



# Supplementary Guidance on **Interpreting an Audiogram for Indications of Occupational Noise-Induced Hearing Loss (NIHL)**

Revised October 2024



## Summary

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Reflecting continuous improvement, this Society of Occupational Medicine ***Guide on Interpreting Audiograms for Noise-Induced Hearing Loss*** builds on previous publications to reflect feedback from OH practitioners, and aims to assist in compliance with regulatory guidance on noise health surveillance.

The guide provides key clinical practice points, whilst acknowledging that in an era dominated by evidence-based guidelines, there is little to no published evidence for some areas covered. Consequently, much of the advice is based on expert opinion and accumulated clinical experience.

This guide has been developed in consultation with the SOM Noise Special Interest Group.



# Introduction

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**Occupational Health professionals should be aware that around a fifth of the British working population is exposed to damaging noise and sound levels (>85 dBA)<sup>1</sup>.**

Short-term exposure to loud noise and sound causes temporary hearing dullness, while repeated exposure over many years leads to Noise-Induced Hearing Loss (NIHL)<sup>2</sup>.

Impulsive noise (e.g., gunshots) is considered more damaging than continuous noise and sound, likely due to bone conduction and less effective biological reflexes<sup>2</sup>.

Although individual susceptibility plays a key role, the main risk factors that exacerbate occupational noise-induced auditory health effects include combined effects of solvents, vibration, heavy metals, CO, smoking, chemicals, aging, heat, and shiftwork<sup>2</sup>.

## **Work context**

Workplaces must take meaningful steps to reduce the likelihood of harmful effects from workplace exposures. Under the Health and Safety at Work etc Act 1974 and Control of Noise at Work Regulations 2005, employers are required to conduct risk assessments to identify and mitigate potential noise and sound exposure. Using the hierarchy of controls, the most effective measures should be implemented whenever practical.

Where there is a residual risk and **workers are exposed to an eight-hour time-weighted average of 85dBA or higher, they must be part of a suitable health surveillance programme involving audiometric testing as outlined in HSE's guidance document L108 (The Control of Noise at Work Regulations 2005)<sup>3</sup>. Health Surveillance may also be necessary below the 85dB action value<sup>4</sup>.**

Health surveillance is a form of workplace screening that aims to identify early signs of Occupational Noise Induced Hearing Loss (NIHL). In Great Britain, it usually consists of a symptom questionnaire followed by screening audiometry, undertaken at regular intervals.

Workers identified during health surveillance with new hearing symptoms or audiometric results indicative of NIHL should be referred to an Occupational Health Physician (OHP) for confirmation of likely Occupational NIHL.

In 2021, the HSE revised L108:

1. Table 12. A new column was added for reviewing 'NIHL seen on audiogram?'
2. Paragraph 24 specifies that the initial step is to assess the surveillance audiogram for the presence of NIHL.
3. Referral requirements:
  - If NIHL is newly identified or progressive, the worker should be placed in Category 3
  - The worker should be referred for medical assessment by an appropriately trained doctor, i.e. an occupational physician.

This guide aims to provide supplementary information to HSE's L108 guidance on how to undertake an 'assessment' of screening audiometry in a consistent, expert-informed, and practical manner. This guidance is not obligatory, and occupational health providers may use any preferred means for interpreting screening audiometry, provided it is a valid and trusted methodology for these purposes.

1. <https://www.hse.gov.uk/research/assets/docs/whec/whec-19.pdf>

2. [https://journals.lww.com/nohe/fulltext/2019/21010/the\\_combined\\_effects\\_of\\_occupational\\_exposure\\_to.1.aspx](https://journals.lww.com/nohe/fulltext/2019/21010/the_combined_effects_of_occupational_exposure_to.1.aspx)

3. <https://www.hse.gov.uk/pubns/priced/l108.pdf> Paragraph 102

4. <https://www.hse.gov.uk/pubns/priced/l108.pdf> Paragraph 103



# Suggested approach to Interpreting Screening Audiometry: Guidance for Practitioners

## STEP 1: ESTABLISHING A BASELINE SCREENING AUDIOGRAM

### Timing

- Before (or as soon as possible after) employment in a role with noise and sound exposure at or above the upper exposure action values, the employer must establish a valid baseline audiogram for future comparisons.
- A valid baseline may require multiple retests to confirm it accurately represents hearing ability, without influence of Temporary Threshold Shift (TTS) or artefacts due to suboptimal quality testing or test environment (e.g. background noise).

