McMaster University | HEALTH FORUM

Rapid Evidence Profile

Examining the association between noise exposure and delayed hearing loss

10 May 2024

[MHF product code: REP 71]

Box 1: Evidence and other types of information

+ Global evidence drawn upon

Evidence syntheses selected based on relevance, quality, and recency of search

+ Forms of domestic evidence used (🍁 = Canadian)

Data analytics

Modeling

*** Additional notable features**

Prepared in three-business days using an 'all hands on deck' approach

Context

- Much of the existing literature notes that the effects of exposure to noise cease once the exposure itself has stopped.
- However, there is some concern that exposure to particular types of noise may result in hearing loss later in life despite not showing up on audiograms shortly after the exposure.

Questions

- Does significant noise exposure, without losses on audiogram at the time or shortly after the noise exposure ceases, cause an increased incidence or severity of hearing loss in the long term?

High-level summary of key findings

- We identified 12 evidence documents, of which we determined eight to be highly relevant, which include one recent low-quality evidence synthesis and seven single studies that directly address the question.
- Most of the studies examined cochlear synaptopathy – damage to the auditory nerve – as a potential explanation for the delay in measurable hearing loss using an audiogram.
- Mixed findings were reported for effects of noise exposure on cochlear synaptopathy, with one recent low-quality evidence synthesis reporting little association, while single studies examining military and Veteran personnel reported evidence of biomarkers consistent with cochlear synaptopathy from noise exposure while controlling for age.

Framework to organize what we looked for

- Population exposed to noise
  - Civilian/general population
  - Military personnel
- Type of noise exposure
  - Impulsive noise exposure
    - One-off
    - Repetitive exposure

    - Steady or continuous noise exposure
        - One-off
        - Repetitive exposure
- Level of noise exposure
    - 0–85 dBA
    - 85–110 dBA
    - 110–140 dBA
    - Over 140 dBA
- Time elapsed since noise exposure and resulting measurement for hearing loss
- Extent of hearing loss later in life
    - Mild hearing loss (26–40 dBs)
    - Moderate hearing loss (41–60 dBs)
    - Severe hearing loss (61–80 dBs)
    - Profound hearing loss (more than 81 dBs)
- Additional effects of noise exposure experienced later in life
    - Tinnitus

What we found

We identified 12 evidence documents, of which we determined eight to be highly relevant. These include:

- one recent low-quality evidence synthesis
- seven single studies.

Studies were determined to be medium or low relevancy because they did not report on a delay in the measurement of perception of hearing loss.

Coverage by and gaps in existing evidence syntheses and domestic evidence

Though there is a significant evidence base examining and categorizing hearing loss and tinnitus in the military, very little of it directly addressed the question of delayed hearing loss or delayed detection of hearing loss. An emerging hypothesis is that damage to the auditory nerve – cochlear synaptopathy – resulting from noise exposure and aging that is not detectable on audiograms after noise exposure may be the cause of the delay in hearing loss. However, the evidence available about this hypothesis is still nascent. Evidence syntheses and studies addressing cochlear synaptopathy focused on impulsive noise exposure, however no threshold level of noise exposure needed to result in cochlear synaptopathy was reported. In addition, history of noise exposure was based on self-reports rather than empirical measurements.

We did not include animal studies as part of this profile, but we have identified potentially relevant animal studies in Appendix 4.

Box 2: Approach and supporting materials

We identified evidence addressing the question by searching Health Systems Evidence, ACCESSSS, PubMed, and CINAHL. All searches were conducted on 29 April 2024. The search strategies used are included in Appendix 1. In contrast to synthesis methods that provide an in-depth understanding of the evidence, this profile focuses on providing an overview and key insights from relevant documents.

We searched for full evidence syntheses (or synthesis-derived products such as overviews of evidence syntheses), protocols for evidence syntheses, and single studies.

We appraised the methodological quality of evidence syntheses that were deemed to be highly relevant using the first version of the AMSTAR tool. AMSTAR rates overall quality on a scale of 0 to 11, where 11/11 represents a review of the highest quality, medium-quality evidence syntheses are those with scores between four and seven, and low-quality evidence syntheses are those with scores less than four. The AMSTAR tool was developed to assess reviews focused on clinical interventions, so not all criteria apply to evidence syntheses pertaining to delivery, financial or governance arrangements within health systems or implementation strategies.

A separate appendix document includes:
1) methodological details (Appendix 1)
2) details about each included evidence synthesis (Appendix 2)
3) details about each included single study (Appendix 3)
4) excluded evidence documents that were based on animal studies (Appendix 4)
5) documents that were excluded in the final stages of review (Appendix 5).

This rapid evidence profile was prepared in the equivalent of three days of a 'full court press' by all involved staff.

Key findings from included evidence documents

Most of the identified evidence documents – the recent low-quality evidence synthesis and five of the singles studies – report on 'hidden hearing loss' despite normal audiograms.(1) These studies point to cochlear synaptopathy, which describes the loss of synapses that connect inner hair cells to the auditory nerve and can produce below-threshold levels of abnormalities including speech-in-noise difficulties and tinnitus that overtime can progress to more substantial hearing loss. The auditory nerve is more vulnerable than other parts of the cochlear structure to aging and to noise exposure; however, damage to the nerve tends to disrupt encoding of complex information, such as speech, rather than single tones and so may not be detected as part of typical audiograms.

While cochlear synaptopathy is well established in animals, its occurrence in humans is less well understood as well-established approaches to its detection are invasive and involve examining the temporal bone post-mortem. More recently, studies have begun using biomarkers to better understand the occurrence of cochlear synaptopathy among individuals and its association with noise exposure and aging.

The evidence documents we identified revealed mixed effects for the association between noise exposure and aging on cochlear synaptopathy. The recent low-quality evidence synthesis, which included a meta-analysis, found conclusive evidence of the relationship between reduced auditory nerve function and age, but identified only a weak association between noise exposure history and auditory nerve responses.(1) In contrast, all five single studies report biomarkers consistent with cochlear synaptopathy among military personnel and Veterans with a history of impulsive noise exposure.(2-6)

We also identified two studies related to new-onset and progressive hearing loss among U.S. military members and Veterans more generally. One study re-analyzed data from three published studies on the effects of noise exposure on the progression of hearing loss and found that noise exposure can accelerate the progression of hearing loss where the hearing loss is absent or mild at the end of military service (i.e., threshold levels up to 50 db HL).(7)

The final study found that in a significant sample of U.S. military members (n=48,000), 7.5% reported new-onset hearing loss during follow-up surveys administered three years after the baseline reporting. New-onset hearing loss was associated with a history of combat deployment, being male, and older age. Among deployed military members, new-onset hearing loss was associated with reported proximity to improvised explosive devices and having experienced a combat-related head injury.(8)

Next steps based on the identified evidence

Though the evidence-base for this question is still evolving, there are existing efforts to address gaps in evidence about military service and auditory disorders. In particular, the Institute of Medicine in the U.S. issued a recommendation for a large-scale longitudinal cohort study to examine the long-term effects of noise exposure during military careers. This work was taken up by investigators at the Veterans Affairs Rehabilitation Research and Development National Center for Rehabilitative Auditory Research in Portland, who are now running a longitudinal cohort study with Veterans, which could be an important source of future data to help answer this question.

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