnaires:</b></p> <p>TQ score (mean ± SD): 27.72 ± 15.23</p> <p>VAS-L score (mean ± SD): 5.44 ± 2.46</p> <p><b>Results:</b></p> <p>The majority of young individuals had bilateral, pure-tone type of tinnitus with minor tinnitus discomfort (on average a grade 1 on the TQ).</p>	Authors concluded that in the absence of detectable peripheral damage, the presence of (noise-induced) tinnitus might occur, resulting in more central plasticity than predicted. Cortical reorganisation may occur because of repeated recreational noise exposure in the absence of detectable peripheral hearing loss.



		<p>attended parties /concerts at least once a week and/or used personal listening devices (PLDs) multiple times a week at a volume level of 70% or higher of the device's full capacity.</p> <p>Tinnitus analysis was carried out by asking the type of tinnitus as pulsatile or non-pulsatile tinnitus, laterality, duration of perception, perceived as constant or intermittent, the sound of the tinnitus was pure-tone (ringing), a noise (hissing) or a mixture of different sounds (polyphonic).</p>	<p>The average duration of tinnitus was 2 years (SD=1.2 years), and none of the tinnitus sufferers reported tinnitus being present from childhood.</p>	
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## **Chapter 4**

### **Discussion**

This review is the first systematic approach to identify and collect data on the various characteristics of tinnitus and its findings in NIHL patients. Data from the previous decade (2010-2020) were used to create a profile of tinnitus characteristics studied in people with NIHL (see Table 3.2).

The review intended to determine all of the tinnitus characteristics found in NIHL by evaluating 12 papers (listed in Table 3.1). We came across various tinnitus characteristics such as tinnitus pitch, tinnitus loudness, frequency of occurrence of tinnitus, laterality, severity and discomfort of tinnitus, sex difference, duration of tinnitus, type of tinnitus, tinnitus subjective quality, severity of tinnitus based on assessment of various tinnitus questionnaires like Tinnitus handicap inventory (THI), Tinnitus questionnaire (TQ), and visual analogue scale for loudness grading (VAS - L).

Most of the research articles reviewed were cross-sectional studies (a total of seven) followed by two longitudinal studies, two cohort studies and one retrospective study with good quality except two having fair quality as analysed by NIH quality analysis tool (shown in Table 3.1). The major aim of this systematic review was to review the tinnitus characteristics among individuals with NIHL in detail. The details of findings from those studies are given below.

#### **4.1 Laterality of tinnitus**

There was no statistically significant difference in pitch or loudness of tinnitus in patients with unilateral and bilateral tinnitus. Because of the lack of differences between patients with unilateral or bilateral tinnitus suggests that it is possible to treat both forms similarly (Nageris et al., 2010). When mean hearing loss and loudness of

tinnitus on the right and left sides were correlated, they found the closed correlation at 6 kHz when individual frequencies were evaluated, however individuals with bilateral tinnitus (53%) were slightly more than unilateral tinnitus (47%) but there no significant difference between the two ears (Mazurek, 2010). Similar results were shown by Flores (2016), where there was no significant difference between laterality of tinnitus with that of gender & age. With respect to occurrence of tinnitus no significant difference was noticed between the two ears (Boger et al., 2017). Ralli et al. (2017) reported that tinnitus was mostly bilateral, followed by left ear in case of unilateral patients. Individuals with unilateral or bilateral tinnitus do not differ significantly from one other, suggesting that both conditions may be treated similarly (Nageris et al., 2010).

#### **4.2 Tinnitus pitch and loudness**

On evaluating a sample of crew members exposed to noise on board ships, persistent and high-pitched tinnitus was found, which did not differ significantly by age group (Chenqing et al., 2018). In Individuals with average tinnitus pitch was reported to be around 7 - 8 kHz and loudness was 4-6 dB SL. During the Test-retest reliable, the tinnitus characteristics in patients with NIHL revealed that there was no statistically significant variation in pitch of tinnitus or loudness between the two tests. Subjective evaluation of tinnitus pitch and loudness secondary to NIHL is reliable and reproducible, making it an important tool for diagnosis and follow-up (Nageris et al., 2010). A retrospective study showed that subjects who perceived a pure tone type of tinnitus had a frequency of 6 kHz and a loudness of 34-37 dB HL (Mazurek, 2010). When examined qualitative using Visual Analogue Scale (VAS) which ranged from 0 (no tinnitus) to 10 (severe tinnitus), majority of individuals with permanent tinnitus rated their tinnitus loudness as low with the mean score of 1.86 ( $\pm 1.25$ ). Female students scored considerably higher on the VAS for transient type of tinnitus than male students,