### Employee Preparation

- The standard operating procedure or local policy should include employers notifying employees to avoid high levels of noise and sound exposure including recreational and leisure noise before audiometric examination. The occupational health practitioner should ask workers about exposure to loud noise or sound prior to the test and record any possible influence this could have on results. Noise or sound can be considered 'loud' if it is necessary to shout or use a raised voice to communicate at 1 metre or 3 feet away<sup>5</sup>.
- To minimise the influence of TTS at baseline, and subsequent audiograms, it is recommended workers should avoid loud noise or sound for at least 14 hours before surveillance audiometry<sup>6</sup>. If the results may have been affected by recent noise or sound exposure, then it may be necessary to re-test the subject at a time when they have had no or minimal recent exposure to noise or sound.
- Effective and rigorous use of hearing protectors may be necessary to minimise the influence of noise or sound exposure on audiometric results.

### Testing Environment

- The audiometric testing environment must meet ambient conditions specified in BS EN 26189, with background noise levels established by a formal noise survey and not exceeding those enabling testing to 20dBHL across 500-8kHz in accordance with ISO8253-1. These will ensure accurate and reliable results. If these conditions are not achieved, then testing should not proceed<sup>1</sup>.

5. <https://www.thebsa.org.uk/wp-content/uploads/2023/10/OD104-65-Surveillance-Audiometry.pdf>

6. <https://www.aafp.org/pubs/afp/issues/2013/0101/p41.html>



# Guidance for Practitioners

## STEP 2: EVALUATING FOR OCCUPATIONAL NOISE-INDUCED HEARING LOSS

### Confirm noise or sound exposure and complete questionnaire

- Before (or as soon as possible after) employment in a role with noise and sound exposure at or above the upper exposure action values, the employer must establish a valid baseline audiogram for future comparisons.
- A valid baseline may require multiple retests to confirm it accurately represents hearing ability, without influence of Temporary Threshold Shift (TTS) or artefacts due to suboptimal quality testing or test environment (e.g. background noise).

### Assess the audiogram

- Review the audiogram for the possible presence of NIHL (L108 Appendix 4, para 24). **First and foremost, this should include an assessment of the audiogram for the presence of a notch.**
- The SOM recommend adopting the 4KHz notch, defined as: *Hearing thresholds at 2 and 8 kHz that are both at least 10 dB HL lower than (better than) the threshold at 4kHz.*
- Taken alongside the exposure profile and noise and health questionnaire information, the presence of a notch can be classed as indicative of possible occupational NIHL and placed in the HSE Category 3 when first identified.

### CAVEAT

*The interpretation of notches in audiograms can be difficult, as there is no universally agreed-upon definition or criteria for what constitutes a notch.*

*Before embarking on audiometry as part of hearing health surveillance, practitioners must establish a clear framework to guide their actions.*

*One critical aspect is agreeing on a definition of a notch and defining steps to be taken upon its detection, especially in cases of uncertainty. The agreed definition should consider:*

- *The type of noise and sound exposure (steady-state versus impulse noise).*
- *The fact that notches are a non-specific, lagging indicator of irreversible hearing loss or disease progression.*
- *Not everyone exposed to excessive noise or sound will present with an audiometric notch and the correlation may be weaker for females than males.*
- *There is no consensus on 'recovery' (i.e. improved threshold at higher frequency 8 kHz) or validated approaches for managing notches.*



# Guidance for Practitioners

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## Sum and compare hearing threshold levels

- Sum hearing thresholds obtained at 1, 2, 3, 4 and 6 kHz, for each ear separately.
- Compare these sums with the age and sex-specific values given in Table 13 of Appendix 4 (L108).
- Additionally, sum hearing levels at 3, 4 and 6 kHz to detect any rapid hearing loss as defined in L108 Appendix 4.

