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Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

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Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

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Abstract

Objective: A systematic analysis was conducted to investigate the association between tinnitus prevalence and daily dietary patterns.

Methods: The PubMed, Embase, Web of Science, and Cochrane Library databases underwent searches from their inception to May 25, 2024. Two evaluators, blinded to the studies, chose observational studies from peer–reviewed English–language journals. These studies examined tinnitus presence or severity in adults aged 18 or older, including associated prevalence estimates. Data extraction was independently conducted by two evaluators, who assessed research bias using the Agency for Newcastle–Ottawa Scale (NOS) and applied evidence classification criteria for aggregate grade strength assessment. This study adhered to the guidelines of the Preferred Reporting Project (PRISMA) and Meta-Analysis of Epidemiological Observational Studies (MOOSE), as well as the PROSPERO Registry protocols. A mixed–effects model combined maximum adjusted estimates, with heterogeneity measured using the I^2 statistic. Sensitivity analysis validated the analysis's robustness, while publication bias was assessed qualitatively and quantitatively.

Results: A total of 10 retrospective studies were identified and included in this analysis, with the last eight studies incorporated into the meta–analysis. Fifteen dietary factors were examined. Fruit intake, dietary fiber, caffeine, and dairy product consumption showed negative correlations with tinnitus prevalence (OR = 0.649, [95% CI 0.532, 0.793], p<0.0001), (OR = 0.918, [95% CI 0.851, 0.990], p = 0.03), (OR = 0.898, [95% CI 0.862, 0.935], p

<0.00001), (OR = 0.827, [95% CI, 0.766 to 0.892], p <0.00001), respectively. A sensitivity analysis affirmed the robustness of the findings.

Conclusions: The systematic review and meta-analysis findings suggest a link between particular dietary elements and a lower occurrence of tinnitus.

Keywords: Diet; Tinnitus; Food intake; Nutrition; Odds ratio

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study conducted a thorough literature screening, assessed the quality of the literature based on international standards, and excluded articles with a high risk of bias.
- This review involved a large population base, improving its representation of fundamental population characteristics and ensuring relatively reliable outcomes.
- There was minimal heterogeneity among the studies regarding the main observations, ensuring the solidity of the findings.
- The relatively small number of included articles may have led to certain beneficial dietary factors (such as vegetables and eggs) not demonstrating significant differences. In addition, due to limited data in the original literature, a dose-effect meta-analysis cannot be supported.
- The majority of included articles were cross-sectional studies, underscoring the necessity for further cohort studies or Mendelian

randomization studies to investigate causal relationships and provide additional clinical evidence for the dietary prevention of tinnitus.

Introduction

Tinnitus, characterized by perceived sounds such as buzzing, cicadas, or electric currents, occurs without external auditory stimuli [1]. It is associated with distress, depression, anxiety, stress, and, in severe cases, suicide, significantly affecting overall quality of life[2 3]. Recent epidemiological data suggests a global pooled prevalence of around 14.4% in adults and 13.6% in children and adolescents[4]. The notable prevalence of tinnitus and its substantial impact on life and mental well–being have increasingly become a significant medical and societal concern.

The origins of tinnitus remain elusive and involve a range of factors. Some researchers have suggested neural dysfunction or circulatory issues in the inner ear, abnormal neuronal activity in central auditory pathways, and irregular activity in nonauditory brain regions like the anterior insula, anterior cingulate cortex, and thalamus[5]. In clinical practice, treatments for tinnitus management include psychological counseling, cognitive–behavioral therapy, tinnitus retraining therapy, sound therapy, repetitive transcranial magnetic stimulation, medication, and surgery. However, only cognitive–behavioral therapy has definitively improved tinnitus prevalence in a large randomized controlled trial[6 7]. Due to an incomplete understanding of central neuropathological mechanisms, no single treatment universally meets the needs of all patients[8 9].

In recent times, there has been a growing push to reduce tinnitus prevalence through dietary adjustments[10 11]. However, the precise connection between diet and tinnitus remains unclear. A population study investigating the correlation between diet and tinnitus among UK adults found a decrease in tinnitus occurrence with higher fruit and vegetable consumption. Conversely, avoiding dairy was linked to a higher risk of tinnitus. On the other hand, abstaining from eggs, adding fish to the diet, and consuming caffeinated beverages were suggested to potentially lower the risk of tinnitus [2]. Another study in British adults showed that higher fat intake was associated with a greater likelihood of experiencing tinnitus[11]. Similarly, Lee and Kim identified risk factors for tinnitus, including low water, protein, riboflavin, and niacin intake, although this was unrelated to fruit and vegetable consumption[12]. Tang et al.[13] found that inadequate fruit fiber (<3.6 g/day) and grain fiber (<4.2 g/day) intake were linked to a 65% and 54% increased risk of developing tinnitus over the next decade, respectively. Conflicting results have hindered researchers' ability to understand the potential benefits of diet; hence, a systematic review on the relationship between diet and tinnitus is needed.

As of now, there has not been a comprehensive examination through systematic reviews or meta-analyses regarding the link between typical dietary patterns and tinnitus. Our objective was to systematically explore this association while accounting for potential confounding variables. The study aimed to furnish clinical evidence to inform the development of dietary prevention approaches for tinnitus.

Method

According to the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) [14], the protocol for this study was appropriately registered on PROSPERO under the registration number CRD42023493856. Additionally, my reporting adheres to the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines for epidemiological observational studies, as referenced [15]. **Supplemental eTable 1** contains the MOOSE listings, while Supplemental 2 outlines the PRISMA guidelines.

Search Strategy

We developed an inclusive search strategy covering diet–related and tinnitus-related subjects to capture pertinent literature from the PubMed, Embase, Web of Science, and Cochrane Library databases. The research design was limited to systematic evaluation. There were no language restrictions imposed on the search, and we considered articles published before May 25, 2024.

The databases were systematically explored using a blend of Medical Subject Headings (MeSH) terms, keywords, and various text word variations related to diet, following the guidance outlined by the Scottish Intercollegiate Guidelines Network: ((tinnitus OR Ringing–Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR variety OR caffeine OR carbohydrate OR protein). The screening process is depicted in **Figure 1.**

The following inclusion criteria were applied: (1) inclusion of cohort, case-control, or cross-sectional studies; (2) inclusion of all individuals in the study population; (3) consideration of various dietary intakes; and (4) investigation of tinnitus as a study outcome. Exclusion criteria comprised: (1) studies involving therapeutic interventions; and (2) randomized controlled trials, animal experiments, cell studies, case reports, literature, and incomplete or invalid sources. (3) Additionally, the original literature lacked sufficient data to calculate the risk ratio for tinnitus.

Data collection

In **Table 1,** data compilation was conducted by two reviewers (SZ, MZ), including authors' names, participant counts, age spans, survey/diagnosis specifics, and information on food and tinnitus. Given the treatment of

Table 1: Basic information to be incorporated into the article.

Author	Total	Age	Time frame	Data from	Study design	Diet recording method	Disease diagnosis	Type of diet
Carlotta Micaela Jarach 2023	383	40-65	2016-2019	The Mario Negri Institute in Milan (Italy) , Monza e Brianza, Italy	case control	Self-designed questionnaire	Interviewer administered questionnaire and the Italian validated version of the tinnitus handicap inventory	coffee, eggs, butter, meat, fish, cheese, fruit, vegetable, varied diet, dairy, milk
Diana Tang 2022	1217	>50	1997-2009	Blue Mountains Hearing Study	cohort	Semi-quantitative food frequency questionnaire， FFQ	Audiologist administered questionnaire	dietary flavonoids
Diana Tang 2021	1730	>50	1997-2009	Blue Mountains Hearing Study	cohort	Semi-quantitative food frequency questionnaire， FFQ	Audiologist administered questionnaire	carbohydrate, sugar, fiber, fruit, vegetable
Piers Dawes 2020	34576	30-69	2006-2010	UK Biobank resource (Collins 2012).	cross-sectional	Dietary assessment was based on the Oxford Web-Q	An epidemiologic method of hearing investigation	fiber; Fat; sugar;
Sang-Yeon Lee 2019	3575	40-64	2012-2013	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	chocolate
Doh Young Lee 2018	7621	40-80	2013-2015	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Diet was assessed with a semi-quantitative food-frequency questionnaire	Self-designed questionnaire	water, protein, fat, carbohydrate, fiber
Sang-Youp Lee 2018	13448	>19	2009-2012	The sixth Korea National Health and Nutrition Examination Survey	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	coffee
Christopher Spankovich 2017	2176	20-69	1999-2002	NHANES	cross-sectional	Dietary recall interviews were conducted during 1999–2002 NHANES MEC evaluations.	Self-designed questionnaire	fat, fruit, vegetable, meat, varied diet
Abby McCormack 2014	171722	40-69	2006-2010	UK Biobank resource (Collins 2012).	cross-sectional	The UK Biobank touchscreen questionnaire	Self-designed questionnaire	fruit, vegetable, fish, egg, sugar, coffee, dairy
Jordan T. Glicksman 2014	65085	30-44(registered)	1991-2009	The Nurses' Health Study II	cross-sectional	Extensively validated semiquantitative food frequency questionnaires	Self-designed questionnaire	coffee

dietary intake as a continuous variable, some researchers have typically performed stratified comparisons based on regional intake standards and researchers' characteristics. This strategy aimed to explore the impact of varying levels of increased intake on tinnitus prevalence. For most continuous variables associated with food intake, adjusted OR values were assimilated in the meta-analysis when stratified according to dose intake, with the exclusion of the reference group. In cases of direct comparison, the singular adjusted OR value was integrated. Further insights on odds ratios (ORs) are provided in **Supplemental eTable 2**.

Literature quality evaluation

The assessment of individual study quality was conducted by two reviewers (SZ and MZ) using a modified version of the Newcastle–Ottawa Scale. Previous grading categorized studies as having a high (<5 stars), moderate (5–7 stars), or low (≥8 stars) risk of bias (see eTable 3 in the Supplement).

Statistical analysis

Data analysis was performed using RevMan (version 5.3) and Stata (version 15.0). Mixed–effect models were utilized to aggregate maximally covariate-adjusted odds ratios (ORs) across all studies. Due to infrequent events and short follow–up periods, odds ratios (ORs), relative risks (RRs), and hazard ratios (HRs) showed approximate equality. Our findings align consistently with our previous results in terms of odds ratios (ORs). In cases where the P value of the Q test was <0.10 or the I^2 statistic exceeded 50%, we conducted an assessment to determine significant interstudy heterogeneity. For observational studies, maximally covariate-adjusted estimates were strongly prioritized. If a study employed an analytical method incongruent with synthesis for the majority of other studies, we either converted the effect estimate to the appropriate combined ratio or excluded the study from the meta-analysis.

In cases of considerable heterogeneity in the analysis with significant differences, meta-regression was utilized to explore the source of heterogeneity (please note**: Meta-regression was considered when the data included in the analysis were greater than 10).** We visually assessed the asymmetry of the funnel plot and used Egger's bias to detect possible publication bias, with estimation of missing studies conducted using eMethods if publication bias was suspected (please note**: Publication bias analysis was considered when the data included in the analysis were greater than 6).** Moreover, we conducted a sensitivity analysis of the pooled results employing a one–by–one exclusion method.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Results

Ten articles were found in the search[2 11-13 16-21]. Among these, two articles delved into individual dietary factors, namely, chocolate [18] and flavonoids [17], which were not investigated in other studies. While these two articles were included in the narrative review, they were excluded from the meta-analysis. The remaining eight articles comprised the dataset for the meta-analysis.

Fifteen common dietary factors were analyzed, and dietary sources were assessed using validated nutrition/diet questionnaires. The combined findings revealed that four diets (caffeine, fruit, dietary fiber, and dairy products) exhibited a negative association with the prevalence of tinnitus.

A meta-analysis of dietary factors

The meta-analysis included eight studies with a total of 301,533 people and analyzed 15 dietary factors, as shown **in Figure 2**: carbohydrates (2/8, **Supplemental eFigure 1**), caffeine (4/8, **Supplemental eFigure 2**), varied diets (2/8, **Supplemental eFigure 3**), eggs (2/8, **Supplemental eFigure 4**), fruits (3/9, **Supplemental eFigure 5**), fiber (2/8, **Supplemental eFigure 6**), fat (3/8, **Supplemental eFigure 7**), margarine (2/8, **Supplemental eFigure 8**), meat (2/8, **Supplemental eFigure 9**), sugar (4/8, **Supplemental eFigure 10**), protein (2/8, **Supplemental eFigure 11**), fish (3/8, **Supplemental eFigure 12**), vegetables (4/8, **Supplemental eFigure 13**), water (3/8, **Supplemental eFigure 14**), and dairy (2/8, **Supplemental eFigure 15**). The summary results are depicted **in Figure**

2. Intake of dairy products, fruits, dietary fiber, and caffeine showed negative correlations with the prevalence of tinnitus: 0.827 for dairy [95% CI 0.766–0.892], $I^2 = 0\%$, $p < 0.00001$; 0.649 for fruit [95% CI 0.532–0.793], $I^2 = 0\%$, $p < 0.0001$; 0.918 for fiber [95% CI 0.851–0.990], $I^2 = 63\%$, $p = 0.03$; and 0.898 for caffeine [95% CI 0.862–0.935], $I^2 = 23\%$, $p < 0.003$. Protein intake t increased the risk of tinnitus (OR = 1.002 [95% CI 1.001–1.004], $I^2 = 0\%$, $p = 0.009$). No associations were found between other dietary factors and tinnitus.

Sensitivity analysis

We conducted sensitivity analyses for various dietary intakes based on predefined analysis criteria (requiring data from included articles to exceed 6). Contradictory outcomes were noted in the aggregated results for caffeine **(**refer to **Supplemental eFigure 16)**, with the analysis attributing these contradictions to data within the same article (Abby McCormack 2014). Sequential exclusion of fruit **(**refer to **Supplemental eFigure 17)** and dietary fiber **(**refer to **Supplemental eFigure 18)** maintained the statistical significance of the combined odds ratio. Successive exclusion of summary results for vegetables **(**refer to **Supplemental eFigure 19)** and sugar **(**refer to **Supplemental eFigure 20)** revealed no contradictory outcomes in the combined odds ratio; thus, ensuring the robustness of the meta-analysis results. The comprehensive sensitivity analysis indicated the relative robustness of the meta-analysis results, confirming the association of fruit and dietary fiber intake with the prevalence of tinnitus. No significant associations between other dietary intakes and tinnitus were found.

Publication bias

The funnel plot and Egger test findings for caffeine, fruit, vegetables, diet, sugar, and fat indicated the presence of publication bias (**Supplemental eFigure 21 − 26**). We performed a supplementary analysis using the shear compensation method, yielding consistent results that suggest publication bias did not impact the main outcome.

Discussion

In this systematic review and meta-analysis involving eight observational studies (comprising a total of 301,533 participants), we discovered that increased dietary consumption of fruit, dietary fiber, dairy products, and caffeine was associated with a reduced occurrence of tinnitus. These reductions were 35.1% (20.7%–46.8%) for fruit intake, 9.2% (1%–14.9%) for dietary fiber, 17.3% (10.8%–23.4%) for dairy products, and 10.2% (6.5%–13.8%) caffeine intake, respectively. These results were consistently supported by sensitivity analysis.

The association between caffeine intake and tinnitus remains contentious. Our final findings indicate a positive impact of caffeine on reducing tinnitus occurrence. Some suggest that caffeine might effectively decrease tinnitus prevalence, possibly due to its anxiety-reducing effects. Conversely, some scholars argue that individuals with tinnitus often experience insomnia, which caffeine consumption could worsen; thus, exacerbating tinnitus symptoms. Recent observational studies [22 23] found no link between caffeine consumption and depression or anxiety levels. Furthermore, additional dose analysis revealed a J–pattern association between caffeine intake and psychiatric disorders, with around 2–3 cups per day associated with decreased risk [24]. Caffeine, acting as a nonselective adenosine receptor antagonist, can mitigate anxiety when ingested at a daily dose of 10 mg/kg [25]. Genetic analysis also suggests a correlation between caffeine consumption and reduced tinnitus prevalence [26]. This effect is achieved through adenosine receptor blockade, dopamine release promotion, acetylcholinesterase activity inhibition, and sympathetic nerve stimulation.

Most academics argue that there is a relationship between dietary fiber and fruit intake and the decrease in tinnitus [11 13 20 27], which corresponds to our findings. Some scholars propose that dietary fiber is associated with enhanced insulin sensitivity[28]. Studies indicate that hyperinsulinemia from low insulin sensitivity could disturb the inner ear environment, potentially raising tinnitus risk [29 30]. Conversely, research suggests that fiber and dairy products might enhance blood vessel function[31], a factor correlated with tinnitus. Abnormal microcirculation, for instance, contributes to a sustained reduction in ear blood flow, potentially leading to cochlear damage and increasing tinnitus risk [13].

Unexpectedly, our combined analysis found no correlation between vegetable consumption and tinnitus. Identifying the source of heterogeneity was difficult due to the limited number of articles. Nevertheless, sensitivity analyses reaffirm the strength of our conclusions. Vegetables and fruits, rich in diverse vitamins and minerals crucial for maintaining health, have been shown to improve ear microcirculation, alleviate tinnitus, and offer additional benefits [12 27]. Future studies are expected to shed more light on the discrepancies in results.

Our findings indicate that protein increase the occurrence of tinnitus (OR = 1.002, [95% CI 1.001–1.004], $p = 0.009$). Protein is a crucial nutrient requiring daily consumption and plays a vital role in supporting neuronal activity and neural development[32 33]. Inadequate protein intake can lead to ototoxic side effects and impair the neural function of the auditory system[34]. Dawes et al.'s study demonstrated that a higher intake of dietary pattern factor 3 (high protein) was linked to a reduced likelihood of tinnitus[11]. Although low-protein diets may affect auditory vestibular function, no studies specify the necessary amount of protein in the diet. Our analysis found the links between protein intake and tinnitus risk. Moreover, high–protein diets have been shown to induce oxidative stress in the cerebral cortex and hypothalamus of rats[35]. Hence, further research on the relationship between protein dosage and tinnitus is warranted in the future.

In line with our analysis, no significant effect of sugar intake on tinnitus was observed (OR = 0.997 [95% CI 0.967, 1.027]). Sugars, water, and carbohydrate are essential daily components, and no links with tinnitus have been identified. High sugar consumption is typically associated with an unhealthy lifestyle. Proinflammatory foods, including sugary items, are often linked to increased not only systemic inflammation but also to microvascular damage, particularly microischemic events[36]. Elevated blood glucose levels can harm small blood vessels and nerves in the inner ear, leading to pathological alterations in outer hair cells and spiral ganglion cells. This can result in nerve tissue ischemia and hypoxia, leading to nerve damage[34]. Conversely, Spankovich et al. demonstrated that high carbohydrate intake can prevent hearing loss in older adults[37]. Tang et al. showed a 45% decrease in tinnitus risk for participants in the fourth quartile compared to the first quartile of carbohydrate intake [13]. Lee et al. discovered a significant correlation between reduced water intake and tinnitus–related difficulties in young and middle–aged adults[12]. Additionally, Yang et al. found that adequate water intake and a low–sodium diet improved hearing and alleviated vertigo and tinnitus in patients with Meniere's disease [38].

Both excessive and insufficient dietary intake may have adverse effects on tinnitus, underscoring the need for a dose–response analysis of diet, which would provide valuable insights for dietary tinnitus prevention. Several studies have suggested that increasing the score of healthy foods, such as fruits, vegetables, legumes, nuts, fish, and dairy products, may lower the risk of cardiovascular disease and mortality[39-41]. With each one-fifth increase in the healthy diet score, there was a corresponding decrease in overall mortality rate (HR = 0.92; 0.90–0.93), severe cardiovascular disease (HR = 0.94; 95% CI: 0.93–0.95), myocardial infarction (HR = 0.94; 0.92–0.96), stroke (HR = 0.94; 0.89–0.99), and death or cardiovascular disease (HR = 0.93; 0.92–0.94[42]) .

The outcomes of our analysis did not firmly support a notable connection between fat intake and tinnitus risk, although there was a discernible upward trend. Moreover, high-fat diets contribute to obesity and can lead to insulin resistance[43]. Conversely, adopting a low–fat/low–cholesterol diet might aid in reducing blood cholesterol and triglyceride levels, potentially alleviating tinnitus symptoms[44]. Future studies are needed to verify the relationship between the fat and tinnitus.

A recent study uncovered that increased levels of dietary variety, covering quantity, evenness, and quality, were inversely linked to the risk of depressive symptoms, especially among women and older adults[45]. This could potentially offer relief for tinnitus. Moreover, dietary variety is believed to correlate with insulin resistance[46]. Given the protective effects various diets have shown on human health, further exploration of dietary variety is necessary to validate significant associations. Our pooled analysis indicated that a varied diet was not significantly linked to reduced tinnitus prevalence (OR = 0.653 [95% CI 0.410, 1.038]). However, the favorable end of the 95% confidence interval was prominent, hinting at the potential benefits of a varied diet. Nonetheless, this warrants confirmation through additional studies in the future.

We found only one study that investigated the impact of chocolate and flavonoids on the onset of tinnitus [18], but it did not provide sufficient data for a meta-analysis. Flavonoids, found abundantly in fruits and vegetables, offer antioxidant, anti-inflammatory, and vascular health benefits, which align with the pathophysiology of age-related hearing loss and tinnitus[47]. Additionally, flavonoids interact with signaling cascades involving protein and lipid kinases, inhibiting neuronal death induced by neurotoxicants like oxygen radicals and promoting neuronal survival and synaptic plasticity[48]. Despite the hypothesis that dietary flavonoids might protect against tinnitus development over a 10-year period, Tang et al. [47]. did not support this idea. However, it is important to note that this study had limitations, such as insufficient data collection.

Chocolate is a globally consumed product renowned for its high phenolic compound content (flavonoids being a subclass of polyphenols) [49]. A study by Lee et al. indicated that chocolate consumption is not linked to tinnitus or tinnitus–related issues[18]. An animal study demonstrated that polyphenols alleviate oxidative stress in the cochlea by suppressing apoptotic signaling pathways[50]. Nonetheless, excessive chocolate consumption can have adverse effects on brain hyperexcitability[51]. Future investigations into the association between chocolate consumption and tinnitus should take into account the intake dosage.

This systematic review and meta-analysis mark the first attempt to explore the epidemiological link between diet and tinnitus. While we examined the relationships between fruit, dietary fiber, and caffeine intake and a reduced prevalence of tinnitus, it remains inconclusive whether a causal relationship exists. Additionally, prolonged exposure to stress emerged as a significant predisposing factor for tinnitus[52].

Conclusion

Diet–based strategies for tinnitus prevention are anticipated to play a significant role in chronic tinnitus management. Existing evidence suggests that consuming fruit, dietary fiber, caffeine, and dairy may be associated with a reduced prevalence of tinnitus. The primary underlying mechanisms may involve the protective effects of these diets on blood vessels and nerves, as well as their anti-inflammatory and antioxidant properties. However, it is crucial to interpret our findings cautiously due to the overall low quality of the evidence available. In the future, further well-designed, large-scale, cross-population cohort studies are warranted to complement and verify the relationship between dietary intake and tinnitus. Additionally, focusing on the dosage and categorization of each dietary intake would provide valuable insights.

Author Contribution

All authors contributed to the study's conception and design. SZ, MZ, XW, YJ conducted data collection and analysis. SZ, QZ designed the test plan. QF as the paper guide, control the quality of the paper, XH, XL, XW, HW drew the chart. XC, LW, LF completed the writing of the test plan. XL and QZ revised the manuscript.

Author Declaration

The author has no direct conflict of interest.

Ethical Approval

The article belongs to the review category and does not require the approval of the ethics committee.

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Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

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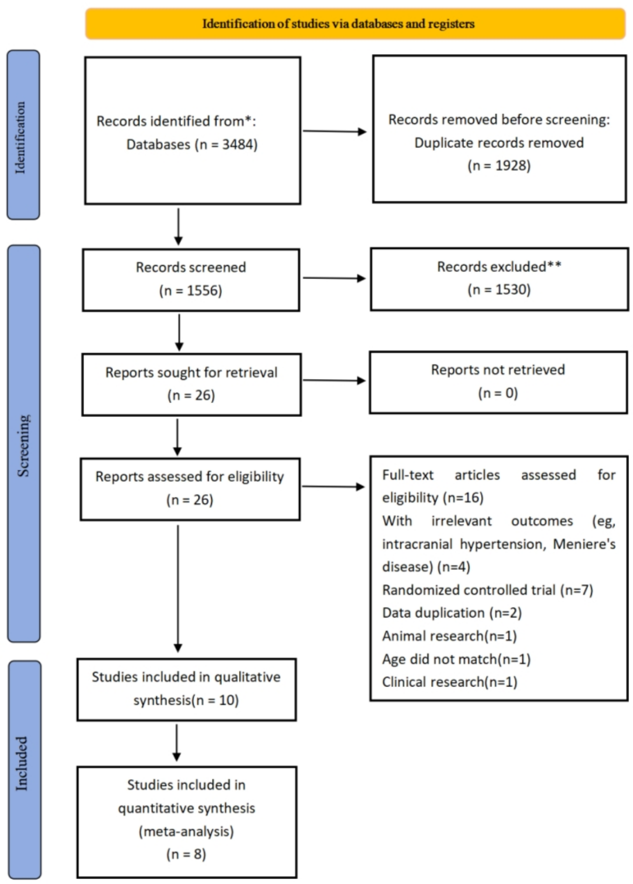
Figure 1: Flow chart

Figure 2: Risk ratio summary of diet and tinnitus prevalence



*means: The search results of the four databases according to the pre-specified database search strategy.
**means: The process of selecting articles for title and abstract based on inclusion exclusion criteria.

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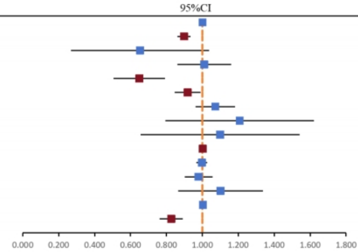
Type of diet	Study, n	I^2	OR	LOR	UOR	95%CI	Grade	Evidence class
Carbohydrate	2	33.0%	1.001	1.000	1.002		Low	NS
Caffeine	3	23.0%	0.898	0.862	0.935		Low	Class II
Varied diet	2	50.0%	0.653	0.410	1.038		Very low	NS
Egg	2	55.0%	1.010	0.880	1.160		Very low	NS
Fruit	3	0.0%	0.649	0.532	0.793		Moderate	Class II
Fiber	3	63.0%	0.918	0.851	0.990		Low	Class II
Fat	3	73.0%	1.072	0.973	1.181		Very low	NS
Margarine	2	0.0%	1.208	0.900	1.622		Low	NS
Meat	2	0.0%	1.099	0.783	1.542		Low	NS
Protein	2	0.0%	1.002	1.001	1.004		Low	Class III
Sugar	3	0.0%	0.997	0.967	1.027		Low	NS
Fish	3	72.0%	0.979	0.907	1.056		Very low	NS
Vegetable	4	0.0%	1.101	0.907	1.337		Very low	NS
Water	3	0.0%	1.003	0.992	1.014		Low	NS
Dairy	2	0.0%	0.827	0.766	0.892		Low	Class II



The blue or red dots represent OR values, and the black linesrepresent confidence intervals
$p<0.05$ indicates statistical difference.
The evidence classification criteria: Class I (convincing evidence), Class II (highly suggestive evidence), Class III (suggestive evidence), Class IV (weak evidence), and NS (non-significant).
GRADE:Grade of Recommendations Assessment, Development, and Evaluation.
Moderate: The results of current efficacy evaluation are likely to be close to the true value;
Low: The reliability of the current efficacy evaluation results is uncertain;
Very low: The reliability of the current efficacy evaluation results is very uncertain;

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Catalogue

Search Strategy

Search Strategy Free text search strategy: Initial search date: 25 May 2024

PubMed 1216

(tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate).

EMBASE 1942

('Tinnitus'/exp OR 'Tinnitus':ab,ti,kw OR 'Ringing-Buzzing'/exp OR 'Ringing-Buzzing':ab,ti,kw OR 'ear buzzing':ab,ti,kw) AND (('Diet'/exp OR 'Diets':ab,ti,kw) OR ('Food'/exp OR 'Food':ab,ti,kw OR 'Foods':ab,ti,kw) OR ('Water'/exp OR 'Water':ab,ti,kw OR 'Hydrogen Oxide':ab,ti,kw) OR ('Milk'/exp OR 'Milk':ab,ti,kw OR 'Cow Milk':ab,ti,kw) OR ('fish'/exp OR 'fish':ab,ti,kw) OR ('vegetable'/exp OR 'vegetable':ab,ti,kw) OR ('Dietary Fiber'/exp OR 'alimentary fiber':ab,ti,kw) OR ('sugar'/exp OR 'sugar':ab,ti,kw) OR ('meat'/exp OR 'meat':ab,ti,kw OR 'sausage':ab,ti,kw) OR ('margarine'/exp OR 'margarine':ab,ti,kw OR 'oleomargarine':ab,ti,kw) OR ('fat'/exp OR 'fat':ab,ti,kw) OR ('egg'/exp OR 'egg':ab,ti,kw) OR ('varietas'/exp OR 'plant variety':ab,ti,kw) OR ('caffeine'/exp OR 'caffeine':ab,ti,kw OR 'coffein':ab,ti,kw) OR ('carbohydrate'/exp OR 'carbohydrate':ab,ti,kw OR 'carbon hydrate':ab,ti,kw OR 'synthetic carbohydrate':ab,ti,kw OR 'saccharide':ab,ti,kw) OR ('protein'/exp OR 'protein':ab,ti,kw))

Web of Science 29

("Tinnitus"(Topic) OR "Tinnitus"(Topic) OR "Ringing-Buzzing"(Topic) OR "Ringing-Buzzing"(Topic) OR "ear buzzing"(Topic)) AND (("Diet"(Topic) OR "Diets"(Topic)) OR ("Food"(Topic) OR "Foods"(Topic)) OR ("Water"(Topic) OR "Hydrogen Oxide"(Topic)) OR ("Milk"(Topic) OR "Cow Milk"(Topic)) OR ("fish"(Topic)) OR ("vegetable"(Topic)) OR ("Dietary Fiber"(Topic) OR "alimentary fiber"(Topic)) OR ("sugar"(Topic)) OR ("meat"(Topic) OR "sausage"(Topic)) OR ("margarine"(Topic) OR "oleomargarine"(Topic)) OR ("fat"(Topic)) OR ("egg"(Topic)) OR ("varietas"(Topic) OR "plant variety"(Topic)) OR ("caffeine"(Topic) OR "coffein"(Topic)) OR ("carbohydrate"(Topic) OR "carbon hydrate"(Topic) OR "synthetic carbohydrate"(Topic) OR "saccharide"(Topic)) OR ("protein"(Topic)))

Cochrane 297

((tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate) in Title Abstract Keyword

Stata analysis

We used mixed-effects models to pool maximally covariate-adjusted odds ratios (ORs) from each study. Due to the low incidence of events and short follow-up events, OR, RR, and HR were approximately equal, so our results were uniformly expressed in OR. If the P-value of the q test was <0.10 or the I^2 statistic was ≥50%, we assessed and considered the inter-study heterogeneity to be significant. For observational studies, we maximally support covariate-adjusted estimates. If a study uses an analytical method that is incompatible with synthesis for most other studies, we convert the effect estimate to the appropriate combined ratio or exclude the study from the meta-analysis.

Publication bias

If the article heterogeneity is large in the analysis with statistical differences, we will use meta regression to investigate the source of heterogeneity. We assessed the asymmetry of the funnel plot with visual and Egger's bias, and estimated the possible missing studies with eMethods if publication bias is suspected.

Analysis software

We conducted all analyses using stata (version 16) and Review Manager (version 5.3). Unless otherwise specified, we considered a two-sided P value of <0.05 as statistically significant.

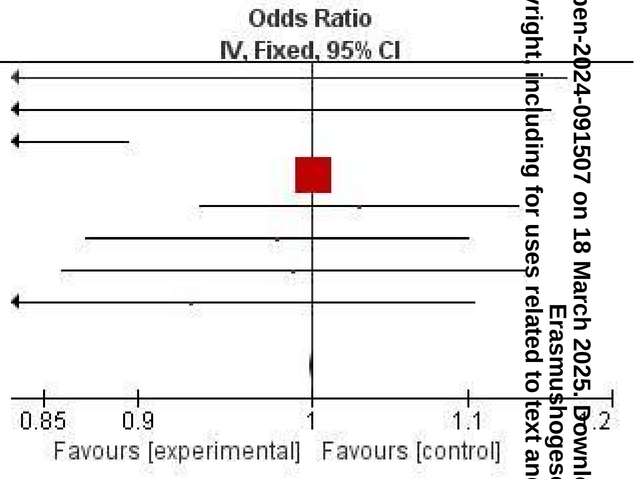
eFigure 1: Forest Plot Showing the Association Between carbohydrate and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.

Carbohydrate: OR=1.00, [95%CI 1.00,1.00], I^2=33%, p=0.05.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Diana Tang 2021a	-0.3011051	0.2326598	0.0%	0.74 [0.47, 1.17]
Diana Tang 2021b	-0.3024573	0.2282614	0.0%	0.74 [0.47, 1.16]
Diana Tang 2021c	-0.597837	0.2483288	0.0%	0.55 [0.34, 0.89]
Doh Young Lee 2018	0.0009995	0.0005102	100.0%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0295588	0.0492101	0.0%	1.03 [0.94, 1.13]
Piers Dawes 2020b	-0.0202027	0.059233	0.0%	0.98 [0.87, 1.10]
Piers Dawes 2020c	-0.0100503	0.0719008	0.0%	0.99 [0.86, 1.14]
Piers Dawes 2020d	-0.0725707	0.0876968	0.0%	0.93 [0.78, 1.10]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 10.46, df = 7 (P = 0.16); I² = 33%
Test for overall effect: Z = 1.95 (P = 0.05)

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            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Diana Tang 2021a     |  0.740       0.469     1.168          0.00
Diana Tang 2021b     |  0.739       0.472     1.156          0.00
Diana Tang 2021c     |  0.550       0.338     0.895          0.00
Doh Young Lee 2018   |  1.001       1.000     1.002         99.97
Piers Dawes 2020a    |  1.030       0.935     1.134          0.01
Piers Dawes 2020b    |  0.980       0.873     1.101          0.01
Piers Dawes 2020c    |  0.990       0.860     1.140          0.01
Piers Dawes 2020d    |  0.930       0.783     1.104          0.00
---------------------+---------------------------------------------------
I-V pooled ES        |  1.001       1.000     1.002        100.00
---------------------+---------------------------------------------------
```

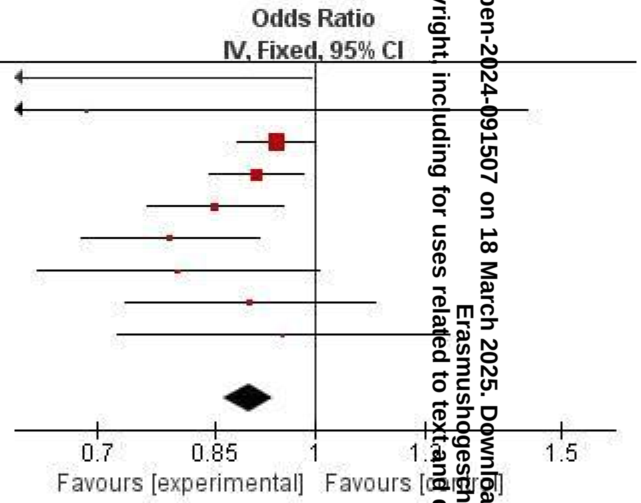
Actually: Carbohydrate: OR=1.001, [95%CI 1.000,1.002]

eFigure 2: Forest Plot Showing the Association Between caffeine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Caffeine: OR=0.90, [95%CI 0.86,0.94], I^2=23% p<0.000001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.7133499	0.3614964	0.3%	0.49 [0.24, 1.00]
Carlotta Micaela Jarach 2023b	-0.3710637	0.36645	0.3%	0.69 [0.34, 1.42]
Jordan T Glicksman 2014a	-0.0618754	0.0326106	40.8%	0.94 [0.88, 1.00]
Jordan T Glicksman 2014b	-0.0943106	0.0393242	28.0%	0.91 [0.84, 0.98]
Jordan T Glicksman 2014c	-0.1625189	0.0569244	13.4%	0.85 [0.76, 0.95]
Jordan T Glicksman 2014d	-0.2357223	0.0743244	7.8%	0.79 [0.68, 0.91]
Sang-Youp Lee 2018	-0.2231435	0.1178662	3.1%	0.80 [0.63, 1.01]
Sang-Youp Lee 2018b	-0.1053605	0.1045972	4.0%	0.90 [0.73, 1.10]
Sang-Youp Lee 2018c	-0.0512933	0.1386774	2.3%	0.95 [0.72, 1.25]
Total (95% CI)			**100.0%**	**0.90 [0.86, 0.94]**

Heterogeneity: Chi² = 10.43, df = 8 (P = 0.24); I² = 23%
Test for overall effect: Z = 5.18 (P < 0.00001)

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              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.490       0.241     0.995          0.33
Carlotta Micaela Jar |  0.690       0.336     1.415          0.32
Jordan T 2014a       |  0.940       0.882     1.002         40.76
Jordan T 2014b       |  0.910       0.842     0.983         28.03
Jordan T 2014c       |  0.850       0.760     0.950         13.38
Jordan T 2014d       |  0.790       0.683     0.914          7.85
Sang-Youp Lee 2018   |  0.800       0.635     1.008          3.12
Sang-Youp Lee 2018   |  0.900       0.733     1.105          3.96
Sang-Youp Lee 2018   |  0.950       0.724     1.247          2.25
---------------------+---------------------------------------------------
I-V pooled ES        |  0.898       0.862     0.935        100.00
---------------------+---------------------------------------------------
```

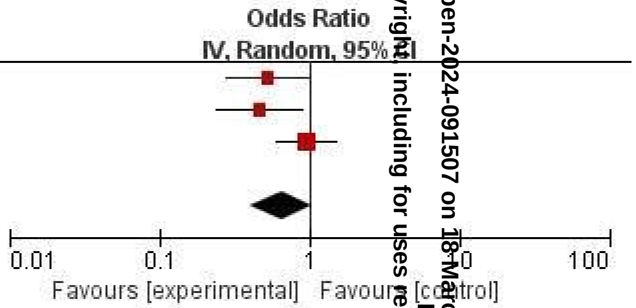
Actually: Caffeine: OR=0.898, [95%CI 0.862,0.935]

eFigure 3: Forest Plot Showing the Association Between diversity and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Diversity: OR=0.65, [95%CI 0.41,1.04], I^2=50% p=0.08.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlotta Micaela Jarach 2023a	-0.6348783	0.3247361	29.9%	0.53 [0.28, 1.00]
Carlotta Micaela Jarach 2023b	-0.7550226	0.3371826	28.7%	0.47 [0.24, 0.91]
Christopher Spankovich 2017	-0.0444	0.2295	41.4%	0.96 [0.61, 1.50]
Total (95% CI)			**100.0%**	**0.65 [0.41, 1.04]**

Heterogeneity: Tau² = 0.09; Chi² = 3.98, df = 2 (P = 0.14); I² = 50%
Test for overall effect: Z = 1.78 (P = 0.08)

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. metan logrr selogrr, label(namevar=author) random eform

             Study     |     ES    [95% Conf. Interval]     % Weight
-----------------------+---------------------------------------------------
Carlotta Micaela Jar   |  0.530       0.280     1.002          29.86
Carlotta Micaela Jar   |  0.470       0.243     0.910          28.60
Christopher Spankovi   |  0.950       0.606     1.490          41.54
-----------------------+---------------------------------------------------
D+L pooled ES          |  0.653       0.410     1.038         100.00
-----------------------+---------------------------------------------------
```

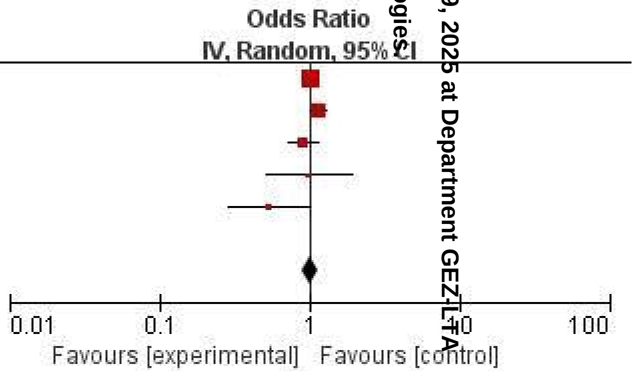
Actually: diversity: OR=0.653, [95%CI 0.410, 1.038].

eFigure 4: Forest Plot Showing the Association Between egg and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis.
Egg: OR=1.02, [95%CI 0.91,1.15], I^2=55% p=0.75.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Abby McCormack 2014a	0.0304592	0.0274031	43.4%	1.03 [0.98, 1.09]
Abby McCormack 2014b	0.1392621	0.0589045	32.9%	1.15 [1.02, 1.29]
Abby McCormack 2014c	-0.10436	0.1166166	17.3%	0.90 [0.72, 1.13]
Carlotta Micaela Jarach 2023a	-0.0100503	0.338181	3.0%	0.99 [0.51, 1.92]
Carlotta Micaela Jarach 2023b	-0.6161861	0.3157843	3.4%	0.54 [0.29, 1.00]
Total (95% CI)			**100.0%**	**1.02 [0.91, 1.15]**

Heterogeneity: Tau² = 0.01; Chi² = 8.83, df = 4 (P = 0.07); I² = 55%
Test for overall effect: Z = 0.32 (P = 0.75)



```
. metan logrr selogrr, label(namevar=author) random eform

           Study      |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  1.031       0.926     1.148          36.13
Abby McCormack 2014a |  1.149       1.024     1.290          35.00
Abby McCormack 2014b |  0.901       0.717     1.133          20.41
Carlotta Micaela Jar |  0.990       0.510     1.921           3.97
Carlotta Micaela Jar |  0.540       0.291     1.003           4.50
---------------------+---------------------------------------------------
D+L pooled ES        |  1.010       0.880     1.160         100.00
---------------------+---------------------------------------------------
```

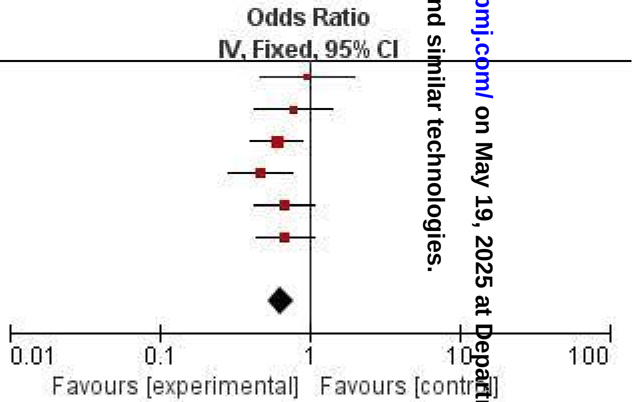
Actually: diversity: OR=1.010, [95%CI 0.880, 1.160].

eFigure 5: Forest Plot Showing the Association Between fruit and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fruit: OR=0.65, [95%CI 0.53,0.79], I^2=0% p<0.0001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.040822	0.3655756	7.7%	0.96 [0.47, 1.97]
Carlotta Micaela Jarach 2023b	-0.2484614	0.3083197	10.9%	0.78 [0.43, 1.43]
Christopher Spankovich 2017	-0.4942963	0.2033897	25.0%	0.61 [0.41, 0.91]
Diana Tang 2021a	-0.7550226	0.2457749	17.1%	0.47 [0.29, 0.76]
Diana Tang 2021b	-0.3856625	0.230163	19.5%	0.68 [0.43, 1.07]
Diana Tang 2021c	-0.3710637	0.2290667	19.7%	0.69 [0.44, 1.08]
Total (95% CI)			**100.0%**	**0.65 [0.53, 0.79]**

Heterogeneity: Chi² = 3.43, df = 5 (P = 0.63); I² = 0%
Test for overall effect: Z = 4.24 (P < 0.0001)



```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.960       0.469     1.965          7.74
Carlotta Micaela Jar |  0.780       0.426     1.427         10.88
Christopher Spankovi |  0.610       0.409     0.909         25.01
Diana Tang 2021a     |  0.470       0.290     0.761         17.13
Diana Tang 2021b     |  0.680       0.433     1.068         19.53
Diana Tang 2021d     |  0.690       0.440     1.081         19.72
---------------------+---------------------------------------------------
I-V pooled ES        |  0.649       0.532     0.793        100.00
---------------------+---------------------------------------------------
```

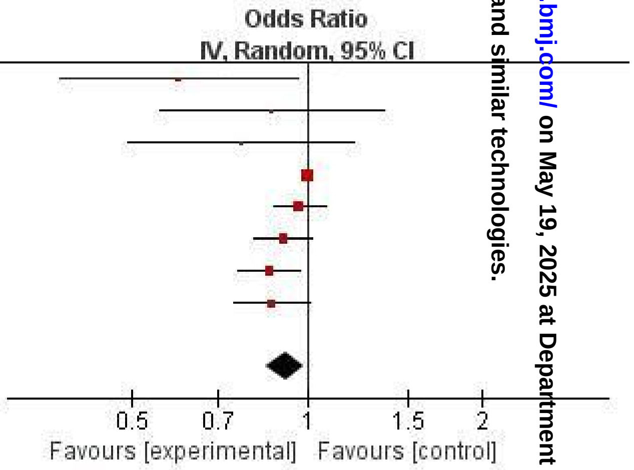
Actually: fruit: OR=0.649, [95%CI 0.532, 0.793].

eFigure 6: Forest Plot Showing the Association Between fiber and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Fiber: OR=0.92, [95%CI 0.85,0.99], I^2=63% p=0.03.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Diana Tang 2021a	-0.5108256	0.243222	2.3%	0.60 [0.37, 0.97]
Diana Tang 2021b	-0.1392621	0.2282217	2.6%	0.87 [0.56, 1.36]
Diana Tang 2021c	-0.2613648	0.2306047	2.5%	0.77 [0.49, 1.21]
Doh Young Lee 2018	0.003992	0.0022879	27.8%	1.00 [1.00, 1.01]
Piers Dawes 2020a	-0.0304592	0.0527859	18.3%	0.97 [0.87, 1.08]
Piers Dawes 2020b	-0.0943106	0.0588071	16.9%	0.91 [0.81, 1.02]
Piers Dawes 2020c	-0.1508229	0.0622392	16.1%	0.86 [0.76, 0.97]
Piers Dawes 2020d	-0.1392621	0.0759266	13.4%	0.87 [0.75, 1.01]
Total (95% CI)			**100.0%**	**0.92 [0.85, 0.99]**

Heterogeneity: Tau² = 0.01; Chi² = 19.09, df = 7 (P = 0.008); I² = 63%
Test for overall effect: Z = 2.21 (P = 0.03)