with mean VAS ratings of 3.78 ( $\pm 2.18$ ) and 2.98 ( $\pm 2.34$ ) respectively (Gilles et al., 2012). When assessing participants who have long-term occupational exposure to noise, divided into two groups according to the occupational risk of developing NIHL, "High" pitched tinnitus was more common in the high-risk group, while "whistling" was more common in the low-risk group (Ralli et al., 2017). The reviewed studies showed persistent and high-pitched tinnitus, which did not substantially differ by gender or age group.

### **4.3 Severity and discomfort of tinnitus**

This review came across a few scales that have been used to evaluate the severity and discomfort of tinnitus like THI and TQ. One of the questions which addressed the severity of tinnitus in Swedish Longitudinal Occupational Survey of Health (SLOSH) questionnaire was "How much do you feel that the tinnitus sounds worry, bother or upset you?" (Not at all, A little, Moderately, Severely). In both working and non-working Swedish population, 87 percent of persons who have tinnitus occasionally are not disturbed by it at all or only a little. On the other hand, 47 percent of individuals who frequently encounter tinnitus are bothered by it. Sixty percent of those who have tinnitus are either highly bothered or seriously affected by it. The study also indicated that tinnitus or hearing loss affects around one-fifth of young individuals (< 40 years old), indicating that future hearing difficulties are on the rise. A part from these four articles that talked about the severity based on TQ and THI scores, TQ Scores demonstrated mild severity in the majority of individuals while the THI revealed that most subjects had no or only a slight handicap (Hasson et al., 2010). There was a significant relationship between the TQ and the THI (Van Eynde et al., 2016). Individuals in the high-risk group of noise exposure had a THI score of 33.1, which is greater than the low-risk group's score of 30.6 (Ralli et al., 2017). So, the majority of

young individuals had bilateral, pure-tone type of tinnitus with minor tinnitus discomfort (on average a grade 1 on the TQ) (Gilles et al., 2016).

#### **4.4 Sex difference**

Six papers featured the gender differences among which five were cross-sectional study and one retrospective study of which similar results were seen in majority of the articles. Stormer et al. (2017) reported that males were more affected (20.6%) than females (14.3%) in rock musicians with tinnitus; however, the difference was not significant. Flores and Gilles et al. (2016) also reported no significant sex differences in NIHL. Similar pattern of results was shown in a retrospective analysis of chronic tinnitus patients with no gender differences (Mazurek, 2010).

A cross-sectional study on 9756 working and 1685 non-workers Swedish population discovered a significant gender difference with the frequency of occurrence of tinnitus being higher in males than in females. Overall, 7% of people had tinnitus all the time; men had a prevalence of 10%, while women had a prevalence of 5% in working group. The impact of permanent and transient tinnitus in a younger population with noise-induced tinnitus (NIT) was assessed on 145 students. The results showed no significant gender differences in the prevalence of permanent tinnitus, but a significant gender difference in transient tinnitus was seen, with female students having 92.9 percent compared to male students having 81.8 percent (Gilles et al., 2012).

#### **4.5 Frequency of occurrence of tinnitus**

Hasson et al. (2010) reported that among the 114411 Swedish population, 87 percent occasionally are not worried by tinnitus at all or only a little, 47 percent are quite or severely disturbed who have often experienced by tinnitus, and 60 percent are quite or severely distressed by presence of tinnitus all the time. According to Boger et

al. (2017), among male industrial employees exposed to noise levels above 85 dB, tinnitus occurs often (41.5 percent) and rarely (58.5 percent) respectively. As a result, young adults and adolescents who are exposed to noise at work are more likely to suffer from hearing loss or tinnitus.