## Consider significant changes in hearing thresholds

Consider if there has been a change in hearing threshold as an early indicator of hearing loss:

- HSE Rapid hearing loss criteria: A 30 dB or more summation at 3, 4, and 6 kHz.
- OSHA Standard Threshold Shift (STS): A 10 dB or more average shift at 2, 3, and 4 kHz in either ear from the baseline surveillance audiogram.\*

*\*Practitioners deciding to adopt the latter should familiarise themselves with the relevant OSHA regulations, not least the definition of 'baseline'.*



# Guidance for Practitioners

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## STEP 3: DETERMINE CATEGORY OF THE ASSESSMENT AND SUBSEQUENT ACTION REQUIRED

- Determine if any indications of NIHL detected through assessment is 'stable' (Category 2) or newly identified/ progressive (Category 3).
- If the sum of 1, 2, 3, 4 and 6 kHz is equal to or exceeds the significant hearing loss level for either ear in the HSE threshold table, or new / progressive NIHL is found through identification of a notch or a significant threshold shift by other methods via step 2, then the individual would fall into Category 3.
- The outcome of step 2 assessment may not be a HSE Category 3 if the audiogram results can be considered a 'stable' situation or condition.
- Stable NIHL (Category 2):
  - > can only be judged in comparison with previous audiogram results (if available).
  - > If there is no notable change from previous test results. +/- 5dB is considered within the range of test-retest variability.
  - > If hearing loss has progressed consistently across all frequencies.
  - > If the hearing loss is indicative of age-related deterioration.
- To determine whether any hearing deterioration can be considered 'stable' practitioners may wish to retest at up to six months in the future to ensure this is a real newly identified or progressive hearing loss or if the screening audiogram can remain a Category 2.
- If a notch is newly identified or progressive, classify the case as possible occupational NIHL and place it in the HSE Category 3.

### Initial screening audiograms and employer responsibility

For a first-time audiogram with the current employer, prior to any occupational exposure in that role:

- referral to an OHP is not usually required, even where indications of NIHL may be suspected, as any harm cannot be attributed to that employer
- The competent occupational health professional (such as an OHA) should decide on any workplace or exposure adaptations to protect the workers hearing if they are deemed vulnerable or susceptible to further noise or sound exposures at work.

### Ongoing assessment and referrals

- If no indications of occupational NIHL are detected and no other hearing health conditions suspected:
  - > the individual will continue with regular health surveillance whilst they remain noise or sound-exposed at work.
- If the individual is categorised as HSE 3 or 4:
  - > arrangements should be made to refer the individual to an occupational physician (OHP) for evaluation and confirmation of indications of occupational NIHL. Referral should include provision of all relevant information and advice gleaned from the Step 2 assessment.





# Guidance for Practitioners

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## STEP 4: OCCUPATIONAL PHYSICIAN REVIEW

Where a HSE Category 3 or 4 is newly identified, the individual must be referred to an occupational physician (OHP) for review.

If non-occupational hearing health concerns are identified, proceed directly to Step 5. This includes suspected unilateral hearing loss as defined in L108 Appendix 4 paragraph 27:

- > *Sum the hearing levels at 1, 2, 3 and 4 kHz for both ears.*
- > *If the difference between the ears is greater than 40dB, the individual should be advised of the findings and referred for medical advice.*

### Assessment by the OHP

- The OHP may apply specialised knowledge and tools, such as the Coles criteria<sup>7</sup>, to conduct in-depth assessments beyond standard noise health surveillance protocols.
- Note that whilst the presence of a notch may indicate possible NIHL, it has its limitations (see [Appendix C](#))
- If the OHP has access to the individual, they may also use the question set outlined in Appendix A of this guide to help distinguish occupational NIHL from other potential causes.
- The OHP may require that the individual has further testing or clinical support via Step 5. Screening Audiometry alone cannot form the basis for defining that a particular noise or sound exposure has caused an individual's hearing loss.
- The diagnosis of NIHL in such cases is complex and typically requires the judgment of an audiologist, otologist, otorhinolaryngologist, or ear, nose, and throat (ENT) specialist based on a detailed history of the individual case.

### Feedback

- The OHP will make a clinical judgement and will be required to provide advice to the employer on whether there are indications of occupational NIHL
- This advice will trigger specific legal duties as outlined in Reg 9(4) of the Control of Noise at Work Regulations requiring the employer to review their risk assessment and make adaptations to the workplace in terms of control improvement
- Feedback will also be provided to the individual which may include recommendations and advice on their fitness for continued exposure to noise or sound in the workplace.