```
. metan logrr selogrr, label(namevar=author) random eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Diana Tang 2021a     |  0.600      0.372     0.966          2.31
Diana Tang 2021b     |  0.870      0.556     1.361          2.59
Diana Tang 2021d     |  0.770      0.490     1.210          2.54
Doh Young Lee 2018   |  1.004      1.000     1.009         27.81
Piers Dawes 2020a    |  0.970      0.875     1.076         18.30
Piers Dawes 2020b    |  0.910      0.811     1.021         16.90
Piers Dawes 2020c    |  0.860      0.761     0.972         16.14
Piers Dawes 2020d    |  0.870      0.750     1.010         13.40
---------------------+---------------------------------------------------
D+L pooled ES        |  0.918      0.851     0.990        100.00
---------------------+---------------------------------------------------
```

Actually: fruit: OR=0.918, [95%CI 0.851, 0.990].

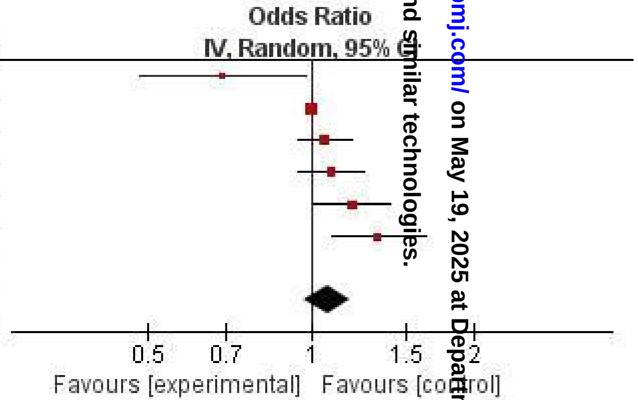
eFigure 7: Forest Plot Showing the Association Between fat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Fat: OR=1.07, [95%CI 0.97,1.18], I²=73% p=0.16.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Christopher Spankovich 2017	-0.3710637	0.1794132	5.9%	0.69 [0.49, 0.98]
Doh Young Lee 2018	0.0029955	0.0010173	27.8%	1.00 [1.00, 1.01]
Piers Dawes 2020a	0.0582689	0.0574609	20.2%	1.06 [0.95, 1.19]
Piers Dawes 2020b	0.0861777	0.0700094	17.8%	1.09 [0.95, 1.25]
Piers Dawes 2020c	0.1739534	0.0832964	15.5%	1.19 [1.01, 1.40]
Piers Dawes 2020d	0.285179	0.1010838	12.8%	1.33 [1.09, 1.62]
Total (95% CI)			**100.0%**	**1.07 [0.97, 1.18]**

Heterogeneity: Tau² = 0.01; Chi² = 18.68, df = 5 (P = 0.002); I² = 73%

Test for overall effect: Z = 1.41 (P = 0.16)



```
. metan logrr selogrr, label(namevar=author) random eform

            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Christopher Spankovi |  0.690       0.485     0.981          5.95
Doh Young Lee 2018   |  1.003       1.001     1.005         27.75
Piers Dawes 2020a    |  1.060       0.947     1.186         20.17
Piers Dawes 2020b    |  1.090       0.950     1.250         17.81
Piers Dawes 2020c    |  1.190       1.011     1.401         15.50
Piers Dawes 2020d    |  1.330       1.091     1.621         12.82
---------------------+---------------------------------------------------
D+L pooled ES        |  1.072       0.973     1.181        100.00
---------------------+---------------------------------------------------
```

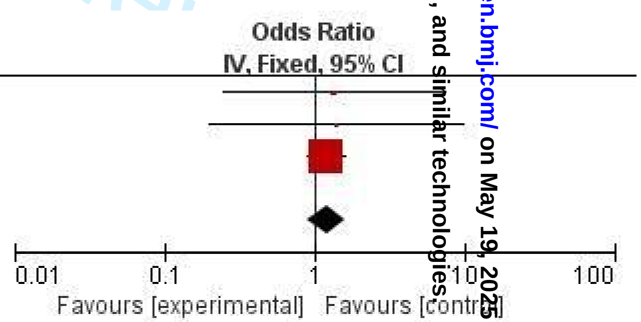
Actually: fat: OR=1.072, [95%CI 0.973, 1.181].

eFigure 8: Forest Plot Showing the Association Between margarine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Margarine: OR=1.21, [95%CI 0.90,1.63], I^2=0% p=0.20.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3001046	0.8652602	3.0%	1.35 [0.25, 7.36]
Carlotta Micaela Jarach 2023b	0.3364722	0.9974543	2.3%	1.40 [0.20, 9.89]
Milena Tomanic 2020	0.1856494	0.154809	94.7%	1.20 [0.89, 1.63]
Total (95% CI)			**100.0%**	**1.21 [0.90, 1.63]**

Heterogeneity: Chi² = 0.04, df = 2 (P = 0.98); I² = 0%
Test for overall effect: Z = 1.28 (P = 0.20)



```
. metan logrr selogrr, label(namevar=author) fixed eform

             Study    |     ES    [95% Conf. Interval]     % Weight
----------------------+---------------------------------------------------
Carlotta Micaela Jar  |  1.350       0.248      7.359          3.01
Carlotta Micaela Jar  |  1.400       0.198      9.889          2.27
Milena Tomanic 2020   |  1.200       0.887      1.624         94.72
----------------------+---------------------------------------------------
I-V pooled ES         |  1.208       0.900      1.622        100.00
----------------------+---------------------------------------------------
```

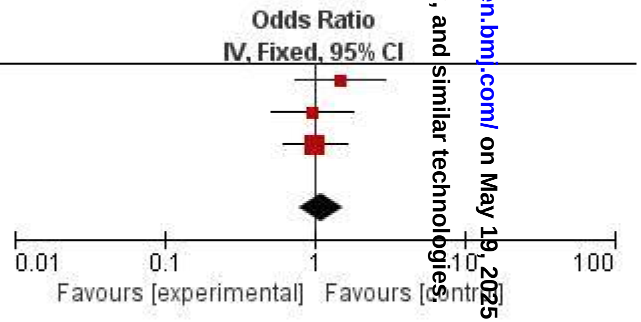
Actually: margarine: OR=1.208, [95%CI 0.900, 1.622].

eFigure 9: Forest Plot Showing the Association Between meat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Meat: OR=1.10, [95%CI 0.78,1.54], I^2=0% p=0.59.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3987761	0.3484928	24.6%	1.49 [0.75, 2.95]
Carlotta Micaela Jarach 2023b	-0.0304592	0.3287067	27.6%	0.97 [0.51, 1.85]
Christopher Spankovich 2017	0.0099503	0.2496967	47.8%	1.01 [0.62, 1.65]
Total (95% CI)			**100.0%**	**1.10 [0.78, 1.54]**

Heterogeneity: Chi² = 1.02, df = 2 (P = 0.60); I² = 0%
Test for overall effect: Z = 0.55 (P = 0.59)



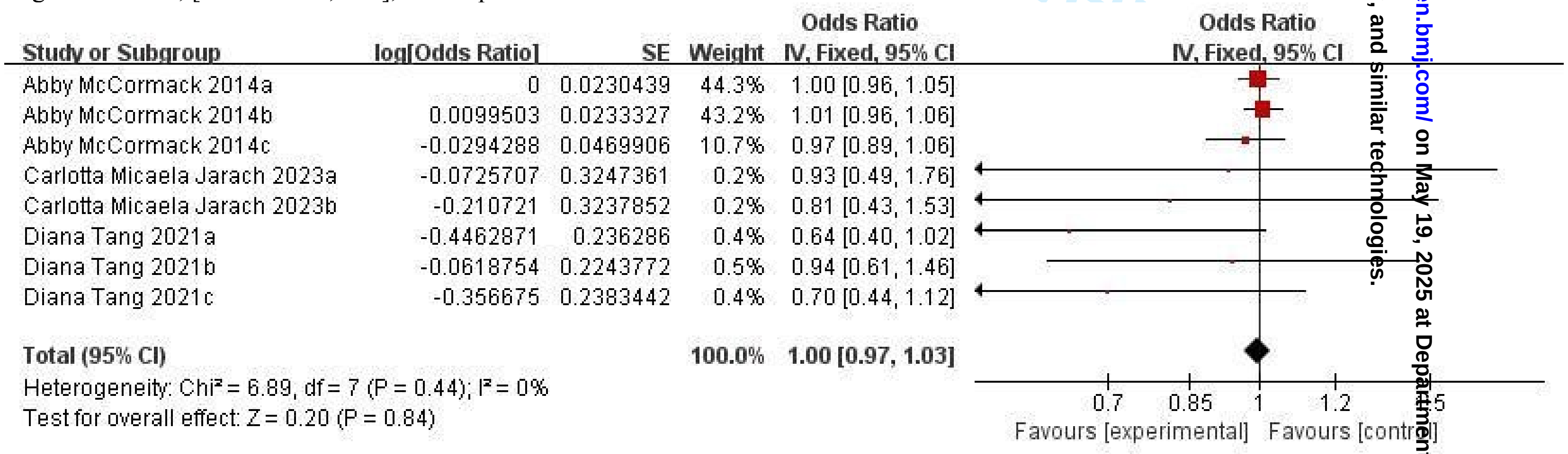
```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
------------------------+--------------------------------------------------
Carlotta Micaela Jar |  1.490       0.753     2.950          24.56
Carlotta Micaela Jar |  0.970       0.509     1.847          27.60
Christopher Spankovi |  1.010       0.619     1.648          47.84
------------------------+--------------------------------------------------
I-V pooled ES           |  1.099       0.783     1.542         100.00
------------------------+--------------------------------------------------
```

Actually: meat: OR=1.099, [95%CI 0.783, 1.542].

eFigure 10: Forest Plot Showing the Association Between sugar and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Sugar: OR=1.00, [95%CI 0.97,1.03], I^2=0% p=0.84.



```
. metan logrr selogrr, label(namevar=author) fixed eform

               Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  1.000       0.956     1.046          44.34
Abby McCormack 2014a |  1.010       0.965     1.057          43.25
Abby McCormack 2014b |  0.971       0.886     1.065          10.66
Carlotta Micaela Jar |  0.930       0.492     1.758           0.22
Carlotta Micaela Jar |  0.810       0.429     1.528           0.22
Diana Tang 2021a     |  0.640       0.403     1.017           0.42
Diana Tang 2021b     |  0.940       0.606     1.459           0.47
Diana Tang 2021c     |  0.700       0.439     1.117           0.41
---------------------+---------------------------------------------------
I-V pooled ES        |  0.997       0.967     1.027         100.00
---------------------+---------------------------------------------------
```

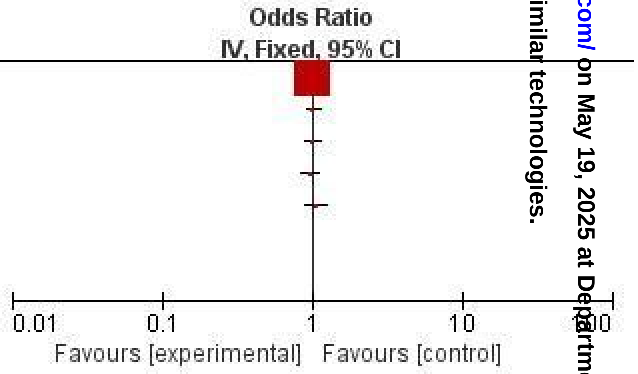
Actually: sugar: OR=0.997, [95%CI 0.967, 1.027].

eFigure 11: Forest Plot Showing the Association Between protein and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis.
Fish: OR=1.00, [95%CI 1.00,1.00], I^2=0% p=0.009.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Doh Young Lee 2018	0.001998	0.0007634	99.9%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0198026	0.0546964	0.0%	1.02 [0.92, 1.14]
Piers Dawes 2020b	0.0099503	0.060906	0.0%	1.01 [0.90, 1.14]
Piers Dawes 2020c	-0.0304592	0.0680814	0.0%	0.97 [0.85, 1.11]
Piers Dawes 2020d	0.0582689	0.0858348	0.0%	1.06 [0.90, 1.25]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 0.78, df = 4 (P = 0.94); I² = 0%
Test for overall effect: Z = 2.62 (P = 0.009)



```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study       |     ES    [95% Conf. Interval]     % Weight
------------------------+-----------------------------------------------
Doh Young Lee 2018      |  1.002       1.001     1.004         99.94
Piers Dawes 2020a       |  1.020       0.916     1.135          0.02
Piers Dawes 2020b       |  1.010       0.896     1.138          0.02
Piers Dawes 2020c       |  0.970       0.849     1.108          0.01
Piers Dawes 2020d       |  1.060       0.896     1.254          0.01
------------------------+-----------------------------------------------
I-V pooled ES           |  1.002       1.001     1.004        100.00
------------------------+-----------------------------------------------
```

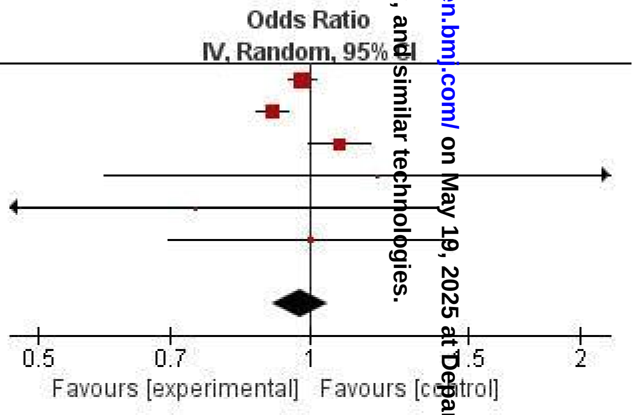
Actually: protein: OR=1.002, [95%CI 1.001, 1.004].

eFigure 12: Forest Plot Showing the Association Between fish and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fish: OR=0.98, [95%CI 0.91,1.05], I^2=72% p=0.57.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Abby McCormack 2014a	-0.0202027	0.0181367	34.4%	0.98 [0.95, 1.02]
Abby McCormack 2014b	-0.0943106	0.0197415	33.9%	0.91 [0.88, 0.95]
Abby McCormack 2014c	0.0769611	0.0404261	25.8%	1.08 [1.00, 1.17]
Carlotta Micaela Jarach 2023a	0.1739534	0.3557993	1.0%	1.19 [0.59, 2.39]
Carlotta Micaela Jarach 2023b	-0.2876821	0.3132832	1.3%	0.75 [0.41, 1.39]
Milena Tomanic 2020	0.003992	0.1847285	3.6%	1.00 [0.70, 1.44]
Total (95% CI)			**100.0%**	**0.98 [0.91, 1.05]**

Heterogeneity: Tau² = 0.00; Chi² = 18.17, df = 5 (P = 0.003); I² = 72%
Test for overall effect: Z = 0.57 (P = 0.57)



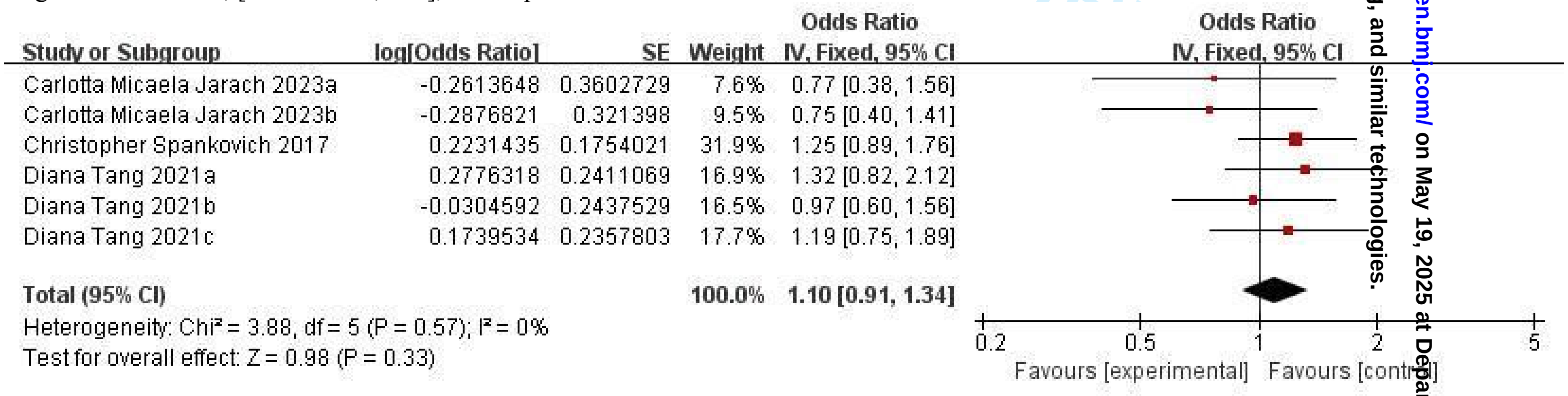
```
. metan logrr selogrr, label(namevar=author) random eform

             Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  0.980       0.946     1.015          35.43
Abby McCormack 2014a |  0.910       0.875     0.946          34.93
Abby McCormack 2014b |  1.080       0.998     1.169          27.04
Carlotta Micaela Jar |  1.190       0.593     2.390           1.14
Carlotta Micaela Jar |  0.750       0.406     1.386           1.46
---------------------+---------------------------------------------------
D+L pooled ES        |  0.979       0.907     1.056         100.00
---------------------+---------------------------------------------------
```

Actually: fish: OR=0.979, [95%CI 0.907, 1.056].

eFigure 13: Forest Plot Showing the Association Between vegetable and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Vegetable: OR=1.10, [95%CI 0.91,1.34], I^2=0% p=0.33..



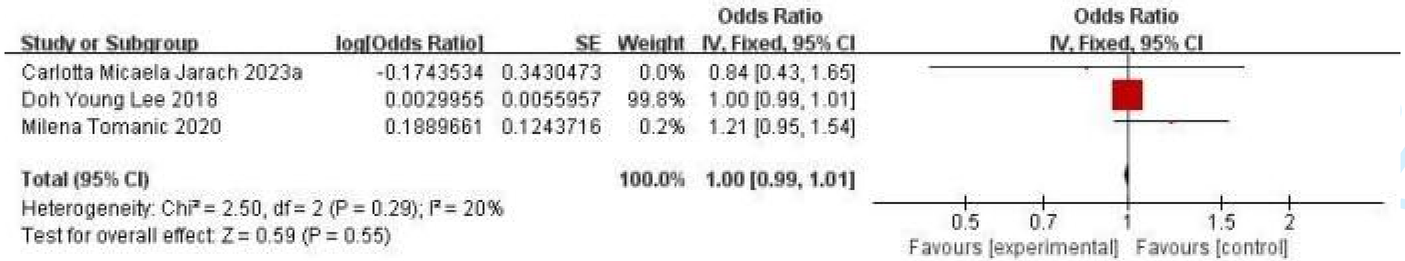
```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+--------------------------------------------------
Carlotta Micaela Jar |  0.770       0.380     1.560          7.56
Carlotta Micaela Jar |  0.750       0.399     1.408          9.50
Christopher Spankovi |  1.250       0.886     1.763         31.89
Diana Tang 2021a     |  1.320       0.823     2.117         16.88
Diana Tang 2021b     |  0.970       0.602     1.564         16.52
Diana Tang 2021c     |  1.190       0.750     1.889         17.65
---------------------+--------------------------------------------------
I-V pooled ES        |  1.101       0.907     1.337        100.00
---------------------+--------------------------------------------------
```

Actually: vegetable: OR=1.101, [95%CI 0.907, 1.337].

eFigure 14: Forest Plot Showing the Association Between water and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Water: OR=1.00, [95%CI 0.99,1.01], I^2=20% p=0.55.



```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study     |     ES    [95% Conf. Interval]     % Weight
----------------------+---------------------------------------------------
Carlotta Micaela Jar  |  0.840       0.429     1.645          0.03
Doh Young Lee 2018    |  1.003       0.992     1.014         99.77
Milena Tomanic 2020   |  1.210       0.950     1.541          0.21
----------------------+---------------------------------------------------
I-V pooled ES         |  1.003       0.992     1.014        100.00
----------------------+---------------------------------------------------
```

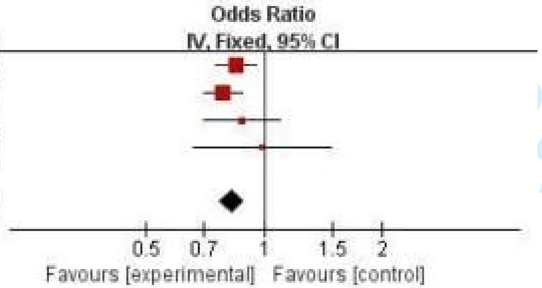
Actually: water: OR=1.003, [95%CI 0.992, 1.014].

eFigure 15: Forest Plot Showing the Association Between dairy and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Dairy: OR=0.83, [95%CI 0.77,0.89], I^2=0% p<0.00001

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Abby McCormack 2014a	-0.1655144	0.0603033	41.2%	0.85 [0.75, 0.95]
Abby McCormack 2014b	-0.2390169	0.0582753	44.1%	0.79 [0.70, 0.88]
Abby McCormack 2014c	-0.1310283	0.1153023	11.3%	0.88 [0.70, 1.10]
Christopher Spankovich 2017	-0.0101	0.2069	3.5%	0.99 [0.66, 1.49]
Total (95% CI)			**100.0%**	**0.83 [0.77, 0.89]**

Heterogeneity: Chi² = 1.89, df = 3 (P = 0.60); I² = 0%
Test for overall effect: Z = 4.87 (P < 0.00001)



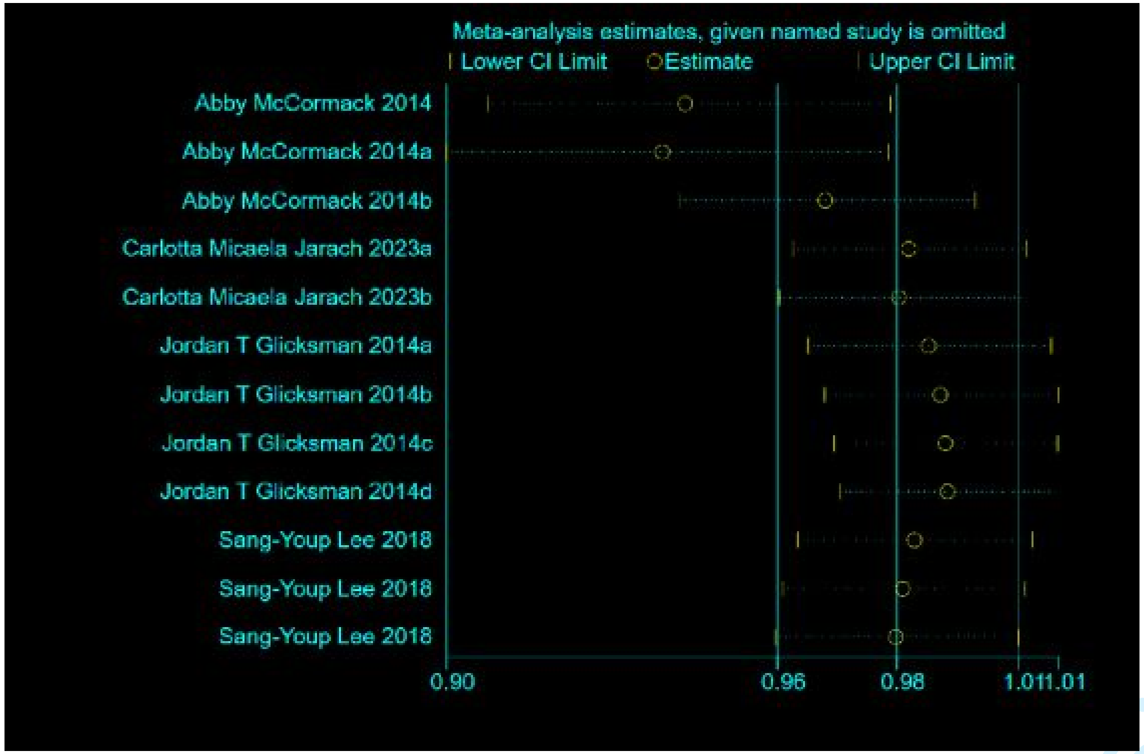
```
. metan logrr selogrr, label(namevar=author) fixed eform