#### **4.6 Type of tinnitus**

Most common type of tinnitus reported was buzzing followed by pure tone, whistle type, noise and others. A total of 319 patients reported to have pure tone tinnitus and 122 of them has noise type which was obtained from a retrospective data on 531 chronic tinnitus patients with NIHL (Mazurek et al., 2010). Ralli et al. (2017) in his study reported on individuals with long-term occupational noise exposure suffering from chronic tinnitus to have buzzing type of tinnitus being prominent in HIGH-RISK group and whistle sounds were more prevalent in the LOW-RISK group. Among the cross-sectional survey conducted on medical students reporting of noise induced tinnitus showed that majority of them (13 out of 19 students) had pure tone type followed by noise type of tinnitus (6 individuals) (Gilles et al., 2016).

Recently, Yeh (2019) mentioned about Subjective quality of tinnitus in 20 patients with NIHL which revealed that most of them had high pitch/ Gee-Gee sound/ hissing sounds i.e., seven patients (35%) followed by low pitch/roaring in 3 patients (15%) and high pitch/ringing in one individual (5%). Combination of sounds were perceived which was described as High-pitch/hissing + Gee-Gee sound and High-pitch/hissing + Chi-Chi sound by one person each.

#### **4.7 Duration of tinnitus**

People with tinnitus and a history of a profession associated with a high risk of occupationally-acquired NIHL differ from those without such a history. Average

Duration of tinnitus among the individuals who are in a high-risk group of noise exposure with chronic tinnitus was 10.9 years and in Low-risk group it was 9.2 years (Ralli et al., 2017). Average duration of tinnitus was reported as  $5.1 \pm 6.3$  years (Mean  $\pm$  SD) (Yeh, 2019). A Norwegian Survey by Stormer et al. (2017) on the rock Musicians disclosed that majority of individuals had tinnitus for one to two days (36.9%), 31.5 % had it for less than two minutes, 6.3 % had for weeks, and 0.9 % for months. Although rock musicians are exposed to loud noise on a regular basis, NIHL is not the only cause for the development of tinnitus but people are at an increased risk of experiencing chronic tinnitus.

All these results correlated well with the finding in the literature as NIHL is a serious problem in many workplaces throughout society which is an irreversible impairment (Lusk, 1997). Long-term exposure to noise can also cause continuous apoptosis of hair cells and degeneration of spiral ganglion neurons, gradually diminishing speech recognition and elevating hearing thresholds, perhaps leading to irreversible hearing loss (Wang et al., 2020). The sensation level of Noise induced permanent tinnitus is usually low and sometimes negative. Usually, the time gap between the beginning of noisy work and the appearance of tinnitus is long (Axelsson & Prasher, 2000).

This systematic review throw light on the 10 different tinnitus characteristics in individuals with NIHL based on that the major characteristics were tinnitus loudness and pitch, laterality, severity and discomfort, duration, type and sex differences which was report by most of the articles whereas minor characteristics include frequency of occurrence of tinnitus, tinnitus onset, tinnitus subjective quality and loudness grading which was reported in very few publications.

## Chapter 5

### Summary and Conclusion

The current systematic review was taken up to document the characteristics of tinnitus in individuals with NIHL as there are no systematic review or meta-analyses done on the same till date. The aim of this review is to provide information on various characteristics of tinnitus in individuals diagnosed with NIHL. Through a systematic search, 12 unique and potentially relevant references were obtained. Two reviewers independently carried out the title and abstract screening and excluded 831 irrelevant articles. Thirty-one publications were considered for full-text screening. Of them, 17 were chosen for the systematic review, and five articles were excluded as they did not meet one or more of the inclusion criteria.

Subjective measurement of tinnitus loudness and pitch secondary to NIHL is accurate and reproducible, making it a useful tool for diagnosis and follow-up. Individuals with unilateral or bilateral tinnitus do not differ significantly from one other, suggesting that both conditions may be treated similarly. Persistent and high-pitched tinnitus were reported by many tinnitus patients. Tinnitus or hearing loss affects about one-fifth of young adults ( $\leq 40$  years old), indicating that future hearing difficulties are on the rise. The loudness of tinnitus in the tested subjects decreased as hearing loss increased. Various questionnaire like TQ, THI, VAS-L are essential to use as it assists in determining various tinnitus characteristics.