7. [Coles, R. R., Lutman, M. E., & Buffin, J. T. \(2000\). Guidelines of the diagnosis of noise- induced hearing loss for medicolegal purposes. Clinical Otolaryngology, 25\(4\), 264-274. doi:10.1046/j.1365-2273.2000.00368.](#)





# Guidance for Practitioners

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## STEP 5: FURTHER TESTING OR CLINICAL SUPPORT

- An occupational health provider or OH Physician may decide that the individual requires further specific audiological or clinical examination and support.
- This may be via their GP, audiology, ENT or other specific specialist referral.
- This will be judged on a case-by-case basis and may follow individual care pathways or local services and audiological support.



# Appendix A: Symptom Questionnaire

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Appendix 5 of L108 has a sample noise and health questionnaire for use prior to audiometry with the purpose of gathering personal, medical, family and military history including tinnitus and potential exposure to ototoxins. However pure tone audiometry, on its own, is a poor predictor of disability experienced with everyday activities that involve hearing. An additional symptom questionnaire including specific questions on hearing loss and associated disability is outlined here. These additional questions are not intended to replace the L108 questionnaire but to supplement it: any cross-over issues relating to past medical and family history are highlighted where relevant. To assist the practitioner's understanding on the specific purpose of these questions some background, clarification notes and references are included.

There are numerous detailed questionnaires often accompanied by studies in the literature specific to individual auditory symptoms such as hyperacusis and tinnitus. It is not the intention to list or repeat these here but to focus on answers to key questions the practitioner may find helpful when receiving a referral with 'NIHL seen on the audiogram'. Taken in the context of workplace health surveillance, which may involve a significant volume of audiograms, these questions are by necessity relatively brief and targeted towards a putative attribution to noise and the exclusion of other causes – as such it is a referral exercise and not a diagnostic one and none of the questions are unique to NIHL. Whilst a lot of symptoms listed will be reflective of significant hearing deficits some such as speech in noise identification and sensitivity are also potential early indicators of damage – a primary aim of health surveillance. A benefit from the collection of these symptoms is they provide a snapshot of overall personal disability in a health surveillance setting without recourse to more extensive questionnaires.

1. Do you consider your hearing to be normal?

Left ear	YES	NO
Right ear	YES	NO

2. If not, how long has that been?

Date of onset:

**If answer to Q1 is NO\*, please complete the following additional questions (\*see note 1):**

- |   |          |           |         |
|---|----------|-----------|---------|
| 3. Did the loss come suddenly or gradually? (Please circle.)            | Suddenly | Gradually |         |
| 4. Do you hear better or worse in a noisy environment? (Please circle.) | Better   | Worse     | Neither |
| 5. Do you have difficulty perceiving speech in a crowded room?          | YES      | NO        |         |
| 6. Do everyday sounds seem louder to you?                               | YES      | NO        |         |
| 7. Do you notice difficulty adjusting between quiet and loud sounds?    | YES      | NO        |         |
| 8. Do you have difficulty perceiving pitch?                             | YES      | NO        |         |
| If you answered yes, is it different between your ears?                 | YES      | NO        |         |
| 9. Do you avoid or feel fatigued by everyday sounds?                    | YES      | NO        |         |