               Study    |       ES    [95% Conf. Interval]      % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |    0.847        0.753     0.953            41.62
Abby McCormack 2014a |    0.787        0.702     0.882            44.21
Abby McCormack 2014b |    0.877        0.699     1.100            11.30
Christopher Spankovi |    0.990        0.631     1.552             2.86
---------------------+---------------------------------------------------
I-V pooled ES        |    0.827        0.766     0.892           100.00
---------------------+---------------------------------------------------
```

Actually: dairy: OR=0.83, [95%CI 0.766, 0.892].

eFigure 16: Sensitivity analysis between caffeine and tinnitus.

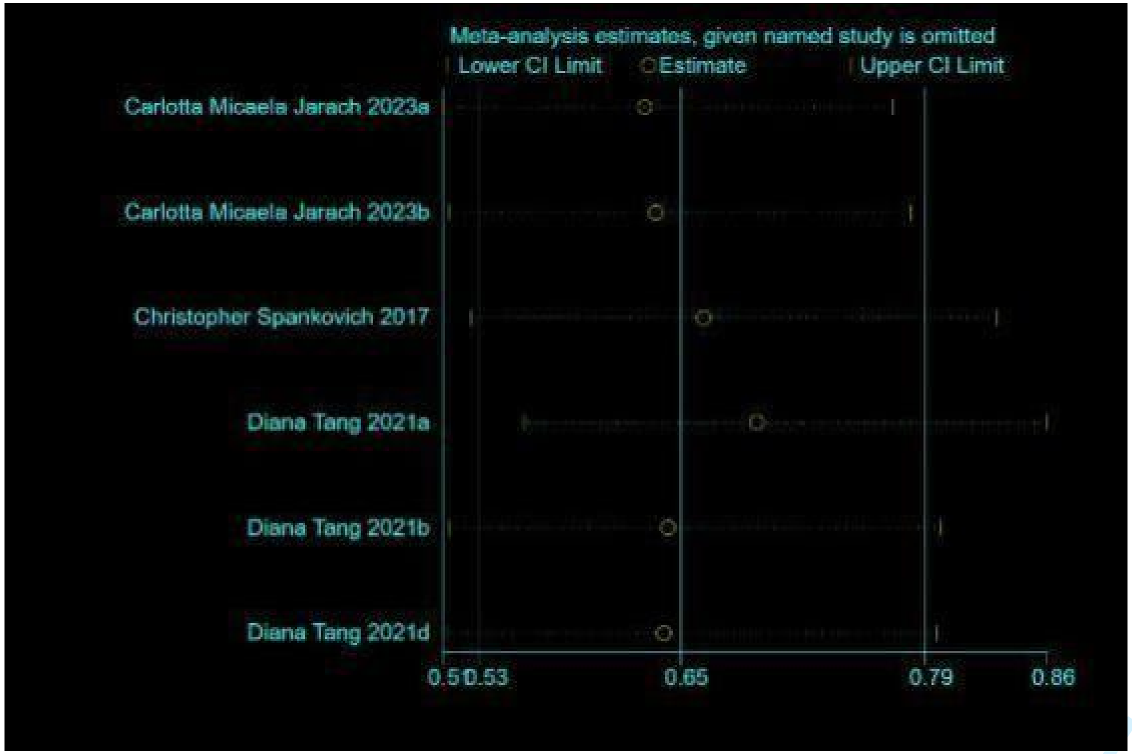
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study at a time, conflicting results emerged and further identification of the source of heterogeneity was needed. It has been confirmed that the main contradiction comes from Abby McCormack 2017, and the sensitivity analysis after removal the reseach did not show contradictory outcome, indicating the robustness of the results.

eFigure 17:Sensitivity analysis between fruit and tinnitus.

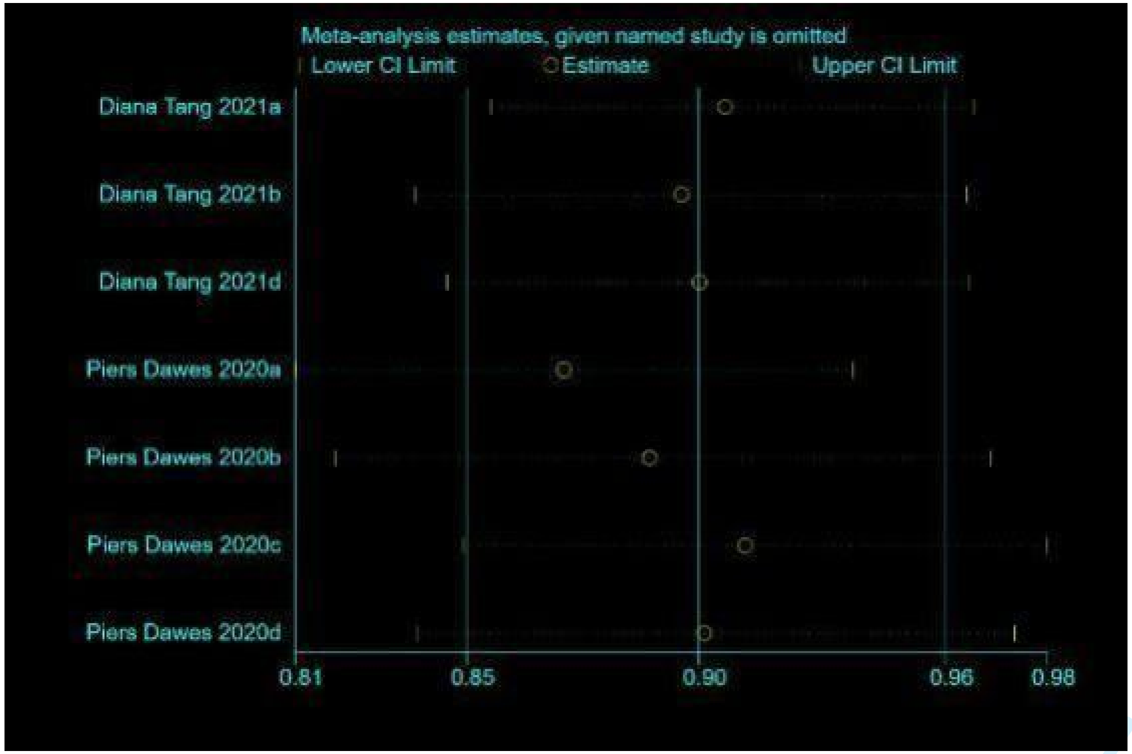
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 18:Sensitivity analysis between fiber and tinnitus.

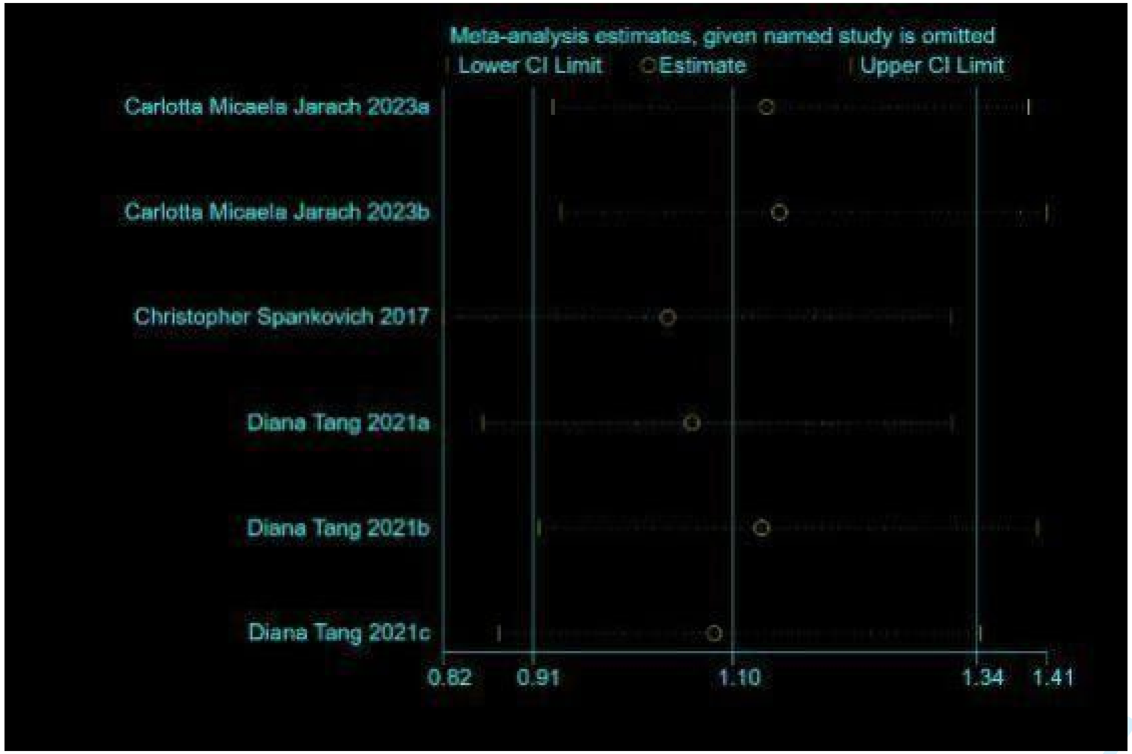
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 19:Sensitivity analysis between vegetable and tinnitus.

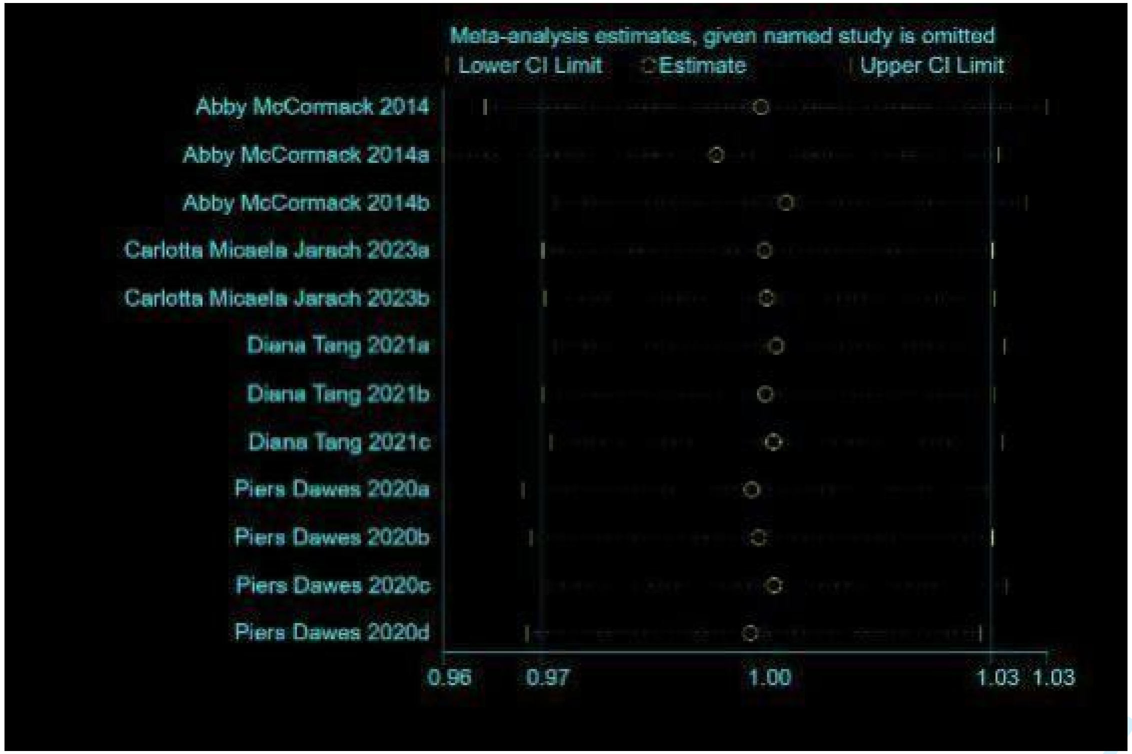
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

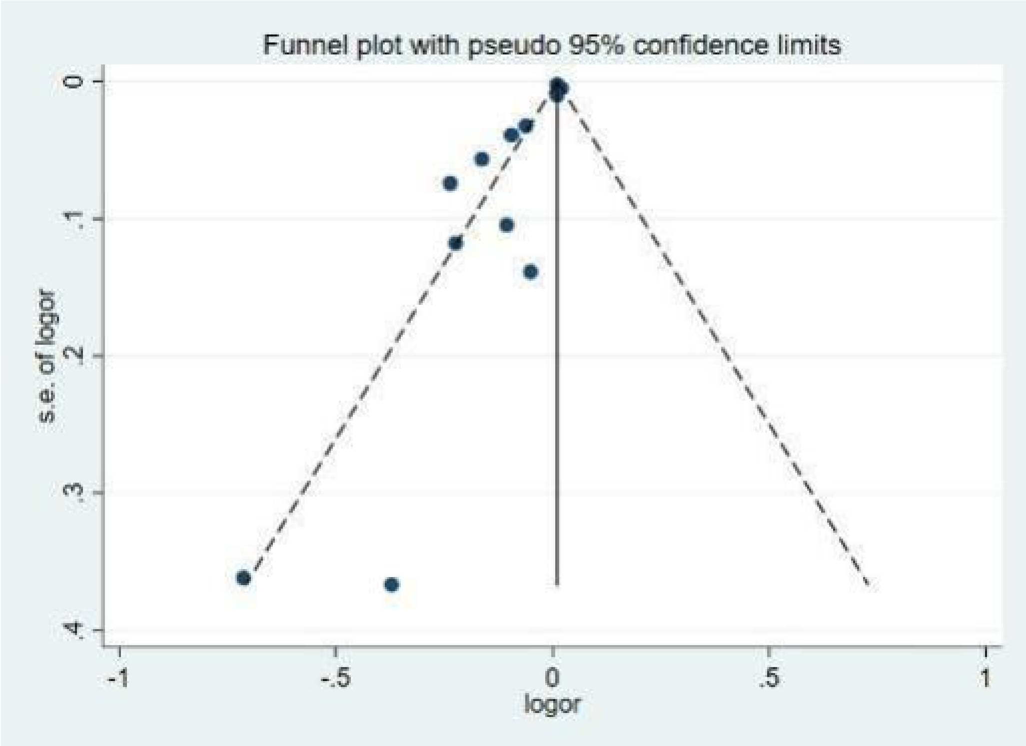
eFigure 20:Sensitivity analysis between sugar and tinnitus.

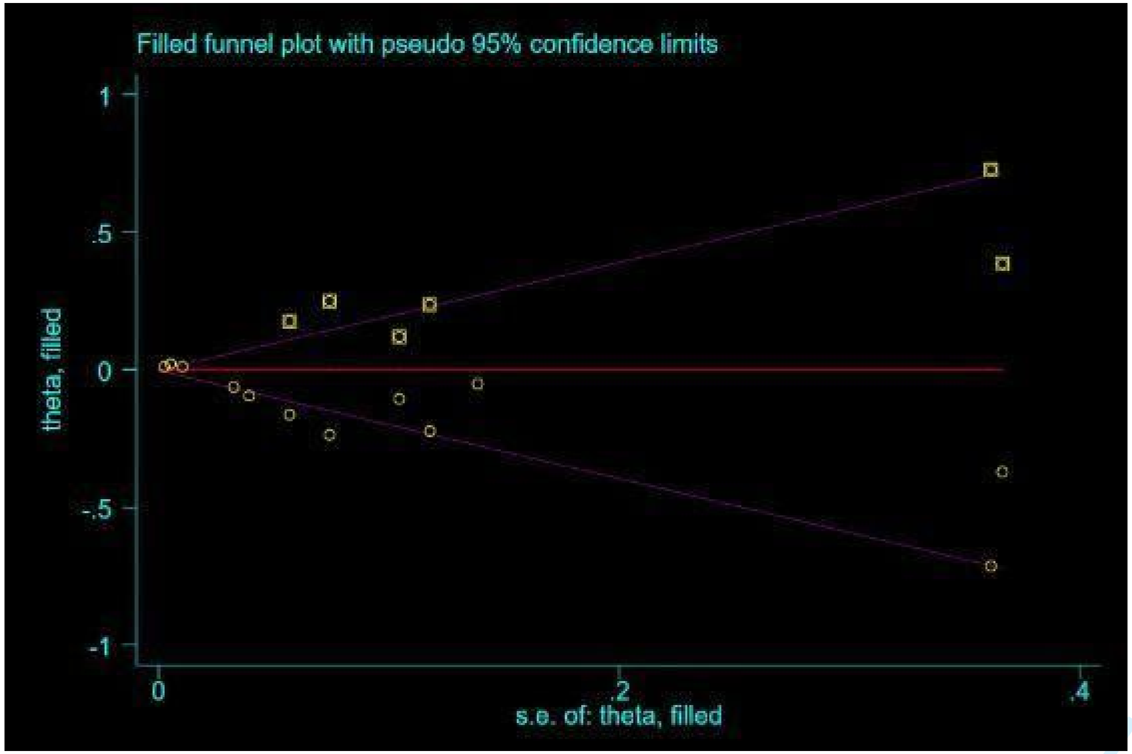
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

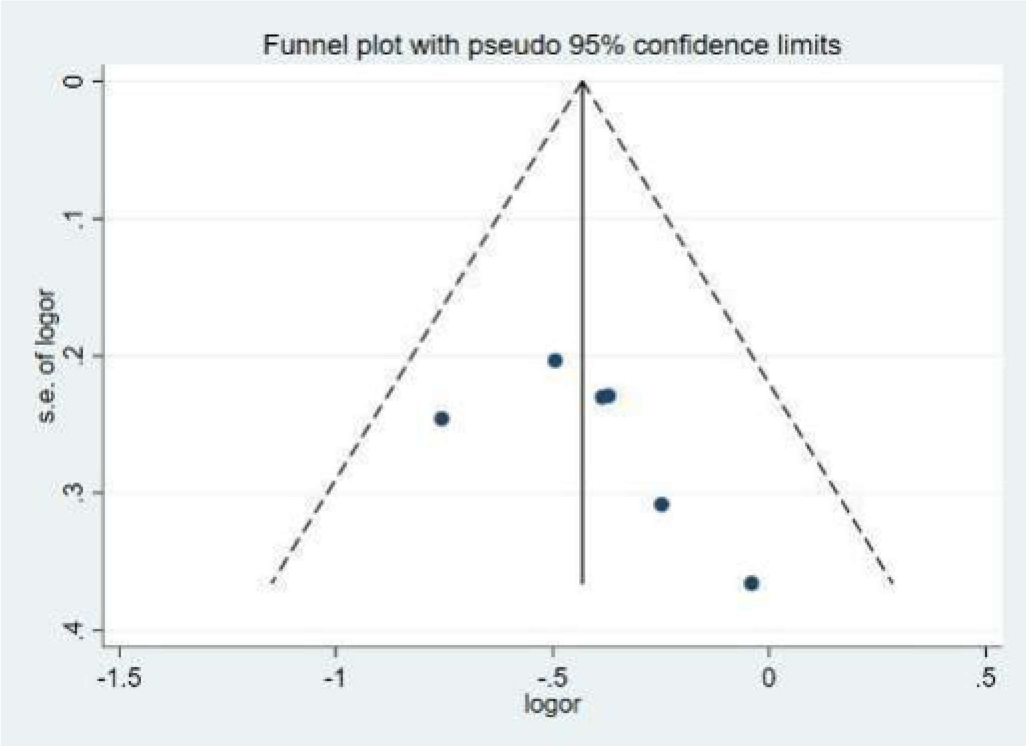
eFigure 21:Publication bias and Egger test on caffeine





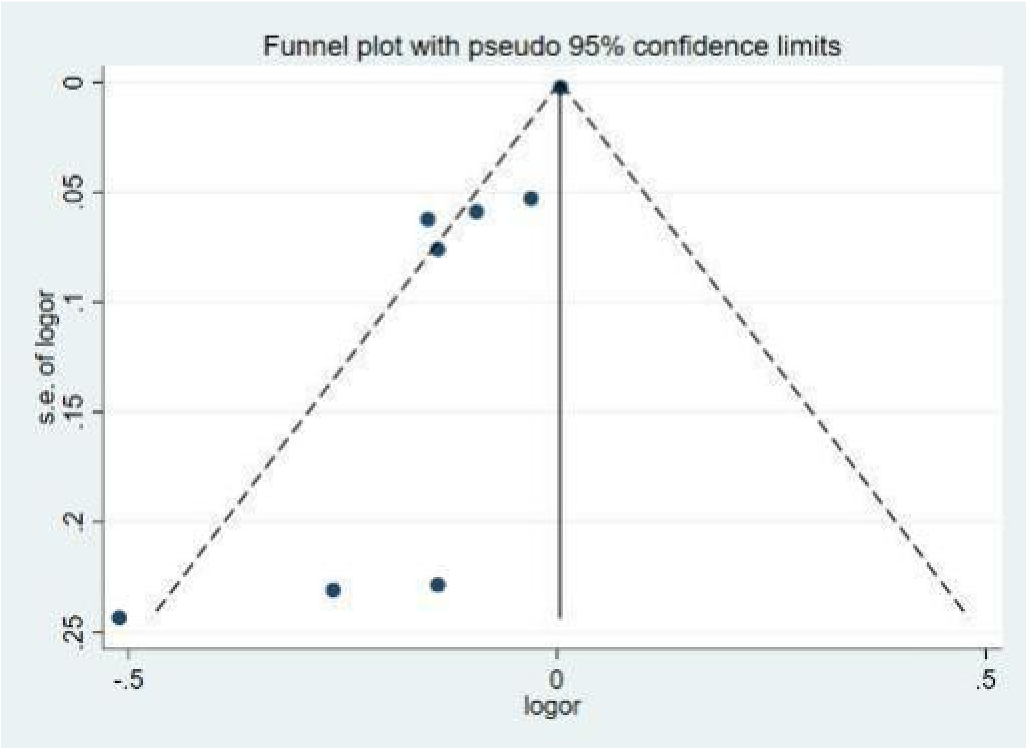
Cut and complement method tips, there was no significant publication bias.

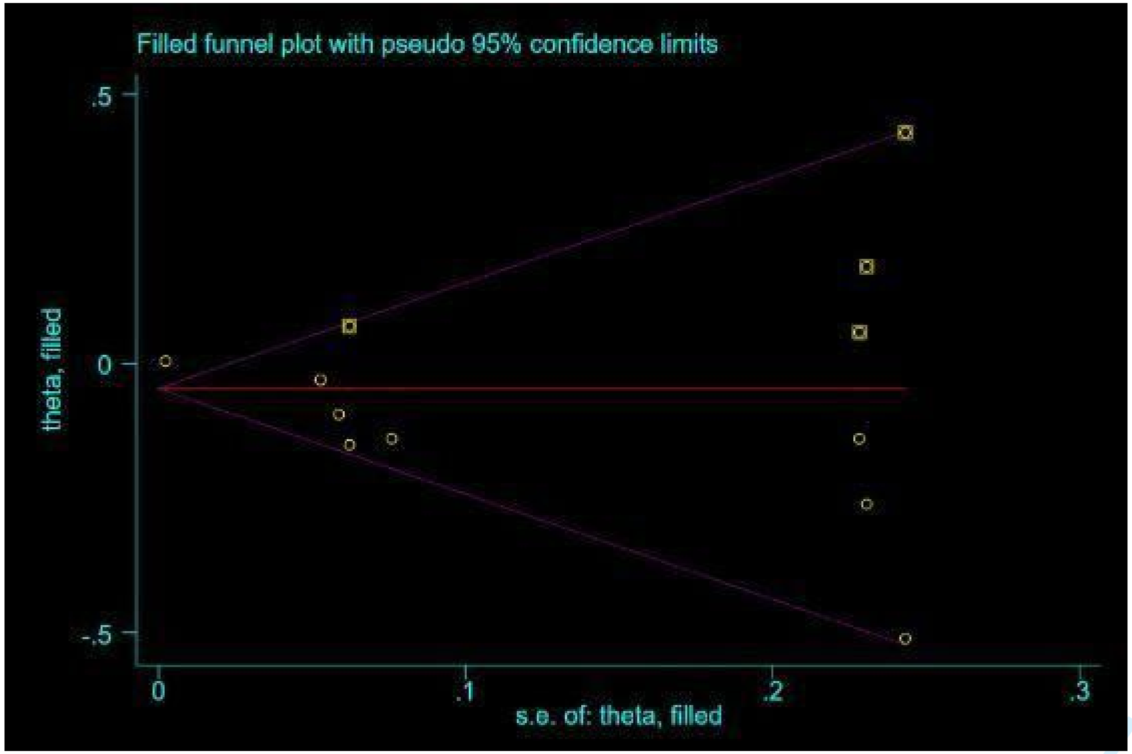
eFigure 22: Publication bias and Egger test on fruit



Egger test: Fruit p=0.205>0.05, there was no significant publication bias.

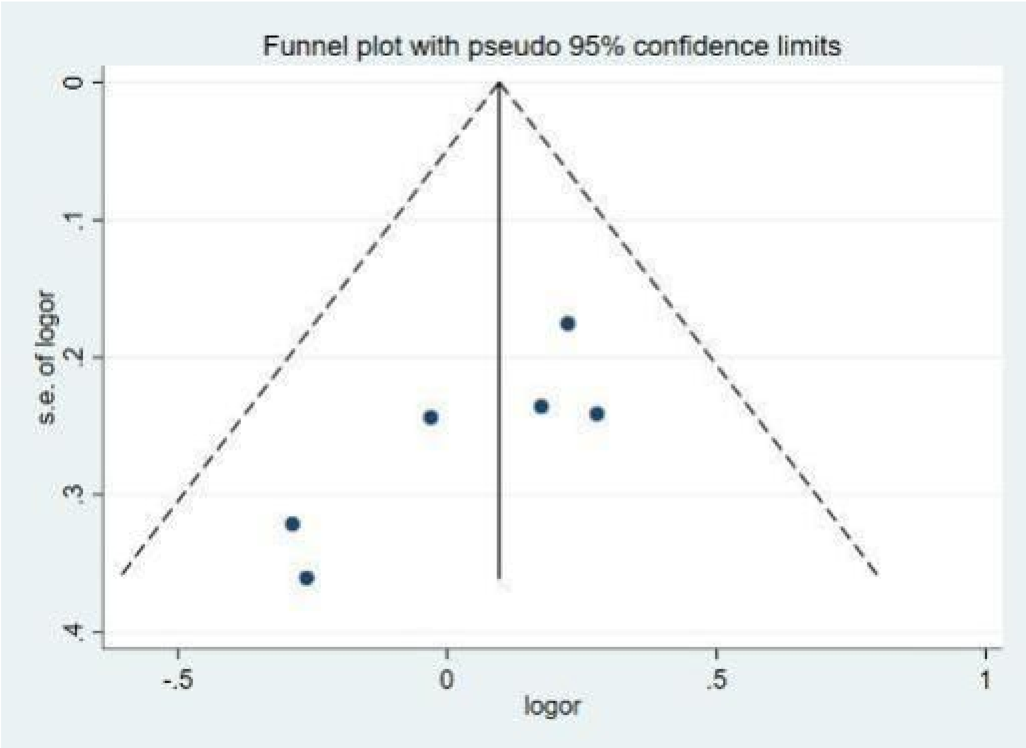
eFigure 23:Publication bias and Egger test on fiber

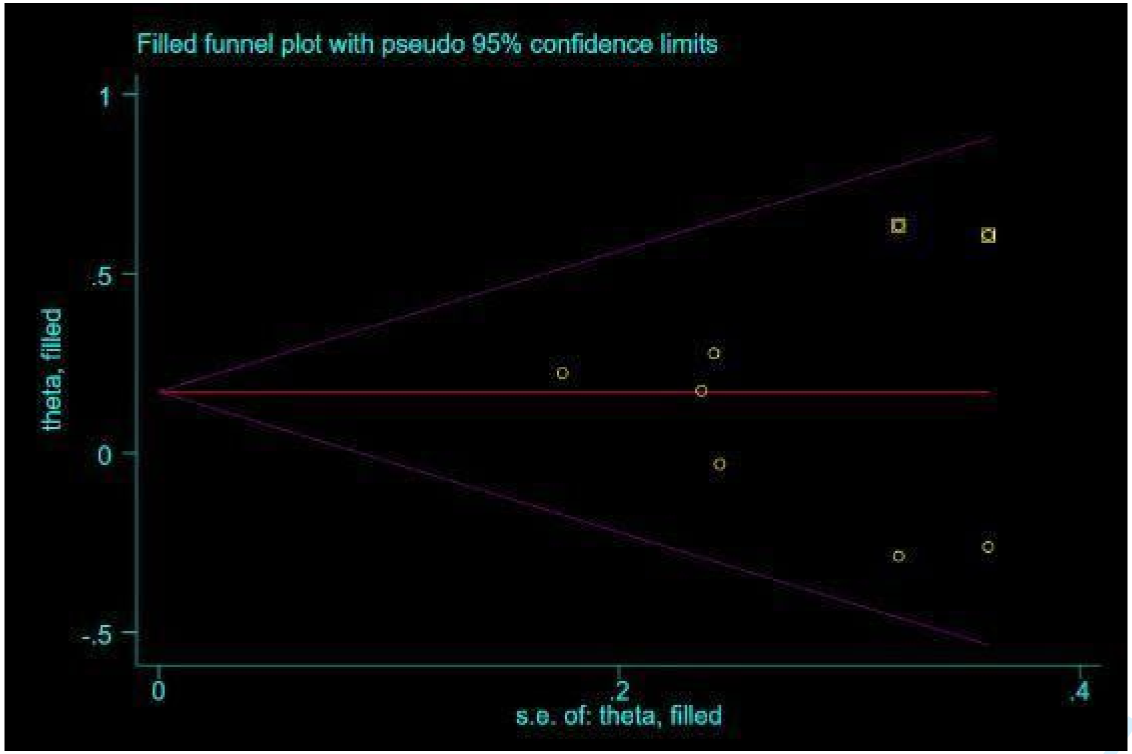




Egger test: Fruit p=0.006<0.05. Cut and complement method tips, there was no significant publication bias.

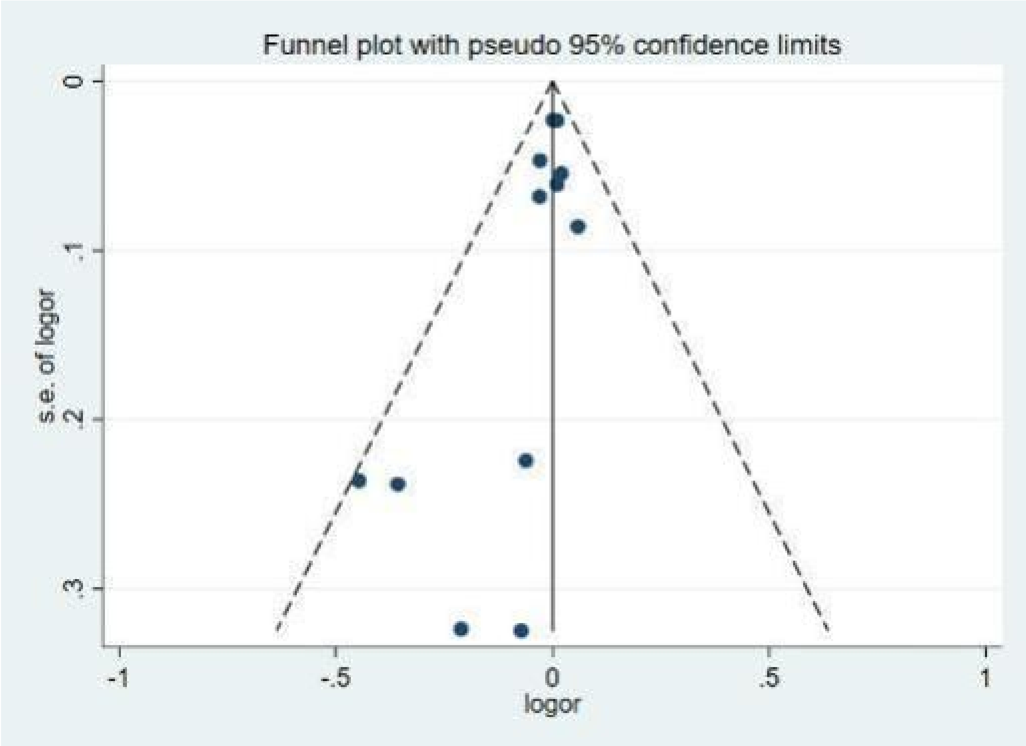
eFigure 24:Publication bias and Egger test on vegetable.

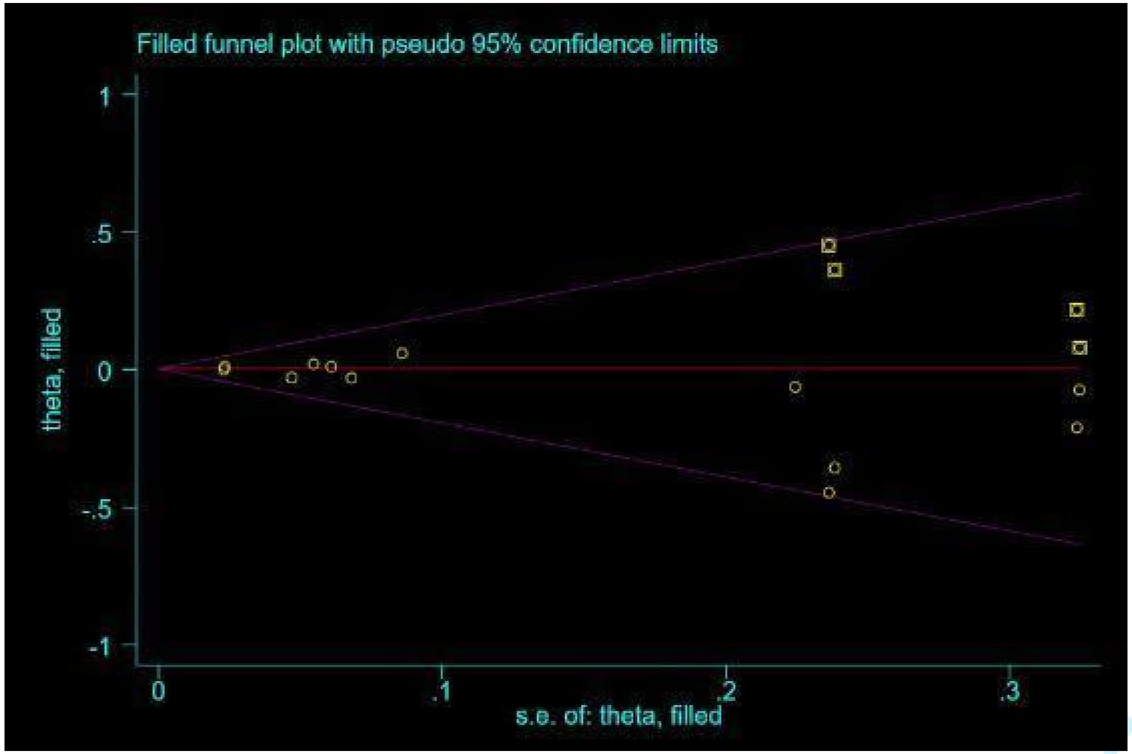




Egger test: Fruit p=0.041<0.05. Cut and complement method tips, there was no significant publication bias.

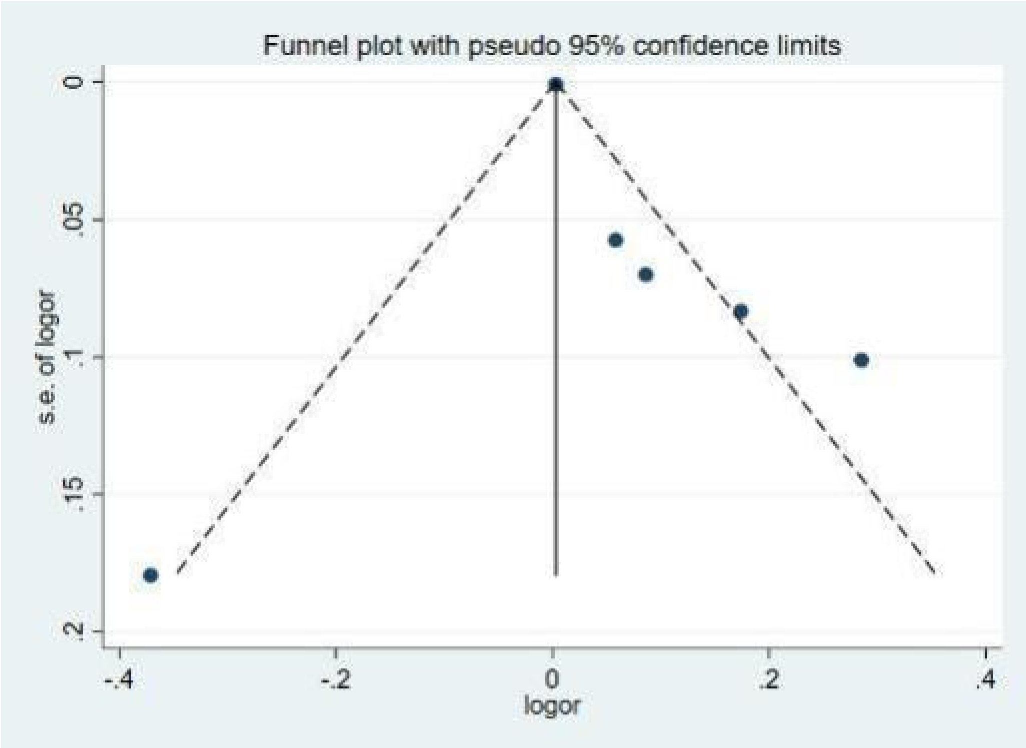
eFigure 25:Publication bias and Egger test on sugar.





Egger test: Fruit p=0.035<0.05. Cut and complement method tips, there was no significant publication bias.

eFigure 26:Publication bias and Egger test on fat.



Egger test: Fat p=0.306>0.05, there was no significant publication bias.

eTable 1. Meta-analysis of Observational Studies in Epidemiology (MOOSE) Checklist

Item No.	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	3-5
2	Hypothesis statement	3-5
3	Description of study outcome(s)	3-5
4	Type of exposure or intervention used	3-5
5	Type of study designs used	-
6	Study population	5
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	6
8	Search strategy, including time period included in the synthesis and keywords	6
9	Effort to include all available studies, including contact with authors	6, 7
10	Databases and registries searched	5,6
11	Search software used, name and version, including special features used (eg, explosion)	8
12	Use of hand searching (eg, reference lists of obtained articles)	6
13	List of citations located and those excluded, including justification	6, Fig 1
14	Method of addressing articles published in languages other than English	7
15	Method of handling abstracts and unpublished studies	6, 7
16	Description of any contact with authors	-
Reporting of methods should include		

17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	8
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	7-8
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	7
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	7
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	7
22	Assessment of heterogeneity	8
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	8
24	Provision of appropriate tables and graphics	Table 1, Fig 1
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	Fig 2, Table 1
26	Table giving descriptive information for each study included	eTable2
27	Results of sensitivity testing (eg, subgroup analysis)	eFig16-20
28	Indication of statistical uncertainty of findings	10,11
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	eFig21-26
30	Justification for exclusion (eg, exclusion of non-English language citations)	Fig 1
31	Assessment of quality of included studies	eTable 5
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	11-19
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	11-19

34	Guidelines for future research	19-20
35	Disclosure of funding source	1

eTable 2: Dietary risk ratio associated with tinnitus

Carlotta Micaela Jarach 2023a	scarce	butter	tinnitus	0.98	0.54	1.77
Carlotta Micaela Jarach 2023b	normal use or high use	butter	tinnitus	0.46	0.23	0.93
Diana Tang 2021a	2nd quartile (>188.4–231.7)	carbohydrate	tinnitus	0.74	0.47	1.17
Diana Tang 2021b	3rd quartile (231.8–280.8)	carbohydrate	tinnitus	0.739	0.47	1.15
Diana Tang 2021c	4th quartile (>280.8–577.7)	carbohydrate	tinnitus	0.55	0.34	0.9
Doh Young Lee 2018	direct	carbohydrate	tinnitus	1.001	0.999	1.001
Piers Dawes 2020a	quintile 2	Carbohydrate	tinnitus	1.03	0.94	1.14
Piers Dawes 2020b	quintile 3	Carbohydrate	tinnitus	0.98	0.88	1.11
Piers Dawes 2020c	quintile 4	Carbohydrate	tinnitus	0.99	0.86	1.14
Piers Dawes 2020d	quintile 5	Carbohydrate	tinnitus	0.93	0.78	1.1
Carlotta Micaela Jarach 2023a	50-100g/week	cheese	tinnitus	1.29	0.63	2.67
Carlotta Micaela Jarach 2023b	100+g/week	cheese	tinnitus	0.85	0.46	1.58
Abby McCormack 2014	direct	coffee	Transient tinnitus	1.020	1.010	1.031
Abby McCormack 2014a	direct	coffee	Persistent tinnitus	1.010	1.010	1.020
Abby McCormack 2014b	direct	coffee	Bothersome tinnitus	1.010	0.990	1.031
Carlotta Micaela Jarach 2023a	2nd quartile (850-1749mg)	coffee	tinnitus	0.49	0.24	0.99
Carlotta Micaela Jarach 2023b	3rd quartile (≥1750mg）	coffee	tinnitus	0.69	0.34	1.43
Jordan T Glicksman 2014a	150-299 mg/day	coffee	tinnitus	0.94	0.88	1
Jordan T Glicksman 2014b	300-449 mg/day	coffee	tinnitus	0.91	0.84	0.98
Jordan T Glicksman 2014c	450-599 mg/day	coffee	tinnitus	0.85	0.76	0.95

Jordan T Glicksman 2014d	600+ mg/day	coffee	tinnitus	0.79	[illegible]	0.91
Sang-Youp Lee 2018	Age 19–39（Daily）	coffee	tinnitus	0.8	0.63	1
Sang-Youp Lee 2018	Age 40-64（Daily）	coffee	tinnitus	0.9	0.73	1.1
Sang-Youp Lee 2018	Age >65（Daily）	coffee	tinnitus	0.95	0.72	1.24
Abby McCormack 2014	direct	dairy	Transient tinnitus	0.847	0.952	0.752
Abby McCormack 2014a	direct	dairy	Persistent tinnitus	0.787	0.885	0.704
Abby McCormack 2014b	direct	dairy	Bothersome tinnitus	0.877	1.099	0.699
Christopher Spankovich 2017	direct	dairy	Persistent tinnitus	0.99	[illegible]	1.50
Carlotta Micaela Jarach 2023a	16-19	diversity	tinnitus	0.53	[illegible]	1
Carlotta Micaela Jarach 2023b	≥20	diversity	tinnitus	0.47	0.24	0.9
Abby McCormack 2014	direct	egg	Transient tinnitus	1.031	[illegible]	0.926
Abby McCormack 2014a	direct	egg	Persistent tinnitus	1.149	[illegible]	1.031
Abby McCormack 2014b	direct	egg	Bothersome tinnitus	0.901	[illegible]	0.719
Carlotta Micaela Jarach 2023a	1/week	eggs	tinnitus	0.99	[illegible]	1.92
Carlotta Micaela Jarach 2023b	2+/week	eggs	tinnitus	0.54	0.29	1
Christopher Spankovich 2017	direct	fat	Persistent tinnitus	0.69	0.49	0.99
Doh Young Lee 2018	direct	fat	tinnitus	1.003	1.001	1.005
Piers Dawes 2020a	quintile 2	fat	tinnitus	1.06	0.95	1.19
Piers Dawes 2020b	quintile 3	fat	tinnitus	1.09	0.95	1.25
Piers Dawes 2020c	quintile 4	fat	tinnitus	1.19	1.01	1.40
Piers Dawes 2020d	quintile 5	fat	tinnitus	1.33	1.09	1.62
Diana Tang 2021a	2nd quartile (>17.8–23.8)	fiber	tinnitus	0.6	[illegible]	0.96
Diana Tang 2021b	3rd quartile (>23.8–30.6)	fiber	tinnitus	0.87	[illegible]	1.37
Diana Tang 2021d	4th quartile (>30.6–89.3)	fiber	tinnitus	0.77	[illegible]	1.21
Doh Young Lee 2018	direct	fiber	tinnitus	1.004	0.999	1.008
Piers Dawes 2020a	quintile 2	fiber	tinnitus	0.97	0.87	1.07
Piers Dawes 2020b	quintile 3	fiber	tinnitus	0.91	0.81	1.02
Piers Dawes 2020c	quintile 4	fiber	tinnitus	0.86	0.76	0.97
Piers Dawes 2020d	quintile 5	fiber	tinnitus	0.87	0.75	1.01

Abby McCormack 2014	direct	fish	Transient tinnitus	0.980	0.950	1.020
Abby McCormack 2014a	direct	fish	Persistent tinnitus	0.910	0.870	0.940
Abby McCormack 2014b	direct	fish	Bothersome tinnitus	1.080	0.990	1.160
Carlotta Micaela Jarach 2023a	300g/week	fish	tinnitus	1.19	0.59	2.38
Carlotta Micaela Jarach 2023b	≥450g/week	fish	tinnitus	0.75	0.41	1.4
Carlotta Micaela Jarach 2023a	900-1050g/week	fruit	tinnitus	0.96	0.47	1.97
Carlotta Micaela Jarach 2023b	≥1200g/week	fruit	tinnitus	0.78	0.43	1.44
Christopher Spankovich 2017	direct	fruit	Persistent tinnitus	0.61	0.41	0.91
Diana Tang 2021a	2nd quartile (>3.6–6.2)	fruit	tinnitus	0.47	0.29	0.76
Diana Tang 2021b	3rd quartile (>6.2–9.7)	fruit	tinnitus	0.68	0.43	1.06
Diana Tang 2021d	4th quartile (>9.7–43.9)	fruit	tinnitus	0.69	0.44	1.08
Carlotta Micaela Jarach 2023a	scarce	margarine	tinnitus	1.35	0.25	7.43
Carlotta Micaela Jarach 2023b	normal use or high use	margarine	tinnitus	1.4	0.2	9.98
Carlotta Micaela Jarach 2023a	300g/week	meat	tinnitus	1.49	0.75	2.94
Carlotta Micaela Jarach 2023b	≥450g/week	meat	tinnitus	0.97	0.51	1.85
Christopher Spankovich 2017	direct	meat	Persistent tinnitus	1.01	0.62	1.65
Carlotta Micaela Jarach 2023a	2nt quartile (1-6 cops/week)	milk	tinnitus	0.68	0.3	1.52
Carlotta Micaela Jarach 2023b	3rt quartile (7+ cops/week)	milk	tinnitus	0.85	0.46	1.55
Doh Young Lee 2018	direct	protein	tinnitus	1.002	1.001	1.004
Piers Dawes 2020a	quintile 2	protein	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	protein	tinnitus	1.01	0.89	1.13
Piers Dawes 2020c	quintile 4	protein	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	protein	tinnitus	1.06	0.9	1.26
Abby McCormack 2014	direct	suger	Transient tinnitus	1.000	0.952	1.042
Abby McCormack 2014a	direct	suger	Persistent tinnitus	1.010	0.971	1.064
Abby McCormack 2014b	direct	suger	Bothersome tinnitus	0.971	0.885	1.064

Carlotta Micaela Jarach 2023a	2nt quartile (1-7 spoon/week)	suger	tinnitus	0.93	0.49	1.75
Carlotta Micaela Jarach 2023b	3rt quartile (8+ spoon/week)	suger	tinnitus	0.81	0.43	1.53
Diana Tang 2021a	2nd quartile (>91.0–120.1)	suger	tinnitus	0.64	0.4	1.01
Diana Tang 2021b	3rd quartile (>120.1–154.0)	suger	tinnitus	0.94	0.61	1.47
Diana Tang 2021c	4th quartile (>154.0–350.8)	suger	tinnitus	0.7	0.44	1.12
Piers Dawes 2020a	quintile 2	suger	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	suger	tinnitus	1.01	0.89	1.13
Piers Dawes 2020c	quintile 4	suger	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	suger	tinnitus	1.06	0.9	1.26
Christopher Spankovich 2017	direct	variety	Persistent tinnitus	0.95	0.61	1.5
Carlotta Micaela Jarach 2023a	900-1050g/week	vegetable	tinnitus	0.77	0.38	1.56
Carlotta Micaela Jarach 2023b	≥1200g/week	vegetable	tinnitus	0.75	0.4	1.41
Christopher Spankovich 2017	direct	vegetable	Persistent tinnitus	1.25	0.9	1.79
Diana Tang 2021a	2nd quartile (>7.2–9.7)	vegetable	tinnitus	1.32	0.82	2.11
Diana Tang 2021b	3rd quartile (>9.7–12.3)	vegetable	tinnitus	0.97	0.60	1.56
Diana Tang 2021c	4th quartile (>12.3–54.5)	vegetable	tinnitus	1.19	0.75	1.89
Abby McCormack 2014	direct	vegetable and fruit	Transient tinnitus	1.000	1.000	1.010
Abby McCormack 2014a	direct	vegetable and fruit	Persistent tinnitus	1.010	1.000	1.010
Abby McCormack 2014b	direct	vegetable and fruit	Bothersome tinnitus	1.010	1.000	1.020
Carlotta Micaela Jarach 2023a	>1 liter/per day	water	tinnitus	0.84	0.43	1.65
Doh Young Lee 2018	direct	water	tinnitus	1.003	0.992	1.014

eTable 3. Evaluation of Risk of Bias Using Newcastle-Ottawa Scale（NOS) for Observational Studies

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Total
Carlotta Micaela Jarach 2023	*	*	*	*	*	*	*	*		8
Diana Tang 2021	*	*	*		*	*	*	*	*	8
Milena Tomanic 2020	*	*	*				*			4
Piers Dawes 2020	*	*	*		*	*	*			6
Sang-Yeon Lee 2019	*	*	*		*	*	*			6
Doh Young Lee 2018	*	*	*		*	*	*			6
Sang-Youp Lee 2018	*	*	*		*	*	*			6
Christopher Spankovich 2017	*	*	*		*	*	*			6
Abby McCormack 2014	*	*	*		*	*	*			6
Jordan T Glicksman 2014	*	*	*		*	*	*		*	7

eTable 4. Literature screening process

Title	Author	Whether to include
The Role of Diet in Tinnitus Onset: A Hospital-Based Case-Control Study from Italy.	Carlotta Micaela Jarach 2023	YES
Associations between intake of dietary flavonoids and the 10-year incidence of tinnitus in older adults.	Diana Tang 2022	YES
Dietary Fibre Intake and the 10-Year Incidence of Tinnitus in Older Adults.	Diana Tang 2021	YES
Relationship Between Diet, Tinnitus, and Hearing Difficulties.	Piers Dawes 2020	YES
Association of Chocolate Consumption with Hearing Loss and Tinnitus in Middle-Aged People Based on the Korean National Health and Nutrition Examination Survey 2012-2013.	Sang-Yeon Lee 2019	YES
Relationship Between Diet and Tinnitus: Korea National Health and Nutrition Examination Survey.	Doh Young Lee 2018	YES
Association of Coffee Consumption with Hearing and Tinnitus Based on a National Population-Based Survey	Sang-Youp Lee 2018	YES
Relationship between dietary quality, tinnitus and hearing level: data from the national health and nutrition examination survey, 1999-2002.	Christopher Spankovich 2017	YES
Association of dietary factors with presence and severity of tinnitus in a middle-aged UK population.	Abby McCormack 2014	YES
A prospective study of caffeine intake and risk of incident tinnitus	Jordan T. Glicksman 2014	YES
The effect of MemoVigor 2 on recent-onset idiopathic tinnitus: a randomized double-blind placebo-controlled clinical trial.	Dimitrios G Balatsouras 2024	No
The effects of dietary and physical activity interventions on tinnitus symptoms: An RCT.	Ümüş Özbey-Yücel 2023	No

Effectiveness of Tinnitan Duo in Subjective Tinnitus with Emotional Affectation: A Prospective, Interventional Study.	Jennifer Knäpper 2023	No
Hyperlipidemia and its relation with tinnitus: Cross-sectional approach.	A Musleh 2022	No
Diet Quality and the Risk of Impaired Speech Reception Threshold in Noise: The UK Biobank cohort	Humberto Yévenes-Briones 2022	No
The effect of caffeine on tinnitus: Randomized triple-blind placebo-controlled clinical trial.	Alleluia Lima Losno Ledesma 2021	No
The effects of diet and physical activity induced weight loss on the severity of tinnitus and quality of life: A randomized controlled trial.	Ümüş Özbey-Yücel 2021	No
Dietary Factors and Tinnitus among Adolescents.	Milena Tomanic 2020	No
Restriction of salt, caffeine and alcohol intake for the treatment of Ménière's disease or syndrome.	Kiran Hussain 2018	No
The effect of supplemental dietary taurine on tinnitus and auditory discrimination in an animal model.	Thomas J Brozoski 2010	No
Low energy diet and intracranial pressure in women with idiopathic intracranial hypertension: prospective cohort study.	Alexandra J Sinclair 2010	No
Caffeine abstinence: an ineffective and potentially distressing tinnitus therapy.	Lindsay St Claire 2010	No
The role of endogenous Antisecretory Factor (AF) in the treatment of Meniere's Disease: A two-year follow-up study. Preliminary results.	Pasquale Viola 2020	No
Caffeine intake and Meniere's disease: Is there relationship?	Inés Sánchez-Seller 2018	No
Tinnitus features according to caffeine consumption.	Ricardo Rodrigues Figueiredo 2021	No
The Influence of Diet on Tinnitus Severity: Results of a Large-Scale, Online Survey	Steven C. Marcrum 2022	No

BMJ Open

Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-091507.R1
Article Type:	Original research
Date Submitted by the Author:	19-Dec-2024
Complete List of Authors:	Zhang, Mengni; Chengdu University of Traditional Chinese Medicine, Wang, Xiaocui ; Hospital of Chengdu University of Traditional Chinese Medicine Zhang, Shipeng; Hospital of Chengdu University of Traditional Chinese Medicine, He, Xinyi; Chengdu University of Traditional Chinese Medicine Chen, Xi; Hospital of Chengdu University of Traditional Chinese Medicine Wang, Lu ; Hospital of Chengdu University of Traditional Chinese Medicine Fu, Li ; Hospital of Chengdu University of Traditional Chinese Medicine wang, hanyu; Chengdu University of Traditional Chinese Medicine Fu, Qinwei; Hospital of Chengdu University of Traditional Chinese Medicine jiang, yanjie; Nanjing University of Chinese Medicine Li, Xinrong; Hospital of Chengdu University of Traditional Chinese Medicine Zhang, Qinxiu; Chengdu University of Traditional Chinese Medicine, Hospital of Chengdu University of Traditional Chinese Medicine; Chengdu University of Traditional Chinese Medicine, School of Medical and Life Sciences
Primary Subject Heading:	Ear, nose and throat/otolaryngology
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	OTOLARYNGOLOGY, NUTRITION & DIETETICS, Meta-Analysis, Neurotology < OTOLARYNGOLOGY

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Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

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Abstract

Objective: A systematic analysis was conducted to investigate the association between tinnitus prevalence and daily dietary patterns.

Methods: The PubMed, Embase, Web of Science, and Cochrane Library databases underwent searches from their inception to May 25, 2024. Two evaluators, blinded to the studies, chose observational studies from peer–reviewed English–language journals. These studies examined tinnitus presence or severity in adults aged 18 or older, including associated prevalence estimates. Data extraction was independently conducted by two evaluators, who assessed research bias using the Agency for Newcastle–Ottawa Scale (NOS) and applied evidence classification criteria for aggregate grade strength assessment. This study adhered to the guidelines of the Preferred Reporting Project (PRISMA) and Meta-Analysis of Epidemiological Observational Studies (MOOSE), as well as the PROSPERO Registry protocols. A mixed–effects model combined maximum adjusted estimates, with heterogeneity measured using the I^2 statistic. Sensitivity analysis validated the analysis's robustness, while publication bias was assessed qualitatively and quantitatively.

Results: A total of 10 retrospective studies were identified and included in this analysis, with the last eight studies incorporated into the meta–analysis. Fifteen dietary factors were examined. Fruit intake, dietary fiber, caffeine, and dairy product consumption showed negative correlations with tinnitus prevalence (OR = 0.649, [95% CI 0.532, 0.793], p<0.0001), (OR = 0.918, [95% CI 0.851, 0.990], p = 0.03), (OR = 0.898, [95% CI 0.862, 0.935], p

<0.00001), (OR = 0.827, [95% CI, 0.766 to 0.892], p <0.00001), respectively. A sensitivity analysis affirmed the robustness of the findings.

Conclusions: The systematic review and meta-analysis findings suggest a link between particular dietary elements and a lower occurrence of tinnitus.

Keywords: Diet; Tinnitus; Food intake; Nutrition; Odds ratio

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study conducted a thorough literature screening, assessed the quality of the literature based on international standards, and excluded articles with a high risk of bias.
- This review involved a large population base, improving its representation of fundamental population characteristics and ensuring relatively reliable outcomes.
- There was minimal heterogeneity among the studies regarding the main observations, ensuring the solidity of the findings.
- The relatively small number of included articles may have led to certain conventionally accepted as beneficial dietary factors (such as vegetables and eggs) not demonstrating significant differences. In addition, due to limited data in the original literature, a dose-effect meta-analysis cannot be supported.
- The majority of included articles were cross-sectional studies, underscoring the necessity for further cohort studies or Mendelian

randomization studies to investigate causal relationships and provide additional clinical evidence for the dietary prevention of tinnitus.

Introduction

Tinnitus, characterized by perceived sounds such as buzzing, cicadas, or electric currents, occurs without external auditory stimuli [1]. It is associated with distress, depression, anxiety, stress, and, in severe cases, suicide, significantly affecting overall quality of life[2 3]. Recent epidemiological data suggests a global pooled prevalence of around 14.4% in adults and 13.6% in children and adolescents[4]. The notable prevalence of tinnitus and its substantial impact on life and mental well–being have increasingly become a significant medical and societal concern[5].

The origins of tinnitus remain elusive and involve a range of factors. Some researchers have suggested neural dysfunction or circulatory issues in the inner ear, abnormal neuronal activity in central auditory pathways, and irregular activity in nonauditory brain regions like the anterior insula, anterior cingulate cortex, and thalamus[6]. In clinical practice, treatments for tinnitus management include psychological counseling, cognitive–behavioral therapy, tinnitus retraining therapy, sound therapy, surgery, pharmacological interventions, non-pharmacological interventions (including electrical stimulation, repetitive transcranial magnetic stimulation, nerve block, bimodal neuromodulation, tinnitus retraining therapy et al.), as well as hearing aids and cochlear implants for patients with a relevant hearing loss[7 8]. Due to an incomplete understanding of central neuropathological mechanisms, no single treatment universally meets the needs of all patients[9 10].

The role of diet in tinnitus has been identified as a research priority by both patients and physicians. In recent years, the need for nutritional treatment programs for chronic tinnitus has increased. Diet can have a significant impact on tinnitus, but the exact connection between diet and tinnitus is unclear[11]. A population study investigating the correlation between diet and tinnitus among UK adults found a decrease in tinnitus occurrence with higher fruit and vegetable consumption. Conversely, avoiding dairy was linked to a higher risk of tinnitus. On the other hand, abstaining from eggs, adding fish to the diet, and consuming caffeinated beverages were suggested to potentially lower the risk of tinnitus [2]. Another study in British adults showed that higher fat intake was associated with a greater likelihood of experiencing tinnitus[11]. Similarly, Lee and Kim identified risk factors for tinnitus, including low water, protein, riboflavin, and niacin intake, although this was unrelated to fruit and vegetable consumption[12]. It is thought that intake of high-quality nutrients through food can have a positive effect on the hearing system by improving blood flow to the cochlea, reducing oxidative damage and reducing inflammation. In contrast, high saturated fat intake may increase the risk of tinnitus through cardiovascular pathways[11 13]. Tang et al.[14] found that inadequate fruit fiber (<3.6 g/day) and grain fiber (<4.2 g/day) intake were linked to a 65% and 54% increased risk of developing tinnitus over the next decade, respectively. Conflicting results have hindered researchers' ability to understand the potential benefits of diet; hence, a systematic review on the relationship between diet and tinnitus is needed.

As of now, there has not been a comprehensive examination through systematic reviews or meta-analyses regarding the link between typical dietary patterns and tinnitus. Our objective was to systematically explore this association while accounting for potential confounding variables. The study aimed to furnish clinical evidence to inform the development of dietary prevention approaches for tinnitus.

Method

According to the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA), a set of evidence-based standards for the research quality of systematic reviews, apply to published reviews of literature that contain primary data sources and aim to improve the scientific rigor of systematic reviews[15], the protocol for this study was appropriately registered on PROSPERO under the registration number CRD42023493856. Additionally, my reporting is guided by the Meta-analysis of Observational Studies in Epidemiology (MOOSE) standards for epidemiological observational studies, which was developed by a group of experts to improve the quality and transparency of Meta-analysis and Systematic Evaluation of Observational Studies, contributing to the scientific validity and credibility of such studies, as referenced [16]. **Supplemental eTable 1** contains the MOOSE listings, while Supplemental 2 outlines the PRISMA instructions.

Search Strategy

We developed an inclusive search strategy covering diet–related and tinnitus-related subjects to capture pertinent literature from the PubMed, Embase, Web of Science, and Cochrane Library databases. The research design was limited to systematic evaluation. There were no language restrictions imposed on the search, and we considered articles published before May 25, 2024. For publications in unknown languages, we proceed through specialized translation software.

The search strategy was designed to identify studies linking tinnitus and diet, and two specific terms 'Tinnitus' and 'Diet' come from Medical Subject Headings (MeSH) Major Topic were identified. The databases were systematically explored using a blend of MeSH terms, keywords, and various text word variations related to diet, following the guidance outlined by the Scottish Intercollegiate Guidelines Network: ((tinnitus OR Ringing–Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR variety OR caffeine OR carbohydrate OR protein). The screening process is depicted in **Figure 1.**

The following inclusion criteria were applied: (1) inclusion of cohort, case-control, or cross-sectional studies; (2) inclusion of all individuals in the study population; (3) consideration of various dietary intakes; and (4) investigation of tinnitus as a study outcome provided effect sizes or other data on the association between dietary intake and tinnitus as an outcome. Exclusion criteria comprised: (1) studies involving therapeutic interventions; and (2) randomized controlled trials, animal experiments, cell studies, case reports, literature, and incomplete or invalid sources, and the original literature lacked sufficient data to calculate the risk ratio for tinnitus (some publications do not report effect sizes, but instead allow the raw data to be used to calculate them. In these cases, use RevMan (version 5.3) to calculate the OR). ***Data collection***

In **Table 1,** data compilation was conducted by two reviewers (SZ, MZ), including authors' names, participant counts, age spans, survey/diagnosis specifics, and information on food and tinnitus. Given the treatment of dietary intake as a continuous variable, some researchers have typically performed stratified comparisons based on regional intake standards and researchers' characteristics. This strategy aimed to explore the impact of varying levels of increased intake on tinnitus prevalence. For most continuous variables associated with food intake, adjusted OR values were

Table 1: Basic information to be incorporated into the article.

Author	Total	Age	Time frame	Data from	Study design	Diet recording method	Disease diagnosis	Type of diet
Carlotta Micaela Jarach 2023	383	40-65	2016-2019	The Mario Negri Institute in Milan (Italy) , Monza e Brianza, Italy	case control	Self-designed questionnaire	Interviewer administered questionnaire and the Italian validated version of the tinnitus handicap inventory	coffee, eggs, butter, meat, fish, cheese, fruit, vegetable, varied diet, dairy, milk
Diana Tang 2022	1217	>50	1997-2009	Blue Mountains Hearing Study	cohort	Semi-quantitative food frequency questionnaire， FFQ	Audiologist administered questionnaire	dietary flavonoids
Diana Tang 2021	1730	>50	1997-2009	Blue Mountains Hearing Study	cohort	Semi-quantitative food frequency questionnaire， FFQ	Audiologist administered questionnaire	carbohydrate, sugar, fiber, fruit, vegetable
Piers Dawes 2020	34576	30-69	2006-2010	UK Biobank resource (Collins 2012).	cross-sectional	Dietary assessment was based on the Oxford Web-Q	An epidemiologic method of hearing investigation	fiber, fat, sugar
Sang-Yeon Lee 2019	3575	40-64	2012-2013	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	chocolate
Doh Young Lee 2018	7621	40-80	2013-2015	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Diet was assessed with a semi-quantitative food-frequency questionnaire	Self-designed questionnaire	water, protein, fat, carbohydrate, fiber
Sang-Youp Lee 2018	13448	>19	2009-2012	The sixth Korea National Health and Nutrition Examination Survey	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	coffee
Christopher Spankovich 2017	2176	20-69	1999-2002	NHANES	cross-sectional	Dietary recall interviews were conducted during 1999–2002 NHANES MEC evaluations.	Self-designed questionnaire	fat, fruit, vegetable, meat, varied diet
Abby McCormack 2014	171722	40-69	2006-2010	UK Biobank resource (Collins 2012).	cross-sectional	The UK Biobank touchscreen questionnaire	Self-designed questionnaire	fruit, vegetable, fish, egg, sugar, coffee, dairy
Jordan T. Glicksman 2014	65085	30-44(registered)	1991-2009	The Nurses' Health Study II	cross-sectional	Extensively validated semiquantitative food frequency questionnaires	Self-designed questionnaire	coffee

assimilated in the meta-analysis when stratified according to dose intake, with the exclusion of the reference group. In cases of direct comparison, the singular adjusted OR value was integrated. Further insights on odds ratios (ORs) are provided in **Supplemental eTable 2**.

Literature quality evaluation

The assessment of individual study quality was conducted by two reviewers (SZ and MZ) using a modified version of the Newcastle–Ottawa Scale. Previous grading categorized studies as having a high (<5 stars), moderate (5–7 stars), or low (≥8 stars) risk of bias (see eTable 3 in the Supplement).

Statistical analysis

Data analysis was performed using RevMan (version 5.3) and Stata (version 15.0). Mixed–effect models were utilized to aggregate maximally covariate-adjusted odds ratios (ORs) across all studies. According to current practice, odds ratios (ORs), relative risks (RRs), and hazard ratios (HRs) are approximately equal when events occur infrequently. For this situation, it is acceptable to include OR, RR, and HR in the same meta-analysis. In cases where the P value of the Q test was <0.10 or the I^2 statistic exceeded 50%, we conducted an assessment to determine significant interstudy heterogeneity. For observational studies, maximally covariate-adjusted estimates were strongly prioritized. If a study employed an analytical method incongruent with synthesis for the majority of other studies, we either converted the effect estimate to the appropriate combined ratio or excluded the study from the meta-analysis.

In cases of considerable heterogeneity in the analysis with significant differences, meta-regression was utilized to explore the source of heterogeneity (please note**:** Meta-regression was considered when the data included in the analysis were greater than 10). We visually assessed the asymmetry of the funnel plot and used Egger's bias to detect possible publication bias, with estimation of missing studies conducted using eMethods if publication bias was suspected (please note: Publication bias analysis was considered when the data included in the analysis were greater than 6). Moreover, we conducted a sensitivity analysis of the pooled results employing a one–by–one exclusion method.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Results

Literature screening process is depicted in **Supplemental eTable 4**. Ten articles were found in the search[2 11 12 14 17-22]. Among these, two articles delved into individual dietary factors, namely, chocolate [19] and flavonoids [18], which were not investigated in other studies. While these two articles were included in the narrative review, they were excluded from the meta-analysis. The remaining eight articles comprised the dataset for the meta-analysis.

Fifteen common dietary factors were analyzed, and dietary sources were assessed using validated nutrition/diet questionnaires. The combined findings revealed that four diets (caffeine, fruit, dietary fiber, and dairy products) exhibited a negative association with the prevalence of tinnitus, that is, the higher the intake of caffeine, fruit, dietary fiber, and dairy products, the lower the prevalence of tinnitus.

A meta-analysis of dietary factors

The meta-analysis included eight studies with a total of 301,533 people and analyzed 15 dietary factors, as shown **in Figure 2**: carbohydrates (2/8, **Supplemental eFigure 1**), caffeine (4/8, **Supplemental eFigure 2**), varied diets (2/8, **Supplemental eFigure 3**), eggs (2/8, **Supplemental eFigure 4**), fruits (3/9, **Supplemental eFigure 5**), fiber (2/8, **Supplemental eFigure 6**), fat (3/8, **Supplemental eFigure 7**), margarine (2/8, **Supplemental eFigure 8**), meat (2/8, **Supplemental eFigure 9**), sugar (4/8, **Supplemental eFigure 10**), protein (2/8, **Supplemental eFigure 11**), fish (3/8, **Supplemental eFigure 12**), vegetables (4/8, **Supplemental eFigure 13**), water (3/8, **Supplemental eFigure 14**), and dairy (2/8, **Supplemental eFigure 15**). The summary results are depicted **in Figure 2**. Intake of dairy products, fruits, dietary fiber, and caffeine showed negative correlations with the prevalence of tinnitus: 0.827 for dairy [95%

CI 0.766–0.892], $I^2 = 0\%$, $p < 0.00001$; 0.649 for fruit [95% CI 0.532–0.793], $I^2 = 0\%$, $p < 0.0001$; 0.918 for fiber [95% CI 0.851–0.990], $I^2 = 63\%$, $p = 0.03$; and 0.898 for caffeine [95% CI 0.862–0.935], $I^2 = 23\%$, $p < 0.003$. Protein intake t increased the risk of tinnitus (OR = 1.002 [95% CI 1.001–1.004], $I^2 = 0\%$, $p = 0.009$). No associations were found between other dietary factors and tinnitus.

Sensitivity analysis

We conducted sensitivity analyses for various dietary intakes based on predefined analysis criteria (requiring data from included articles to exceed 6). Contradictory outcomes were noted in the aggregated results for caffeine **(**refer to **Supplemental eFigure 16)**, with the analysis attributing these contradictions to data within the same article (Abby McCormack 2014). Sequential exclusion of fruit **(**refer to **Supplemental eFigure 17)** and dietary fiber **(**refer to **Supplemental eFigure 18)** maintained the statistical significance of the combined odds ratio. Successive exclusion of summary results for vegetables **(**refer to **Supplemental eFigure 19)** and sugar **(**refer to **Supplemental eFigure 20)** revealed no contradictory outcomes in the combined odds ratio; thus, ensuring the robustness of the meta-analysis results. The comprehensive sensitivity analysis indicated the relative robustness of the meta-analysis results, confirming the association of fruit and dietary fiber intake with the prevalence of tinnitus. No significant associations between other dietary intakes and tinnitus were found.

Publication bias

The funnel plot and Egger test findings for caffeine, fruit, vegetables, diet, sugar, and fat indicated the presence of publication bias (**Supplemental eFigure 21－26**). We performed a supplementary analysis using the shear compensation method, yielding consistent results that suggest publication bias did not impact the main outcome.

Discussion

In this systematic review and meta-analysis involving eight observational studies (comprising a total of 301,533 participants), we discovered that increased dietary consumption of fruit, dietary fiber, dairy products, and caffeine was associated with a reduced occurrence of tinnitus. These reductions were 35.1% (20.7%–46.8%) for fruit intake, 9.2% (1%–14.9%) for dietary fiber, 17.3% (10.8%–23.4%) for dairy products, and 10.2% (6.5%–13.8%) caffeine intake, respectively. These results were consistently supported by sensitivity analysis.

The association between caffeine intake and tinnitus remains contentious. Our final findings indicate a positive impact of caffeine on reducing tinnitus occurrence. Some suggest that caffeine might effectively decrease tinnitus prevalence, possibly due to its anxiety-reducing effects.

Conversely, some scholars argue that individuals with tinnitus often experience insomnia, which caffeine consumption could worsen; thus, exacerbating tinnitus symptoms. Recent observational studies [23 24] found no link between caffeine consumption and depression or anxiety levels. Furthermore, additional dose analysis revealed a J–pattern association between caffeine intake and psychiatric disorders, with around 2–3 cups per day associated with decreased risk [25]. Caffeine, acting as a nonselective adenosine receptor antagonist, can mitigate anxiety when ingested at a daily dose of 10 mg/kg [26]. Genetic analysis also suggests a correlation between caffeine consumption and reduced tinnitus prevalence [27]. This effect is achieved through adenosine receptor blockade, dopamine release promotion, acetylcholinesterase activity inhibition, and sympathetic nerve stimulation.

In addition, our findings suggest that dietary fiber and fruit intake has a positive impact on reducing the occurrence of tinnitus, which is consistent with the results of most scientists[11 14 21 28]. Some scholars propose that dietary fiber is associated with enhanced insulin sensitivity[29]. Studies indicate that hyperinsulinemia from low insulin sensitivity could disturb the inner ear environment, potentially raising tinnitus risk [30 31]. Conversely, research suggests that fiber and dairy products might enhance blood vessel function[32], a factor correlated with tinnitus. Abnormal microcirculation, for instance, contributes to a sustained reduction in ear blood flow, potentially leading to cochlear damage and increasing tinnitus risk [14].

Our combined analysis found no correlation between vegetable consumption and tinnitus. Identifying the source of heterogeneity was difficult due to the limited number of articles. Nevertheless, sensitivity analyses reaffirm the strength of our conclusions. Vegetables and fruits, rich in diverse vitamins and minerals crucial for maintaining health, have been shown to improve ear microcirculation, alleviate tinnitus, and offer additional benefits [12 28]. Future studies are expected to shed clearer results.

The body has three main sources of energy: carbohydrates (sugars), fats and proteins. Our findings indicate that protein increase the occurrence of tinnitus (OR = 1.002, [95% CI 1.001–1.004], $p = 0.009$). Protein is a crucial nutrient requiring daily consumption and plays a vital role in supporting neuronal activity and neural development[33 34]. Inadequate protein intake can lead to ototoxic side effects and impair the neural function of the auditory system[35]. Dawes et al.'s study demonstrated that a higher intake of dietary pattern factor 3 (high protein) was linked to a reduced likelihood of tinnitus[11]. Although low-protein diets may affect auditory vestibular function, no studies specify the necessary amount of protein in the diet. Our analysis found the links between protein intake and tinnitus risk. Moreover, high–protein diets have been shown to induce oxidative stress in the cerebral cortex and hypothalamus of rats[36]. Hence, further research on the relationship between protein dosage and tinnitus is warranted in the future.

In line with our analysis, no significant effect of sugar intake on tinnitus was observed (OR = 0.997 [95% CI 0.967, 1.027]). Sugars, water, and carbohydrate are essential daily components, and no links with tinnitus have been identified. High sugar consumption is typically associated with an unhealthy lifestyle. Proinflammatory foods, including sugary items, are often linked to increased not only systemic inflammation but also to microvascular damage, particularly microischemic events[37]. Elevated blood glucose levels can harm small blood vessels and nerves in the inner ear, leading to pathological alterations in outer hair cells and spiral ganglion cells. This can result in nerve tissue ischemia and hypoxia, leading to nerve damage[35]. Conversely, Spankovich et al. demonstrated that high carbohydrate intake can prevent hearing loss in older adults[38]. Tang et al. showed a 45% decrease in tinnitus risk for participants in the fourth quartile compared to the first quartile of carbohydrate intake [14]. Lee et al. discovered a significant correlation between reduced water intake and tinnitus–related difficulties in young and middle–aged adults[12]. Additionally, Yang et al. found that adequate water intake and a low–sodium diet improved hearing and alleviated vertigo and tinnitus in patients with Meniere’s disease [39].

Both excessive and insufficient dietary intake may have adverse effects on tinnitus, underscoring the need for a dose–response analysis of diet, which would provide valuable insights for dietary tinnitus prevention. Several studies have suggested that increasing the score of healthy foods, such as fruits, vegetables, legumes, nuts, fish, and dairy products, may lower the risk of cardiovascular disease and mortality[40-42]. With each one-fifth increase in the healthy diet score, there was a corresponding decrease in overall mortality rate (HR = 0.92; 0.90–0.93), severe cardiovascular disease (HR = 0.94; 95% CI: 0.93–0.95), myocardial infarction (HR = 0.94; 0.92–0.96), stroke (HR = 0.94; 0.89–0.99), and death or cardiovascular disease (HR = 0.93; 0.92–0.94[43]) .

The outcomes of our analysis did not support a notable connection between fat intake and tinnitus risk, although there was a discernible upward trend. Moreover, high-fat diets contribute to obesity and can lead to insulin resistance[44]. Conversely, adopting a low–fat/low–cholesterol diet might aid in reducing blood cholesterol and triglyceride levels, potentially alleviating tinnitus symptoms[45]. Future studies are needed to verify the relationship between the fat and tinnitus.

A recent study uncovered that increased levels of dietary variety, covering quantity, evenness, and quality, were inversely linked to the risk of depressive symptoms, especially among women and older adults[46]. This could potentially offer relief for tinnitus. Moreover, dietary variety is believed to correlate with insulin resistance[47]. Given the protective effects various diets have shown on human health, further exploration of dietary variety is necessary to validate significant associations. Our pooled analysis indicated that a varied diet was not significantly linked to reduced tinnitus prevalence (OR = 0.653 [95% CI 0.410, 1.038]) based on the currently available evidence.

We found only one study that investigated the impact of chocolate and flavonoids on the onset of tinnitus [19], but it did not provide sufficient data for a meta-analysis. Flavonoids, found abundantly in fruits and vegetables, offer antioxidant, anti-inflammatory, and vascular health benefits, which align with the pathophysiology of age-related hearing loss and tinnitus[48]. Additionally, flavonoids interact with signaling cascades involving protein and lipid kinases, inhibiting neuronal death induced by neurotoxicants like oxygen radicals and promoting neuronal survival and synaptic plasticity[49]. Despite the hypothesis that dietary flavonoids might protect against tinnitus development over a 10-year period, Tang et al. [48]. did not support this idea. However, it is important to note that this study had limitations, such as insufficient data collection.

Chocolate is a globally consumed product renowned for its high phenolic compound content (flavonoids being a subclass of polyphenols) [50]. A study by Lee et al. indicated that chocolate consumption is not linked to tinnitus or tinnitus–related issues[19]. An animal study demonstrated that polyphenols alleviate oxidative stress in the cochlea by suppressing apoptotic signaling pathways[51]. Nonetheless, excessive chocolate consumption can have adverse effects on brain hyperexcitability[52]. Future investigations into the association between chocolate consumption and tinnitus should take into account the intake dosage.

This systematic review and meta-analysis mark the first attempt to explore the epidemiological link between diet and tinnitus. While we examined the relationships between fruit, dietary fiber, and caffeine intake and a reduced prevalence of tinnitus, it remains inconclusive whether a causal relationship exists.

Conclusion

Diet–based strategies for tinnitus prevention are anticipated to play a significant role in chronic tinnitus management. Existing evidence suggests that consuming fruit, dietary fiber, caffeine, and dairy may be associated with a reduced prevalence of tinnitus. The primary underlying mechanisms may involve the protective effects of these diets on blood vessels and nerves, as well as their anti-inflammatory and antioxidant properties. However, it is crucial to interpret our findings cautiously due to the overall low quality of the evidence available. In the future, further well-designed, large-scale, cross-population cohort studies are warranted to complement and verify the relationship between dietary intake and tinnitus.

Additionally, focusing on the dosage and categorization of each dietary intake would provide valuable insights.

Author Contribution

All authors contributed to the study's conception and design. SZ, MZ, XW, YJ conducted data collection and analysis. SZ, QZ designed the test plan. QF as the paper guide, control the quality of the paper, XH, XL, XW, HW drew the chart. XC, LW, LF completed the writing of the test plan. XL and QZ revised the manuscript. QZ is responsible for the overall content as the guarantor.

Author Declaration

The author has no direct conflict of interest.

Ethical Approval

The article belongs to the review category and does not require the approval of the ethics committee.

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Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

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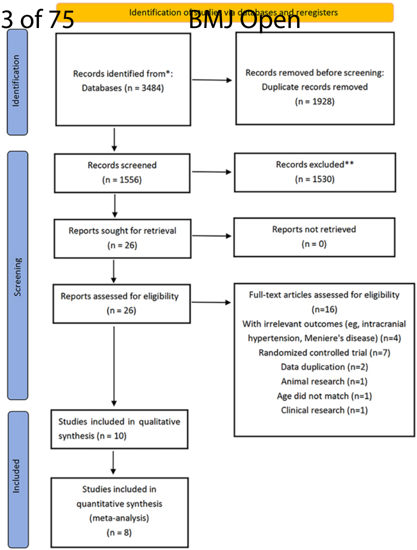
Figure 1: Flow chart

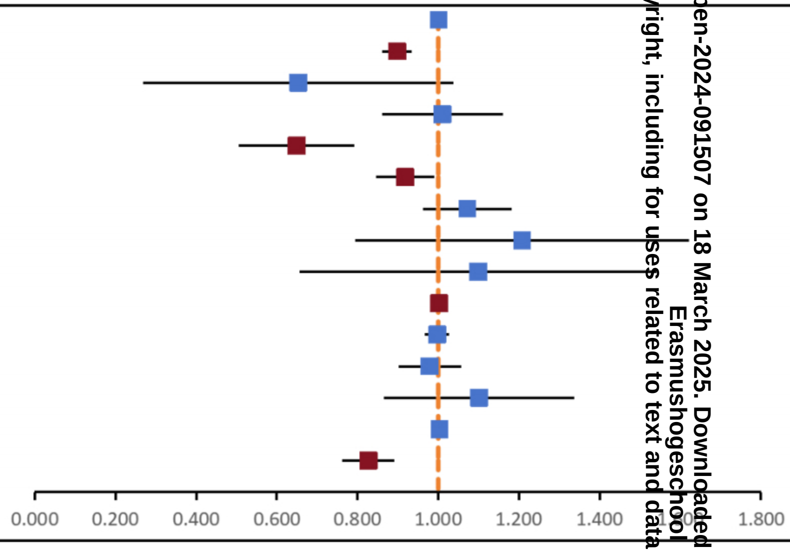
Figure 2: Risk ratio summary of diet and tinnitus prevalence



*means: The search results of the four databases according to the pre-specified database search strategy.

**means: The process of selecting articles for title and abstract based on inclusion exclusion criteria.

Type of diet	Study，n	I^2	OR	LOR	UOR	95%CI	Grade	Evidence class
Carbohydrate	2	33.0%	1.001	1.000	1.002		Low	NS
Caffeine	3	23.0%	0.898	0.862	0.935		Low	Class II
Varied diet	2	50.0%	0.653	0.410	1.038		Very low	NS
Egg	2	55.0%	1.010	0.880	1.160		Very low	NS
Fruit	3	0.0%	0.649	0.532	0.793		Moderate	Class II
Fiber	3	63.0%	0.918	0.851	0.990		Low	Class II
Fat	3	73.0%	1.072	0.973	1.181		Very low	NS
Margarine	2	0.0%	1.208	0.900	1.622		Low	NS
Meat	2	0.0%	1.099	0.783	1.542		Low	NS
Protein	2	0.0%	1.002	1.001	1.004		Low	Class III
Sugar	3	0.0%	0.997	0.967	1.027		Low	NS
Fish	3	72.0%	0.979	0.907	1.056		Very low	NS
Vegetable	4	0.0%	1.101	0.907	1.337		Very low	NS
Water	3	0.0%	1.003	0.992	1.014		Low	NS
Dairy	2	0.0%	0.827	0.766	0.892		Low	Class II



The blue or red dots represent OR values, and the black linesrepresent confidence intervals
p<0.05 indicates statistical difference.
The evidence classification criteria: Class I (convincing evidence), Class II (highly suggestive evidence), Class III (suggestive evidence), Class IV (weak evidence), and NS (non-significant).
GRADE:Grade of Recommendations Assessment, Development, and Evaluation.
Moderate: The results of current efficacy evaluation are likely to be close to the true value;
Low: The reliability of the current efficacy evaluation results is uncertain;
Very low: The reliability of the current efficacy evaluation results is very uncertain;

Catalogue

Search Strategy

Search Strategy Free text search strategy: Initial search date: 25 May 2024

PubMed 1216

(tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate).

EMBASE 1942

('Tinnitus'/exp OR 'Tinnitus':ab,ti,kw OR 'Ringing-Buzzing'/exp OR 'Ringing-Buzzing':ab,ti,kw OR 'ear buzzing':ab,ti,kw) AND (('Diet'/exp OR 'Diets':ab,ti,kw) OR ('Food'/exp OR 'Food':ab,ti,kw OR 'Foods':ab,ti,kw) OR ('Water'/exp OR 'Water':ab,ti,kw OR 'Hydrogen Oxide':ab,ti,kw) OR ('Milk'/exp OR 'Milk':ab,ti,kw OR 'Cow Milk':ab,ti,kw) OR ('fish'/exp OR 'fish':ab,ti,kw) OR ('vegetable'/exp OR 'vegetable':ab,ti,kw) OR ('Dietary Fiber'/exp OR 'alimentary fiber':ab,ti,kw) OR ('sugar'/exp OR 'sugar':ab,ti,kw) OR ('meat'/exp OR 'meat':ab,ti,kw OR 'sausage':ab,ti,kw) OR ('margarine'/exp OR 'margarine':ab,ti,kw OR 'oleomargarine':ab,ti,kw) OR ('fat'/exp OR 'fat':ab,ti,kw) OR ('egg'/exp OR 'egg':ab,ti,kw) OR ('varietas'/exp OR 'plant variety':ab,ti,kw) OR ('caffeine'/exp OR 'caffeine':ab,ti,kw OR 'coffein':ab,ti,kw) OR ('carbohydrate'/exp OR 'carbohydrate':ab,ti,kw OR 'carbon hydrate':ab,ti,kw OR 'synthetic carbohydrate':ab,ti,kw OR 'saccharide':ab,ti,kw) OR ('protein'/exp OR 'protein':ab,ti,kw))

Web of Science 29

("Tinnitus"(Topic) OR "Tinnitus"(Topic) OR "Ringing-Buzzing"(Topic) OR "Ringing-Buzzing"(Topic) OR "ear buzzing"(Topic)) AND (("Diet"(Topic) OR "Diets"(Topic)) OR ("Food"(Topic) OR "Foods"(Topic)) OR ("Water"(Topic) OR "Hydrogen Oxide"(Topic)) OR ("Milk"(Topic) OR "Cow Milk"(Topic)) OR ("fish"(Topic)) OR ("vegetable"(Topic)) OR ("Dietary Fiber"(Topic) OR "alimentary fiber"(Topic)) OR ("sugar"(Topic)) OR ("meat"(Topic) OR "sausage"(Topic)) OR ("margarine"(Topic) OR "oleomargarine"(Topic)) OR ("fat"(Topic)) OR ("egg"(Topic)) OR ("varietas"(Topic) OR "plant variety"(Topic)) OR ("caffeine"(Topic) OR "coffein"(Topic)) OR ("carbohydrate"(Topic) OR "carbon hydrate"(Topic) OR "synthetic carbohydrate"(Topic) OR "saccharide"(Topic)) OR ("protein"(Topic)))

Cochrane 297

((tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate) in Title Abstract Keyword

Stata analysis

We used mixed-effects models to pool maximally covariate-adjusted odds ratios (ORs) from each study. Due to the low incidence of events and short follow-up events, OR, RR, and HR were approximately equal, so our results were uniformly expressed in OR. If the P-value of the q test was <0.10 or the I^2 statistic was ≥50%, we assessed and considered the inter-study heterogeneity to be significant. For observational studies, we maximally support covariate-adjusted estimates. If a study uses an analytical method that is incompatible with synthesis for most other studies, we convert the effect estimate to the appropriate combined ratio or exclude the study from the meta-analysis.

Publication bias

If the article heterogeneity is large in the analysis with statistical differences, we will use meta regression to investigate the source of heterogeneity. We assessed the asymmetry of the funnel plot with visual and Egger's bias, and estimated the possible missing studies with eMethods if publication bias is suspected.

Analysis software

We conducted all analyses using stata (version 16) and Review Manager (version 5.3). Unless otherwise specified, we considered a two-sided P value of <0.05 as statistically significant.

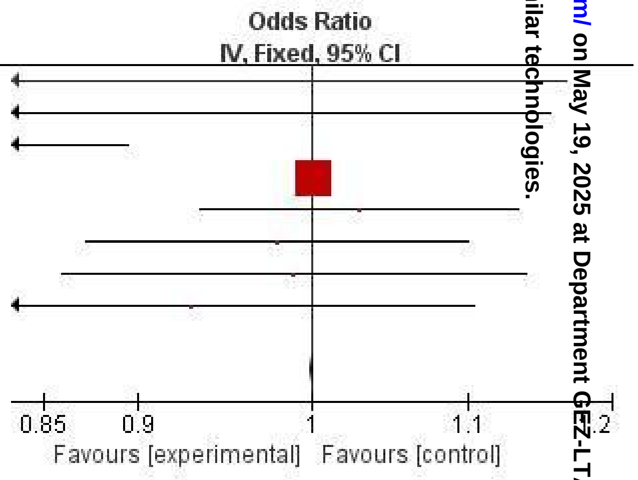
eFigure 1: Forest Plot Showing the Association Between carbohydrate and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.

Carbohydrate: OR=1.00, [95%CI 1.00,1.00], I^2=33%, p=0.05.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Diana Tang 2021a	-0.3011051	0.2326598	0.0%	0.74 [0.47, 1.17]
Diana Tang 2021b	-0.3024573	0.2282614	0.0%	0.74 [0.47, 1.16]
Diana Tang 2021c	-0.597837	0.2483288	0.0%	0.55 [0.34, 0.89]
Doh Young Lee 2018	0.0009995	0.0005102	100.0%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0295588	0.0492101	0.0%	1.03 [0.94, 1.13]
Piers Dawes 2020b	-0.0202027	0.059233	0.0%	0.98 [0.87, 1.10]
Piers Dawes 2020c	-0.0100503	0.0719008	0.0%	0.99 [0.86, 1.14]
Piers Dawes 2020d	-0.0725707	0.0876968	0.0%	0.93 [0.78, 1.10]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 10.46, df = 7 (P = 0.16); I² = 33%
Test for overall effect: Z = 1.95 (P = 0.05)



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            Study       |     ES    [95% Conf. Interval]     % Weight
------------------------+--------------------------------------------------
Diana Tang 2021a        |  0.740       0.469     1.168          0.00
Diana Tang 2021b        |  0.739       0.472     1.156          0.00
Diana Tang 2021c        |  0.550       0.338     0.895          0.00
Doh Young Lee 2018      |  1.001       1.000     1.002         99.97
Piers Dawes 2020a       |  1.030       0.935     1.134          0.01
Piers Dawes 2020b       |  0.980       0.873     1.101          0.01
Piers Dawes 2020c       |  0.990       0.860     1.140          0.01
Piers Dawes 2020d       |  0.930       0.783     1.104          0.00
------------------------+--------------------------------------------------
I-V pooled ES           |  1.001       1.000     1.002        100.00
------------------------+--------------------------------------------------
```