Noise exposure in the workplace, as well as personal listening devices, is a significant risk factor for developing hearing loss or tinnitus in young adults and adolescents. Chronic tinnitus is more likely to affect rock musicians. Overexposure to noise causes not just hearing loss but also tinnitus and its associated co-morbidities,



which results in deterioration of quality of life. The severity of tinnitus reflects the level of hearing loss. Tinnitus onsets ranges from acute (within one month) to more than a year.

Noise induced Tinnitus affects a substantial proportion of young adults, yet they do not use hearing protection as a result, probably due to a lack of information about the consequences of loud music. Tinnitus should be seen as a warning sign rather than a natural result of listening to loud music by young adults. This is a first step toward changing people's views towards noise in order to boost the use of hearing protection in this group. Absence of detectable peripheral damage, the presence of (noise-induced) tinnitus might occur, resulting in more central plasticity than predicted. Cortical reorganisation may occur because of repeated exposure to recreational noise in the absence of detectable peripheral hearing loss. People with tinnitus and a history of a profession associated with an exposure to occupationally developed NIHL differ from those without such a history. Tinnitus was mostly bilateral, followed by left-sided, and reported as buzzing or high-pitched in people working in high-risk jobs. There was a correlation between age, duration of tinnitus, and worse hearing.

### **5.1 Implications of the study**

The most important strength of this systematic review is to provide a recent updated global record of all the available characteristics of tinnitus in adult individual with NIHL.

- Outcome of the study gave use better understanding of various characteristic features like type, severity, laterality, duration, pitch, loudness, age, gender, ear difference and occurrences of tinnitus in individuals with NIHL.

- This review also includes the findings of many tinnitus questionnaires that were used to collect information about tinnitus characteristics and its severity.
- Further testing and the recommendation of management options will be made easier by using the major and minor characteristics noted in the review.
- The results and conclusion drawn can be incorporated in counselling during the hearing conversation program regarding the prevention of tinnitus and hearing loss among the individuals working in the noisy setup.

## **5.2 Limitations of the study**

- This systematic review includes only research publications on the NIHL adult population suffering from tinnitus so studies on the characteristic's findings of tinnitus in paediatric population is not reviewed.
- Research articles published on objective tinnitus was not reviewed.
- The present review did not include the characteristics finding of tinnitus in animal subjects exposed to noise.
- There might be additional research articles related to the same topic that could not be considered for the present review as one of our limitations was to exclude the articles that were published in non-English language due to the lack of availability of those articles in English language.

## **5.3 Future Directions**

- Further studies must work on evaluating the effect of each characteristic across age group as tinnitus is highly variable among individuals.
- Studies can also aim in finding out the correlation between each characteristic and evaluate the effect on one another.

- More longitudinal studies are required to understand the long-term changes in each of these tinnitus characteristics found in present review.

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## Annexure

### **S2 Table: NIH Quality Assessment Tool for Observational Cohort and Cross - Sectional Studies**

The National Institutes of Health (NIH) Quality Assessment Tool was used for observational cohort and cross-sectional studies. All the studies were assigned a yes, no, or other to each of the 14 criteria outlined in the appraisal tool. Then by considering each criterion, the investigators evaluated the overall quality of the study and assigned an overall good, fair, poor rating to each study.

Criteria	Yes	No	Other (CD, NA, NR)*
1. Was the research question or objective in this paper clearly stated?			
2. Was the study population clearly specified and defined?			
3. Was the participation rate of eligible persons at least 50%?			
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?			
5. Was a sample size justification, power description, or variance and effect estimates provided?			
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?			
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?			
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?			
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
10. Was the exposure(s) assessed more than once over time?			
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
12. Were the outcome assessors blinded to the exposure status of participants?			
13. Was loss to follow-up after baseline 20% or less?			
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?			

\*CD, cannot determine; NA, not applicable; NR, not reported