

Review Article

A scoping review of the evidence linking metabolic dysfunction-associated steatotic liver disease and hearing loss: mapping the liver-ear axis

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ABSTRACT

Fatty liver disease, currently termed metabolic dysfunction-associated steatotic liver disease (MASLD), is increasingly recognised as a systemic metabolic disorder with potential extrahepatic manifestations. However, the association between MASLD and hearing loss has not been systematically evaluated. We conducted a scoping review to evaluate the association between fatty liver disease and hearing impairment. Our review adhered to the PRISMA-ScR checklist and searched using keywords in four databases (PubMed, EMBASE, Scopus, and Cochrane). Studies assessing the association between MASLD and hearing outcomes were included. Risk of bias assessment was conducted using the Newcastle-Ottawa Scale and Joanna Briggs Institute checklist. Of 415 records identified, two studies involving 210,939 participants, including 192,467 individuals with fatty liver disease, met the inclusion criteria. Both studies demonstrated high methodological quality. Fatty liver disease was assessed using fatty liver index-based steatosis definitions, while hearing outcomes were evaluated using pure tone audiometry and validated ICD-based diagnoses of sudden sensorineural hearing loss. In both studies, individuals with fatty liver disease had a higher proportion of hearing impairment. Current evidence suggests a possible association between fatty liver disease and hearing impairment, supporting the concept of a metabolic-auditory link. Nevertheless, the evidence base remains limited, and further longitudinal studies using standardized MASLD definitions and objective hearing assessments are required to clarify causality and clinical implications.

Keywords: Hearing Loss, Hearing impairment, Fatty liver, Metabolic dysfunction, Sensorineural hearing loss, Steatosis

INTRODUCTION

Hearing loss is a major global public health concern, affecting over 1.5 billion people worldwide.¹ Sensorineural hearing loss (SNHL), a subtype, occurs due to damage in the inner ear (cochlea) or the auditory nerve pathways, mostly associated with aging, environmental exposures, and established associations with systemic diseases, including non-communicable disease risk

factors such as hypertension, diabetes, obesity, and metabolic derangements.²

The nomenclature of fatty liver disease has evolved substantially over the past decade in response to advances in understanding its pathophysiology and concerns regarding disease classification. Historically, non-alcoholic fatty liver disease (NAFLD) was defined by the presence of hepatic steatosis in individuals without

significant alcohol consumption or other secondary causes of liver disease. However, this exclusion-based definition was criticized for failing to emphasize the central role of metabolic dysfunction in disease development. To address these limitations, the term metabolic dysfunction-associated fatty liver disease (MAFLD) was proposed in 2020, introducing positive diagnostic criteria based on the presence of hepatic steatosis together with metabolic abnormalities, irrespective of alcohol consumption or coexisting liver diseases. More recently, an international multi-society consensus recommended the term metabolic dysfunction-associated steatotic liver disease (MASLD), replacing NAFLD as part of a broader steatotic liver disease nomenclature. This change aimed to reduce stigmatizing language, employ inclusion-based diagnostic criteria, and better align disease classification with its underlying cardiometabolic basis.³ MASLD is defined as steatosis ($\geq 5\%$ fat accumulation in hepatocytes by imaging) with the presence of cardiometabolic factors.³

Given the shared metabolic underpinnings, MASLD represents a systemic disorder with potential extrahepatic manifestations beyond the liver. The cochlea, characterised by high metabolic demand and end-arterial blood supply, is particularly vulnerable to microvascular dysfunction, oxidative stress, and chronic inflammation pathways central to MASLD pathophysiology. These mechanisms overlap with those implicated in Sensorineural Hearing Loss, suggesting a biologically plausible link between hepatic steatosis and auditory impairment.^{2,4,5} Research documented that recovery of metabolic syndrome patients with hearing loss was 7% lower compared to those patients without the syndrome.² Although individual studies have explored associations between fatty liver disease and hearing outcomes, few gaps were documented. Firstly, there is substantial heterogeneity in disease definitions, with studies variably applying exclusion-based (NAFLD) versus inclusion-based (MAFLD/MASLD) criteria, often without harmonisation. Secondly, inconsistent operationalisation of steatosis and metabolic dysfunction (imaging modalities, biomarker thresholds, or cardiometabolic criteria) limits comparability across cohorts. Thirdly, hearing assessment methods range from self-reported impairment to pure-tone audiometry, introducing outcome misclassification. With over one-third (39.9%) of the projected adult population with MAFLD and growing prevalence of cardiometabolic disease, the magnitude of association with hearing impairment was not well established.⁶ In this context, we conducted a scoping review to document the association between fatty liver and hearing impairment.