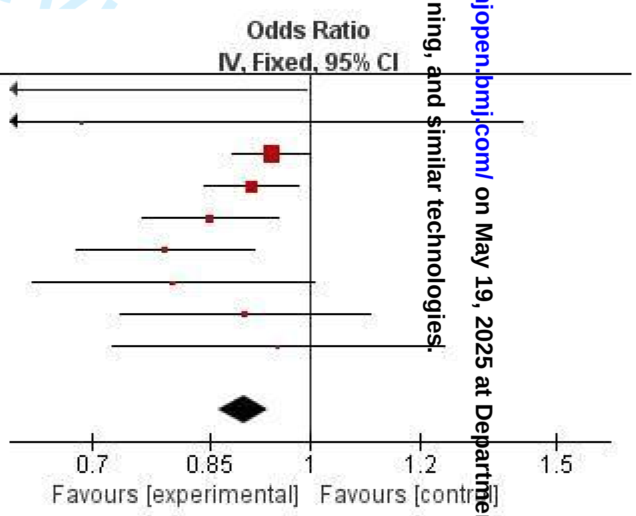
Actually: Carbohydrate: OR=1.001, [95%CI 1.000,1.002]

eFigure 2: Forest Plot Showing the Association Between caffeine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Caffeine: OR=0.90, [95%CI 0.86,0.94], I^2=23% p<0.000001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.7133499	0.3614964	0.3%	0.49 [0.24, 1.00]
Carlotta Micaela Jarach 2023b	-0.3710637	0.36645	0.3%	0.69 [0.34, 1.42]
Jordan T Glicksman 2014a	-0.0618754	0.0326106	40.8%	0.94 [0.88, 1.00]
Jordan T Glicksman 2014b	-0.0943106	0.0393242	28.0%	0.91 [0.84, 0.98]
Jordan T Glicksman 2014c	-0.1625189	0.0569244	13.4%	0.85 [0.76, 0.95]
Jordan T Glicksman 2014d	-0.2357223	0.0743244	7.8%	0.79 [0.68, 0.91]
Sang-Youp Lee 2018	-0.2231435	0.1178662	3.1%	0.80 [0.63, 1.01]
Sang-Youp Lee 2018b	-0.1053605	0.1045972	4.0%	0.90 [0.73, 1.10]
Sang-Youp Lee 2018c	-0.0512933	0.1386774	2.3%	0.95 [0.72, 1.25]
Total (95% CI)			**100.0%**	**0.90 [0.86, 0.94]**

Heterogeneity: Chi² = 10.43, df = 8 (P = 0.24); I² = 23%
Test for overall effect: Z = 5.18 (P < 0.00001)



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           Study        |     ES     [95% Conf. Interval]     % Weight
------------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.490       0.241     0.995          0.33
Carlotta Micaela Jar |  0.690       0.336     1.415          0.32
Jordan T 2014a       |  0.940       0.882     1.002         40.76
Jordan T 2014b       |  0.910       0.842     0.983         28.03
Jordan T 2014c       |  0.850       0.760     0.950         13.38
Jordan T 2014d       |  0.790       0.683     0.914          7.85
Sang-Youp Lee 2018   |  0.800       0.635     1.008          3.12
Sang-Youp Lee 2018   |  0.900       0.733     1.105          3.96
Sang-Youp Lee 2018   |  0.950       0.724     1.247          2.25
------------------------+---------------------------------------------------
I-V pooled ES        |  0.898       0.862     0.935        100.00
------------------------+---------------------------------------------------
```

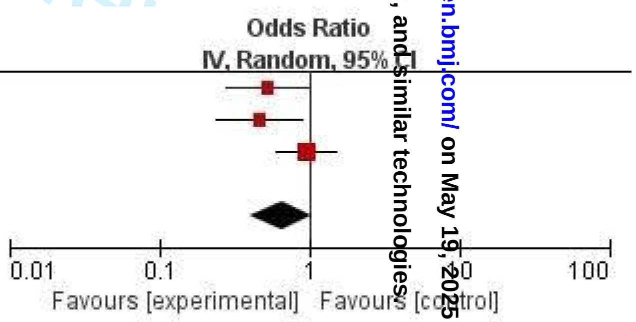
Actually: Caffeine: OR=0.898, [95%CI 0.862,0.935]

eFigure 3: Forest Plot Showing the Association Between diversity and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Diversity: OR=0.65, [95%CI 0.41,1.04], I^2=50% p=0.08.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlotta Micaela Jarach 2023a	-0.6348783	0.3247361	29.9%	0.53 [0.28, 1.00]
Carlotta Micaela Jarach 2023b	-0.7550226	0.3371826	28.7%	0.47 [0.24, 0.91]
Christopher Spankovich 2017	-0.0444	0.2295	41.4%	0.96 [0.61, 1.50]
Total (95% CI)			**100.0%**	**0.65 [0.41, 1.04]**

Heterogeneity: Tau² = 0.09; Chi² = 3.98, df = 2 (P = 0.14); I² = 50%
Test for overall effect: Z = 1.78 (P = 0.08)



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            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.530       0.280     1.002          29.86
Carlotta Micaela Jar |  0.470       0.243     0.910          28.60
Christopher Spankovi |  0.950       0.606     1.490          41.54
---------------------+---------------------------------------------------
D+L pooled ES        |  0.653       0.410     1.038         100.00
---------------------+---------------------------------------------------
```

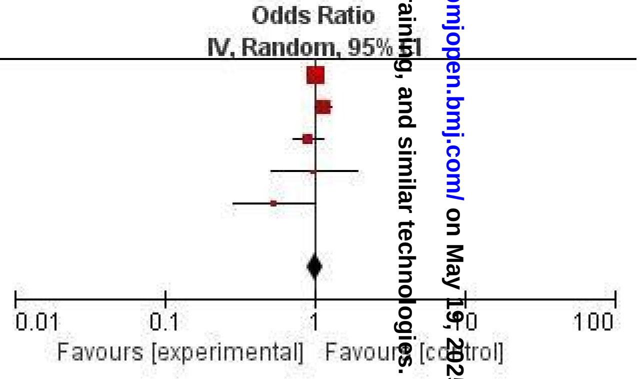
Actually: diversity: OR=0.653, [95%CI 0.410, 1.038].

eFigure 4: Forest Plot Showing the Association Between egg and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis.
Egg: OR=1.02, [95%CI 0.91,1.15], I^2=55% p=0.75.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Abby McCormack 2014a	0.0304592	0.0274031	43.4%	1.03 [0.98, 1.09]
Abby McCormack 2014b	0.1392621	0.0589045	32.9%	1.15 [1.02, 1.29]
Abby McCormack 2014c	-0.10436	0.1166166	17.3%	0.90 [0.72, 1.13]
Carlotta Micaela Jarach 2023a	-0.0100503	0.338181	3.0%	0.99 [0.51, 1.92]
Carlotta Micaela Jarach 2023b	-0.6161861	0.3157843	3.4%	0.54 [0.29, 1.00]
Total (95% CI)			**100.0%**	**1.02 [0.91, 1.15]**

Heterogeneity: Tau² = 0.01; Chi² = 8.83, df = 4 (P = 0.07); I² = 55%
Test for overall effect: Z = 0.32 (P = 0.75)



```
. metan logrr selogrr, label(namevar=author) random eform

          Study          |     ES    [95% Conf. Interval]     % Weight
-------------------------+--------------------------------------------------
Abby McCormack 2014      |  1.031       0.926     1.148          36.13
Abby McCormack 2014a     |  1.149       1.024     1.290          35.00
Abby McCormack 2014b     |  0.901       0.717     1.133          20.41
Carlotta Micaela Jar     |  0.990       0.510     1.921           3.97
Carlotta Micaela Jar     |  0.540       0.291     1.003           4.50
-------------------------+--------------------------------------------------
D+L pooled ES            |  1.010       0.880     1.160         100.00
-------------------------+--------------------------------------------------
```

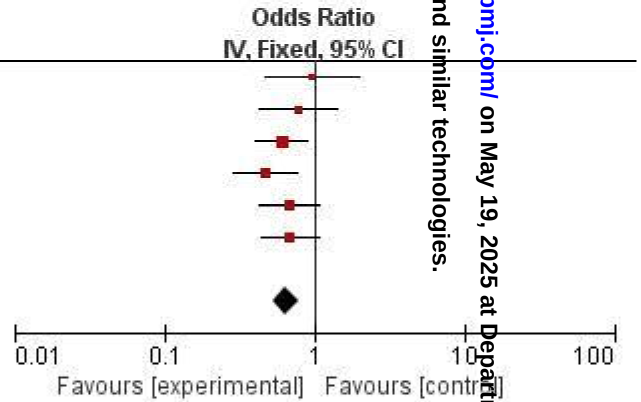
Actually: diversity: OR=1.010, [95%CI 0.880, 1.160].

eFigure 5: Forest Plot Showing the Association Between fruit and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fruit: OR=0.65, [95%CI 0.53,0.79], I^2=0% p<0.0001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.040822	0.3655756	7.7%	0.96 [0.47, 1.97]
Carlotta Micaela Jarach 2023b	-0.2484614	0.3083197	10.9%	0.78 [0.43, 1.43]
Christopher Spankovich 2017	-0.4942963	0.2033897	25.0%	0.61 [0.41, 0.91]
Diana Tang 2021a	-0.7550226	0.2457749	17.1%	0.47 [0.29, 0.76]
Diana Tang 2021b	-0.3856625	0.230163	19.5%	0.68 [0.43, 1.07]
Diana Tang 2021c	-0.3710637	0.2290667	19.7%	0.69 [0.44, 1.08]
Total (95% CI)			**100.0%**	**0.65 [0.53, 0.79]**

Heterogeneity: Chi² = 3.43, df = 5 (P = 0.63); I² = 0%
Test for overall effect: Z = 4.24 (P < 0.0001)



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.960       0.469     1.965          7.74
Carlotta Micaela Jar |  0.780       0.426     1.427         10.88
Christopher Spankovi |  0.610       0.409     0.909         25.01
Diana Tang 2021a     |  0.470       0.290     0.761         17.13
Diana Tang 2021b     |  0.680       0.433     1.068         19.53
Diana Tang 2021d     |  0.690       0.440     1.081         19.72
---------------------+---------------------------------------------------
I-V pooled ES        |  0.649       0.532     0.793        100.00
---------------------+---------------------------------------------------
```

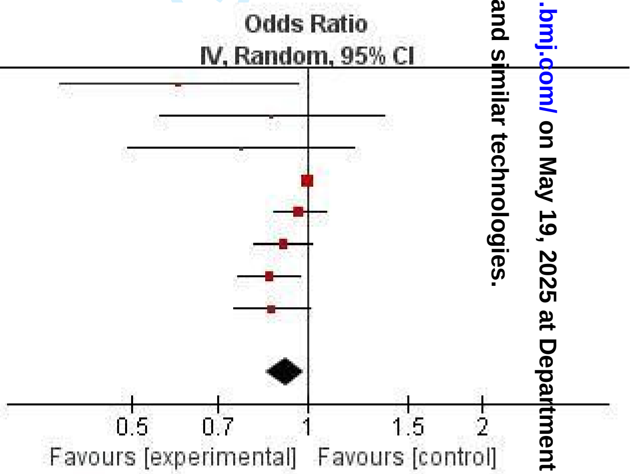
Actually: fruit: OR=0.649, [95%CI 0.532, 0.793].

eFigure 6: Forest Plot Showing the Association Between fiber and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Fiber: OR=0.92, [95%CI 0.85,0.99], I^2=63% p=0.03.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Diana Tang 2021a	-0.5108256	0.243222	2.3%	0.60 [0.37, 0.97]
Diana Tang 2021b	-0.1392621	0.2282217	2.6%	0.87 [0.56, 1.36]
Diana Tang 2021c	-0.2613648	0.2306047	2.5%	0.77 [0.49, 1.21]
Doh Young Lee 2018	0.003992	0.0022879	27.8%	1.00 [1.00, 1.01]
Piers Dawes 2020a	-0.0304592	0.0527859	18.3%	0.97 [0.87, 1.08]
Piers Dawes 2020b	-0.0943106	0.0588071	16.9%	0.91 [0.81, 1.02]
Piers Dawes 2020c	-0.1508229	0.0622392	16.1%	0.86 [0.76, 0.97]
Piers Dawes 2020d	-0.1392621	0.0759266	13.4%	0.87 [0.75, 1.01]
Total (95% CI)			**100.0%**	**0.92 [0.85, 0.99]**

Heterogeneity: Tau² = 0.01; Chi² = 19.09, df = 7 (P = 0.008); I² = 63%
Test for overall effect: Z = 2.21 (P = 0.03)



```
. metan logrr selogrr, label(namevar=author) random eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Diana Tang 2021a        |  0.600       0.372     0.966           2.31
Diana Tang 2021b        |  0.870       0.556     1.361           2.59
Diana Tang 2021d        |  0.770       0.490     1.210           2.54
Doh Young Lee 2018      |  1.004       1.000     1.009          27.81
Piers Dawes 2020a       |  0.970       0.875     1.076          18.30
Piers Dawes 2020b       |  0.910       0.811     1.021          16.90
Piers Dawes 2020c       |  0.860       0.761     0.972          16.14
Piers Dawes 2020d       |  0.870       0.750     1.010          13.40
---------------------+---------------------------------------------------
D+L pooled ES           |  0.918       0.851     0.990         100.00
---------------------+---------------------------------------------------
```

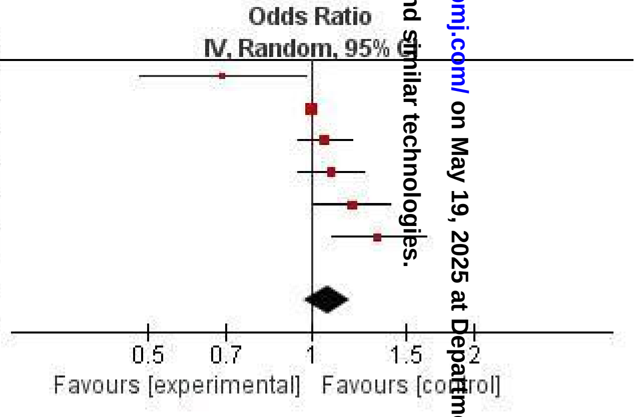
Actually: fruit: OR=0.918, [95%CI 0.851, 0.990].

eFigure 7: Forest Plot Showing the Association Between fat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Fat: OR=1.07, [95%CI 0.97,1.18], I^2=73% p=0.16.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Christopher Spankovich 2017	-0.3710637	0.1794132	5.9%	0.69 [0.49, 0.98]
Doh Young Lee 2018	0.0029955	0.0010173	27.8%	1.00 [1.00, 1.01]
Piers Dawes 2020a	0.0582689	0.0574609	20.2%	1.06 [0.95, 1.19]
Piers Dawes 2020b	0.0861777	0.0700094	17.8%	1.09 [0.95, 1.25]
Piers Dawes 2020c	0.1739534	0.0832964	15.5%	1.19 [1.01, 1.40]
Piers Dawes 2020d	0.285179	0.1010838	12.8%	1.33 [1.09, 1.62]
Total (95% CI)			**100.0%**	**1.07 [0.97, 1.18]**

Heterogeneity: Tau² = 0.01; Chi² = 18.68, df = 5 (P = 0.002); I² = 73%
Test for overall effect: Z = 1.41 (P = 0.16)



```
. metan logrr selogrr, label(namevar=author) random eform

           Study        |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Christopher Spankovi |   0.690       0.485     0.981          5.95
Doh Young Lee 2018   |   1.003       1.001     1.005         27.75
Piers Dawes 2020a    |   1.060       0.947     1.186         20.17
Piers Dawes 2020b    |   1.090       0.950     1.250         17.81
Piers Dawes 2020c    |   1.190       1.011     1.401         15.50
Piers Dawes 2020d    |   1.330       1.091     1.621         12.82
---------------------+---------------------------------------------------
D+L pooled ES        |   1.072       0.973     1.181        100.00
---------------------+---------------------------------------------------
```

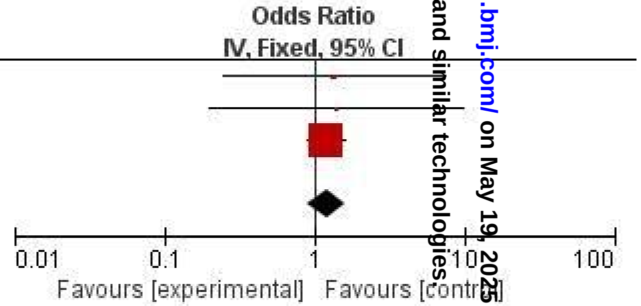
Actually: fat: OR=1.072, [95%CI 0.973, 1.181].

eFigure 8: Forest Plot Showing the Association Between margarine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Margarine: OR=1.21, [95%CI 0.90,1.63], I^2=0% p=0.20.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3001046	0.8652602	3.0%	1.35 [0.25, 7.36]
Carlotta Micaela Jarach 2023b	0.3364722	0.9974543	2.3%	1.40 [0.20, 9.89]
Milena Tomanic 2020	0.1856494	0.154809	94.7%	1.20 [0.89, 1.63]
Total (95% CI)			**100.0%**	**1.21 [0.90, 1.63]**

Heterogeneity: Chi² = 0.04, df = 2 (P = 0.98); I² = 0%
Test for overall effect: Z = 1.28 (P = 0.20)



```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study     |     ES    [95% Conf. Interval]     % Weight
----------------------+---------------------------------------------------
Carlotta Micaela Jar  |  1.350       0.248     7.359          3.01
Carlotta Micaela Jar  |  1.400       0.198     9.889          2.27
Milena Tomanic 2020   |  1.200       0.887     1.624         94.72
----------------------+---------------------------------------------------
I-V pooled ES         |  1.208       0.900     1.622        100.00
----------------------+---------------------------------------------------
```

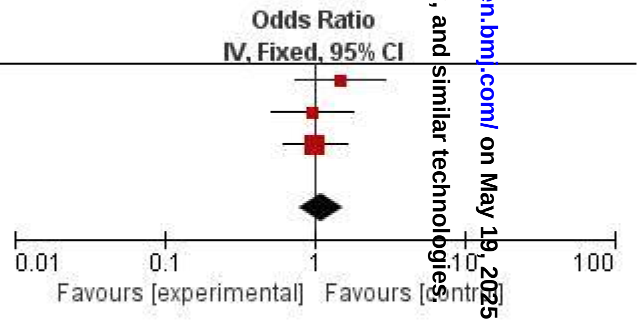
Actually: margarine: OR=1.208, [95%CI 0.900, 1.622].

eFigure 9: Forest Plot Showing the Association Between meat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Meat: OR=1.10, [95%CI 0.78,1.54], I^2=0% p=0.59.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3987761	0.3484928	24.6%	1.49 [0.75, 2.95]
Carlotta Micaela Jarach 2023b	-0.0304592	0.3287067	27.6%	0.97 [0.51, 1.85]
Christopher Spankovich 2017	0.0099503	0.2496967	47.8%	1.01 [0.62, 1.65]
Total (95% CI)			**100.0%**	**1.10 [0.78, 1.54]**

Heterogeneity: Chi² = 1.02, df = 2 (P = 0.60); I² = 0%
Test for overall effect: Z = 0.55 (P = 0.59)



```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  1.490       0.753     2.950          24.56
Carlotta Micaela Jar |  0.970       0.509     1.847          27.60
Christopher Spankovi |  1.010       0.619     1.648          47.84
---------------------+---------------------------------------------------
I-V pooled ES        |  1.099       0.783     1.542         100.00
---------------------+---------------------------------------------------
```

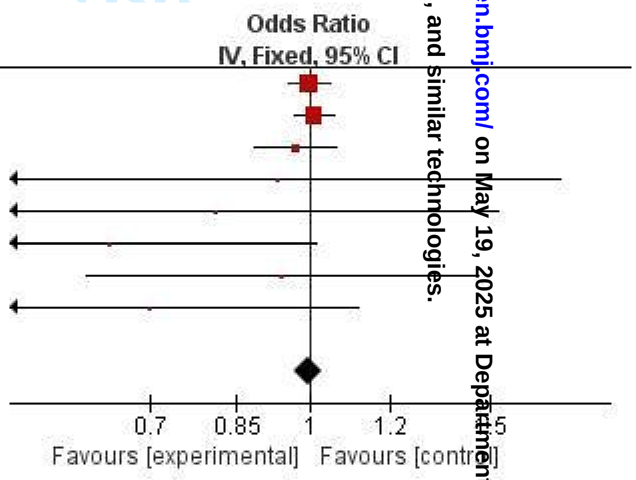
Actually: meat: OR=1.099, [95%CI 0.783, 1.542].

eFigure 10: Forest Plot Showing the Association Between sugar and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Sugar: OR=1.00, [95%CI 0.97,1.03], I^2=0% p=0.84.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Abby McCormack 2014a	0	0.0230439	44.3%	1.00 [0.96, 1.05]
Abby McCormack 2014b	0.0099503	0.0233327	43.2%	1.01 [0.96, 1.06]
Abby McCormack 2014c	-0.0294288	0.0469906	10.7%	0.97 [0.89, 1.06]
Carlotta Micaela Jarach 2023a	-0.0725707	0.3247361	0.2%	0.93 [0.49, 1.76]
Carlotta Micaela Jarach 2023b	-0.210721	0.3237852	0.2%	0.81 [0.43, 1.53]
Diana Tang 2021a	-0.4462871	0.236286	0.4%	0.64 [0.40, 1.02]
Diana Tang 2021b	-0.0618754	0.2243772	0.5%	0.94 [0.61, 1.46]
Diana Tang 2021c	-0.356675	0.2383442	0.4%	0.70 [0.44, 1.12]
Total (95% CI)			**100.0%**	**1.00 [0.97, 1.03]**

Heterogeneity: Chi² = 6.89, df = 7 (P = 0.44); I² = 0%
Test for overall effect: Z = 0.20 (P = 0.84)



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+--------------------------------------------------
Abby McCormack 2014  |  1.000       0.956     1.046          44.34
Abby McCormack 2014a |  1.010       0.965     1.057          43.25
Abby McCormack 2014b |  0.971       0.886     1.065          10.66
Carlotta Micaela Jar |  0.930       0.492     1.758           0.22
Carlotta Micaela Jar |  0.810       0.429     1.528           0.22
Diana Tang 2021a     |  0.640       0.403     1.017           0.42
Diana Tang 2021b     |  0.940       0.606     1.459           0.47
Diana Tang 2021c     |  0.700       0.439     1.117           0.41
---------------------+--------------------------------------------------
I-V pooled ES        |  0.997       0.967     1.027         100.00
---------------------+--------------------------------------------------
```

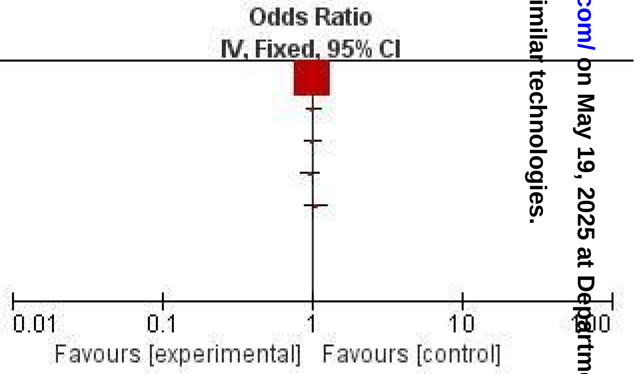
Actually: sugar: OR=0.997, [95%CI 0.967, 1.027].

eFigure 11: Forest Plot Showing the Association Between protein and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fish: OR=1.00, [95%CI 1.00,1.00], I^2=0% p=0.009.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Doh Young Lee 2018	0.001998	0.0007634	99.9%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0198026	0.0546964	0.0%	1.02 [0.92, 1.14]
Piers Dawes 2020b	0.0099503	0.060906	0.0%	1.01 [0.90, 1.14]
Piers Dawes 2020c	-0.0304592	0.0680814	0.0%	0.97 [0.85, 1.11]
Piers Dawes 2020d	0.0582689	0.0858348	0.0%	1.06 [0.90, 1.25]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 0.78, df = 4 (P = 0.94); I² = 0%
Test for overall effect: Z = 2.62 (P = 0.009)



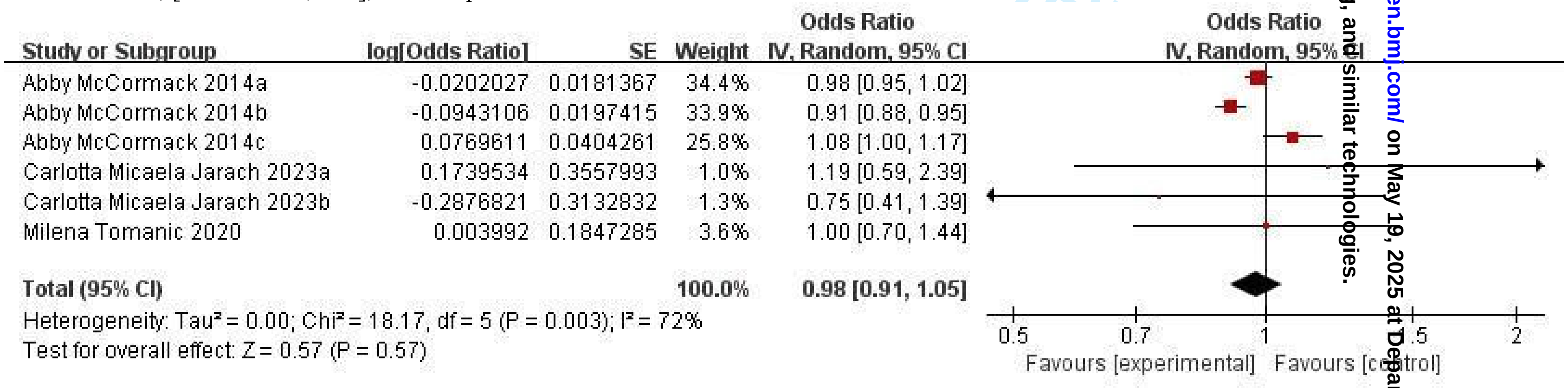
```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Doh Young Lee 2018   |  1.002       1.001     1.004          99.94
Piers Dawes 2020a    |  1.020       0.916     1.135           0.02
Piers Dawes 2020b    |  1.010       0.896     1.138           0.02
Piers Dawes 2020c    |  0.970       0.849     1.108           0.01
Piers Dawes 2020d    |  1.060       0.896     1.254           0.01
---------------------+---------------------------------------------------
I-V pooled ES        |  1.002       1.001     1.004         100.00
---------------------+---------------------------------------------------
```

Actually: protein: OR=1.002, [95%CI 1.001, 1.004].

eFigure 12: Forest Plot Showing the Association Between fish and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fish: OR=0.98, [95%CI 0.91,1.05], I^2=72% p=0.57.