# Appendix B:

## Notes to Symptom Questions

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- 1/2. Individuals are sometimes unsure regarding whether and how long they have had hearing loss, and it can be advantageous, if practicable, to verify this with a spouse, partner or family member.<sup>1</sup> Paradoxically, it can be a partner's description of their hard-to-hear soft speech which might point to otosclerosis (particularly if accompanied by a Carhart notch at 2 kHz on the bone conduction audiogram reflecting the impaired resonant frequency of the ossicles).<sup>2</sup> Any indication of a unilateral audiometric hearing loss, whether symptomatic or not, should be investigated to exclude an acoustic neuroma prior to attributing to atypical/asymmetrical occupational noise exposure.
3. Whilst the majority of cases of NIHL will develop over many years (notably the first 10 years), symptoms of hearing loss are often not noticed until they involve speech frequency identification. However, otosclerosis and presbycusis similarly develop slowly. A number of conditions can develop suddenly, such as Ménière's disease or bacterial and viral infections. A temporal association with head injury or acoustic trauma from very loud noise exposure should be self-evident in sudden causes.
4. This seemingly abstruse question may point to the eponymous phenomenon of 'paracusis of Willis' (or 'Willisii'), where the person hears better in noise than in quiet, indicating a conductive loss. Those with sensorineural loss have difficulty hearing in a noisy environment whereas those with conductive loss tend to hear better due to the raised volume of speech in others (the Lombard reflex). Whilst valuable when reported, its discriminatory value has been questioned.<sup>3</sup>
5. Sometimes referred to as the 'cocktail party effect', this symptom of speech identification in a crowded room is commonly described by those with sensorineural hearing loss. However, the assessing practitioner needs to be alert to the possibility of an auditory processing disorder (APD) sometimes a feature of those with neurodiversity.<sup>4</sup>
6. Hyperacusis or 'sound sensitivity' is defined as an abnormal lowered tolerance to sound, often coincident with tinnitus, both of which can occur in sensorineural hearing loss. It is unclear but generally thought to be a defect in central or neural auditory processing. Whilst relatively uncommon, it can result from prolonged exposure to noise and occur in the absence of actual sensorineural hearing loss. An inventory of hyperacusis symptoms has been developed.<sup>5</sup>
7. Recruitment is another phenomenon where sound is perceived to become suddenly louder with increasing sound level. This can have the paradoxical effect whereby those affected request an initial "speak louder" followed by a complaint of "stop shouting". This is a feature of cochlear damage (stereocilia damage to the outer hair cells (OHCs) of the basilar membrane; OHCs are a feature of NIHL) or, more simply, more the sensory than the neural aspect of sensorineural hearing loss. For hearing loss of up to about 45dB, audibility is the single most important factor, but as losses increase, poor discrimination of suprathreshold audible stimuli (including temporal and pitch discrimination) becomes more important.<sup>6</sup>

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## Appendix B: Notes to Symptom Questions (cont.)

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8. Pitch perception is another suprathreshold discriminatory problem, sometimes referred to as 'double hearing'. Diplacusis is a specific term describing an anomaly whereby the same tone is perceived as having a different pitch when presented to the right and the left ear of the same listener. Important for speech and music appreciation, it may manifest symptomatically as another feature of the complex noises of the 'cocktail party effect', where the individual is not able to segregate sounds that arrive from different sources, such as the punchline of a joke, because of others' laughter.<sup>7</sup>
9. In addition to hearing loss, tinnitus and sound sensitivity, long-term noise exposure can lead to sound-induced auditory fatigue, which results in avoidance behaviour to everyday sound and the seeking of silence. Though probably more a reflection of exposure, there has been report of statistically significant associations between occupational noise, tinnitus, and sound-induced auditory fatigue.<sup>8</sup>

7. Oxenham AJ. Pitch perception and auditory stream segregation: implications for hearing loss and cochlear implants. *Trends Amplif.* 2008; 12(4): 316–31. doi: 10.1177/1084713808325881

8. Fredriksson S, Hammar O, Torén K et al. The effect of occupational noise exposure on tinnitus and sound-induced auditory fatigue among obstetrics personnel: a cross-sectional study. *BMJ Open* 2015; 5: e005793. doi:10.1136/bmjopen-2014-005793



## Appendix C:

# The audiometric notch in NIHL and associated limitations

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A notch on the audiogram is often regarded as a classical sign of NIHL. However in terms of diagnostic use in NIHL there are a number of limitations and the presence of a notch on its own is not pathognomonic of NIHL.

The limitations of 'notches' can be broadly summarised as:

- The range of definitions
- Presence in the general population
- Presence in those not occupationally exposed to noise
- Asymmetry
- Sensitivity
- Specificity
- Other causes

Four definitions of what may constitute an audiometric notch are listed in Step 1 although a number of others have been used. It most typically occurs at 4KHz with a range between 3-6KHz, sometimes influenced by the type and source of noise e.g. impact noise and 6KHz notch.<sup>1-5</sup> Some definitions of occupational noise induced hearing loss put emphasis on lower frequencies 0.5- 4KHz where hearing and speech problems may be detected first whereas others on higher frequencies 3-6KHz being most susceptible to early signs of harmful noise exposure.<sup>6</sup> With progression a notch can be lost with the development of a trough or bulge across 3-6KHz frequencies.