METHODS

Study design and search strategy

We conducted a scoping review in accordance with the Preferred Reporting Items for Systematic Reviews and

Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist. We used keywords such as Fatty liver, NAFLD, MAFLD, MASLD, hearing impairment or hearing loss, with Boolean operators (OR and AND). We searched in four databases including PubMed, EMBASE, SCOPUS, and Cochrane. We included primary study designs assessing the association between hearing impairment and fatty liver, since the inception of evidence availability till date of the search (April 9, 2026). We excluded review articles, editorials, and conference abstracts without data and non-English literature. We registered the protocol in PROSPERO (Registration ID: CRD420261365271).

Inclusion and exclusion criteria

The review was conducted using the PICO (Population, Intervention/ Exposure, Comparison, and Outcome) framework. The population included individuals of any age or gender from general or clinical settings who were assessed for hearing impairment or fatty liver disease. The exposure of interest was fatty liver disease, including NAFLD, MAFLD, or MASLD, assessed using imaging modalities, biochemical indices such as fatty liver index (FLI), or clinical definitions.

The comparison group comprised individuals without fatty liver disease. The outcomes of interest included hearing-related measures such as hearing loss, sudden sensorineural hearing loss using pure tone audiometry thresholds, or valid hearing assessment tools (Table 1).

Table 1: Inclusion and exclusion criteria for studies in review.

Component	Description
Population (P)	Individuals (any age or gender) from general or clinical populations, assessed for fatty liver disease (FLD/ NAFLD/MAFLD/ MASLD) or hearing impairment
Exposure/ Intervention (I)	Fatty liver disease assessed using imaging (ultrasound, MRI, FibroScan), biochemical indices, or clinical definitions
Comparison (C)	Individuals without fatty liver disease
Outcome (O)	Hearing outcomes including hearing loss, sudden sensorineural hearing loss (SSNHL) assessed using pure tone audiometry (PTA), frequency-specific thresholds, clinical diagnosis or valid hearing assessment tools

Screening process

Following extraction of articles from four databases, the files were imported into Rayyan software, and duplicates were removed. The title and abstract screening were conducted by two independent authors (YP and MK), and

discrepancies were resolved by the third expert (LA). The articles selected were screened for full text and screened in a similar process to title and abstract by two reviewers (YP and MK).

Data extraction process

From the selected full-text studies, data extraction was performed independently by two reviewers using an extraction form. The following information was extracted from each included study: author details, year of publication, country, study design, study population characteristics, sample size, method of fatty liver disease assessment (imaging, fatty liver index etc.), method of hearing assessment (audiometry, pure tone average or International Classification of Diseases (ICD) based diagnosis, demographic characteristics (age and sex), outcomes related to hearing impairment, and key findings including effect estimates. Any discrepancies between reviewers were resolved through discussion and consensus, and where necessary, a third reviewer was consulted.

Risk of bias assessment

The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for cross-sectional studies and Newcastle–Ottawa Scale (NOS) for cohort studies.^{7,8} The JBI checklist evaluates methodological quality across domains including participant selection, exposure and outcome measurement, identification and management of confounding factors, and statistical analysis.

The NOS assesses study quality across three domains: selection of study groups, comparability of groups, and ascertainment of exposure and outcomes, with a maximum score of nine stars indicating the lowest risk of bias. Two reviewers independently conducted the risk-of-bias assessment, and any discrepancies were resolved through discussion or consultation with a third reviewer. Given the anticipated heterogeneity in study design, exposure definitions, outcome assessment methods, and study populations, a quantitative meta-analysis was considered inappropriate. Therefore, findings were synthesized narratively.