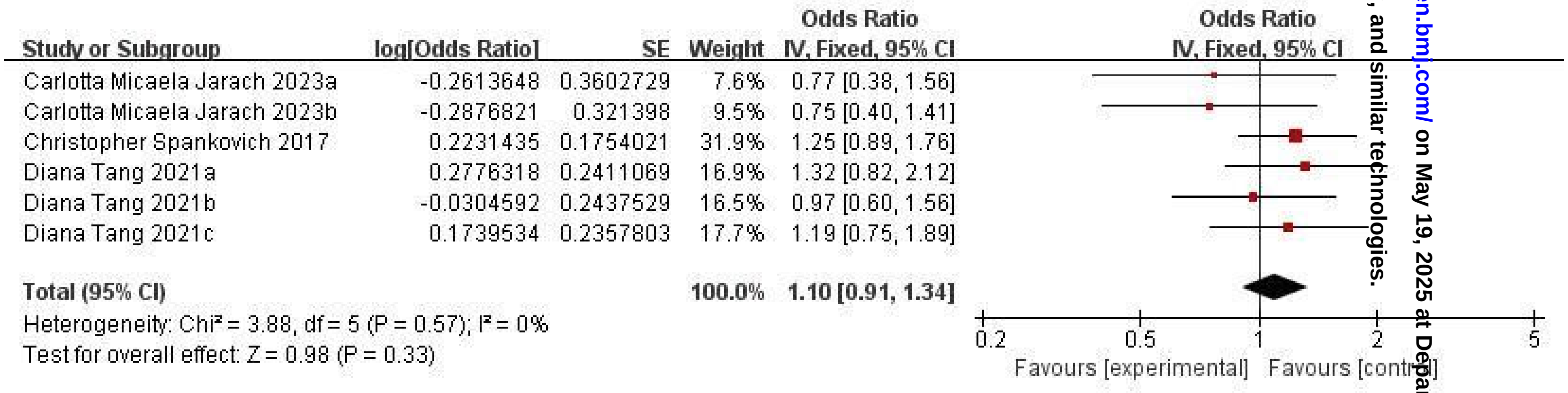
```
. metan logrr selogrr, label(namevar=author) random eform

             Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  0.980       0.946     1.015          35.43
Abby McCormack 2014a |  0.910       0.875     0.946          34.93
Abby McCormack 2014b |  1.080       0.998     1.169          27.04
Carlotta Micaela Jar |  1.190       0.593     2.390           1.14
Carlotta Micaela Jar |  0.750       0.406     1.386           1.46
---------------------+---------------------------------------------------
D+L pooled ES        |  0.979       0.907     1.056         100.00
---------------------+---------------------------------------------------
```

Actually: fish: OR=0.979, [95%CI 0.907, 1.056].

eFigure 13: Forest Plot Showing the Association Between vegetable and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Vegetable: OR=1.10, [95%CI 0.91,1.34], I^2=0% p=0.33..



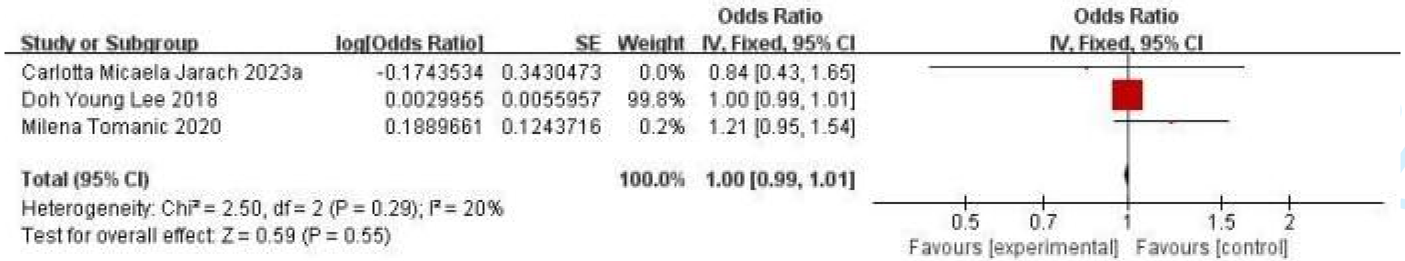
```
. metan logrr selogrr, label(namevar=author) fixed eform

           Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.770       0.380     1.560          7.56
Carlotta Micaela Jar |  0.750       0.399     1.408          9.50
Christopher Spankovi |  1.250       0.886     1.763         31.89
Diana Tang 2021a     |  1.320       0.823     2.117         16.88
Diana Tang 2021b     |  0.970       0.602     1.564         16.52
Diana Tang 2021c     |  1.190       0.750     1.889         17.65
---------------------+---------------------------------------------------
I-V pooled ES        |  1.101       0.907     1.337        100.00
---------------------+---------------------------------------------------
```

Actually: vegetable: OR=1.101, [95%CI 0.907, 1.337].

eFigure 14: Forest Plot Showing the Association Between water and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Water: OR=1.00, [95%CI 0.99,1.01], I^2=20% p=0.55.