Another difficulty with interpretation is the presence of a notch in the general population with some studies suggesting more than 40% showing a notch.<sup>3</sup> This is further compounded by workers without any noise exposure reporting up to 50% notching.<sup>7</sup>

Notwithstanding the importance of investigating asymmetrical hearing loss in Step 2 to exclude an acoustic neuroma the majority of work environments lead to symmetrical noise exposure to both ears with few exceptions such as firearms exposure. However unilateral 4KHz notches have been reported to occur twice as often as bilateral notches, but again this finding is very dependent on the definition of a notch.<sup>3</sup>

In addition using a 4KHz notch as a 'diagnostic test' has other limitations; a notch is not found in every case of occupational NIHL and as above is sometimes found in the absence of noise exposure. In this sense the use of a notch to 'diagnose' NIHL has limited sensitivity (at identifying all true cases) and limited specificity (at excluding all false cases).<sup>8</sup>

Finally and importantly there are numerous other conditions that may present with a notched audiogram. As covered in this supplementary guidance document to 'diagnose' or assign a case of NIHL to occupational noise exposure is not necessarily straight forward. However, as well as having had noise exposure sufficient to cause NIHL, other potential causes of a notched audiogram should be considered. A number of conditions that can show a 4KHz notch have been identified Sataloff & Sataloff.<sup>9</sup> While some of these listed are relatively rare their inclusion is necessary to raise awareness in occupational physicians called upon to make a judgement on whether an audiometric pattern suggestive of NIHL should be attributed to occupational noise exposure.



## Appendix C: The audiometric notch in NIHL and associated limitations (cont.)

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**1. Viral Infection** Whilst viral and bacterial infection can lead to short term conductive hearing loss as a result of middle ear blockage, a number of viruses such as rubella, measles, herpes, mumps and cytomegalovirus can lead to cochleitis and long-term sensorineural hearing loss, sometimes manifesting as 4KHz notch.

**2. Head Injury** Head injury, particularly temporal bone and concussive events, can produce a 4KHz notch.

**3. Hereditary** Some with syndromic and non-syndromic familial sensorineural loss can present audiometric notches similar to occupational NIHL.

**4. Ototoxicity** Either temporary hearing loss from high dose aspirin or more permanent effects from aminoglycoside antibiotics (e.g Gentamicin) or diuretics and certain anti-malarials is well documented. Quite severe hearing loss can result but a resultant audiometric pattern can include a 4KHz notch. Certain solvent exposures in the workplace such as styrene and toluene have the potential to cause ototoxicity. Of note in ototoxicity is the phenomenon of synergistic effects of combined noise and solvent exposure induced hearing loss, SIHL. In other words there is a higher odds of acquiring hearing loss from noise and solvent exposure than solvents alone.<sup>10</sup> These combinations of exposure are more likely to be evident to the occupational health practitioner than the ENT specialist.\*

**5. Acoustic Neuroma** A Schwannoma, although rare, can manifest with a 4KHz notch and needs to be excluded in unilateral hearing loss. Also important to consider in presumptive bilateral post exposure TTS that recovers on one side only.

**6. Sudden hearing loss** Sudden hearing loss, usually unilateral but can be bilateral, which cannot be explained by external or middle-ear causes is classed as an otological emergency.<sup>11</sup> In some cases there may be a history to suggest acoustic trauma or barotrauma following short duration heavy intensity noise causing physical damage usually evident by a defined acoustic incident. These should not be conflated with the relatively recent phenomenon of 'acoustic shock' often reported in telecommunication workers leading to otological and non-otological symptoms such as headaches or psychological symptoms, often with normal audiometry.<sup>12</sup>

**7. Multiple Sclerosis** A variable and fluctuating pattern of notching may be observed in those with MS.

**8. Other causes** These could include post bacterial meningitis, septicaemia, hypoxia and neonatal hyperbilirubinaemia. Added to this now are reports of new cases of sensorineural hearing loss following Covid-19, post-covid syndrome<sup>13</sup> and Covid-19 vaccine and including a case report with maximum hearing loss at 6KHz.<sup>14</sup>

*\*OSHA have identified a list of neurotoxicants, cochleotoxicants and vestibulotoxicants along with associated industries with the potential for combined solvent and noise exposures e.g. construction:*

<https://www.cdc.gov/niosh/docs/2018-124/pdfs/2018-124.pdf>



# Appendix C:

## The audiometric notch in NIHL and associated limitations (cont.)

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