RESULTS

Selection of studies

Database search yielded 415 studies, and 184 duplicates were removed. Of the 231 screened using title and abstract, three were eligible for full-text screening. Lastly, two articles aligning with the objective were included in the final review, and one article was excluded because hearing impairment was assessed in liver fibrosis rather than fatty liver exclusively (Figure 1).⁹

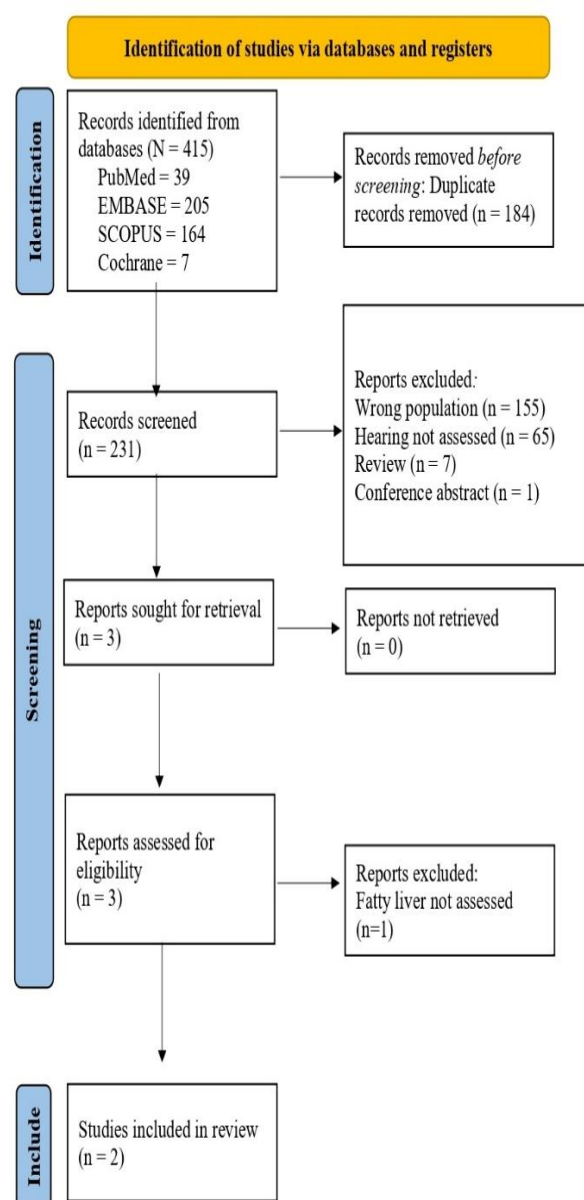


Figure 1: PRISMA flow diagram depicting the selection of studies.

Characteristics of included studies

Both studies were conducted in Korea and were funded. Among the selected studies, one was retrospective observational and the other was a population-based cohort study using data from the Korean National Health Insurance Service (KNHIS)-Senior cohort.^{10,11} The methods used to assess fatty liver disease varied across studies. Jung et al utilized the FLI with a cutoff of ≥ 60 to define fatty liver disease, whereas Kang et al defined steatotic liver disease (SLD) based on $\text{FLI} \geq 30$ and further categorized MASLD using cardiometabolic risk factors.^{10,11} Hearing outcomes were assessed using audiometric evaluation (Pure tone audiometry-PTA) in Jung et al. and ICD-10 diagnostic coding (H912) for sudden sensorineural hearing loss in Kang et al (Table 2).

Given these differences in study design, population characteristics, exposure definitions, outcome measures, and follow-up structure, a quantitative meta-analysis was

not performed due to the limited number of studies and the substantial heterogeneity between them.

Table 2: Characteristics of included studies.