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
------------------------+--------------------------------------------------
Carlotta Micaela Jar    |   0.840       0.429     1.645          0.03
Doh Young Lee 2018      |   1.003       0.992     1.014         99.77
Milena Tomanic 2020     |   1.210       0.950     1.541          0.21
------------------------+--------------------------------------------------
I-V pooled ES           |   1.003       0.992     1.014        100.00
------------------------+--------------------------------------------------
```

Actually: water: OR=1.003, [95%CI 0.992, 1.014].

eFigure 15: Forest Plot Showing the Association Between dairy and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Dairy: OR=0.83, [95%CI 0.77,0.89], I^2=0% p<0.00001

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Abby McCormack 2014a	-0.1655144	0.0603033	41.2%	0.85 [0.75, 0.95]
Abby McCormack 2014b	-0.2390169	0.0582753	44.1%	0.79 [0.70, 0.88]
Abby McCormack 2014c	-0.1310283	0.1153023	11.3%	0.88 [0.70, 1.10]
Christopher Spankovich 2017	-0.0101	0.2069	3.5%	0.99 [0.66, 1.49]
Total (95% CI)			**100.0%**	**0.83 [0.77, 0.89]**

Heterogeneity: Chi² = 1.89, df = 3 (P = 0.60); I² = 0%
Test for overall effect: Z = 4.87 (P < 0.00001)

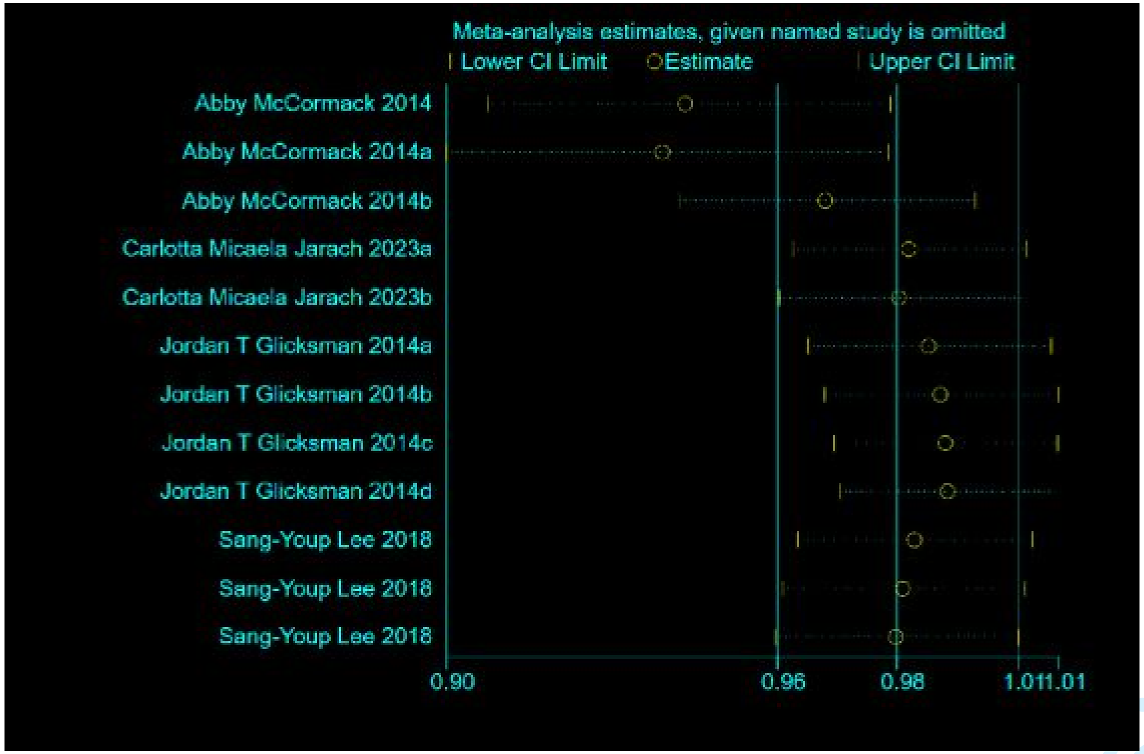
```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  0.847      0.753     0.953          41.62
Abby McCormack 2014a |  0.787      0.702     0.882          44.21
Abby McCormack 2014b |  0.877      0.699     1.100          11.30
Christopher Spankovi |  0.990      0.631     1.552           2.86
---------------------+---------------------------------------------------
I-V pooled ES        |  0.827      0.766     0.892         100.00
---------------------+---------------------------------------------------
```

Actually: dairy: OR=0.83, [95%CI 0.766, 0.892].

eFigure 16: Sensitivity analysis between caffeine and tinnitus.

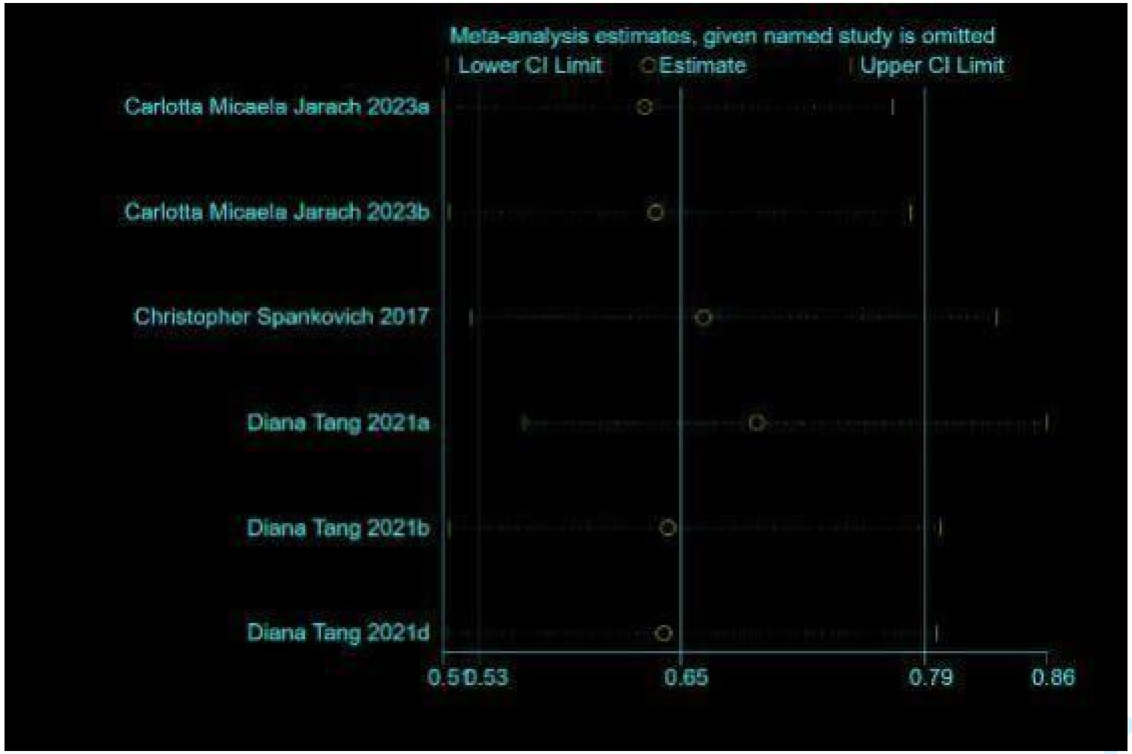
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study at a time, conflicting results emerged and further identification of the source of heterogeneity was needed. It has been confirmed that the main contradiction comes from Abby McCormack 2017, and the sensitivity analysis after removal the reseach did not show contradictory outcome, indicating the robustness of the results.

eFigure 17:Sensitivity analysis between fruit and tinnitus.

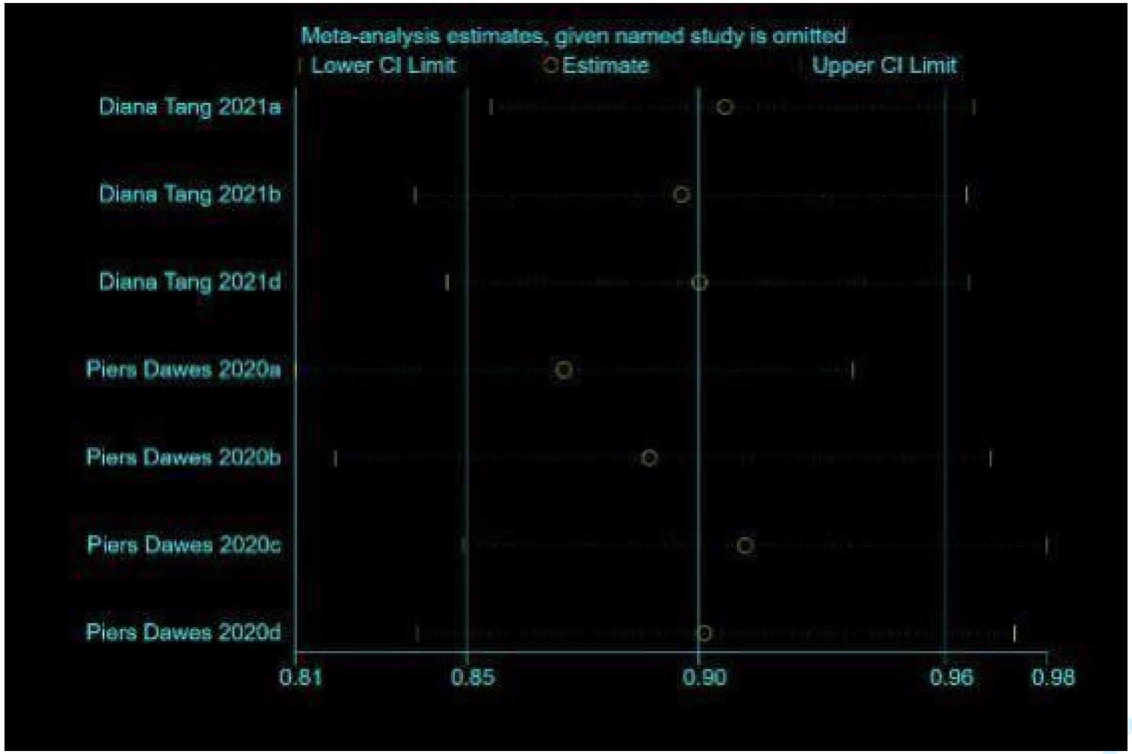
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 18:Sensitivity analysis between fiber and tinnitus.

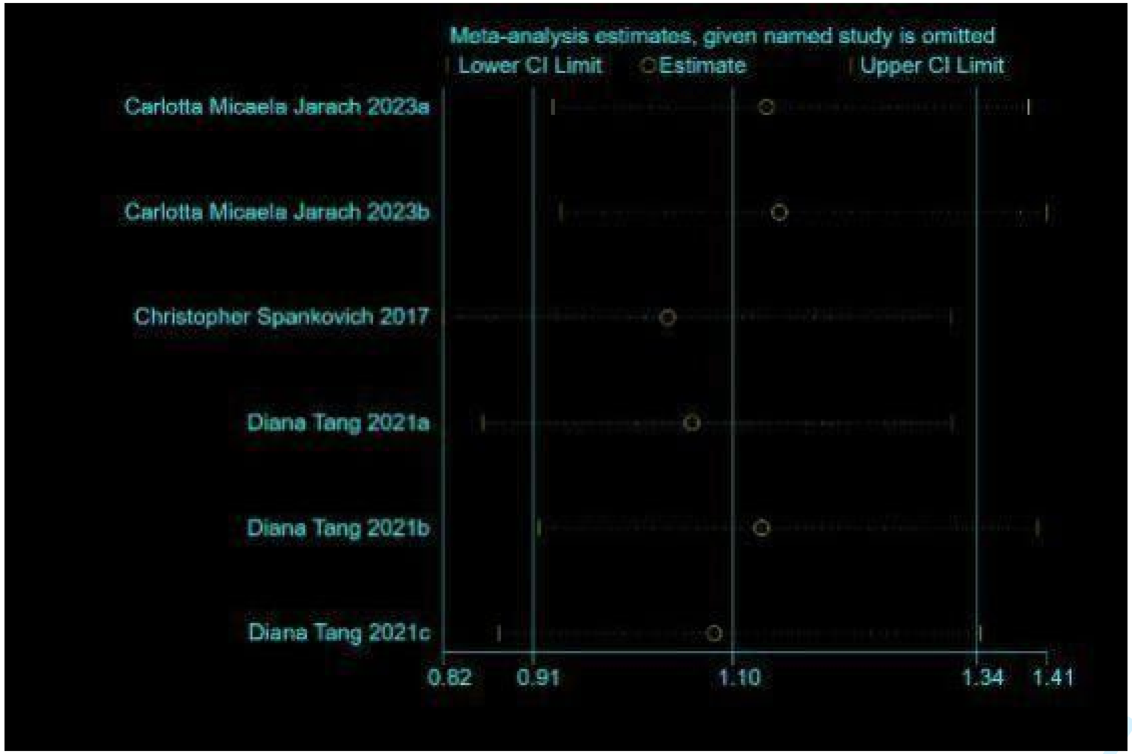
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 19:Sensitivity analysis between vegetable and tinnitus.

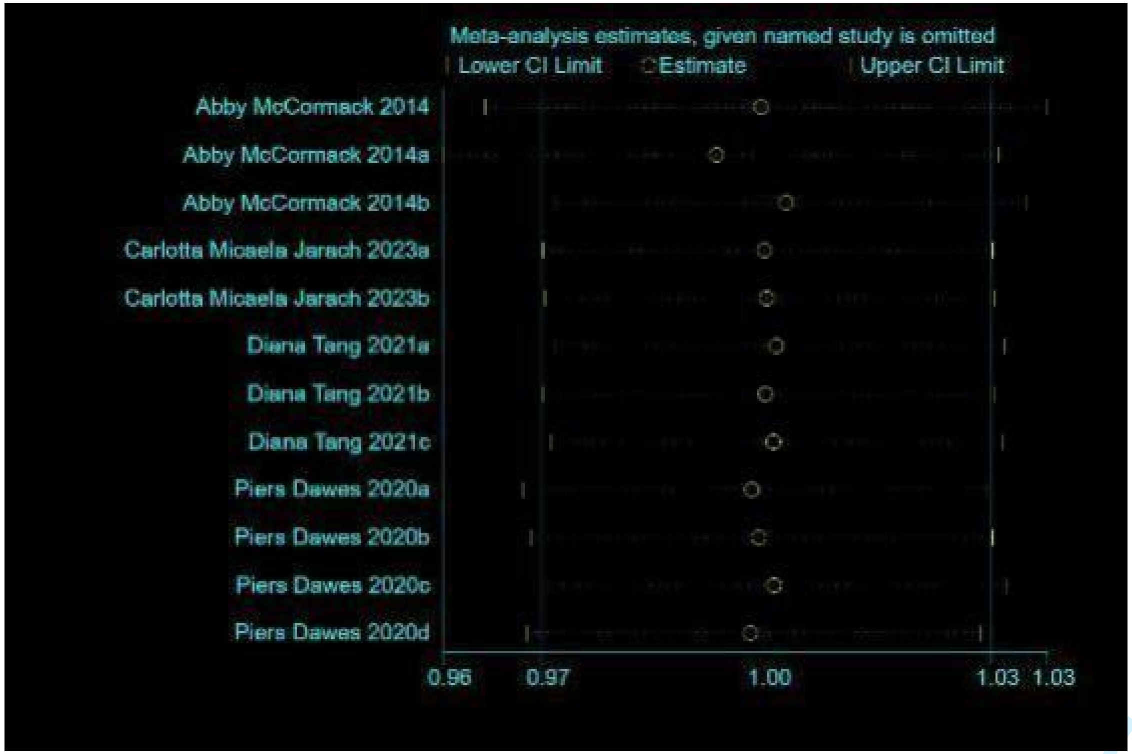
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

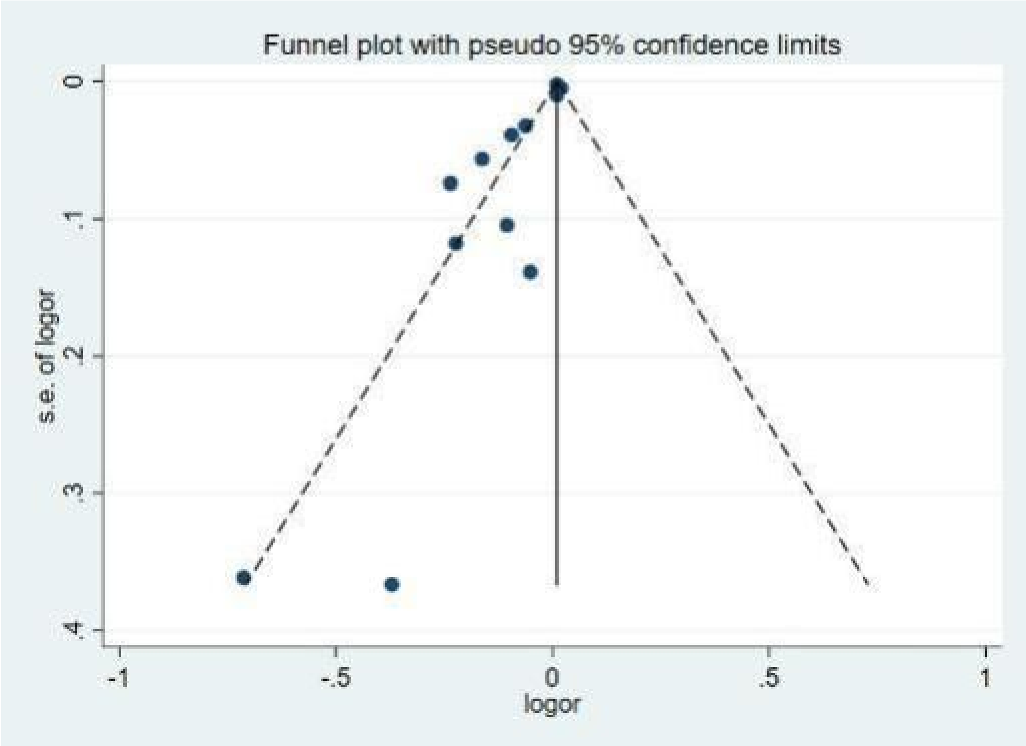
eFigure 20:Sensitivity analysis between sugar and tinnitus.

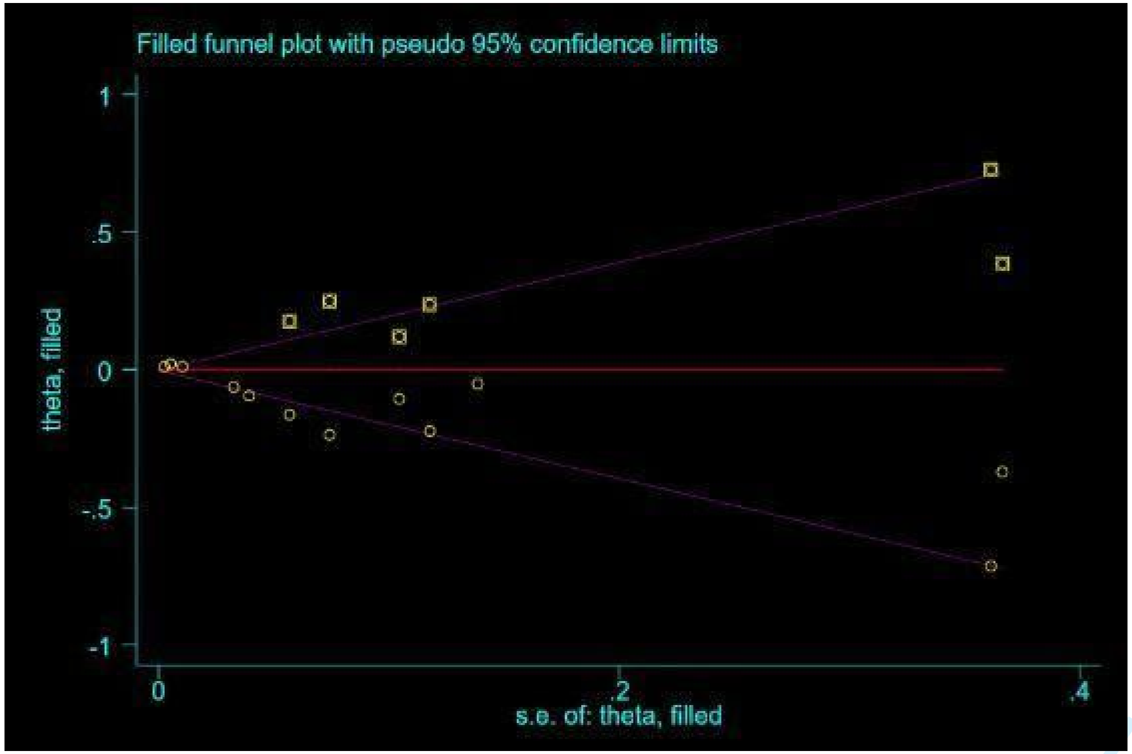
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

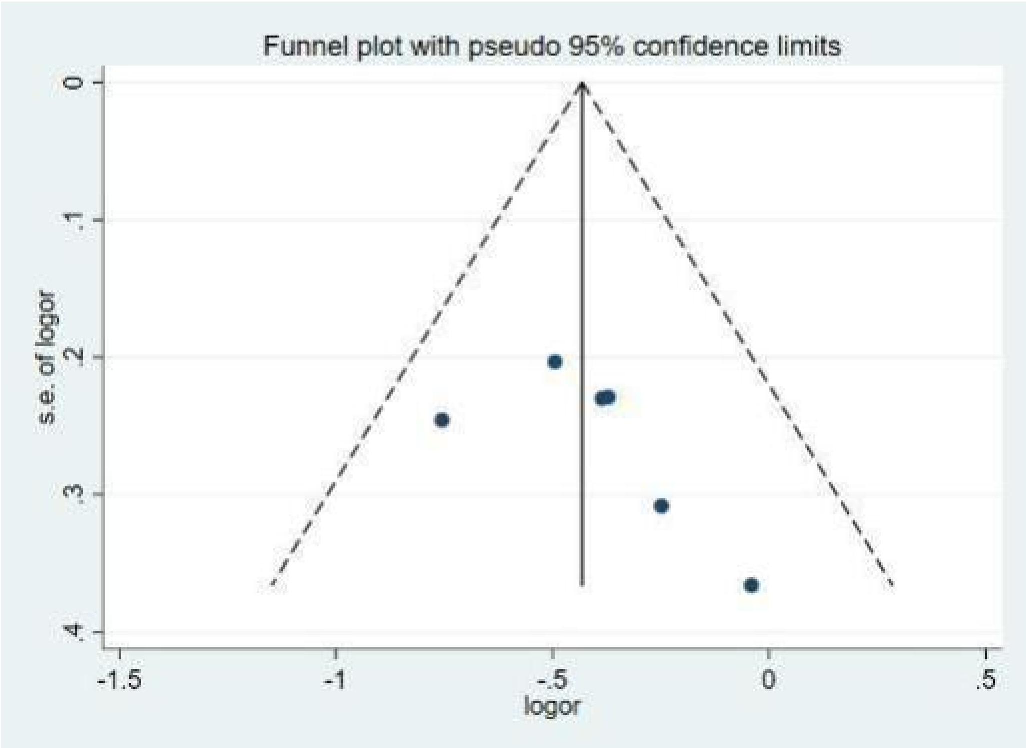
eFigure 21:Publication bias and Egger test on caffeine





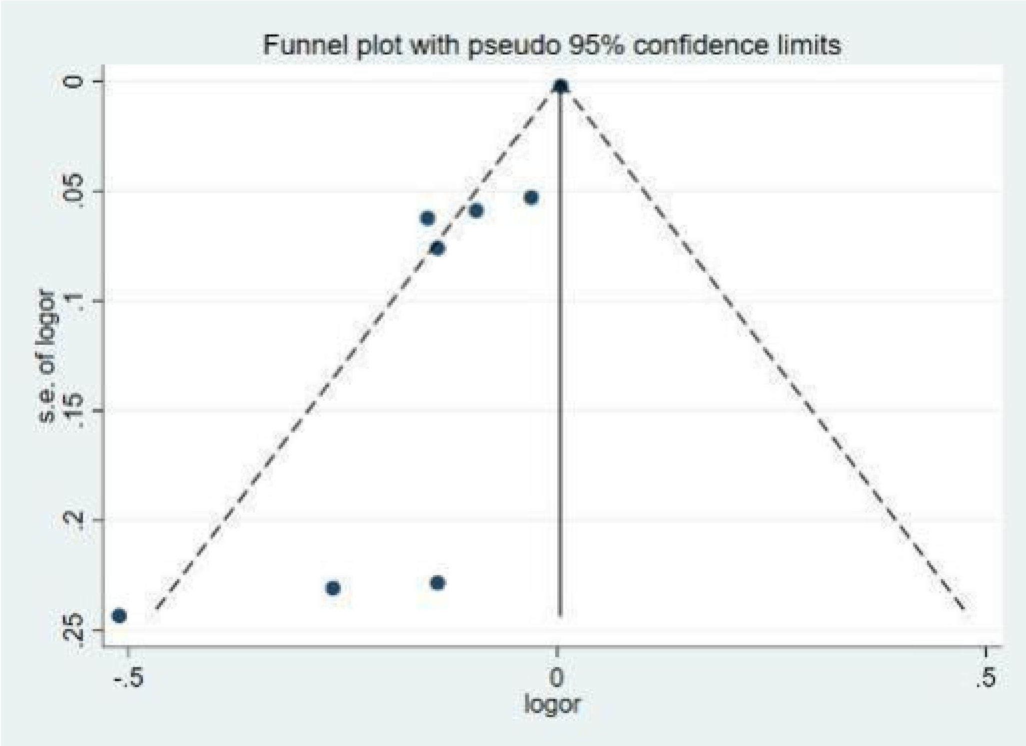
Cut and complement method tips, there was no significant publication bias.

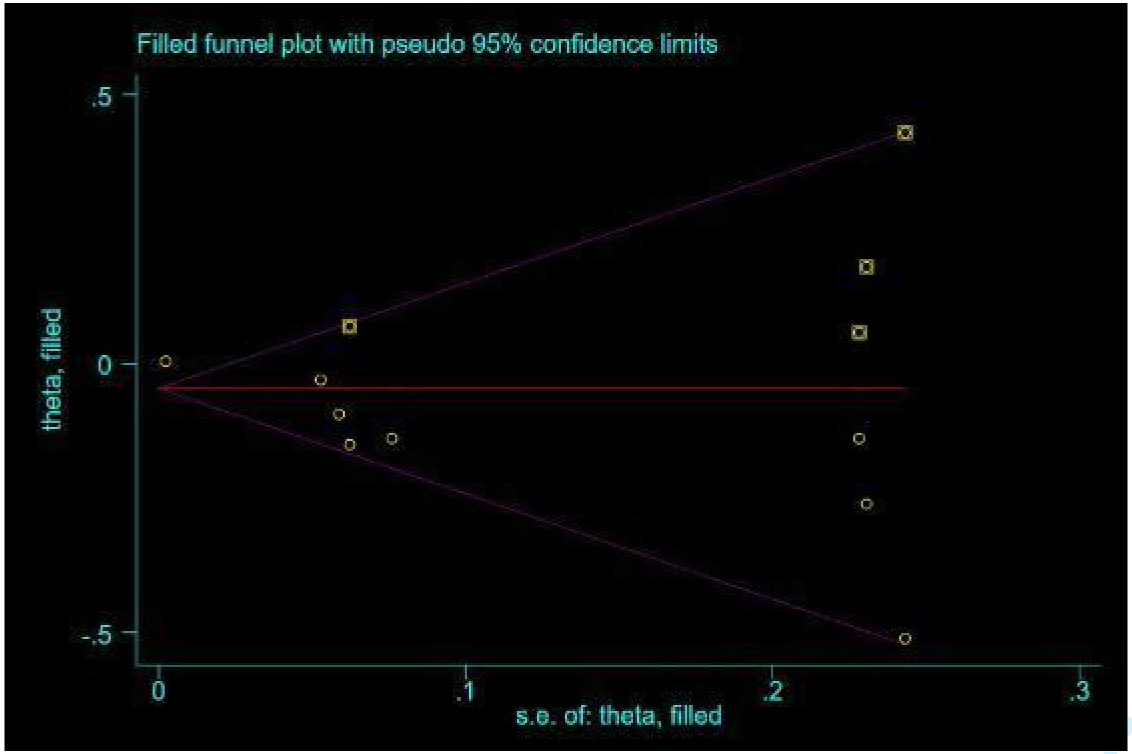
eFigure 22: Publication bias and Egger test on fruit



Egger test: Fruit p=0.205>0.05, there was no significant publication bias.

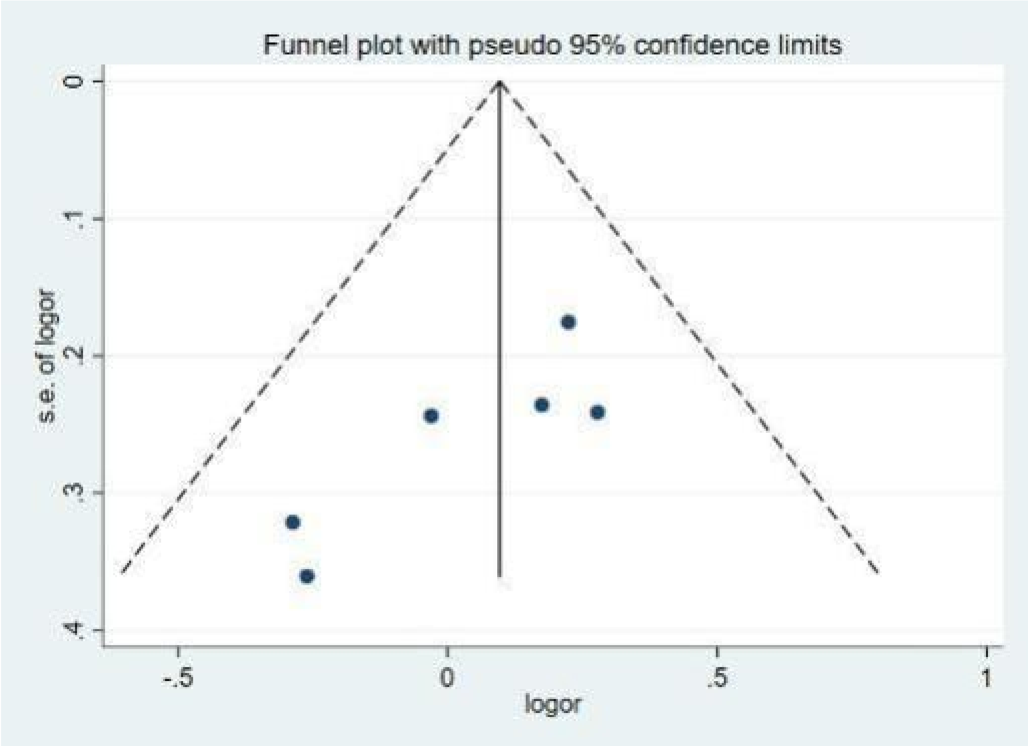
eFigure 23:Publication bias and Egger test on fiber

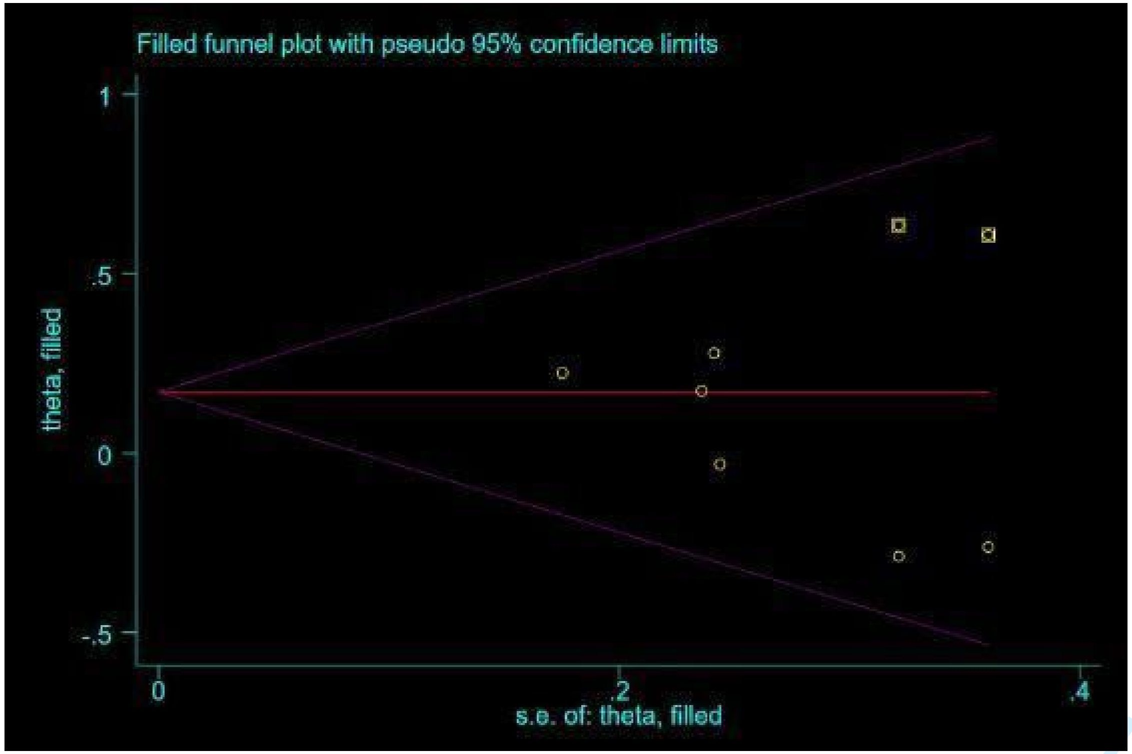




Egger test: Fruit p=0.006<0.05. Cut and complement method tips, there was no significant publication bias.

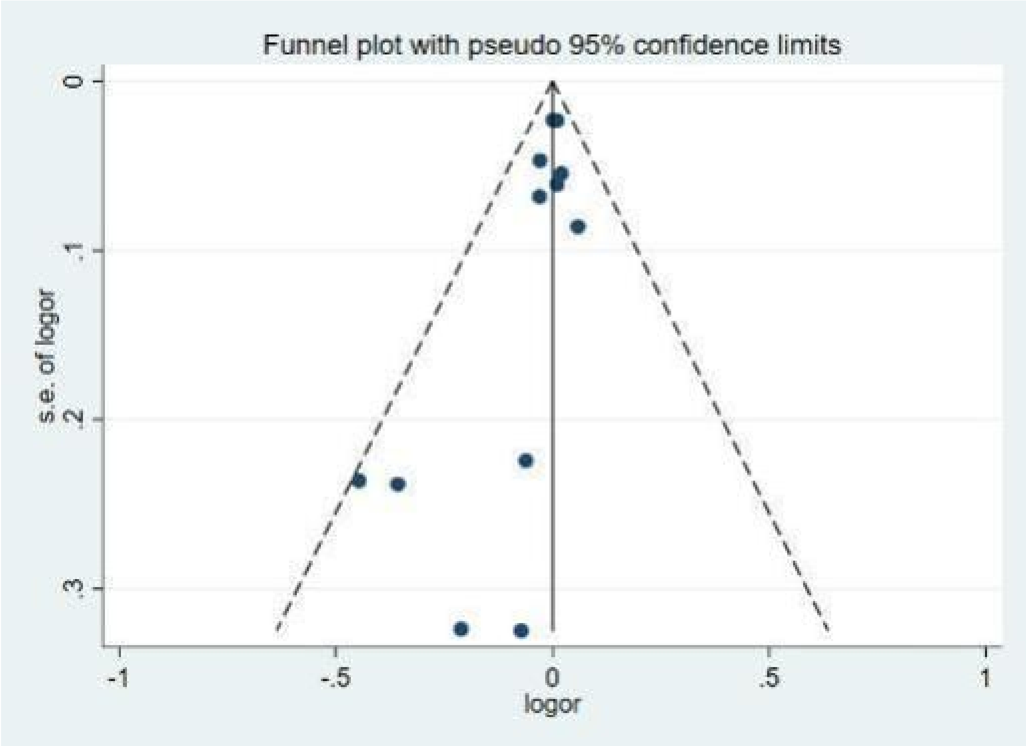
eFigure 24:Publication bias and Egger test on vegetable.

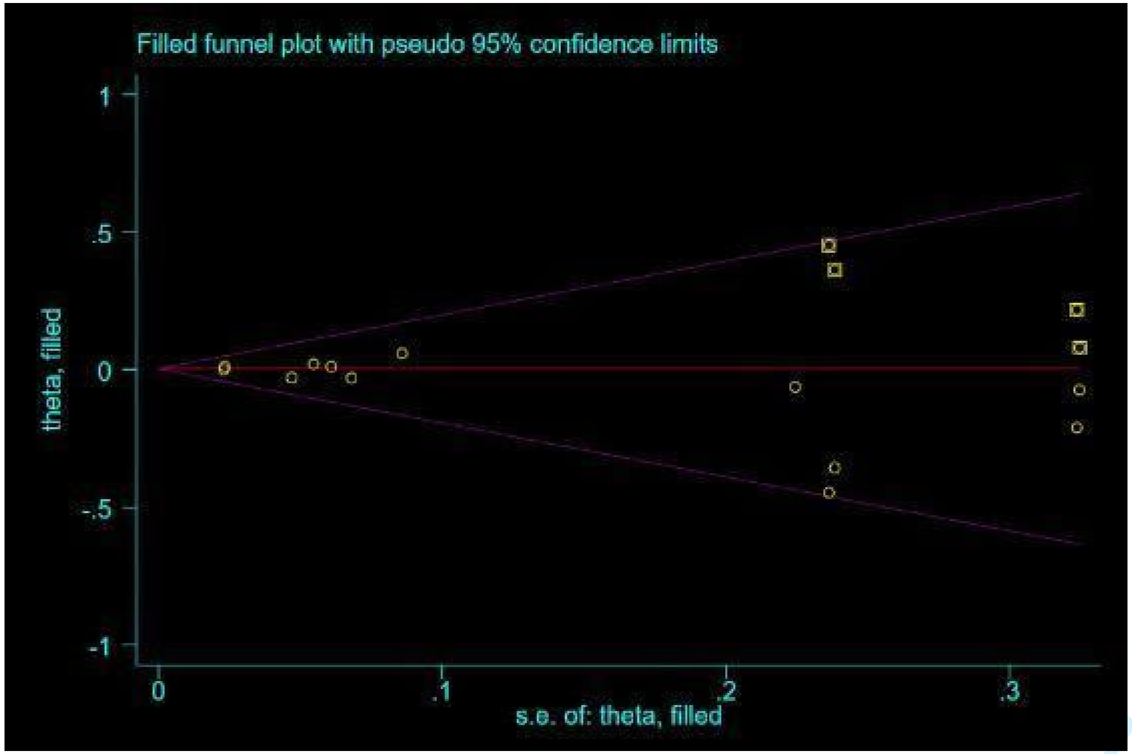




Egger test: Fruit p=0.041<0.05. Cut and complement method tips, there was no significant publication bias.

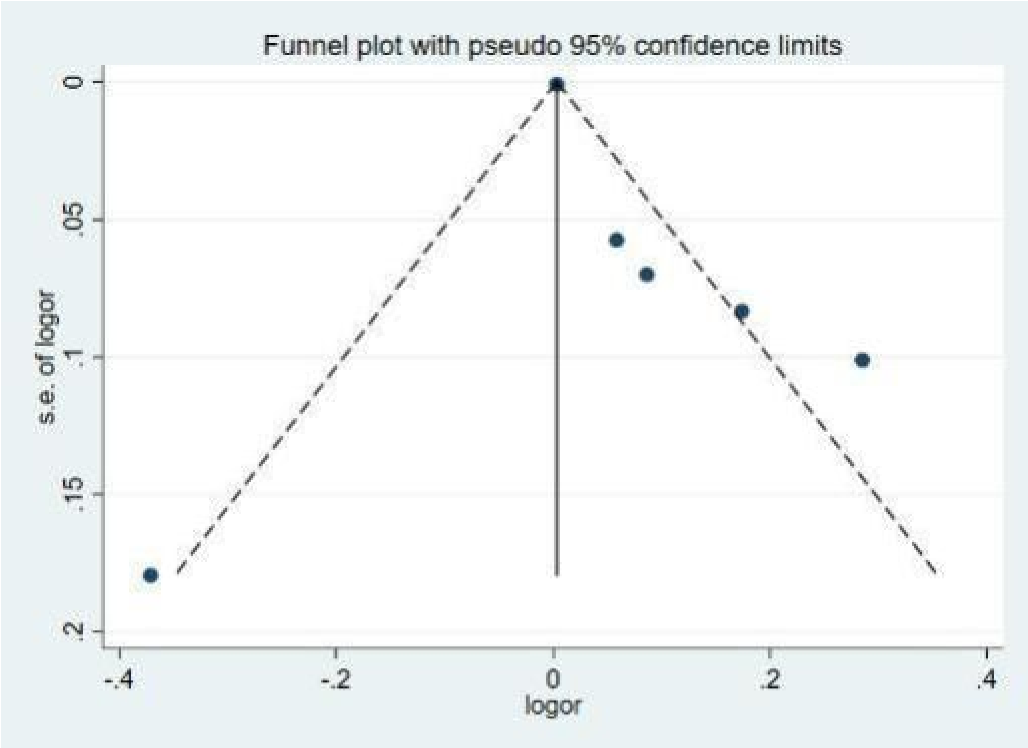
eFigure 25:Publication bias and Egger test on sugar.





Egger test: Fruit p=0.035<0.05. Cut and complement method tips, there was no significant publication bias.

eFigure 26:Publication bias and Egger test on fat.



Egger test: Fat p=0.306>0.05, there was no significant publication bias.

eTable 1. Meta-analysis of Observational Studies in Epidemiology (MOOSE) Checklist

Item No.	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	3-5
2	Hypothesis statement	3-5
3	Description of study outcome(s)	3-5
4	Type of exposure or intervention used	3-5
5	Type of study designs used	-
6	Study population	5
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	6
8	Search strategy, including time period included in the synthesis and keywords	6
9	Effort to include all available studies, including contact with authors	6, 7
10	Databases and registries searched	5,6
11	Search software used, name and version, including special features used (eg, explosion)	8
12	Use of hand searching (eg, reference lists of obtained articles)	6
13	List of citations located and those excluded, including justification	6, Fig 1
14	Method of addressing articles published in languages other than English	7
15	Method of handling abstracts and unpublished studies	6, 7
16	Description of any contact with authors	-
Reporting of methods should include		

17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	8
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	7-8
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	7
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	7
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	7
22	Assessment of heterogeneity	8
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	8
24	Provision of appropriate tables and graphics	Table 1, Fig 1
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	Fig 2, Table 1
26	Table giving descriptive information for each study included	eTable2
27	Results of sensitivity testing (eg, subgroup analysis)	eFig16-20
28	Indication of statistical uncertainty of findings	10,11
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	eFig21-26
30	Justification for exclusion (eg, exclusion of non-English language citations)	Fig 1
31	Assessment of quality of included studies	eTable 5
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	11-19
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	11-19

34	Guidelines for future research	19-20
35	Disclosure of funding source	1

eTable 2: Dietary risk ratio associated with tinnitus

Carlotta Micaela Jarach 2023a	scarce	butter	tinnitus	0.98	0.[illegible]4	1.77
Carlotta Micaela Jarach 2023b	normal use or high use	butter	tinnitus	0.46	0.[illegible]3	0.93
Diana Tang 2021a	2nd quartile (>188.4–231.7)	carbohydrate	tinnitus	0.74	0.[illegible]	1.17
Diana Tang 2021b	3rd quartile (231.8–280.8)	carbohydrate	tinnitus	0.739	0.[illegible]	1.15
Diana Tang 2021c	4th quartile (>280.8–577.7)	carbohydrate	tinnitus	0.55	0.[illegible]4	0.9
Doh Young Lee 2018	direct	carbohydrate	tinnitus	1.001	0.[illegible]99	1.001
Piers Dawes 2020a	quintile 2	Carbohydrate	tinnitus	1.03	0.[illegible]4	1.14
Piers Dawes 2020b	quintile 3	Carbohydrate	tinnitus	0.98	0.[illegible]8	1.11
Piers Dawes 2020c	quintile 4	Carbohydrate	tinnitus	0.99	0.[illegible]6	1.14
Piers Dawes 2020d	quintile 5	Carbohydrate	tinnitus	0.93	0.78	1.1
Carlotta Micaela Jarach 2023a	50-100g/week	cheese	tinnitus	1.29	0.[illegible]3	2.67
Carlotta Micaela Jarach 2023b	100+g/week	cheese	tinnitus	0.85	0.[illegible]6	1.58
Abby McCormack 2014	direct	coffee	Transient tinnitus	1.020	1.[illegible]10	1.031
Abby McCormack 2014a	direct	coffee	Persistent tinnitus	1.010	1.[illegible]10	1.020
Abby McCormack 2014b	direct	coffee	Bothersome tinnitus	1.010	0.[illegible]90	1.031
Carlotta Micaela Jarach 2023a	2nd quartile (850-1749mg)	coffee	tinnitus	0.49	0.[illegible]4	0.99
Carlotta Micaela Jarach 2023b	3rd quartile (≥1750mg）	coffee	tinnitus	0.69	0.34	1.43
Jordan T Glicksman 2014a	150-299 mg/day	coffee	tinnitus	0.94	0.88	1
Jordan T Glicksman 2014b	300-449 mg/day	coffee	tinnitus	0.91	0.84	0.98
Jordan T Glicksman 2014c	450-599 mg/day	coffee	tinnitus	0.85	0.76	0.95

Jordan T Glicksman 2014d	600+ mg/day	coffee	tinnitus	0.79	[illegible]	0.91
Sang-Youp Lee 2018	Age 19–39（Daily）	coffee	tinnitus	0.8	[illegible]	1
Sang-Youp Lee 2018	Age 40-64（Daily）	coffee	tinnitus	0.9	0.73	1.1
Sang-Youp Lee 2018	Age >65（Daily）	coffee	tinnitus	0.95	0.72	1.24
Abby McCormack 2014	direct	dairy	Transient tinnitus	0.847	0.952	0.752
Abby McCormack 2014a	direct	dairy	Persistent tinnitus	0.787	0.885	0.704
Abby McCormack 2014b	direct	dairy	Bothersome tinnitus	0.877	1.099	0.699
Christopher Spankovich 2017	direct	dairy	Persistent tinnitus	0.99	[illegible]	1.50
Carlotta Micaela Jarach 2023a	16-19	diversity	tinnitus	0.53	[illegible]	1
Carlotta Micaela Jarach 2023b	≥20	diversity	tinnitus	0.47	0.24	0.9
Abby McCormack 2014	direct	egg	Transient tinnitus	1.031	[illegible]	0.926
Abby McCormack 2014a	direct	egg	Persistent tinnitus	1.149	[illegible]	1.031
Abby McCormack 2014b	direct	egg	Bothersome tinnitus	0.901	[illegible]	0.719
Carlotta Micaela Jarach 2023a	1/week	eggs	tinnitus	0.99	0.51	1.92
Carlotta Micaela Jarach 2023b	2+/week	eggs	tinnitus	0.54	0.29	1
Christopher Spankovich 2017	direct	fat	Persistent tinnitus	0.69	0.49	0.99
Doh Young Lee 2018	direct	fat	tinnitus	1.003	1.001	1.005
Piers Dawes 2020a	quintile 2	fat	tinnitus	1.06	0.95	1.19
Piers Dawes 2020b	quintile 3	fat	tinnitus	1.09	0.95	1.25
Piers Dawes 2020c	quintile 4	fat	tinnitus	1.19	1.01	1.40
Piers Dawes 2020d	quintile 5	fat	tinnitus	1.33	1.09	1.62
Diana Tang 2021a	2nd quartile (>17.8–23.8)	fiber	tinnitus	0.6	[illegible]	0.96
Diana Tang 2021b	3rd quartile (>23.8–30.6)	fiber	tinnitus	0.87	[illegible]	1.37
Diana Tang 2021d	4th quartile (>30.6–89.3)	fiber	tinnitus	0.77	[illegible]	1.21
Doh Young Lee 2018	direct	fiber	tinnitus	1.004	0.999	1.008
Piers Dawes 2020a	quintile 2	fiber	tinnitus	0.97	0.87	1.07
Piers Dawes 2020b	quintile 3	fiber	tinnitus	0.91	0.81	1.02
Piers Dawes 2020c	quintile 4	fiber	tinnitus	0.86	0.76	0.97
Piers Dawes 2020d	quintile 5	fiber	tinnitus	0.87	0.75	1.01

Abby McCormack 2014	direct	fish	Transient tinnitus	0.980	0.950	1.020
Abby McCormack 2014a	direct	fish	Persistent tinnitus	0.910	0.870	0.940
Abby McCormack 2014b	direct	fish	Bothersome tinnitus	1.080	0.990	1.160
Carlotta Micaela Jarach 2023a	300g/week	fish	tinnitus	1.19	0.59	2.38
Carlotta Micaela Jarach 2023b	≥450g/week	fish	tinnitus	0.75	0.41	1.4
Carlotta Micaela Jarach 2023a	900-1050g/week	fruit	tinnitus	0.96	0.47	1.97
Carlotta Micaela Jarach 2023b	≥1200g/week	fruit	tinnitus	0.78	0.43	1.44
Christopher Spankovich 2017	direct	fruit	Persistent tinnitus	0.61	0.41	0.91
Diana Tang 2021a	2nd quartile (>3.6–6.2)	fruit	tinnitus	0.47	0.29	0.76
Diana Tang 2021b	3rd quartile (>6.2–9.7)	fruit	tinnitus	0.68	0.43	1.06
Diana Tang 2021d	4th quartile (>9.7–43.9)	fruit	tinnitus	0.69	0.44	1.08
Carlotta Micaela Jarach 2023a	scarce	margarine	tinnitus	1.35	0.25	7.43
Carlotta Micaela Jarach 2023b	normal use or high use	margarine	tinnitus	1.4	0.2	9.98
Carlotta Micaela Jarach 2023a	300g/week	meat	tinnitus	1.49	0.75	2.94
Carlotta Micaela Jarach 2023b	≥450g/week	meat	tinnitus	0.97	0.51	1.85
Christopher Spankovich 2017	direct	meat	Persistent tinnitus	1.01	0.62	1.65
Carlotta Micaela Jarach 2023a	2nt quartile (1-6 cops/week)	milk	tinnitus	0.68	0.3	1.52
Carlotta Micaela Jarach 2023b	3rt quartile (7+ cops/week)	milk	tinnitus	0.85	0.46	1.55
Doh Young Lee 2018	direct	protein	tinnitus	1.002	1.001	1.004
Piers Dawes 2020a	quintile 2	protein	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	protein	tinnitus	1.01	0.89	1.13
Piers Dawes 2020c	quintile 4	protein	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	protein	tinnitus	1.06	0.9	1.26
Abby McCormack 2014	direct	suger	Transient tinnitus	1.000	0.952	1.042
Abby McCormack 2014a	direct	suger	Persistent tinnitus	1.010	0.971	1.064
Abby McCormack 2014b	direct	suger	Bothersome tinnitus	0.971	0.885	1.064

Carlotta Micaela Jarach 2023a	2nt quartile (1-7 spoon/week)	suger	tinnitus	0.93	0.49	1.75
Carlotta Micaela Jarach 2023b	3rt quartile (8+ spoon/week)	suger	tinnitus	0.81	0.43	1.53
Diana Tang 2021a	2nd quartile (>91.0–120.1)	suger	tinnitus	0.64	0.4	1.01
Diana Tang 2021b	3rd quartile (>120.1–154.0)	suger	tinnitus	0.94	0.61	1.47
Diana Tang 2021c	4th quartile (>154.0–350.8)	suger	tinnitus	0.7	0.44	1.12
Piers Dawes 2020a	quintile 2	suger	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	suger	tinnitus	1.01	0.90	1.13
Piers Dawes 2020c	quintile 4	suger	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	suger	tinnitus	1.06	0.9	1.26
Christopher Spankovich 2017	direct	variety	Persistent tinnitus	0.95	0.61	1.5
Carlotta Micaela Jarach 2023a	900-1050g/week	vegetable	tinnitus	0.77	0.38	1.56
Carlotta Micaela Jarach 2023b	≥1200g/week	vegetable	tinnitus	0.75	0.4	1.41
Christopher Spankovich 2017	direct	vegetable	Persistent tinnitus	1.25	0.9	1.79
Diana Tang 2021a	2nd quartile (>7.2–9.7)	vegetable	tinnitus	1.32	0.82	2.11
Diana Tang 2021b	3rd quartile (>9.7–12.3)	vegetable	tinnitus	0.97	0.60	1.56
Diana Tang 2021c	4th quartile (>12.3–54.5)	vegetable	tinnitus	1.19	0.75	1.89
Abby McCormack 2014	direct	vegetable and fruit	Transient tinnitus	1.000	1.000	1.010
Abby McCormack 2014a	direct	vegetable and fruit	Persistent tinnitus	1.010	1.000	1.010
Abby McCormack 2014b	direct	vegetable and fruit	Bothersome tinnitus	1.010	1.000	1.020
Carlotta Micaela Jarach 2023a	>1 liter/per day	water	tinnitus	0.84	0.43	1.65
Doh Young Lee 2018	direct	water	tinnitus	1.003	0.992	1.014

eTable 3. Evaluation of Risk of Bias Using Newcastle-Ottawa Scale（NOS) for Observational Studies

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Total
Carlotta Micaela Jarach 2023	*	*	*	*	*	*	*	*		8
Diana Tang 2021	*	*	*		*	*	*	*		8
Milena Tomanic 2020	*	*	*				*			4
Piers Dawes 2020	*	*	*		*	*	*			6
Sang-Yeon Lee 2019	*	*	*		*	*	*			6
Doh Young Lee 2018	*	*	*		*	*	*			6
Sang-Youp Lee 2018	*	*	*		*	*	*			6
Christopher Spankovich 2017	*	*	*		*	*	*			6
Abby McCormack 2014	*	*	*		*	*	*			6
Jordan T Glicksman 2014	*	*	*		*	*	*		*	7

eTable 4. Literature screening process

Title	Author	Whether to include
The Role of Diet in Tinnitus Onset: A Hospital-Based Case-Control Study from Italy.	Carlotta Micaela Jarach 2023	YES
Associations between intake of dietary flavonoids and the 10-year incidence of tinnitus in older adults.	Diana Tang 2022	YES
Dietary Fibre Intake and the 10-Year Incidence of Tinnitus in Older Adults.	Diana Tang 2021	YES
Relationship Between Diet, Tinnitus, and Hearing Difficulties.	Piers Dawes 2020	YES
Association of Chocolate Consumption with Hearing Loss and Tinnitus in Middle-Aged People Based on the Korean National Health and Nutrition Examination Survey 2012-2013.	Sang-Yeon Lee 2019	YES
Relationship Between Diet and Tinnitus: Korea National Health and Nutrition Examination Survey.	Doh Young Lee 2018	YES
Association of Coffee Consumption with Hearing and Tinnitus Based on a National Population-Based Survey	Sang-Youp Lee 2018	YES
Relationship between dietary quality, tinnitus and hearing level: data from the national health and nutrition examination survey, 1999-2002.	Christopher Spankovich 2017	YES
Association of dietary factors with presence and severity of tinnitus in a middle-aged UK population.	Abby McCormack 2014	YES
A prospective study of caffeine intake and risk of incident tinnitus	Jordan T. Glicksman 2014	YES
The effect of MemoVigor 2 on recent-onset idiopathic tinnitus: a randomized double-blind placebo-controlled clinical trial.	Dimitrios G Balatsouras 2024	No
The effects of dietary and physical activity interventions on tinnitus symptoms: An RCT.	Ümüş Özbey-Yücel 2023	No

Effectiveness of Tinnitan Duo in Subjective Tinnitus with Emotional Affectation: A Prospective, Interventional Study.	Jennifer Knäpper 2023	No
Hyperlipidemia and its relation with tinnitus: Cross-sectional approach.	A Musleh 2022	No
Diet Quality and the Risk of Impaired Speech Reception Threshold in Noise: The UK Biobank cohort	Humberto Yévenes-Briones 2022	No
The effect of caffeine on tinnitus: Randomized triple-blind placebo-controlled clinical trial.	Alleluia Lima Losno Ledesma 2021	No
The effects of diet and physical activity induced weight loss on the severity of tinnitus and quality of life: A randomized controlled trial.	Ümüş Özbey-Yücel 2021	No
Dietary Factors and Tinnitus among Adolescents.	Milena Tomanic 2020	No
Restriction of salt, caffeine and alcohol intake for the treatment of Ménière's disease or syndrome.	Kiran Hussain 2018	No
The effect of supplemental dietary taurine on tinnitus and auditory discrimination in an animal model.	Thomas J Brozoski 2010	No
Low energy diet and intracranial pressure in women with idiopathic intracranial hypertension: prospective cohort study.	Alexandra J Sinclair 2010	No
Caffeine abstinence: an ineffective and potentially distressing tinnitus therapy.	Lindsay St Claire 2010	No
The role of endogenous Antisecretory Factor (AF) in the treatment of Meniere's Disease: A two-year follow-up study. Preliminary results.	Pasquale Viola 2020	No
Caffeine intake and Meniere's disease: Is there relationship?	Inés Sánchez-Seller 2018	No
Tinnitus features according to caffeine consumption.	Ricardo Rodrigues Figueiredo 2021	No
The Influence of Diet on Tinnitus Severity: Results of a Large-Scale, Online Survey	Steven C. Marcrum 2022	No

BMJ Open

Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

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Date Submitted by the Author:	28-Jan-2025
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Primary Subject Heading:	Ear, nose and throat/otolaryngology
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	OTOLARYNGOLOGY, NUTRITION & DIETETICS, Meta-Analysis, Neurotology < OTOLARYNGOLOGY

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Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

Abstract

Objective A systematic analysis was conducted to investigate the association between tinnitus incidence and daily dietary patterns.

Design Systematic review and meta-analysis using the Grading of Recommendation, Assessment, Development, and Evaluation (GRADE) approach.

Data sources The PubMed, Embase, Web of Science, and Cochrane Library databases were searched from their inception to May 25, 2024.

Eligibility criteria for selecting studies We included observational studies from peer–reviewed English–language journals that examined tinnitus presence or severity in adults aged 18 years or older, including associated prevalence estimates.

Data extraction and synthesis Data extraction was independently conducted by two evaluators, who assessed research bias using the Agency for Newcastle-Ottawa Scale (NOS) and applied evidence classification criteria for aggregate grade strength assessment. This study adhered to the guidelines of the Preferred Reporting Project (PRISMA) and Meta-Analysis of Epidemiological Observational Studies (MOOSE), as well as the PROSPERO Registry protocols. A mixed-effects model combined maximum adjusted estimates, with heterogeneity measured using the I^2 statistic. Sensitivity analysis validated the robustness of the analysis, and publication bias was assessed qualitatively and quantitatively.

Results A total of 10 retrospective studies were identified and included in this analysis, with the last eight studies incorporated into the meta-analysis. Fifteen dietary factors were examined. Fruit intake, dietary fiber, caffeine, and dairy product consumption were negatively correlated with tinnitus incidence (OR = 0.649, [95% CI 0.532, 0.793], p<0.0001), (OR = 0.918, [95% CI 0.851, 0.990], p = 0.03), (OR = 0.898, [95% CI 0.862, 0.935], p <0.00001), (OR = 0.827, [95% CI, 0.766 to 0.892], p <0.00001), respectively. A sensitivity analysis confirmed the robustness of the findings.

Conclusions This systematic review and meta-analysis suggest a link between particular dietary elements and a lower incidence of tinnitus.

PROSPERO registration number CRD42023493856

Keywords: Diet; Tinnitus; Food intake; Nutrition; Odds ratio

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study conducted a thorough literature screening, assessed the quality of the literature based on international standards, and excluded articles with a high risk of bias.
- This review involves a large population base, improving its representation of fundamental population characteristics and ensuring relatively reliable outcomes.
- There was minimal heterogeneity among the studies regarding the main observations, ensuring the solidity of the findings.
- The relatively small number of included articles may have led to certain conventionally accepted beneficial dietary factors (such as vegetables and eggs) not demonstrating significant differences. In addition, owing to the limited data in the original literature, a dose-effect meta-analysis cannot be supported.
- The majority of the included articles were cross-sectional studies, underscoring the necessity for further cohort studies or Mendelian randomization studies to investigate causal relationships and provide additional clinical evidence for the dietary prevention of tinnitus.

Introduction

Tinnitus, characterized by perceived sounds such as buzzing, cicadas, or electric currents, occurs without external auditory stimuli [1]. It is associated with distress, depression, anxiety, stress, and, in severe cases, suicide, significantly affecting overall quality of life[2 3]. Recent epidemiological data suggest a global pooled prevalence of about 14.4% in adults and 13.6% in children and adolescents[4]. The notable prevalence of tinnitus and its substantial impact on life and mental well-being have increasingly become significant medical and societal concerns[5].

The origins of tinnitus remain elusive and involve a range of factors. Some researchers have suggested neural dysfunction or circulatory issues in the inner ear, abnormal neuronal activity in central auditory pathways, and irregular activity in nonauditory brain regions such as the anterior insula, anterior cingulate cortex, and thalamus[6]. In clinical practice, treatments for tinnitus management include psychological counseling, cognitive-behavioral therapy, tinnitus retraining therapy, sound therapy, surgery, pharmacological interventions, and nonpharmacological interventions (including electrical stimulation, repetitive transcranial magnetic stimulation, nerve block, bimodal neuromodulation, tinnitus retraining therapy, etc.), as well as hearing aids and cochlear implants for patients with relevant hearing loss[7 8]. Owing to an incomplete understanding of central neuropathological mechanisms, no single treatment universally meets the needs of all patients[9 10].

Diet can have a significant impact on tinnitus, but it remains uncertain which specific foods worsen or relieve tinnitus symptoms. Diet is an uncertain factor for tinnitus, as mentioned in the James Lind Alliance

89 prioritization statement. Optimizing nutritional intake is an essential part of multidimensional efforts to prevent and treat chronic diseases. In recent years, the need for nutritional treatment programs for chronic tinnitus has increased[11]. A population study investigating the correlation between diet and tinnitus among UK adults revealed a decrease in tinnitus incidence with increased fruit and vegetable consumption. Conversely, avoiding dairy was linked to a greater risk of tinnitus. On the other hand, abstaining from eggs, adding fish to the diet, and consuming caffeinated beverages are suggested to potentially lower the risk of tinnitus [2]. Another study in British adults revealed that greater fat intake was associated with a greater likelihood of experiencing tinnitus[12]. Similarly, Lee and Kim identified risk factors for tinnitus, including low water, protein, riboflavin, and niacin intake, although this was unrelated to fruit and vegetable consumption[13]. It is thought that the intake of high-quality nutrients through food can have a positive effect on the hearing system by improving blood flow to the cochlea, reducing oxidative damage and reducing inflammation. In contrast, high saturated fat intake may increase the risk of tinnitus through cardiovascular pathways[11 12]. Tang et al.[14] reported that inadequate fruit fiber (<3.6 g/day) and grain fiber (<4.2 g/day) intake were linked to a 65% and 54% increased risk of developing tinnitus over the next decade, respectively. Conflicting results have hindered researchers' ability to understand the potential benefits of diet; hence, a systematic review on the

relationship between diet and tinnitus is needed.

To date, there has not been a comprehensive examination through systematic reviews or meta-analyses regarding the link between typical dietary patterns and tinnitus. Our objective was to systematically explore this association while accounting for potential confounding variables. This study aimed to provide clinical evidence to inform the development of dietary prevention approaches for tinnitus.

Method

According to the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA), a set of evidence-based standards for the research quality of systematic reviews, which apply to published reviews of literature that contain primary data sources and aim to improve the scientific rigor of systematic reviews[15], the protocol for this study was appropriately registered on PROSPERO under the registration number CRD42023493856. Additionally, our reporting is guided by the Meta-analysis of Observational Studies in Epidemiology (MOOSE) standards for epidemiological observational studies, which were developed by a group of experts to improve the quality and transparency of meta-analysis and systematic evaluation of observational studies, contributing to the scientific validity and credibility of such studies, as referenced [16]. **Supplemental eTable 1** contains the MOOSE listings, whereas

Supplemental 2 outlines the PRISMA instructions.

Search Strategy

We developed an inclusive search strategy covering diet-related and tinnitus-related subjects to capture pertinent literature from the PubMed, Embase, Web of Science, and Cochrane Library databases. The research design was limited to systematic evaluation. There were no language restrictions imposed on the search, and we considered articles published before May 25, 2024. We used special translation software for publications in unknown languages.

The search strategy was designed to identify studies linking tinnitus and diet, and two specific terms, 'Tinnitus' and 'Diet', from the Medical Subject Headings (MeSH) Major Topic were identified. The databases were systematically explored via a blend of MeSH terms, keywords, and various text word variations related to diet, following the guidance outlined by the Scottish Intercollegiate Guidelines Network: ((tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR variety OR caffeine OR carbohydrate OR protein). The search strategy for each database is described in **Supplemental Search Strategy**. The screening process is depicted in **Figure 1.**

The following inclusion criteria were applied: (1) inclusion of cohort, case-control, or cross-sectional studies; (2) inclusion of all individuals in the study population; (3) consideration of various dietary intakes; and (4) investigation of tinnitus as a study outcome provided effect sizes or other data on the association between dietary intake and tinnitus as an outcome. The exclusion criteria were as follows: (1) studies involving therapeutic interventions; (2) randomized controlled trials, animal experiments, cell studies, case reports, literature, and incomplete or invalid sources, and the original literature lacked sufficient data to calculate the risk ratio for tinnitus (some publications do not report effect sizes but instead allow the raw data to be used to calculate them. In these cases, RevMan (version 5.3) was used to calculate the OR).

Data collection

In **Table 1,** data compilation was conducted by two reviewers (SZ, MZ), including authors' names, participant counts, age spans, survey/diagnosis specifics, and information on food and tinnitus. Given that dietary intake is a continuous variable, some researchers have typically performed stratified comparisons on the basis of regional intake standards and researchers' characteristics. This strategy aimed to explore the impact of varying levels of increased intake on tinnitus incidence. For most continuous variables associated with food intake, adjusted OR values were assimilated in the meta-analysis when stratified according to dose intake, with the exclusion of the reference group. In cases of direct comparison, the singular adjusted OR value was integrated. Further insights into the odds ratios (ORs) are provided in **Supplemental eTable 2**.

Literature quality evaluation

The assessment of individual study quality was conducted by two reviewers (SZ and MZ) via a modified version of the Newcastle-Ottawa Scale. Previous studies were categorized as having a high (<5 stars), moderate (5–7 stars), or low (≥8 stars) risk of bias (see eTable 3 in the Supplement).

Statistical analysis

Table 1: Basic information to be incorporated into the article.

Author	Total	Age	Time frame	Data from	Study design	Diet recording method	Disease diagnosis	Type of diet
Jarach 2023	383	40–65	2016–2019	The Mario Negri Institute in Milan (Italy) , Monza e Brianza, Italy	case control	Self-designed questionnaire	Interviewer administered a questionnaire and the Italian-validated version of the tinnitus handicap inventory	coffee, eggs, butter, meat, fish, cheese, fruit, vegetable, varied diet, dairy, milk
Tang 2022	1217	>50	1997－2009	Blue Mountains Hearing Study	cohort	Semiquantitative food frequency questionnaire, FFQ	Audiologist administered questionnaire	dietary flavonoids
Tang 2021	1730	>50	1997–2009	Blue Mountains Hearing Study	cohort	Semiquantitative food frequency questionnaire, FFQ	Audiologist administered questionnaire	carbohydrate, sugar, fiber, fruit, vegetable
Dawes 2020	34576	30–69	2006–2010	UK Biobank resource (Collins 2012).	cross-sectional	Dietary assessment was based on the Oxford Web-Q	An epidemiologic method of hearing investigation	fiber, fat, sugar
Lee 2019	3575	40–64	2012–2013	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	chocolate
Lee 2018	7621	40–80	2013–2015	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Diet was assessed with a semiquantitative food-frequency questionnaire	Self-designed questionnaire	water, protein, fat, carbohydrate, fiber
Lee 2018	13448	>19	2009－2012	The sixth Korea National Health and Nutrition Examination Survey	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	coffee
Spankovich 2017	2176	20–69	1999–2002	NHANES	cross-sectional	Dietary recall interviews were conducted during 1999–2002 NHANES MEC evaluations.	Self-designed questionnaire	fat, fruit, vegetable, meat, varied diet
McCormack 2014	171722	40–69	2006–2010	UK Biobank resource (Collins 2012).	cross-sectional	The UK Biobank touchscreen questionnaire	Self-designed questionnaire	fruit, vegetable, fish, egg, sugar, coffee, dairy
Glicksman 2014	65085	30–44(registered)	1991–2009	The Nurses' Health Study II	cross-sectional	Extensively validated semiquantitative food frequency questionnaires	Self-designed questionnaire	coffee

Data analysis was performed via RevMan (version 5.3) and Stata (version 15.0). Mixed-effect models were utilized to aggregate maximally covariate-adjusted odds ratios (ORs) across all studies. In current practice, odds ratios (ORs), relative risks (RRs), and hazard ratios (HRs) are about equal when events occur infrequently. For this situation, it is acceptable to include OR, RR, and HR in the same meta-analysis. In cases where the P value of the Q test was <0.10 or the I^2 statistic exceeded 50%, we conducted an assessment to determine significant interstudy heterogeneity. For observational studies, maximally covariate-adjusted estimates were strongly prioritized. If a study employed an analytical method incongruent with synthesis for the majority of other studies, we either converted the effect estimate to the appropriate combined ratio or excluded the study from the meta-analysis.

In cases of considerable heterogeneity in the analysis with significant differences, meta-regression was used to explore the source of heterogeneity (please note that meta-regression was considered when the data included in the analysis were greater than 10). We visually assessed the asymmetry of the funnel plot and used Egger's bias to detect possible publication bias, with estimation of missing studies conducted via eMethods if publication bias was suspected (please note that publication bias analysis was considered when the data included in the analysis were greater than 6). Moreover, we conducted a sensitivity analysis of the pooled results employing a one-by-one exclusion method.

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Results

The literature screening process is shown in **Supplemental eTable 4**. Ten articles were found in the search[2, 12-14, 17-22]. Among these, two articles delved into individual dietary factors, namely, chocolate [19] and flavonoids [18], which were not investigated in other studies. While these two articles were included in the narrative review, they were excluded from the meta-analysis. The remaining eight articles composed the dataset for the meta-analysis.

Fifteen common dietary factors were analyzed, and dietary sources were assessed via validated nutrition/diet questionnaires. The combined findings revealed that four diets (caffeine, fruit, dietary fiber, and dairy products) were negatively associated with the incidence of tinnitus; that is, the higher the intake of caffeine, fruit, dietary fiber, and dairy products was, the lower the prevalence of tinnitus.

A meta-analysis of dietary factors

The meta-analysis included eight studies with a total of 301,533 people and analyzed 15 dietary factors, as shown **in Figure 2**: carbohydrates (2/8, **Supplemental eFigure 1**), caffeine (4/8, **Supplemental eFigure 2**), varied diets (2/8, **Supplemental eFigure 3**), eggs (2/8, **Supplemental eFigure 4**), fruits (3/9, **Supplemental eFigure 5**), fibers (2/8, **Supplemental eFigure 6**), fat (3/8, **Supplemental eFigure 7**), margarine (2/8, **Supplemental eFigure 8**), meat (2/8, **Supplemental eFigure 9**), sugar (4/8, **Supplemental eFigure 10**), protein (2/8, **Supplemental eFigure 11**), fish (3/8, **Supplemental eFigure 12**), vegetables (4/8, **Supplemental eFigure 13**), water (3/8, **Supplemental eFigure 14**), and dairy (2/8, **Supplemental eFigure 15**). The summary results are depicted **in Figure 2**. The intake of dairy products, fruits, dietary fiber, and caffeine was negatively correlated with the prevalence of tinnitus: 0.827 for dairy [95% CI 0.766–0.892], $I^2 = 0\%$, $p < 0.00001$; 0.649 for fruit [95% CI 0.532–0.793], $I^2 = 0\%$, $p < 0.0001$; 0.918 for fiber [95% CI 0.851–0.990], $I^2 = 63\%$, $p = 0.03$; and 0.898 for caffeine [95% CI 0.862–0.935], $I^2 = 23\%$, $p < 0.003$. Protein intake increased the risk of tinnitus (OR = 1.002 [95% CI 1.001–1.004], $I^2 = 0\%$, $p = 0.009$). No associations were found between other dietary factors and tinnitus.

Sensitivity analysis

We conducted sensitivity analyses for various dietary intakes on the basis of predefined analysis criteria (requiring data from the included articles to exceed 6). Contradictory outcomes were noted in the aggregated results for caffeine **(**refer to **Supplemental eFigure 16)**, with the analysis attributing these contradictions to data within the same article (Abby McCormack 2014). Sequential exclusion of fruit **(**refer to **Supplemental eFigure 17)** and dietary fiber **(**refer to **Supplemental eFigure 18)** maintained the statistical significance of the combined odds ratio. Successive exclusion of summary results for vegetables **(**refer to **Supplemental eFigure 19)** and sugar **(**refer to **Supplemental eFigure 20)** revealed no contradictory outcomes in the combined odds ratio, thus ensuring the robustness of the meta-analysis results. The comprehensive sensitivity analysis revealed the relative robustness of the meta-analysis results, confirming the associations of fruit and dietary fiber intake with the prevalence of tinnitus. No significant associations between other dietary intakes and tinnitus were found.

Publication bias

The funnel plot and Egger test findings for caffeine, fruit, vegetables, diet, sugar, and fat indicated the presence of publication bias (**Supplemental eFigure 21－26**). We performed a supplementary analysis using the shear compensation method, which yielded consistent results that suggest that publication bias did not impact the main outcome.

Discussion

In this systematic review and meta-analysis involving eight observational studies (comprising a total of 301,533 participants), we discovered that increased dietary consumption of fruit, dietary fiber, dairy products, and caffeine was associated with a reduced occurrence of tinnitus. These reductions were 35.1% (20.7%–46.8%) for fruit intake, 9.2% (1%–14.9%) for dietary fiber, 17.3% (10.8%–23.4%) for dairy products, and 10.2% (6.5%–13.8%) for caffeine intake. These results were consistently supported by the sensitivity analysis.

The association between caffeine intake and tinnitus remains contentious. Our findings indicate that caffeine has a positive effect on tinnitus incidence. Some suggest that caffeine might effectively decrease tinnitus incidence, possibly because of its anxiety-reducing effects. Conversely, some scholars argue that individuals with tinnitus often experience insomnia, in which caffeine consumption could worsen, thus exacerbating tinnitus symptoms. Recent observational studies [23 24] have revealed no link between caffeine consumption and depression or anxiety levels. Furthermore, additional dose analysis revealed a J-pattern association between caffeine intake and psychiatric disorders, with about 2–3 cups per day associated with decreased risk [25]. Caffeine, which acts as a nonselective adenosine receptor antagonist, can mitigate anxiety when it is ingested at a daily dose of 10 mg/kg [26]. Genetic analysis also suggested a correlation between caffeine consumption and reduced tinnitus incidence

[27]. This effect is achieved through adenosine receptor blockade, dopamine release promotion, acetylcholinesterase activity inhibition, and sympathetic nerve stimulation.

The results of most studies[12 14 21 28] showed that dietary fiber and fruit intake have a positive impact on reducing the occurrence of tinnitus, and the findings of our meta-analysis clarify this reliably and comprehensively by integrating and analyzing the results of all relevant studies. Some scholars have proposed that dietary fiber is associated with increased insulin sensitivity[29]. Studies indicate that hyperinsulinemia resulting from low insulin sensitivity could disturb the inner ear environment, potentially increasing tinnitus risk [30 31]. Conversely, research suggests that fiber and dairy products might enhance blood vessel function[32], a factor correlated with tinnitus. Abnormal microcirculation, for example, contributes to a sustained reduction in ear blood flow, potentially leading to cochlear damage and increasing tinnitus risk [14].

Our combined analysis revealed no correlation between vegetable consumption and tinnitus. Identifying the source of heterogeneity was difficult because of the limited number of articles. Nevertheless, sensitivity analyses reaffirmed the strength of our conclusions. Vegetables and fruits, which are rich in diverse vitamins and minerals crucial for maintaining health, have been shown to improve ear microcirculation, alleviate tinnitus, and offer additional benefits [13,28]. Future studies are expected to provide clearer results.

The body has three main sources of energy: carbohydrates (sugars), fats and proteins. Our findings indicate that protein do not increase the occurrence of tinnitus (OR = 1.002, [95% CI 1.001–1.004], $p = 0.009$). Protein is a crucial nutrient that requires daily consumption and plays a vital role in supporting neuronal activity and neural development[33,34]. Inadequate protein intake can lead to ototoxic side effects and impair the neural function of the auditory system[35]. Dawes et al. demonstrated that a higher intake of dietary pattern factor 3 (high protein) was linked to a reduced likelihood of tinnitus[12]. Although low-protein diets may affect auditory vestibular function, no studies have specified the necessary amount of protein in the diet. Our analysis revealed links between protein intake and tinnitus risk. Moreover, high-protein diets have been shown to induce oxidative stress in the cerebral cortex and hypothalamus of rats[36]. Hence, further research on the relationship between protein dosage and tinnitus is warranted in the future.

Sugar is an essential daily component, in line with our analysis, no significant effect of sugar intake on tinnitus incidence was observed (OR = 0.997 [95% CI 0.967, 1.027]). High sugar consumption is typically associated with an unhealthy lifestyle. Proinflammatory foods, including sugary items, are often associated with increased systemic inflammation and microvascular damage, particularly microischemic events[37]. Elevated blood glucose levels can harm small blood vessels and nerves in the inner ear, leading to pathological alterations in outer hair cells and spiral ganglion cells. This can result in nerve tissue ischemia and hypoxia, leading to nerve damage[35]. Conversely, Spankovich et al. demonstrated that high carbohydrate intake can prevent hearing loss in older adults[38]. Tang et al. reported a 45% decrease in tinnitus risk for participants in the fourth quartile compared with the first quartile of carbohydrate intake [14].

Both excessive and insufficient dietary intake may have adverse effects on tinnitus, underscoring the need for a dose-response analysis of diet, which would provide valuable insights for preventing dietary tinnitus. Several studies have suggested that increasing the score of healthy foods, such as fruits, vegetables, legumes, nuts, fish, and dairy products, may lower the risk of cardiovascular disease and mortality[40-42]. Each one-fifth increase in the healthy diet score was associated with a corresponding decrease in overall mortality rate (HR = 0.92; 0.90–0.93), severe cardiovascular disease (HR = 0.94; 95% CI: 0.93–0.95), myocardial infarction (HR = 0.94; 0.92–0.96), stroke (HR = 0.94; 0.89–0.99), and death or cardiovascular disease (HR = 0.93; 0.92–0.94[43]).

The outcomes of our analysis did not support a notable connection between fat intake and tinnitus risk, although there was a discernible upward trend. Moreover, high-fat diets contribute to obesity and can lead to insulin resistance[44]. Conversely, adopting a low-fat/low-cholesterol diet might aid in reducing blood cholesterol and triglyceride levels, potentially alleviating tinnitus symptoms[45]. Future studies are needed to verify the relationship between fat and tinnitus.

A recent study revealed that increased levels of dietary variety, including quantity, evenness, and quality, were inversely linked to the risk of depressive symptoms, especially among women and older adults[46]. This could offer relief for tinnitus patients. Moreover, dietary variety is believed to be correlated with insulin resistance[47]. Given the protective effects of various diets on human health, further exploration of dietary variety is necessary to validate significant associations. Our pooled analysis indicated that a varied in diet was not significantly linked to a reduced tinnitus incidence (OR = 0.653 [95% CI 0.410, 1.038]) based on the currently available evidence.

We found only one study that investigated the impact of chocolate and flavonoids on the onset of tinnitus [19], but it did not provide sufficient data for a meta-analysis. Flavonoids, which are abundant in fruits and vegetables, offer antioxidant, anti-inflammatory, and vascular health benefits, which align with the pathophysiology of age-related hearing loss and tinnitus[48]. Additionally, flavonoids interact with signaling cascades involving protein and lipid kinases, inhibiting neuronal death induced by neurotoxicants such as oxygen radicals and promoting neuronal survival and synaptic plasticity[49]. Despite the hypothesis that dietary flavonoids might protect against tinnitus development over a 10-year period, Tang et al. [48]. did not support this idea. However, it is important to note that this study has limitations, such as insufficient data collection.

Chocolate is a globally consumed product renowned for its high phenolic compound content (flavonoids are a subclass of polyphenols) [50]. A study by Lee et al. indicated that chocolate consumption is not linked to tinnitus or tinnitus-related issues[19]. An animal study demonstrated that polyphenols alleviate oxidative stress in the cochlea by suppressing apoptotic signaling pathways[51]. Nonetheless, excessive chocolate consumption can have adverse effects on brain hyperexcitability[52]. Future investigations into the association between chocolate consumption and tinnitus should consider the intake dosage.

This systematic review and meta-analysis represents the first attempt to explore the epidemiological link between diet and tinnitus. While we examined the relationships between fruit, dietary fiber, and caffeine intake and a reduced incidence of tinnitus, it remains inconclusive whether a causal relationship exists.

Conclusion

Diet-based strategies for tinnitus prevention are anticipated to play a significant role in chronic tinnitus management. Existing evidence suggests that consuming fruit, dietary fiber, caffeine, and dairy may be associated with a reduced incidence of tinnitus. The primary underlying mechanisms may involve the protective effects of these diets on blood vessels and nerves, as well as their anti-inflammatory and antioxidant properties. However, it is crucial to interpret our findings cautiously because of the overall low quality of the evidence available. In the future, further well-designed, large-scale, cross-population cohort studies are warranted to complement and verify the relationship between dietary intake and tinnitus. Additionally, focusing on the dosage and categorization of each dietary intake would provide valuable insights.

Author Contribution

All authors contributed to the study's conception and design. SZ, MZ, XW, YJ conducted data collection and analysis. SZ, QZ designed the test plan. QF as the paper guide, control the quality of the paper, XH, XL, XW, HW drew the chart. XC, LW, LF completed the writing of the test plan. XL and QZ revised the manuscript. QZ is responsible for the overall content as the guarantor.

Author Declaration

The author has no direct conflict of interest.

Ethical Approval

The article belongs to the review category and does not require the approval of the ethics committee.

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Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

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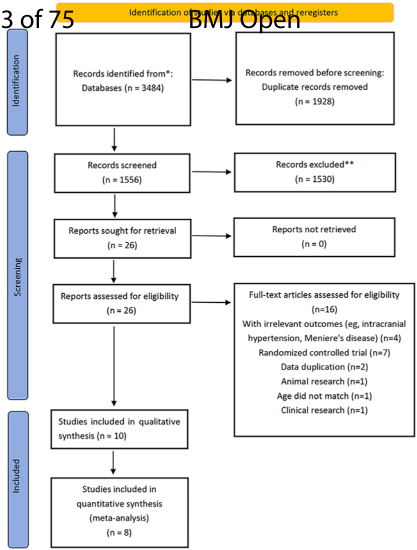
Figure 1: Flow chart

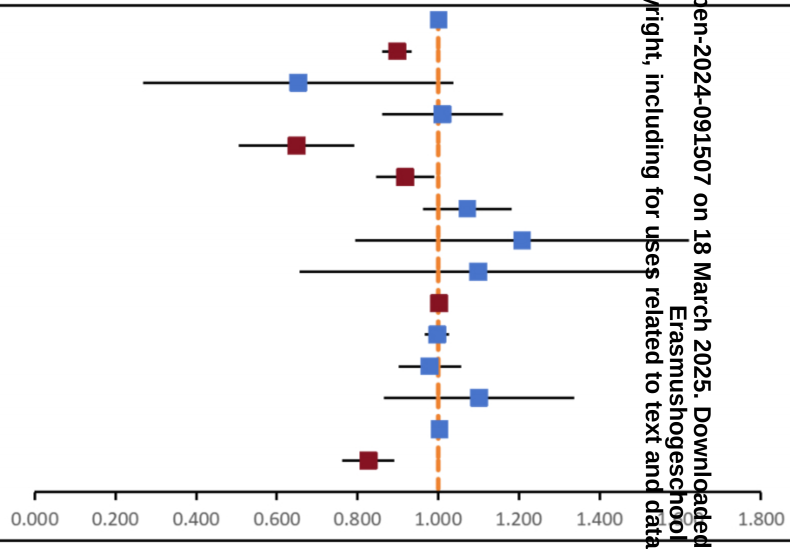
Figure 2: Risk ratio summary of diet and tinnitus incidence



*means: The search results of the four databases according to the pre-specified database search strategy.

**means: The process of selecting articles for title and abstract based on inclusion exclusion criteria.

Type of diet	Study，n	I^2	OR	LOR	UOR	95%CI	Grade	Evidence class
Carbohydrate	2	33.0%	1.001	1.000	1.002		Low	NS
Caffeine	3	23.0%	0.898	0.862	0.935		Low	Class II
Varied diet	2	50.0%	0.653	0.410	1.038		Very low	NS
Egg	2	55.0%	1.010	0.880	1.160		Very low	NS
Fruit	3	0.0%	0.649	0.532	0.793		Moderate	Class II
Fiber	3	63.0%	0.918	0.851	0.990		Low	Class II
Fat	3	73.0%	1.072	0.973	1.181		Very low	NS
Margarine	2	0.0%	1.208	0.900	1.622		Low	NS
Meat	2	0.0%	1.099	0.783	1.542		Low	NS
Protein	2	0.0%	1.002	1.001	1.004		Low	Class III
Sugar	3	0.0%	0.997	0.967	1.027		Low	NS
Fish	3	72.0%	0.979	0.907	1.056		Very low	NS
Vegetable	4	0.0%	1.101	0.907	1.337		Very low	NS
Water	3	0.0%	1.003	0.992	1.014		Low	NS
Dairy	2	0.0%	0.827	0.766	0.892		Low	Class II



The blue or red dots represent OR values, and the black linesrepresent confidence intervals

$p<0.05$ indicates statistical difference.

The evidence classification criteria: Class I (convincing evidence), Class II (highly suggestive evidence), Class III (suggestive evidence), Class IV (weak evidence), and NS (non-significant).

GRADE:Grade of Recommendations Assessment, Development, and Evaluation.

Moderate: The results of current efficacy evaluation are likely to be close to the true value;

Low: The reliability of the current efficacy evaluation results is uncertain;

Very low: The reliability of the current efficacy evaluation results is very uncertain;

Catalogue

Search Strategy

Search Strategy Free text search strategy: Initial search date: 25 May 2024

PubMed 1216

(tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate).

EMBASE 1942

('Tinnitus'/exp OR 'Tinnitus':ab,ti,kw OR 'Ringing-Buzzing'/exp OR 'Ringing-Buzzing':ab,ti,kw OR 'ear buzzing':ab,ti,kw) AND (('Diet'/exp OR 'Diets':ab,ti,kw) OR ('Food'/exp OR 'Food':ab,ti,kw OR 'Foods':ab,ti,kw) OR ('Water'/exp OR 'Water':ab,ti,kw OR 'Hydrogen Oxide':ab,ti,kw) OR ('Milk'/exp OR 'Milk':ab,ti,kw OR 'Cow Milk':ab,ti,kw) OR ('fish'/exp OR 'fish':ab,ti,kw) OR ('vegetable'/exp OR 'vegetable':ab,ti,kw) OR ('Dietary Fiber'/exp OR 'alimentary fiber':ab,ti,kw) OR ('sugar'/exp OR 'sugar':ab,ti,kw) OR ('meat'/exp OR 'meat':ab,ti,kw OR 'sausage':ab,ti,kw) OR ('margarine'/exp OR 'margarine':ab,ti,kw OR 'oleomargarine':ab,ti,kw) OR ('fat'/exp OR 'fat':ab,ti,kw) OR ('egg'/exp OR 'egg':ab,ti,kw) OR ('varietas'/exp OR 'plant variety':ab,ti,kw) OR ('caffeine'/exp OR 'caffeine':ab,ti,kw OR 'coffein':ab,ti,kw) OR ('carbohydrate'/exp OR 'carbohydrate':ab,ti,kw OR 'carbon hydrate':ab,ti,kw OR 'synthetic carbohydrate':ab,ti,kw OR 'saccharide':ab,ti,kw) OR ('protein'/exp OR 'protein':ab,ti,kw))

Web of Science 29

("Tinnitus"(Topic) OR "Tinnitus"(Topic) OR "Ringing-Buzzing"(Topic) OR "Ringing-Buzzing"(Topic) OR "ear buzzing"(Topic)) AND (("Diet"(Topic) OR "Diets"(Topic)) OR ("Food"(Topic) OR "Foods"(Topic)) OR ("Water"(Topic) OR "Hydrogen Oxide"(Topic)) OR ("Milk"(Topic) OR "Cow Milk"(Topic)) OR ("fish"(Topic)) OR ("vegetable"(Topic)) OR ("Dietary Fiber"(Topic) OR "alimentary fiber"(Topic)) OR ("sugar"(Topic)) OR ("meat"(Topic) OR "sausage"(Topic)) OR ("margarine"(Topic) OR "oleomargarine"(Topic)) OR ("fat"(Topic)) OR ("egg"(Topic)) OR ("varietas"(Topic) OR "plant variety"(Topic)) OR ("caffeine"(Topic) OR "coffein"(Topic)) OR ("carbohydrate"(Topic) OR "carbon hydrate"(Topic) OR "synthetic carbohydrate"(Topic) OR "saccharide"(Topic)) OR ("protein"(Topic)))

Cochrane 297

((tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate) in Title Abstract Keyword

Stata analysis

We used mixed-effects models to pool maximally covariate-adjusted odds ratios (ORs) from each study. Due to the low incidence of events and short follow-up events, OR, RR, and HR were approximately equal, so our results were uniformly expressed in OR. If the P-value of the q test was <0.10 or the I^2 statistic was ≥50%, we assessed and considered the inter-study heterogeneity to be significant. For observational studies, we maximally support covariate-adjusted estimates. If a study uses an analytical method that is incompatible with synthesis for most other studies, we convert the effect estimate to the appropriate combined ratio or exclude the study from the meta-analysis.

Publication bias

If the article heterogeneity is large in the analysis with statistical differences, we will use meta regression to investigate the source of heterogeneity. We assessed the asymmetry of the funnel plot with visual and Egger's bias, and estimated the possible missing studies with eMethods if publication bias is suspected.

Analysis software

We conducted all analyses using stata (version 16) and Review Manager (version 5.3). Unless otherwise specified, we considered a two-sided P value of <0.05 as statistically significant.

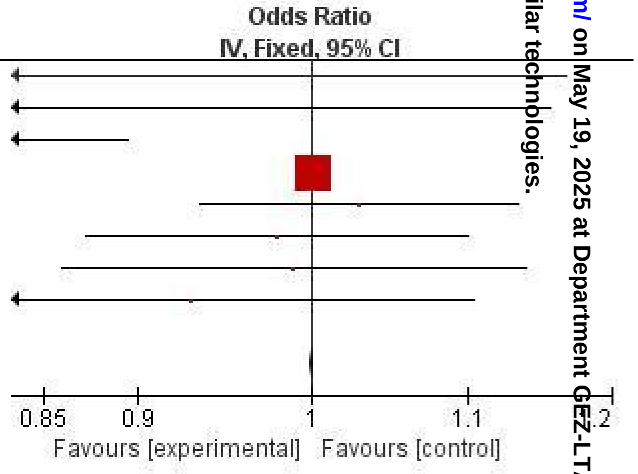
eFigure 1: Forest Plot Showing the Association Between carbohydrate and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.

Carbohydrate: OR=1.00, [95%CI 1.00,1.00], I^2=33%, p=0.05.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Diana Tang 2021a	-0.3011051	0.2326598	0.0%	0.74 [0.47, 1.17]
Diana Tang 2021b	-0.3024573	0.2282614	0.0%	0.74 [0.47, 1.16]
Diana Tang 2021c	-0.597837	0.2483288	0.0%	0.55 [0.34, 0.89]
Doh Young Lee 2018	0.0009995	0.0005102	100.0%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0295588	0.0492101	0.0%	1.03 [0.94, 1.13]
Piers Dawes 2020b	-0.0202027	0.059233	0.0%	0.98 [0.87, 1.10]
Piers Dawes 2020c	-0.0100503	0.0719008	0.0%	0.99 [0.86, 1.14]
Piers Dawes 2020d	-0.0725707	0.0876968	0.0%	0.93 [0.78, 1.10]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 10.46, df = 7 (P = 0.16); I² = 33%
Test for overall effect: Z = 1.95 (P = 0.05)



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             Study     |     ES    [95% Conf. Interval]     % Weight
-----------------------+---------------------------------------------------
Diana Tang 2021a       |  0.740       0.469     1.168          0.00
Diana Tang 2021b       |  0.739       0.472     1.156          0.00
Diana Tang 2021c       |  0.550       0.338     0.895          0.00
Doh Young Lee 2018     |  1.001       1.000     1.002         99.97
Piers Dawes 2020a      |  1.030       0.935     1.134          0.01
Piers Dawes 2020b      |  0.980       0.873     1.101          0.01
Piers Dawes 2020c      |  0.990       0.860     1.140          0.01
Piers Dawes 2020d      |  0.930       0.783     1.104          0.00
-----------------------+---------------------------------------------------
I-V pooled ES          |  1.001       1.000     1.002        100.00
-----------------------+---------------------------------------------------
```

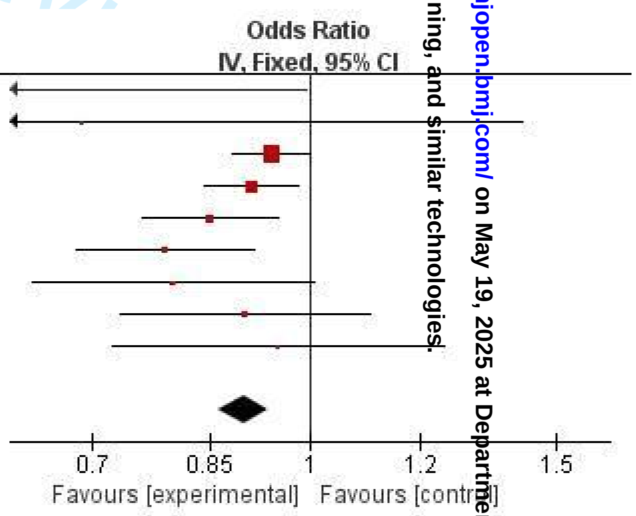
Actually: Carbohydrate: OR=1.001, [95%CI 1.000,1.002]

eFigure 2: Forest Plot Showing the Association Between caffeine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Caffeine: OR=0.90, [95%CI 0.86,0.94], I^2=23% p<0.000001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.7133499	0.3614964	0.3%	0.49 [0.24, 1.00]
Carlotta Micaela Jarach 2023b	-0.3710637	0.36645	0.3%	0.69 [0.34, 1.42]
Jordan T Glicksman 2014a	-0.0618754	0.0326106	40.8%	0.94 [0.88, 1.00]
Jordan T Glicksman 2014b	-0.0943106	0.0393242	28.0%	0.91 [0.84, 0.98]
Jordan T Glicksman 2014c	-0.1625189	0.0569244	13.4%	0.85 [0.76, 0.95]
Jordan T Glicksman 2014d	-0.2357223	0.0743244	7.8%	0.79 [0.68, 0.91]
Sang-Youp Lee 2018	-0.2231435	0.1178662	3.1%	0.80 [0.63, 1.01]
Sang-Youp Lee 2018b	-0.1053605	0.1045972	4.0%	0.90 [0.73, 1.10]
Sang-Youp Lee 2018c	-0.0512933	0.1386774	2.3%	0.95 [0.72, 1.25]
Total (95% CI)			**100.0%**	**0.90 [0.86, 0.94]**

Heterogeneity: Chi² = 10.43, df = 8 (P = 0.24); I² = 23%
Test for overall effect: Z = 5.18 (P < 0.00001)



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              Study     |     ES    [95% Conf. Interval]     % Weight
------------------------+---------------------------------------------------
Carlotta Micaela Jar    |   0.490       0.241     0.995          0.33
Carlotta Micaela Jar    |   0.690       0.336     1.415          0.32
Jordan T 2014a          |   0.940       0.882     1.002         40.76
Jordan T 2014b          |   0.910       0.842     0.983         28.03
Jordan T 2014c          |   0.850       0.760     0.950         13.38
Jordan T 2014d          |   0.790       0.683     0.914          7.85
Sang-Youp Lee 2018      |   0.800       0.635     1.008          3.12
Sang-Youp Lee 2018      |   0.900       0.733     1.105          3.96
Sang-Youp Lee 2018      |   0.950       0.724     1.247          2.25
------------------------+---------------------------------------------------
I-V pooled ES           |   0.898       0.862     0.935        100.00
------------------------+---------------------------------------------------
```

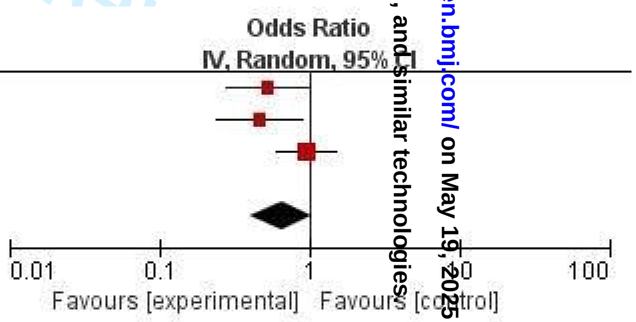
Actually: Caffeine: OR=0.898, [95%CI 0.862,0.935]

eFigure 3: Forest Plot Showing the Association Between diversity and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Diversity: OR=0.65, [95%CI 0.41,1.04], I^2=50% p=0.08.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlotta Micaela Jarach 2023a	-0.6348783	0.3247361	29.9%	0.53 [0.28, 1.00]
Carlotta Micaela Jarach 2023b	-0.7550226	0.3371826	28.7%	0.47 [0.24, 0.91]
Christopher Spankovich 2017	-0.0444	0.2295	41.4%	0.96 [0.61, 1.50]
Total (95% CI)			**100.0%**	**0.65 [0.41, 1.04]**

Heterogeneity: Tau² = 0.09; Chi² = 3.98, df = 2 (P = 0.14); I² = 50%
Test for overall effect: Z = 1.78 (P = 0.08)



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         Study         |     ES    [95% Conf. Interval]     % Weight
-----------------------+----------------------------------------------------
Carlotta Micaela Jar |  0.530       0.280      1.002          29.86
Carlotta Micaela Jar |  0.470       0.243      0.910          28.60
Christopher Spankovi |  0.950       0.606      1.490          41.54
-----------------------+----------------------------------------------------
D+L pooled ES          |  0.653       0.410      1.038         100.00
-----------------------+----------------------------------------------------
```

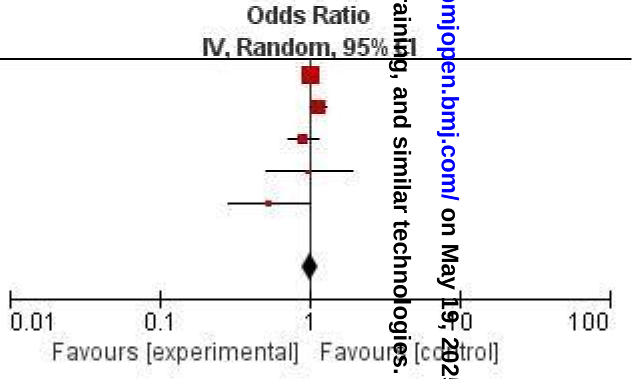
Actually: diversity: OR=0.653, [95%CI 0.410, 1.038].

eFigure 4: Forest Plot Showing the Association Between egg and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis.
Egg: OR=1.02, [95%CI 0.91,1.15], I^2=55% p=0.75.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Abby McCormack 2014a	0.0304592	0.0274031	43.4%	1.03 [0.98, 1.09]
Abby McCormack 2014b	0.1392621	0.0589045	32.9%	1.15 [1.02, 1.29]
Abby McCormack 2014c	-0.10436	0.1166166	17.3%	0.90 [0.72, 1.13]
Carlotta Micaela Jarach 2023a	-0.0100503	0.338181	3.0%	0.99 [0.51, 1.92]
Carlotta Micaela Jarach 2023b	-0.6161861	0.3157843	3.4%	0.54 [0.29, 1.00]
Total (95% CI)			**100.0%**	**1.02 [0.91, 1.15]**

Heterogeneity: Tau² = 0.01; Chi² = 8.83, df = 4 (P = 0.07); I² = 55%
Test for overall effect: Z = 0.32 (P = 0.75)



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            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  1.031       0.926     1.148          36.13
Abby McCormack 2014a |  1.149       1.024     1.290          35.00
Abby McCormack 2014b |  0.901       0.717     1.133          20.41
Carlotta Micaela Jar |  0.990       0.510     1.921           3.97
Carlotta Micaela Jar |  0.540       0.291     1.003           4.50
---------------------+---------------------------------------------------
D+L pooled ES        |  1.010       0.880     1.160         100.00
---------------------+---------------------------------------------------
```

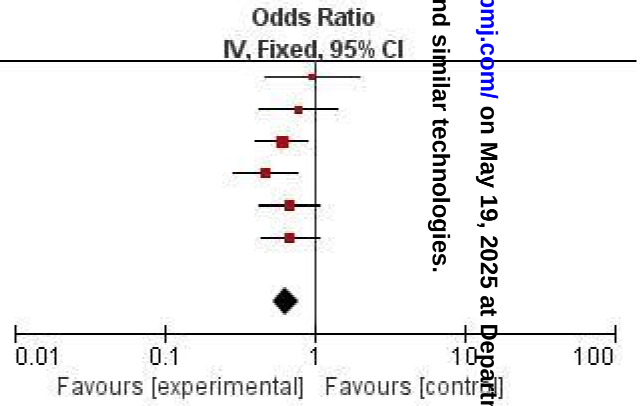
Actually: diversity: OR=1.010, [95%CI 0.880, 1.160].

eFigure 5: Forest Plot Showing the Association Between fruit and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis.
Fruit: OR=0.65, [95%CI 0.53,0.79], I^2=0% p<0.0001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.040822	0.3655756	7.7%	0.96 [0.47, 1.97]
Carlotta Micaela Jarach 2023b	-0.2484614	0.3083197	10.9%	0.78 [0.43, 1.43]
Christopher Spankovich 2017	-0.4942963	0.2033897	25.0%	0.61 [0.41, 0.91]
Diana Tang 2021a	-0.7550226	0.2457749	17.1%	0.47 [0.29, 0.76]
Diana Tang 2021b	-0.3856625	0.230163	19.5%	0.68 [0.43, 1.07]
Diana Tang 2021c	-0.3710637	0.2290667	19.7%	0.69 [0.44, 1.08]
Total (95% CI)			**100.0%**	**0.65 [0.53, 0.79]**

Heterogeneity: Chi^2 = 3.43, df = 5 (P = 0.63); I^2 = 0%
Test for overall effect: Z = 4.24 (P < 0.0001)



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. metan logrr selogrr, label(namevar=author) fixed eform

           Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.960       0.469     1.965          7.74
Carlotta Micaela Jar |  0.780       0.426     1.427         10.88
Christopher Spankovi |  0.610       0.409     0.909         25.01
Diana Tang 2021a     |  0.470       0.290     0.761         17.13
Diana Tang 2021b     |  0.680       0.433     1.068         19.53
Diana Tang 2021d     |  0.690       0.440     1.081         19.72
---------------------+---------------------------------------------------
I-V pooled ES        |  0.649       0.532     0.793        100.00
---------------------+---------------------------------------------------
```

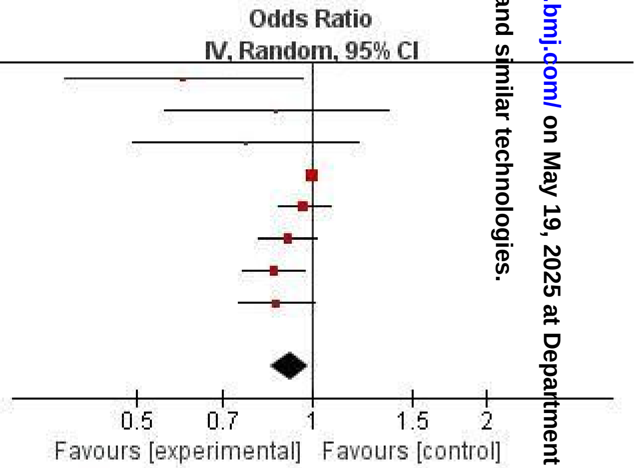
Actually: fruit: OR=0.649, [95%CI 0.532, 0.793].

eFigure 6: Forest Plot Showing the Association Between fiber and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Fiber: OR=0.92, [95%CI 0.85,0.99], I^2=63% p=0.03.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Diana Tang 2021a	-0.5108256	0.243222	2.3%	0.60 [0.37, 0.97]
Diana Tang 2021b	-0.1392621	0.2282217	2.6%	0.87 [0.56, 1.36]
Diana Tang 2021c	-0.2613648	0.2306047	2.5%	0.77 [0.49, 1.21]
Doh Young Lee 2018	0.003992	0.0022879	27.8%	1.00 [1.00, 1.01]
Piers Dawes 2020a	-0.0304592	0.0527859	18.3%	0.97 [0.87, 1.08]
Piers Dawes 2020b	-0.0943106	0.0588071	16.9%	0.91 [0.81, 1.02]
Piers Dawes 2020c	-0.1508229	0.0622392	16.1%	0.86 [0.76, 0.97]
Piers Dawes 2020d	-0.1392621	0.0759266	13.4%	0.87 [0.75, 1.01]
Total (95% CI)			**100.0%**	**0.92 [0.85, 0.99]**

Heterogeneity: Tau² = 0.01; Chi² = 19.09, df = 7 (P = 0.008); I² = 63%
Test for overall effect: Z = 2.21 (P = 0.03)



```
. metan logrr selogrr, label(namevar=author) random eform

            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Diana Tang 2021a      |  0.600       0.372     0.966          2.31
Diana Tang 2021b      |  0.870       0.556     1.361          2.59
Diana Tang 2021d      |  0.770       0.490     1.210          2.54
Doh Young Lee 2018    |  1.004       1.000     1.009         27.81
Piers Dawes 2020a     |  0.970       0.875     1.076         18.30
Piers Dawes 2020b     |  0.910       0.811     1.021         16.90
Piers Dawes 2020c     |  0.860       0.761     0.972         16.14
Piers Dawes 2020d     |  0.870       0.750     1.010         13.40
---------------------+---------------------------------------------------
D+L pooled ES         |  0.918       0.851     0.990        100.00
---------------------+---------------------------------------------------
```

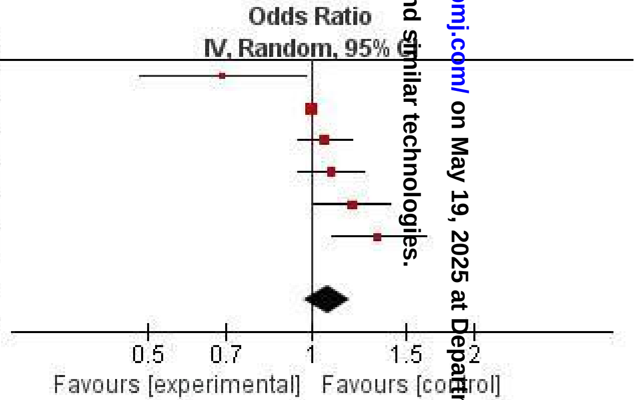
Actually: fruit: OR=0.918, [95%CI 0.851, 0.990].

eFigure 7: Forest Plot Showing the Association Between fat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Fat: OR=1.07, [95%CI 0.97,1.18], I^2=73% p=0.16.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Christopher Spankovich 2017	-0.3710637	0.1794132	5.9%	0.69 [0.49, 0.98]
Doh Young Lee 2018	0.0029955	0.0010173	27.8%	1.00 [1.00, 1.01]
Piers Dawes 2020a	0.0582689	0.0574609	20.2%	1.06 [0.95, 1.19]
Piers Dawes 2020b	0.0861777	0.0700094	17.8%	1.09 [0.95, 1.25]
Piers Dawes 2020c	0.1739534	0.0832964	15.5%	1.19 [1.01, 1.40]
Piers Dawes 2020d	0.285179	0.1010838	12.8%	1.33 [1.09, 1.62]
Total (95% CI)			**100.0%**	**1.07 [0.97, 1.18]**

Heterogeneity: Tau² = 0.01; Chi² = 18.68, df = 5 (P = 0.002); I² = 73%
Test for overall effect: Z = 1.41 (P = 0.16)



```
. metan logrr selogrr, label(namevar=author) random eform

           Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Christopher Spankovi |  0.690       0.485     0.981          5.95
Doh Young Lee 2018   |  1.003       1.001     1.005         27.75
Piers Dawes 2020a    |  1.060       0.947     1.186         20.17
Piers Dawes 2020b    |  1.090       0.950     1.250         17.81
Piers Dawes 2020c    |  1.190       1.011     1.401         15.50
Piers Dawes 2020d    |  1.330       1.091     1.621         12.82
---------------------+---------------------------------------------------
D+L pooled ES        |  1.072       0.973     1.181        100.00
---------------------+---------------------------------------------------
```

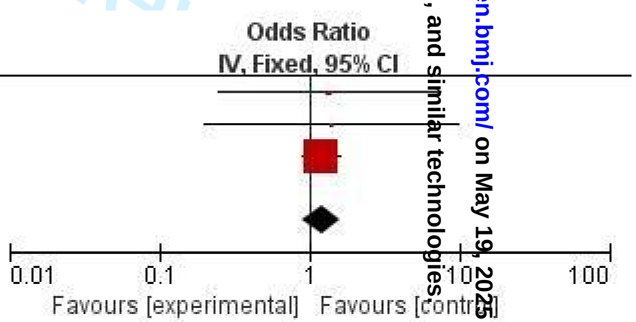
Actually: fat: OR=1.072, [95%CI 0.973, 1.181].

eFigure 8: Forest Plot Showing the Association Between margarine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Margarine: OR=1.21, [95%CI 0.90,1.63], I^2=0% p=0.20.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3001046	0.8652602	3.0%	1.35 [0.25, 7.36]
Carlotta Micaela Jarach 2023b	0.3364722	0.9974543	2.3%	1.40 [0.20, 9.89]
Milena Tomanic 2020	0.1856494	0.154809	94.7%	1.20 [0.89, 1.63]
Total (95% CI)			**100.0%**	**1.21 [0.90, 1.63]**

Heterogeneity: Chi² = 0.04, df = 2 (P = 0.98); I² = 0%
Test for overall effect: Z = 1.28 (P = 0.20)



```
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              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  1.350       0.248      7.359          3.01
Carlotta Micaela Jar |  1.400       0.198      9.889          2.27
Milena Tomanic 2020  |  1.200       0.887      1.624         94.72
---------------------+---------------------------------------------------
I-V pooled ES        |  1.208       0.900      1.622        100.00
---------------------+---------------------------------------------------
```

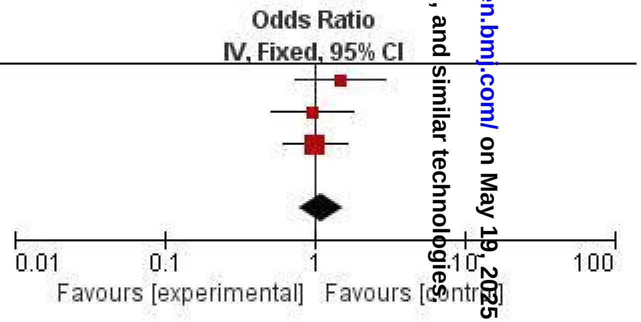
Actually: margarine: OR=1.208, [95%CI 0.900, 1.622].

eFigure 9: Forest Plot Showing the Association Between meat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Meat: OR=1.10, [95%CI 0.78,1.54], I^2=0% p=0.59.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3987761	0.3484928	24.6%	1.49 [0.75, 2.95]
Carlotta Micaela Jarach 2023b	-0.0304592	0.3287067	27.6%	0.97 [0.51, 1.85]
Christopher Spankovich 2017	0.0099503	0.2496967	47.8%	1.01 [0.62, 1.65]
Total (95% CI)			**100.0%**	**1.10 [0.78, 1.54]**

Heterogeneity: Chi² = 1.02, df = 2 (P = 0.60); I² = 0%
Test for overall effect: Z = 0.55 (P = 0.59)



```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  1.490       0.753     2.950         24.56
Carlotta Micaela Jar |  0.970       0.509     1.847         27.60
Christopher Spankovi |  1.010       0.619     1.648         47.84
---------------------+---------------------------------------------------
I-V pooled ES        |  1.099       0.783     1.542        100.00
---------------------+---------------------------------------------------
```

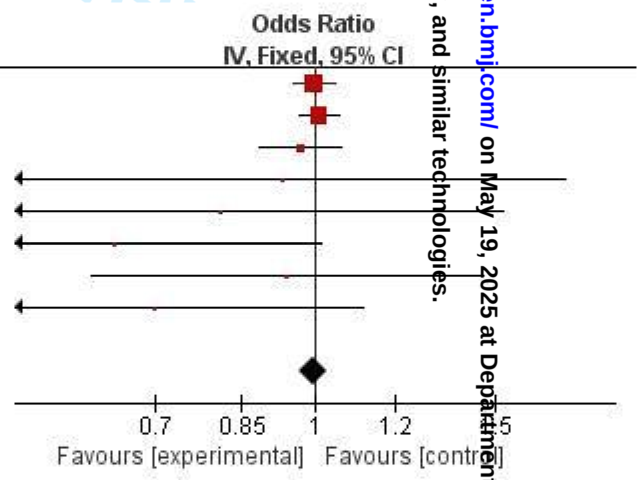
Actually: meat: OR=1.099, [95%CI 0.783, 1.542].

eFigure 10: Forest Plot Showing the Association Between sugar and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Sugar: OR=1.00, [95%CI 0.97,1.03], I^2=0% p=0.84.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Abby McCormack 2014a	0	0.0230439	44.3%	1.00 [0.96, 1.05]
Abby McCormack 2014b	0.0099503	0.0233327	43.2%	1.01 [0.96, 1.06]
Abby McCormack 2014c	-0.0294288	0.0469906	10.7%	0.97 [0.89, 1.06]
Carlotta Micaela Jarach 2023a	-0.0725707	0.3247361	0.2%	0.93 [0.49, 1.76]
Carlotta Micaela Jarach 2023b	-0.210721	0.3237852	0.2%	0.81 [0.43, 1.53]
Diana Tang 2021a	-0.4462871	0.236286	0.4%	0.64 [0.40, 1.02]
Diana Tang 2021b	-0.0618754	0.2243772	0.5%	0.94 [0.61, 1.46]
Diana Tang 2021c	-0.356675	0.2383442	0.4%	0.70 [0.44, 1.12]
Total (95% CI)			**100.0%**	**1.00 [0.97, 1.03]**

Heterogeneity: Chi² = 6.89, df = 7 (P = 0.44); I² = 0%
Test for overall effect: Z = 0.20 (P = 0.84)



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  1.000       0.956     1.046          44.34
Abby McCormack 2014a |  1.010       0.965     1.057          43.25
Abby McCormack 2014b |  0.971       0.886     1.065          10.66
Carlotta Micaela Jar |  0.930       0.492     1.758           0.22
Carlotta Micaela Jar |  0.810       0.429     1.528           0.22
Diana Tang 2021a     |  0.640       0.403     1.017           0.42
Diana Tang 2021b     |  0.940       0.606     1.459           0.47
Diana Tang 2021c     |  0.700       0.439     1.117           0.41
---------------------+---------------------------------------------------
I-V pooled ES        |  0.997       0.967     1.027         100.00
---------------------+---------------------------------------------------
```

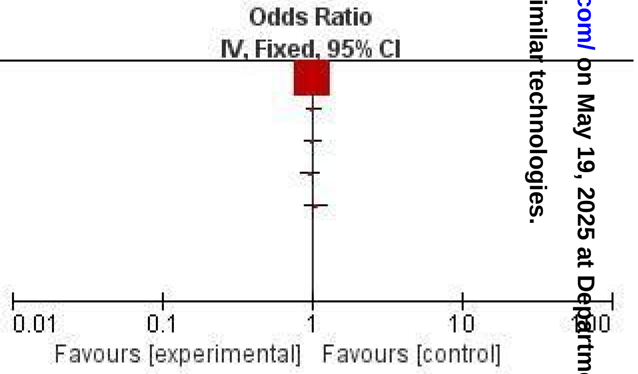
Actually: sugar: OR=0.997, [95%CI 0.967, 1.027].

eFigure 11: Forest Plot Showing the Association Between protein and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fish: OR=1.00, [95%CI 1.00,1.00], I^2=0% p=0.009.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Doh Young Lee 2018	0.001998	0.0007634	99.9%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0198026	0.0546964	0.0%	1.02 [0.92, 1.14]
Piers Dawes 2020b	0.0099503	0.060906	0.0%	1.01 [0.90, 1.14]
Piers Dawes 2020c	-0.0304592	0.0680814	0.0%	0.97 [0.85, 1.11]
Piers Dawes 2020d	0.0582689	0.0858348	0.0%	1.06 [0.90, 1.25]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 0.78, df = 4 (P = 0.94); I² = 0%
Test for overall effect: Z = 2.62 (P = 0.009)



```
. metan logrr selogrr, label(namevar=author) fixed eform

             Study     |     ES    [95% Conf. Interval]     % Weight
-----------------------+---------------------------------------------------
Doh Young Lee 2018     |  1.002      1.001      1.004         99.94
Piers Dawes 2020a      |  1.020      0.916      1.135          0.02
Piers Dawes 2020b      |  1.010      0.896      1.138          0.02
Piers Dawes 2020c      |  0.970      0.849      1.108          0.01
Piers Dawes 2020d      |  1.060      0.896      1.254          0.01
-----------------------+---------------------------------------------------
I-V pooled ES          |  1.002      1.001      1.004        100.00
-----------------------+---------------------------------------------------
```

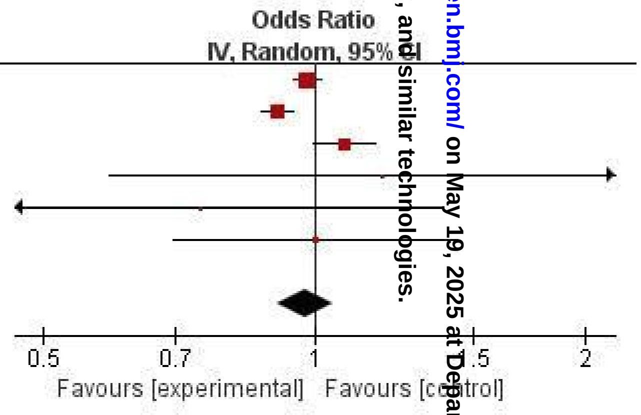
Actually: protein: OR=1.002, [95%CI 1.001, 1.004].

eFigure 12: Forest Plot Showing the Association Between fish and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fish: OR=0.98, [95%CI 0.91,1.05], I^2=72% p=0.57.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Abby McCormack 2014a	-0.0202027	0.0181367	34.4%	0.98 [0.95, 1.02]
Abby McCormack 2014b	-0.0943106	0.0197415	33.9%	0.91 [0.88, 0.95]
Abby McCormack 2014c	0.0769611	0.0404261	25.8%	1.08 [1.00, 1.17]
Carlotta Micaela Jarach 2023a	0.1739534	0.3557993	1.0%	1.19 [0.59, 2.39]
Carlotta Micaela Jarach 2023b	-0.2876821	0.3132832	1.3%	0.75 [0.41, 1.39]
Milena Tomanic 2020	0.003992	0.1847285	3.6%	1.00 [0.70, 1.44]
Total (95% CI)			**100.0%**	**0.98 [0.91, 1.05]**

Heterogeneity: Tau² = 0.00; Chi² = 18.17, df = 5 (P = 0.003); I² = 72%
Test for overall effect: Z = 0.57 (P = 0.57)



```
. metan logrr selogrr, label(namevar=author) random eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  0.980      0.946     1.015          35.43
Abby McCormack 2014a |  0.910      0.875     0.946          34.93
Abby McCormack 2014b |  1.080      0.998     1.169          27.04
Carlotta Micaela Jar |  1.190      0.593     2.390           1.14
Carlotta Micaela Jar |  0.750      0.406     1.386           1.46
---------------------+---------------------------------------------------
D+L pooled ES        |  0.979      0.907     1.056         100.00
---------------------+---------------------------------------------------
```

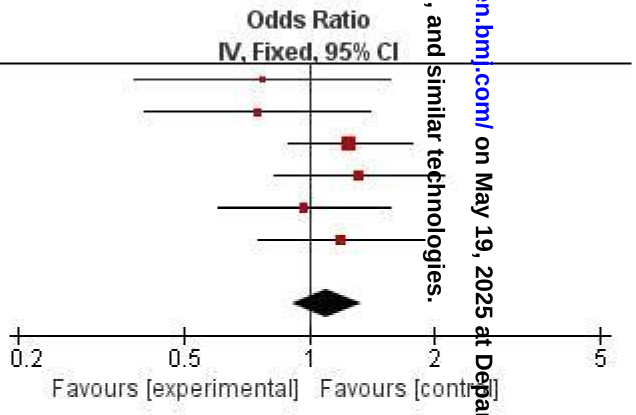
Actually: fish: OR=0.979, [95%CI 0.907, 1.056].

eFigure 13: Forest Plot Showing the Association Between vegetable and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Vegetable: OR=1.10, [95%CI 0.91,1.34], I^2=0% p=0.33..

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.2613648	0.3602729	7.6%	0.77 [0.38, 1.56]
Carlotta Micaela Jarach 2023b	-0.2876821	0.321398	9.5%	0.75 [0.40, 1.41]
Christopher Spankovich 2017	0.2231435	0.1754021	31.9%	1.25 [0.89, 1.76]
Diana Tang 2021a	0.2776318	0.2411069	16.9%	1.32 [0.82, 2.12]
Diana Tang 2021b	-0.0304592	0.2437529	16.5%	0.97 [0.60, 1.56]
Diana Tang 2021c	0.1739534	0.2357803	17.7%	1.19 [0.75, 1.89]
Total (95% CI)			**100.0%**	**1.10 [0.91, 1.34]**

Heterogeneity: Chi² = 3.88, df = 5 (P = 0.57); I² = 0%
Test for overall effect: Z = 0.98 (P = 0.33)



```
. metan logrr selogrr, label(namevar=author) fixed eform

           Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.770       0.380     1.560          7.56
Carlotta Micaela Jar |  0.750       0.399     1.408          9.50
Christopher Spankovi |  1.250       0.886     1.763         31.89
Diana Tang 2021a     |  1.320       0.823     2.117         16.88
Diana Tang 2021b     |  0.970       0.602     1.564         16.52
Diana Tang 2021c     |  1.190       0.750     1.889         17.65
---------------------+---------------------------------------------------
I-V pooled ES        |  1.101       0.907     1.337        100.00
---------------------+---------------------------------------------------
```

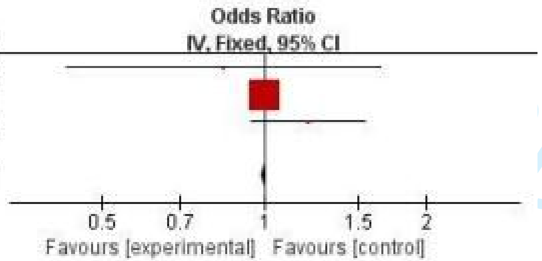
Actually: vegetable: OR=1.101, [95%CI 0.907, 1.337].

eFigure 14: Forest Plot Showing the Association Between water and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Water: OR=1.00, [95%CI 0.99,1.01], I^2=20% p=0.55.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.1743534	0.3430473	0.0%	0.84 [0.43, 1.65]
Doh Young Lee 2018	0.0029955	0.0055957	99.8%	1.00 [0.99, 1.01]
Milena Tomanic 2020	0.1889661	0.1243716	0.2%	1.21 [0.95, 1.54]
Total (95% CI)			**100.0%**	**1.00 [0.99, 1.01]**

Heterogeneity: Chi^2 = 2.50, df = 2 (P = 0.29); I^2 = 20%
Test for overall effect: Z = 0.59 (P = 0.55)



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.840       0.429     1.645             0.03
Doh Young Lee 2018   |  1.003       0.992     1.014            99.77
Milena Tomanic 2020  |  1.210       0.950     1.541             0.21
---------------------+---------------------------------------------------
I-V pooled ES        |  1.003       0.992     1.014           100.00
---------------------+---------------------------------------------------
```

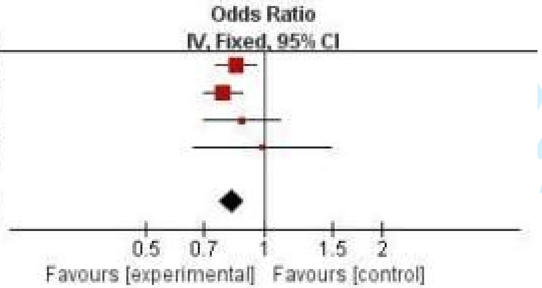
Actually: water: OR=1.003, [95%CI 0.992, 1.014].

eFigure 15: Forest Plot Showing the Association Between dairy and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Dairy: OR=0.83, [95%CI 0.77,0.89], I^2=0% p<0.00001

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Abby McCormack 2014a	-0.1655144	0.0603033	41.2%	0.85 [0.75, 0.95]
Abby McCormack 2014b	-0.2390169	0.0582753	44.1%	0.79 [0.70, 0.88]
Abby McCormack 2014c	-0.1310283	0.1153023	11.3%	0.88 [0.70, 1.10]
Christopher Spankovich 2017	-0.0101	0.2069	3.5%	0.99 [0.66, 1.49]
Total (95% CI)			**100.0%**	**0.83 [0.77, 0.89]**

Heterogeneity: Chi² = 1.89, df = 3 (P = 0.60); I² = 0%
Test for overall effect: Z = 4.87 (P < 0.00001)



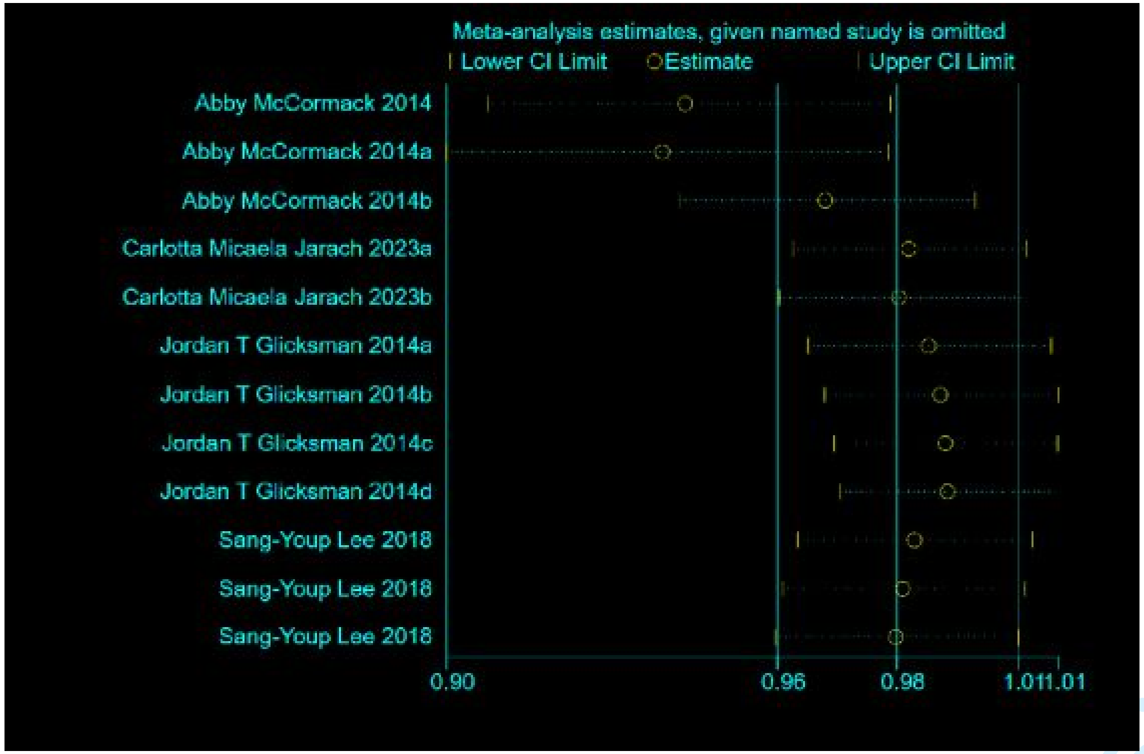
```
. metan logrr selogrr, label(namevar=author) fixed eform

               Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  0.847       0.753     0.953          41.62
Abby McCormack 2014a |  0.787       0.702     0.882          44.21
Abby McCormack 2014b |  0.877       0.699     1.100          11.30
Christopher Spankovi |  0.990       0.631     1.552           2.86
---------------------+---------------------------------------------------
I-V pooled ES        |  0.827       0.766     0.892         100.00
---------------------+---------------------------------------------------
```

Actually: dairy: OR=0.83, [95%CI 0.766, 0.892].

eFigure 16: Sensitivity analysis between caffeine and tinnitus.