Author, year	Study design	Sample size	Assessment of fatty liver/ NAFLD	Hearing assessment	Age	Males (%)	Outcomes	Other findings
Jung, 2023 (Korea)	Retrospective observational	21,316 (Non-FLD: 18,518; FLD: 2,798)	Fatty liver index (FLI) using Bedogni's equation. Categorized into non-fatty liver disease (<60) and fatty liver disease (≥60).	Automatic audiometer at frequencies of 0.5, 1, 2, 3, 4, and 6 kHz with hearing loss cut-off 40 dB.	≥18 years included; non-FLD: 50.7±12.1 FLD: 50.1±10.8	Non-FLD: 9,077 (49%) FLD: 2,486 (88.8%)	Hearing loss in non-FLD: 1,370 (7.4%); FLD: 238 (8.5%); FLI scores in the Non-FLD and FLD groups were 20.1±16.2 and 74.9±10.1	FLI showed a positive correlation with hearing thresholds across all frequencies, indicating worse hearing with higher FLI. Adjusted for age, AST level, and ALT level showed that the OR for HL in the FLD group was 1.47 compared with that in the non-FLD group.
Kang, 2025 (Korea)	Population-based cohort (Data analysed from Korean National Health Insurance Service-Senior Cohort)	Non-SLD: 84,225; MASLD: 1,05,398	Steatotic liver disease: FLI ≥ 30. MASLD: ≥ cardiometabolic risk factors + steatosis.	International Classification of Diseases, 10th Revision (ICD-10) code H912	≥65 years included; non-steatosis: 71.3±4.5 MASLD: 70.6±4.2	Non-steatosis: 30,804 (36.6%); MASLD: 53,899 (51.1%)	SSNHL% in non-steatosis: 3,576 (1.9%); MASLD: 3,803 (2.0%)	Risk of SSNHL was elevated in the MASLD group, with a sub-distribution hazard ratio of 1.06 (95% CI, 0.99–1.13) after adjusting for confounders.

Association between fatty liver disease and hearing outcomes

In the study by Jung et al involving 21,316 (non-FLD: 18,518; FLD: 2,798) adults, the prevalence of hearing loss was higher among individuals with fatty liver disease compared to those without (8.5% vs 7.4%).¹⁰ Additionally, FLI scores were markedly elevated in the fatty liver group (74.9±10.1) compared to the non-fatty liver group (20.1±16.2).

A positive correlation was observed between FLI and hearing thresholds across all frequencies, indicating worsening auditory function with increasing fatty liver severity. In the population-based cohort study by Kang et al which included 189,623 older adults (non-SLD: 84,225; MASLD: 105,398), the incidence of SSNHL was slightly higher in the MASLD group compared to the non-SLD group (2.0% vs 1.9%).¹¹ After adjustment for confounders and competing risks, MASLD was associated with a modest increase in the risk of SSNHL, with a sub distribution hazard ratio of 1.06 (95% confidence interval (CI): 0.99–1.13; $p = 0.092$).

Risk of bias

The methodological quality of the included studies was assessed using study design-specific tools. Both studies utilized large, well-defined populations with appropriate ascertainment of exposure and clearly defined comparison groups. Confounding was adequately addressed through multivariable adjustment for key cardiometabolic factors, including age, sex, diabetes,

hypertension and lipid parameters; the cohort study additionally employed inverse probability weighting to further reduce residual confounding. Outcome assessment was considered robust in both studies, with objective audiometric measurements used in the cross-sectional study and validated diagnostic coding with longitudinal follow-up employed in the cohort study. Overall, the included studies were of high methodological quality with a low risk of bias (Table 3).

Table 3: Risk of bias assessment of the included studies.

Study	Risk of Bias Tool	Domain/Item	Assessment
Jung et al, 2023 ¹⁰	JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies	Inclusion criteria clearly defined	Yes
		Objective and standard criteria used for outcome measurement (pure-tone audiometry)	Yes
		Exposure (FLI-defined FLD) measured validly and reliably	Yes
		Outcomes measured validly and reliably	Yes
		Confounding factors identified	Yes
		Strategies to address confounding stated	Yes
		Appropriate statistical analysis performed	Yes
		Study subjects and the setting described in detail	Yes
		Overall appraisal	Low risk of bias / High quality
Kang et al, 2025 ¹¹	Newcastle–Ottawa Scale (NOS)	Representativeness of exposed cohort	Yes
		Selection of non-exposed cohort	Yes
		Ascertainment of exposure	Yes
		Outcome not present at baseline	Yes
		Comparability: controlled for age and sex	Yes
		Comparability: controlled for additional confounders	Yes
		Outcome assessment	Yes
		Follow-up long enough for outcomes to occur	Yes
		Adequacy of follow-up	–
		Overall appraisal	Low risk of bias / Good quality

DISCUSSION

The present study is one of the initial systematically conducted reviews to document the association between fatty liver disease and hearing outcomes. The findings suggest a directionally consistent association between fatty liver disease and hearing impairment.

Our review included two studies, both of which demonstrated a consistent direction of effect, indicating higher odds of hearing loss among individuals with fatty liver disease. Although both studies demonstrated high methodological quality based on the NOS, there was a difference in the design of the assessment of hearing loss between the studies included. Jung et al assessed the outcome at cross-sectional, limiting inference on temporality and causal interpretation of the association between fatty liver disease and hearing loss. In contrast,

Kang et al. incorporated longitudinal follow-up with incident outcome assessment, strengthening temporal inference and allowing estimation of risk over time. Moreover, discrepancies in fatty liver definitions (FLI thresholds versus MASLD criteria between studies) may have led to exposure misclassification.

MASLD is fundamentally a metabolic disorder characterized by insulin resistance, dyslipidaemia, hypertension, and central obesity. Each of these components has independently been associated with hearing impairment in previous studies.^{12–17} The pooled estimates documented that the individual cardiometabolic components were associated with increased odds of hearing loss, with effect sizes ranging from 1.27–1.40 for obesity, 1.53–1.84 for hypertension, 1.88–1.97 for diabetes, and up to 4.22 for metabolic syndrome, with stronger associations reported in specific populations such as diabetes.^{12–17} Collectively, these findings support

a shared metabolic pathway linking MASLD-related risk factors with auditory dysfunction (Table 4).

Table 4: Systematic reviews and meta-analyses documenting the evidence link between individual criteria of MASLD and hearing loss.

Author, Year	Association of hearing loss with:	Number of studies	Pooled effect estimate
Díaz-Franco et al, 2023 ¹⁶	Metabolic syndrome	28	Odds ratio (OR) of hearing loss in Obesity = 1.27 (95% CI 1.07, 1.51); Diabetes = 1.97 (95% CI 1.51, 2.57); Hypertension = 1.53 (95% CI 1.31, 1.79) Metabolic syndrome = 4.22 (95% CI 1.74, 10.20)
Yang et al, 2020 ¹⁵	Obesity	14	OR of hearing loss in Obesity = 1.40 (95% CI 1.14, 1.72). Relative risk in longitudinal cohort studies in obesity = 1.15 (95% CI 1.01, 1.30)
Mujica-Mota et al, 2018 ¹³	Diabetes type I	21	OR = 7.7, 95% CI 3.32, 17.98
Liu et al, 2025 ¹⁴	Diabetes overall	21	OR = 1.88, 95% CI 1.01, 3.50
Simões et al, 2022 ¹²	Cardiovascular risk factors	21	Hypertriglyceridemia (OR 1.54; 95% CI 1.18-2.02); High levels of total cholesterol (OR 2.09; 95% CI 1.52-2.87)
Jin et al, 2025 ¹⁷	Hypertension	12	OR: 1.84 (95% CI: 1.54, 2.20)

From a pathophysiological perspective, several mechanisms may explain the link between MASLD and hearing impairment. MASLD is associated with chronic low-grade inflammation, endothelial dysfunction, and increased oxidative stress, all of which can impair cochlear microcirculation. The cochlea is highly metabolically active and vulnerable to ischemia; thus, even subtle vascular compromise can result in hair cell damage and hearing loss. In addition, insulin resistance may directly affect cochlear function by altering glucose transport and energy metabolism within the inner ear. These mechanisms collectively support the emerging concept of a “metabolic–auditory axis” or “liver–ear

axis,” where systemic metabolic dysregulation contributes to auditory dysfunction. MASLD, as an umbrella metabolic disorder associated with multiple cardiometabolic abnormalities and non-communicable diseases, may depict a biologically plausible connection of MASLD with hearing loss. The pathophysiological connection of MASLD with SNHL was documented in Figure 2. From a clinical perspective, these findings suggest that patients with MASLD may benefit from holistic risk assessment, including consideration of auditory health. Conversely, hearing impairment may serve as an early marker of systemic metabolic dysfunction.

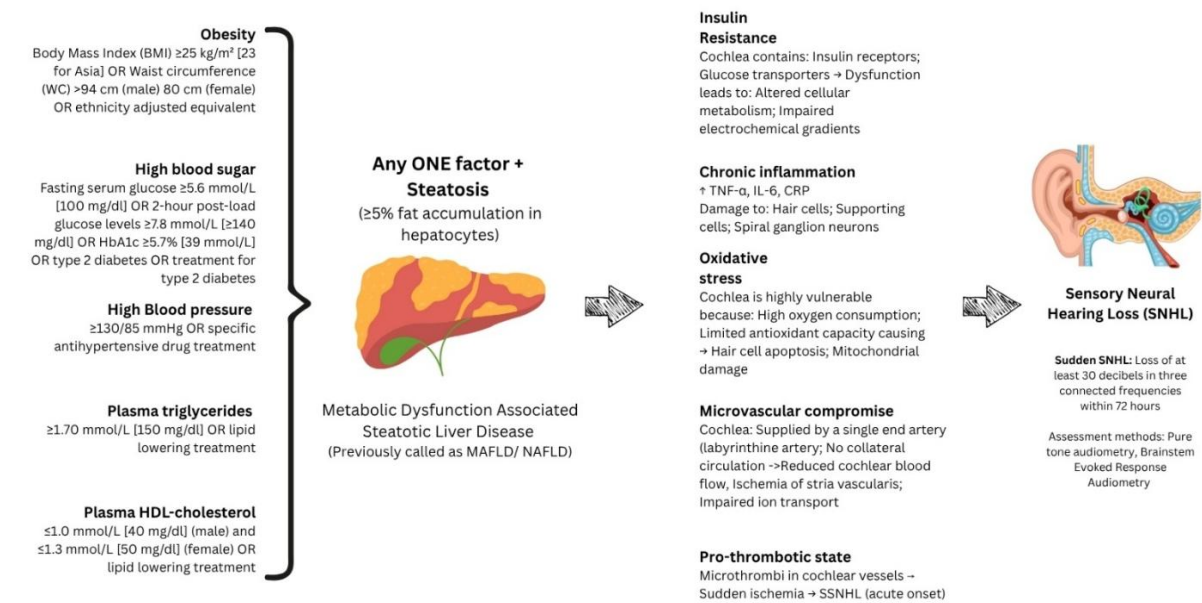


Figure 2: Biological pathways connecting metabolic dysfunction associated steatotic liver disease and sensorineural hearing loss.

In the context of MASLD-related hearing impairment, incorporating additional auditory assessment tools beyond pure tone audiometry may enhance early detection and characterization of subclinical dysfunction. While PTA primarily reflects behavioral thresholds and cochlear sensitivity, objective and functional measures can capture deficits not apparent on routine audiometry. Otoacoustic Emissions (OAE) assess outer hair cell function and can identify early cochlear damage, making them useful for detecting subclinical sensorineural involvement.¹⁸ Brainstem Evoked Response Audiometry (BERA) evaluates neural conduction along the auditory pathway up to the brainstem, enabling detection of subclinical or retro cochlear involvement. A study evaluated BERA in decompensated chronic liver disease and documented abnormalities in auditory pathway conduction. BERA predicted the subclinical neural conduction delays in liver disease, supporting its utility in early detection and monitoring.¹⁹ Additionally, scalable digital tools like the Hear-WHO app offer a rapid, population-level screening approach based on digits-in-noise perception.²⁰ However, it does not differentiate between types of hearing loss and requires confirmatory audiological evaluation. Integrating these complementary tools alongside PTA in both research and clinical settings may provide a more comprehensive evaluation of auditory involvement in MASLD, facilitate early identification of cochlear and neural dysfunction, and improve understanding of the metabolic auditory axis.

Limitations

The review has several limitations. First, only two studies met the inclusion criteria, limiting the strength and generalizability of the evidence. Second, both studies were conducted in Korea, which may reduce applicability to other ethnic and geographic populations. Third, heterogeneity in fatty liver definitions and hearing assessment methods limited direct comparability across studies. Finally, the included studies were observational in design, precluding causal inference between MASLD and hearing impairment.

CONCLUSION

The available evidence suggests a possible association between MASLD and hearing impairment; however, the findings remain preliminary. Consequently, the current evidence is insufficient to establish a robust or clinically meaningful relationship between MASLD and hearing impairment. Further large-scale, multi-ethnic, prospective longitudinal studies with standardized hearing assessments and appropriate adjustment for confounding factors are required to clarify the nature and strength of this association.

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Conflict of interest: None declared

Ethical approval: Not required

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