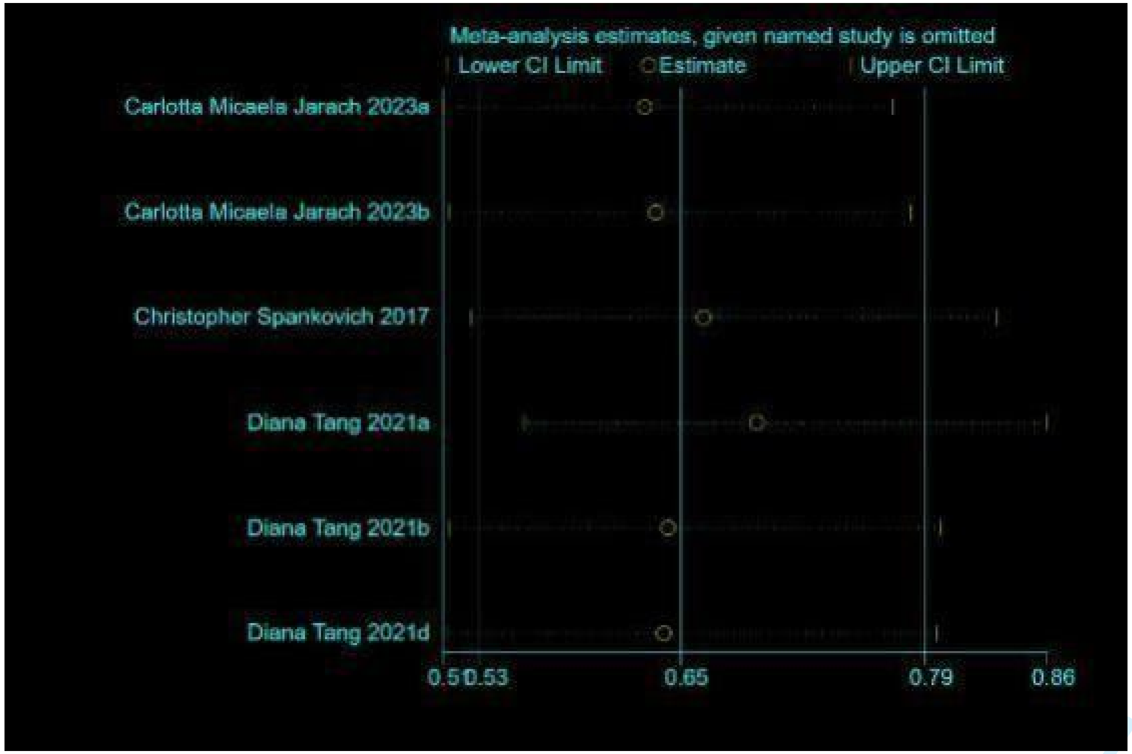
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study at a time, conflicting results emerged and further identification of the source of heterogeneity was needed. It has been confirmed that the main contradiction comes from Abby McCormack 2017, and the sensitivity analysis after removal the reseach did not show contradictory outcome, indicating the robustness of the results.

eFigure 17:Sensitivity analysis between fruit and tinnitus.

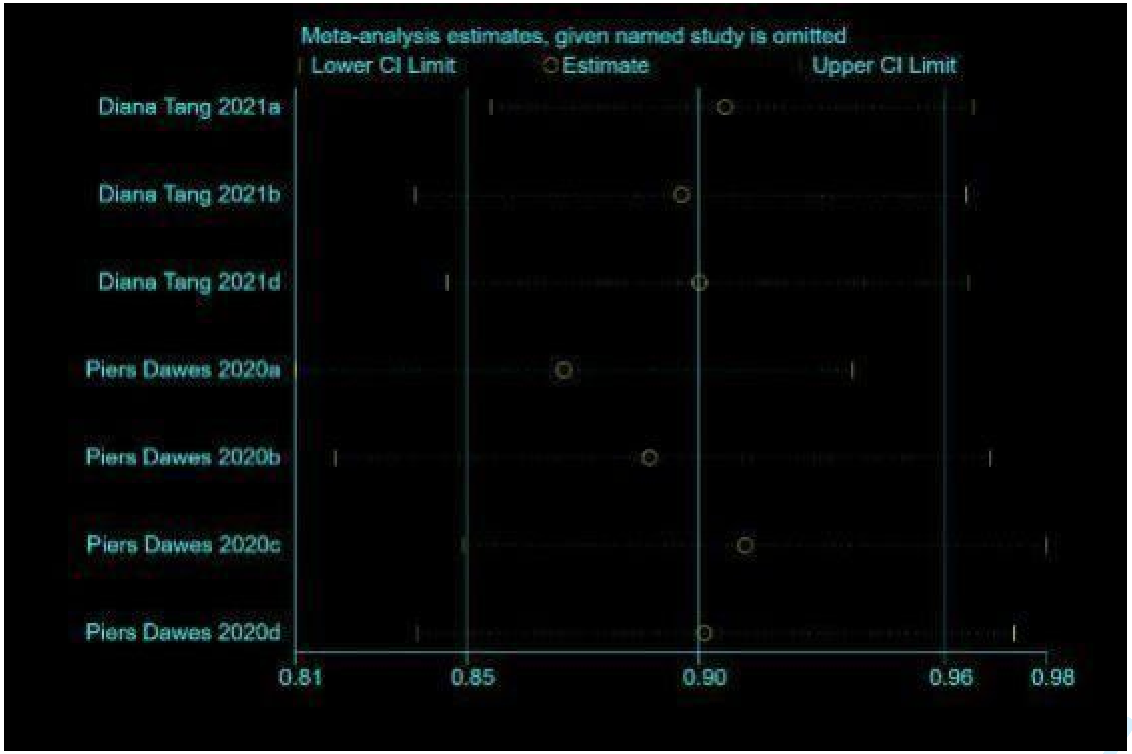
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 18:Sensitivity analysis between fiber and tinnitus.

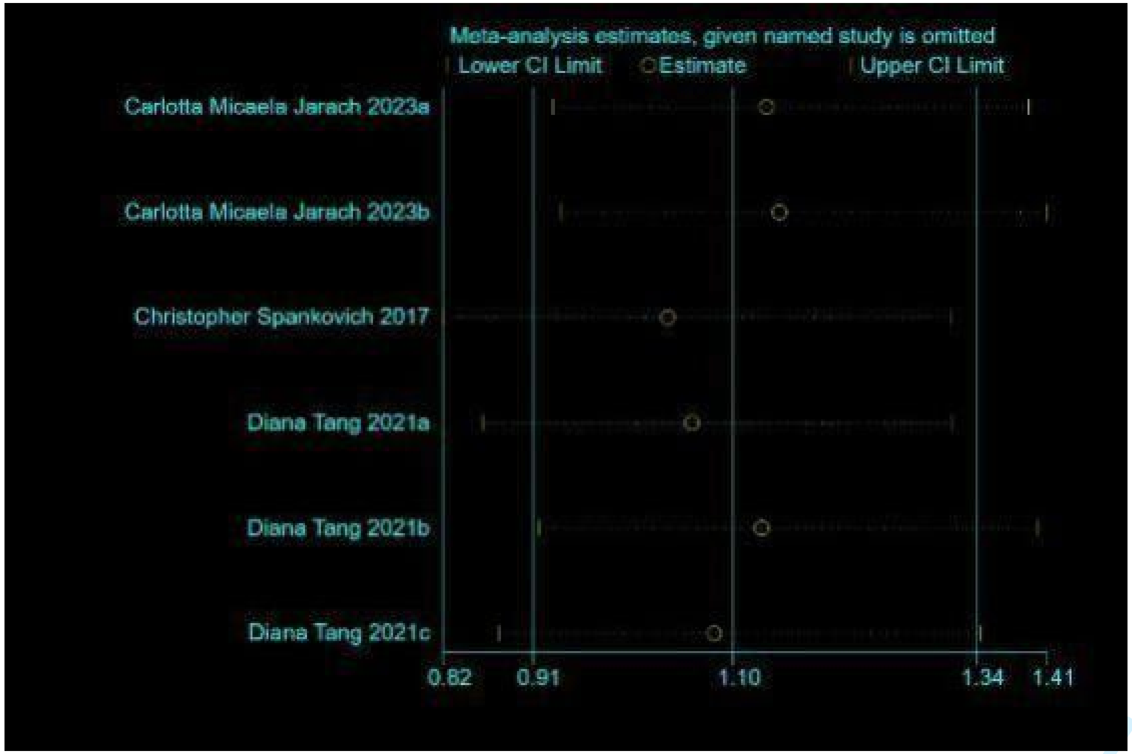
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 19:Sensitivity analysis between vegetable and tinnitus.

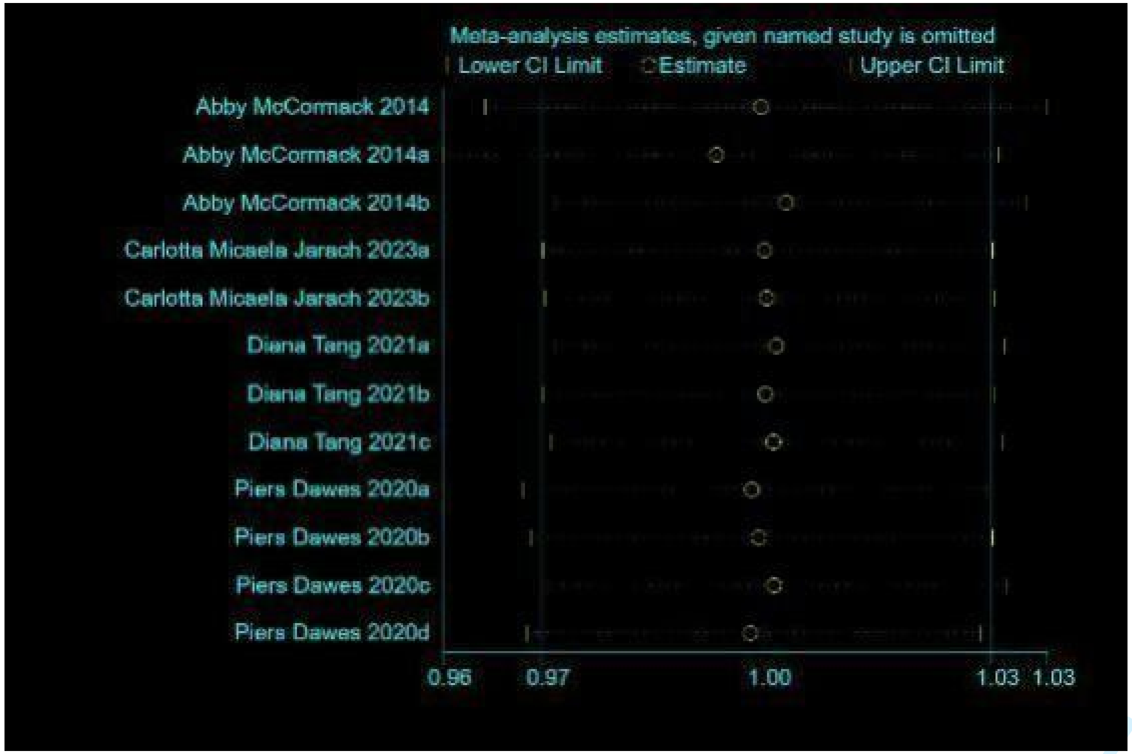
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

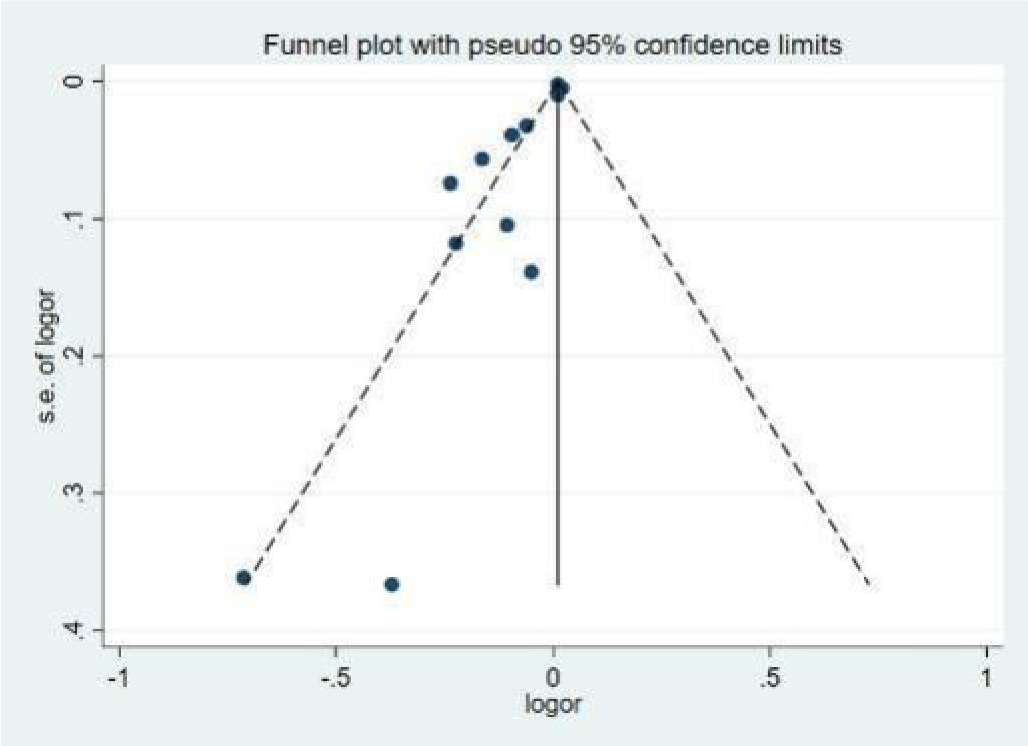
eFigure 20:Sensitivity analysis between sugar and tinnitus.

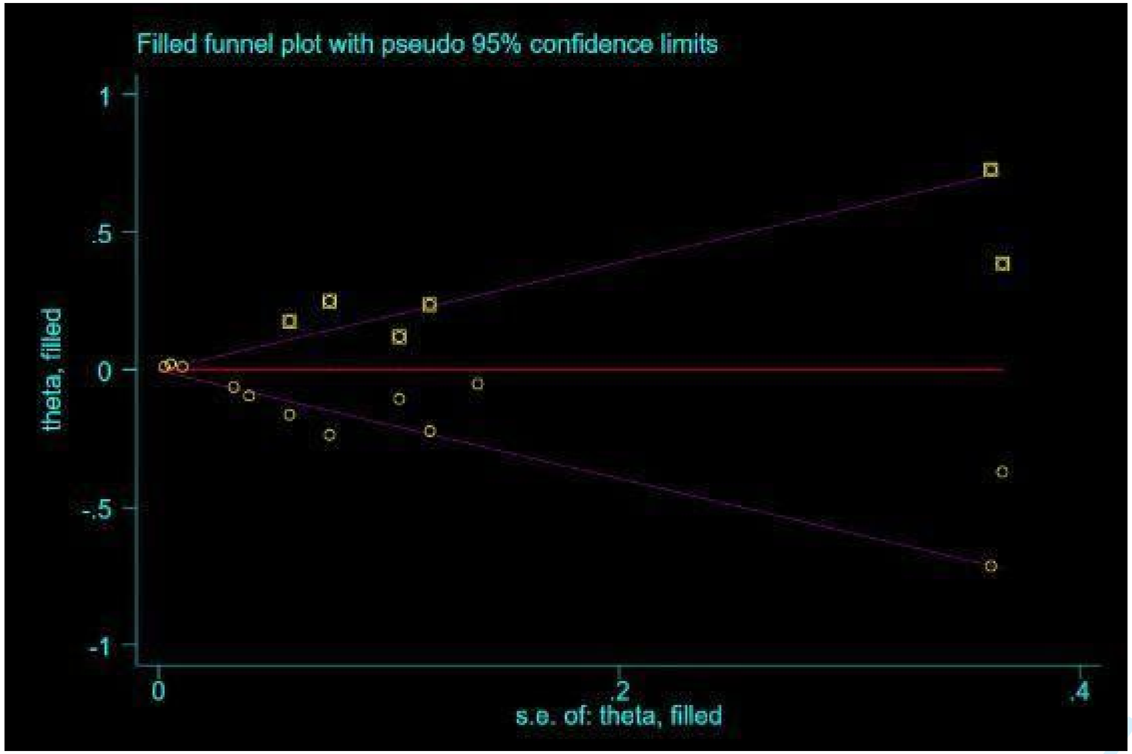
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

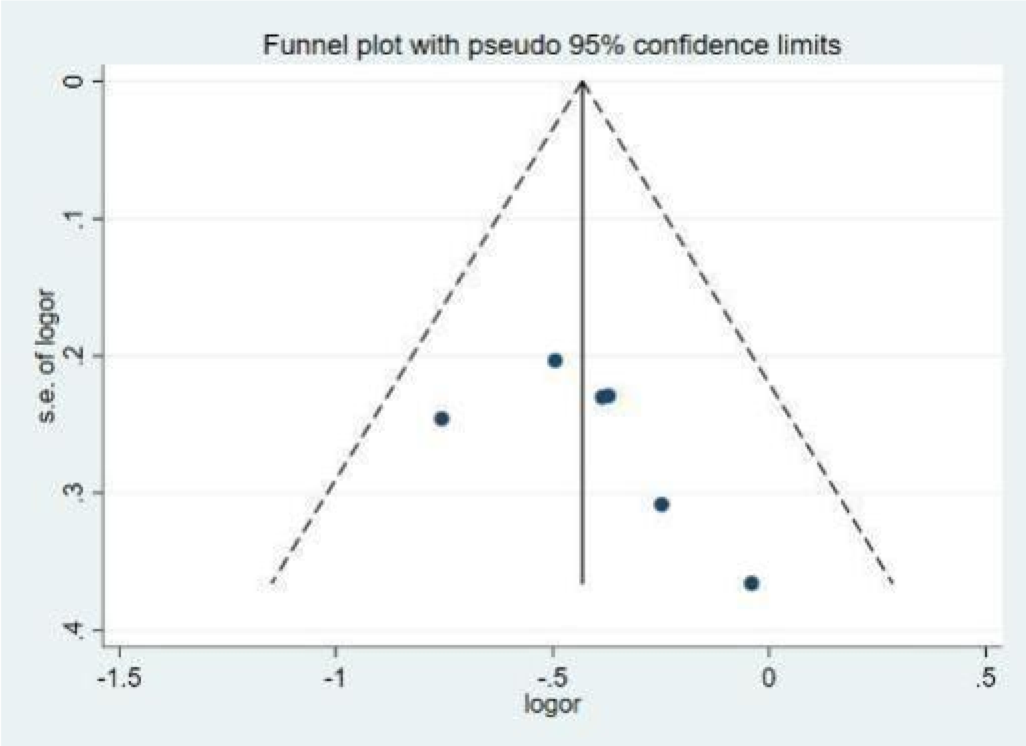
eFigure 21:Publication bias and Egger test on caffeine





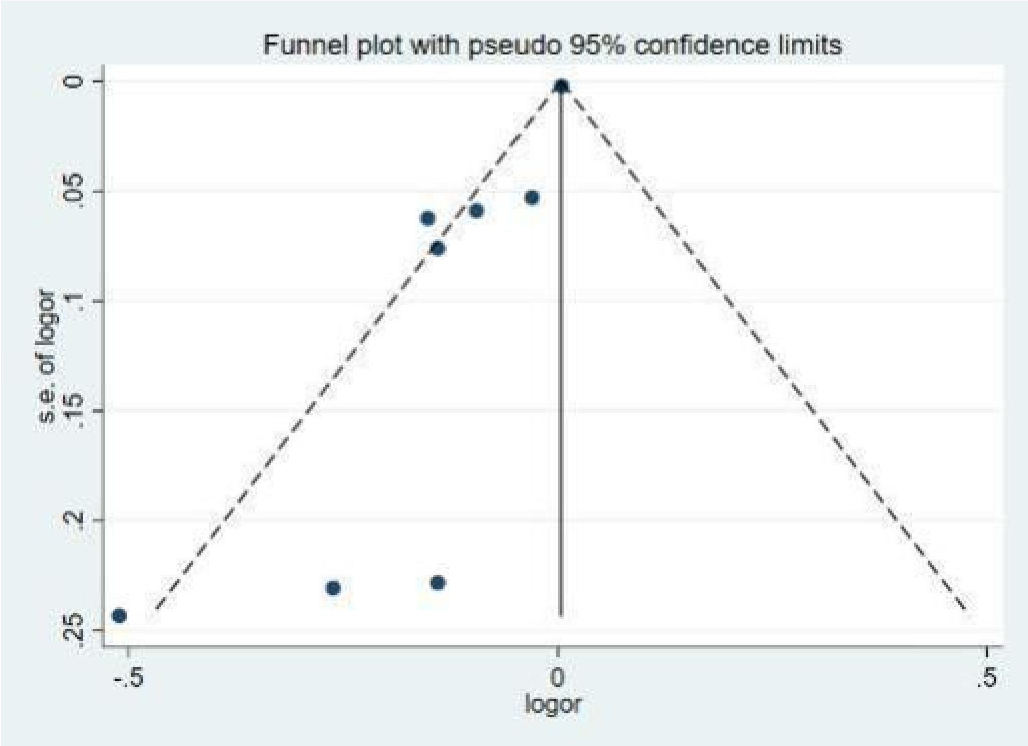
Cut and complement method tips, there was no significant publication bias.

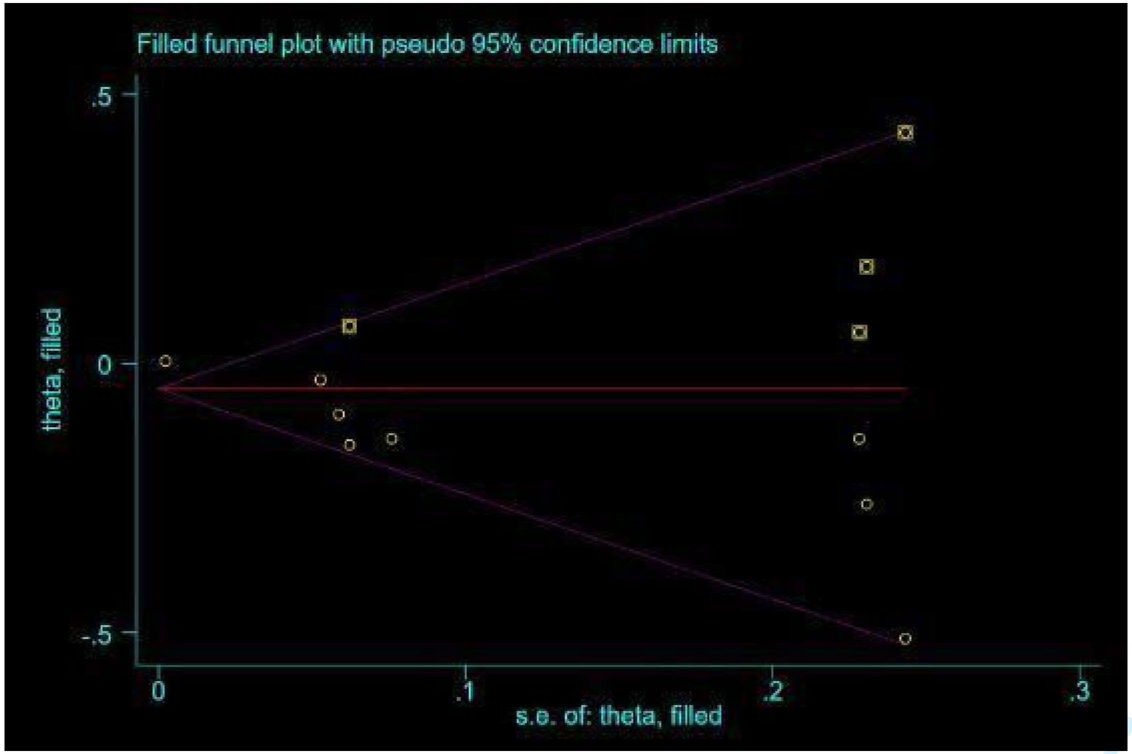
eFigure 22: Publication bias and Egger test on fruit



Egger test: Fruit p=0.205>0.05, there was no significant publication bias.

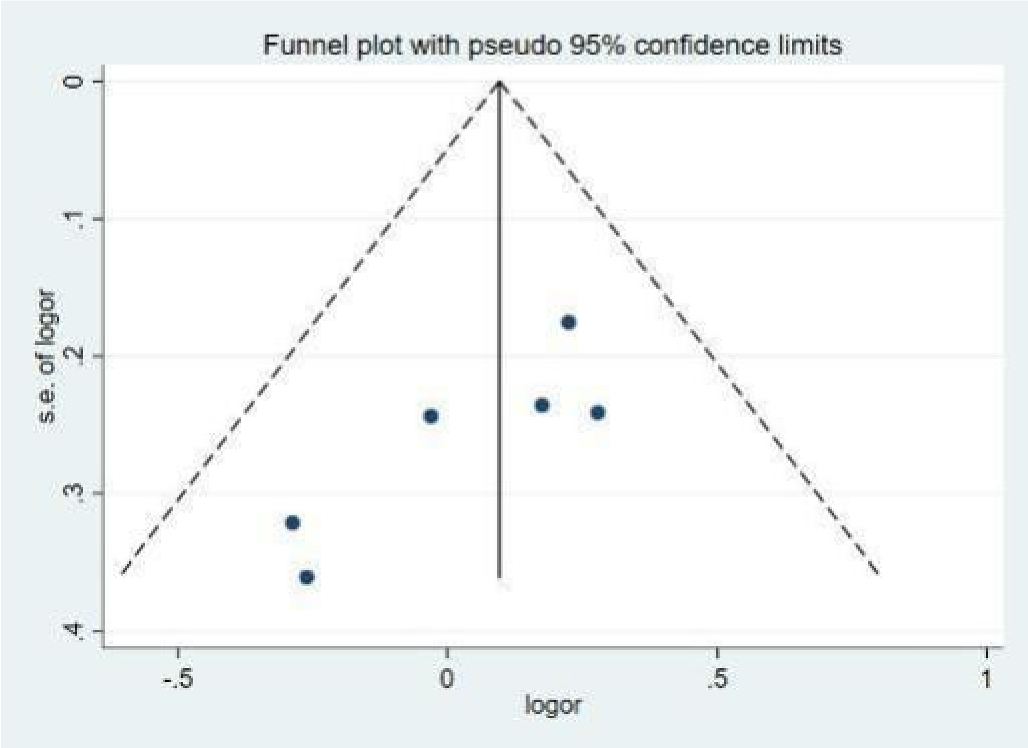
eFigure 23:Publication bias and Egger test on fiber

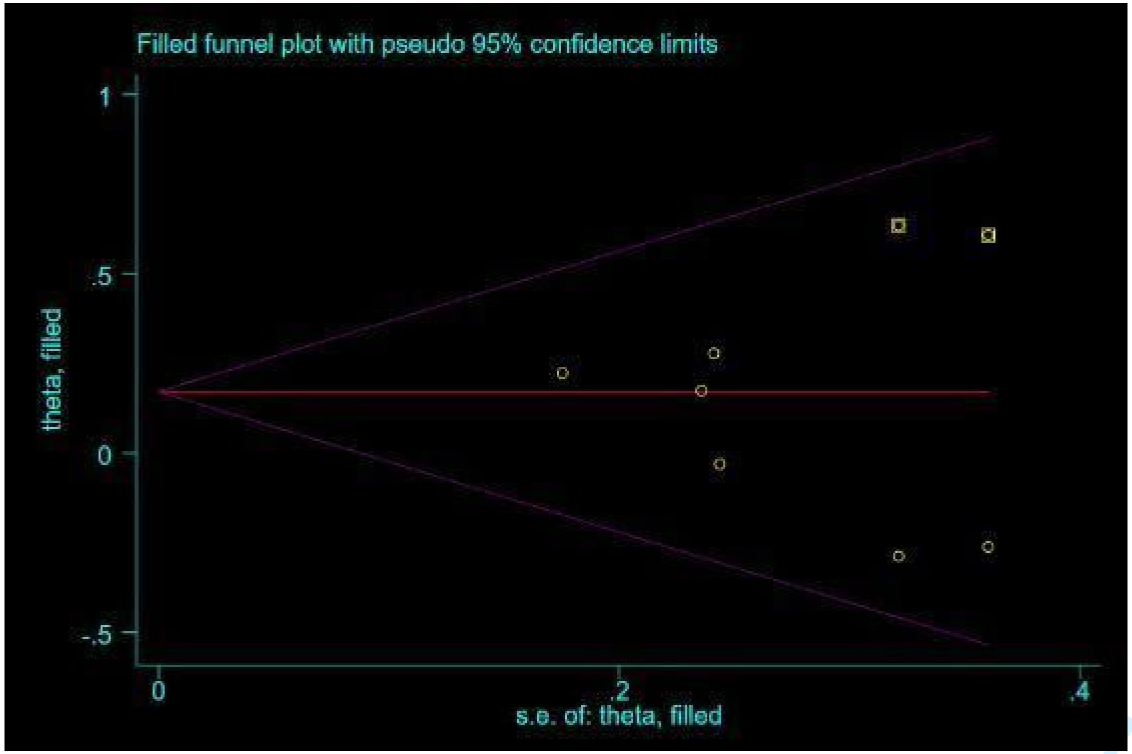




Egger test: Fruit p=0.006<0.05. Cut and complement method tips, there was no significant publication bias.

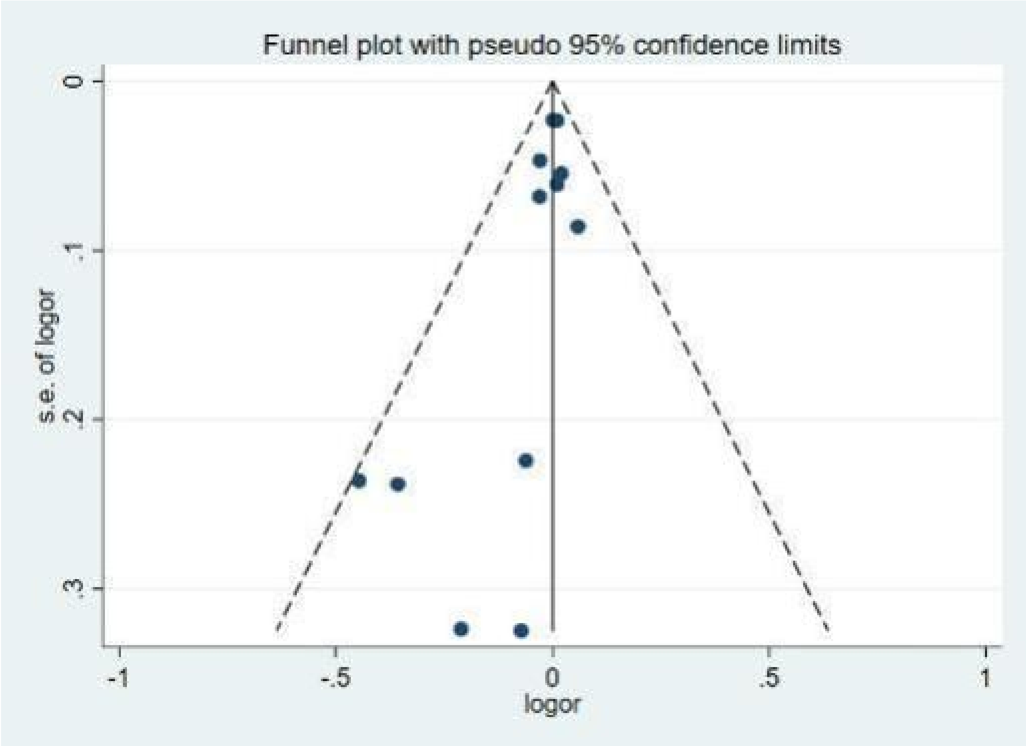
eFigure 24:Publication bias and Egger test on vegetable.

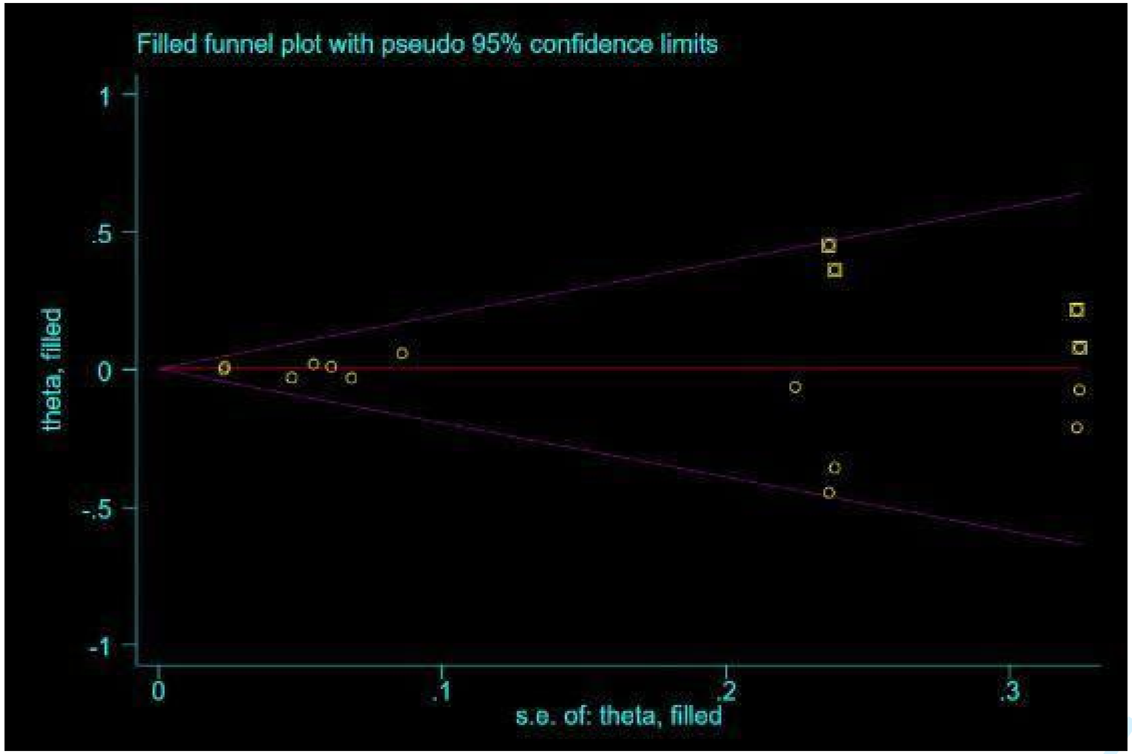




Egger test: Fruit p=0.041<0.05. Cut and complement method tips, there was no significant publication bias.

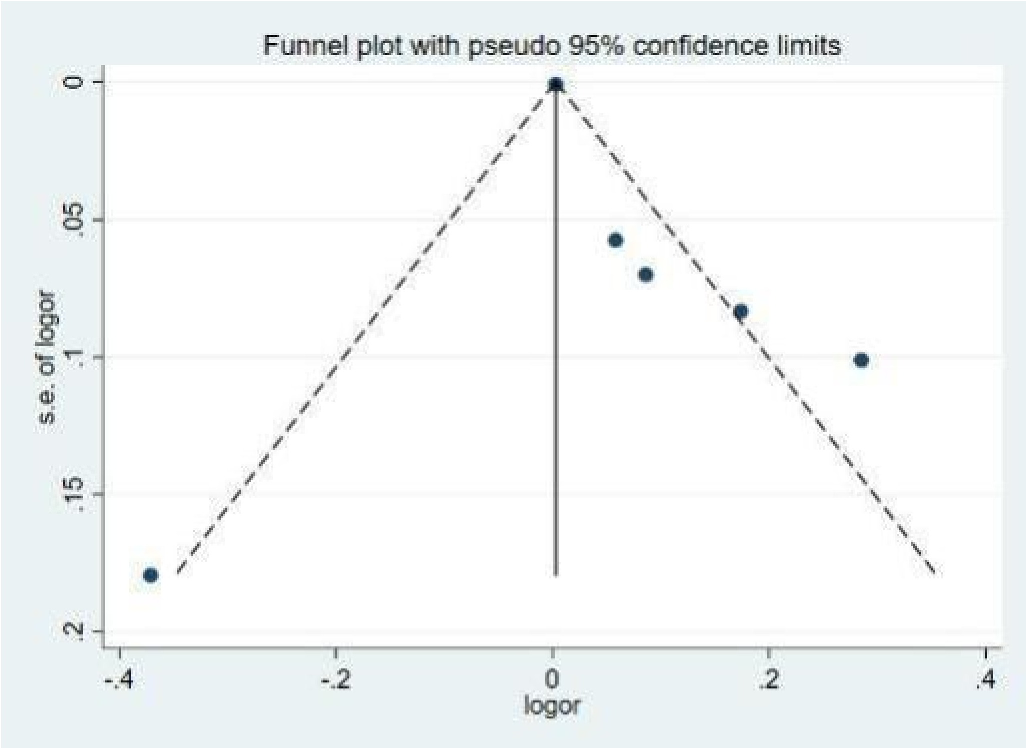
eFigure 25:Publication bias and Egger test on sugar.





Egger test: Fruit p=0.035<0.05. Cut and complement method tips, there was no significant publication bias.

eFigure 26:Publication bias and Egger test on fat.



Egger test: Fat p=0.306>0.05, there was no significant publication bias.

eTable 1. Meta-analysis of Observational Studies in Epidemiology (MOOSE) Checklist

Item No.	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	3-5
2	Hypothesis statement	3-5
3	Description of study outcome(s)	3-5
4	Type of exposure or intervention used	3-5
5	Type of study designs used	-
6	Study population	5
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	6
8	Search strategy, including time period included in the synthesis and keywords	6
9	Effort to include all available studies, including contact with authors	6, 7
10	Databases and registries searched	5,6
11	Search software used, name and version, including special features used (eg, explosion)	8
12	Use of hand searching (eg, reference lists of obtained articles)	6
13	List of citations located and those excluded, including justification	6, Fig 1
14	Method of addressing articles published in languages other than English	7
15	Method of handling abstracts and unpublished studies	6, 7
16	Description of any contact with authors	-
Reporting of methods should include		

17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	8
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	7-8
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	7
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	7
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	7
22	Assessment of heterogeneity	8
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	8
24	Provision of appropriate tables and graphics	Table 1, Fig 1
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	Fig 2, Table 1
26	Table giving descriptive information for each study included	eTable2
27	Results of sensitivity testing (eg, subgroup analysis)	eFig16-20
28	Indication of statistical uncertainty of findings	10,11
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	eFig21-26
30	Justification for exclusion (eg, exclusion of non-English language citations)	Fig 1
31	Assessment of quality of included studies	eTable 5
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	11-19
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	11-19

34	Guidelines for future research	19-20
35	Disclosure of funding source	1

eTable 2: Dietary risk ratio associated with tinnitus

Carlotta Micaela Jarach 2023a	scarce	butter	tinnitus	0.98	0.54	1.77
Carlotta Micaela Jarach 2023b	normal use or high use	butter	tinnitus	0.46	0.23	0.93
Diana Tang 2021a	2nd quartile (>188.4–231.7)	carbohydrate	tinnitus	0.74	0.47	1.17
Diana Tang 2021b	3rd quartile (231.8–280.8)	carbohydrate	tinnitus	0.739	0.47	1.15
Diana Tang 2021c	4th quartile (>280.8–577.7)	carbohydrate	tinnitus	0.55	0.34	0.9
Doh Young Lee 2018	direct	carbohydrate	tinnitus	1.001	0.999	1.001
Piers Dawes 2020a	quintile 2	Carbohydrate	tinnitus	1.03	0.94	1.14
Piers Dawes 2020b	quintile 3	Carbohydrate	tinnitus	0.98	0.88	1.11
Piers Dawes 2020c	quintile 4	Carbohydrate	tinnitus	0.99	0.86	1.14
Piers Dawes 2020d	quintile 5	Carbohydrate	tinnitus	0.93	0.78	1.1
Carlotta Micaela Jarach 2023a	50-100g/week	cheese	tinnitus	1.29	0.63	2.67
Carlotta Micaela Jarach 2023b	100+g/week	cheese	tinnitus	0.85	0.46	1.58
Abby McCormack 2014	direct	coffee	Transient tinnitus	1.020	1.010	1.031
Abby McCormack 2014a	direct	coffee	Persistent tinnitus	1.010	1.010	1.020
Abby McCormack 2014b	direct	coffee	Bothersome tinnitus	1.010	0.990	1.031
Carlotta Micaela Jarach 2023a	2nd quartile (850-1749mg)	coffee	tinnitus	0.49	0.24	0.99
Carlotta Micaela Jarach 2023b	3rd quartile (≥1750mg）	coffee	tinnitus	0.69	0.34	1.43
Jordan T Glicksman 2014a	150-299 mg/day	coffee	tinnitus	0.94	0.88	1
Jordan T Glicksman 2014b	300-449 mg/day	coffee	tinnitus	0.91	0.84	0.98
Jordan T Glicksman 2014c	450-599 mg/day	coffee	tinnitus	0.85	0.76	0.95

Jordan T Glicksman 2014d	600+ mg/day	coffee	tinnitus	0.79	0.68	0.91
Sang-Youp Lee 2018	Age 19–39（Daily）	coffee	tinnitus	0.8	0.63	1
Sang-Youp Lee 2018	Age 40-64（Daily）	coffee	tinnitus	0.9	0.73	1.1
Sang-Youp Lee 2018	Age >65（Daily）	coffee	tinnitus	0.95	0.72	1.24
Abby McCormack 2014	direct	dairy	Transient tinnitus	0.847	0.952	0.752
Abby McCormack 2014a	direct	dairy	Persistent tinnitus	0.787	0.885	0.704
Abby McCormack 2014b	direct	dairy	Bothersome tinnitus	0.877	1.099	0.699
Christopher Spankovich 2017	direct	dairy	Persistent tinnitus	0.99	0.61	1.50
Carlotta Micaela Jarach 2023a	16-19	diversity	tinnitus	0.53	0.28	1
Carlotta Micaela Jarach 2023b	≥20	diversity	tinnitus	0.47	0.24	0.9
Abby McCormack 2014	direct	egg	Transient tinnitus	1.031	1.149	0.926
Abby McCormack 2014a	direct	egg	Persistent tinnitus	1.149	1.292	1.031
Abby McCormack 2014b	direct	egg	Bothersome tinnitus	0.901	1.130	0.719
Carlotta Micaela Jarach 2023a	1/week	eggs	tinnitus	0.99	0.[illegible]1	1.92
Carlotta Micaela Jarach 2023b	2+/week	eggs	tinnitus	0.54	0.29	1
Christopher Spankovich 2017	direct	fat	Persistent tinnitus	0.69	0.49	0.99
Doh Young Lee 2018	direct	fat	tinnitus	1.003	1.001	1.005
Piers Dawes 2020a	quintile 2	fat	tinnitus	1.06	0.95	1.19
Piers Dawes 2020b	quintile 3	fat	tinnitus	1.09	0.95	1.25
Piers Dawes 2020c	quintile 4	fat	tinnitus	1.19	1.01	1.40
Piers Dawes 2020d	quintile 5	fat	tinnitus	1.33	1.09	1.62
Diana Tang 2021a	2nd quartile (>17.8–23.8)	fiber	tinnitus	0.6	0.37	0.96
Diana Tang 2021b	3rd quartile (>23.8–30.6)	fiber	tinnitus	0.87	0.56	1.37
Diana Tang 2021d	4th quartile (>30.6–89.3)	fiber	tinnitus	0.77	0.49	1.21
Doh Young Lee 2018	direct	fiber	tinnitus	1.004	0.999	1.008
Piers Dawes 2020a	quintile 2	fiber	tinnitus	0.97	0.87	1.07
Piers Dawes 2020b	quintile 3	fiber	tinnitus	0.91	0.81	1.02
Piers Dawes 2020c	quintile 4	fiber	tinnitus	0.86	0.76	0.97
Piers Dawes 2020d	quintile 5	fiber	tinnitus	0.87	0.75	1.01

Abby McCormack 2014	direct	fish	Transient tinnitus	0.980	0.950	1.020
Abby McCormack 2014a	direct	fish	Persistent tinnitus	0.910	0.870	0.940
Abby McCormack 2014b	direct	fish	Bothersome tinnitus	1.080	0.990	1.160
Carlotta Micaela Jarach 2023a	300g/week	fish	tinnitus	1.19	0.59	2.38
Carlotta Micaela Jarach 2023b	≥450g/week	fish	tinnitus	0.75	0.41	1.4
Carlotta Micaela Jarach 2023a	900-1050g/week	fruit	tinnitus	0.96	0.47	1.97
Carlotta Micaela Jarach 2023b	≥1200g/week	fruit	tinnitus	0.78	0.43	1.44
Christopher Spankovich 2017	direct	fruit	Persistent tinnitus	0.61	0.41	0.91
Diana Tang 2021a	2nd quartile (>3.6–6.2)	fruit	tinnitus	0.47	0.29	0.76
Diana Tang 2021b	3rd quartile (>6.2–9.7)	fruit	tinnitus	0.68	0.43	1.06
Diana Tang 2021d	4th quartile (>9.7–43.9)	fruit	tinnitus	0.69	0.44	1.08
Carlotta Micaela Jarach 2023a	scarce	margarine	tinnitus	1.35	0.25	7.43
Carlotta Micaela Jarach 2023b	normal use or high use	margarine	tinnitus	1.4	0.2	9.98
Carlotta Micaela Jarach 2023a	300g/week	meat	tinnitus	1.49	0.75	2.94
Carlotta Micaela Jarach 2023b	≥450g/week	meat	tinnitus	0.97	0.51	1.85
Christopher Spankovich 2017	direct	meat	Persistent tinnitus	1.01	0.62	1.65
Carlotta Micaela Jarach 2023a	2nt quartile (1-6 cops/week)	milk	tinnitus	0.68	0.3	1.52
Carlotta Micaela Jarach 2023b	3rt quartile (7+ cops/week)	milk	tinnitus	0.85	0.46	1.55
Doh Young Lee 2018	direct	protein	tinnitus	1.002	1.001	1.004
Piers Dawes 2020a	quintile 2	protein	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	protein	tinnitus	1.01	0.89	1.13
Piers Dawes 2020c	quintile 4	protein	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	protein	tinnitus	1.06	0.9	1.26
Abby McCormack 2014	direct	sugar	Transient tinnitus	1.000	0.952	1.042
Abby McCormack 2014a	direct	sugar	Persistent tinnitus	1.010	0.971	1.064
Abby McCormack 2014b	direct	sugar	Bothersome tinnitus	0.971	0.885	1.064

Carlotta Micaela Jarach 2023a	2nt quartile (1-7 spoon/week)	sugar	tinnitus	0.93	0.49	1.75
Carlotta Micaela Jarach 2023b	3rt quartile (8+ spoon/week)	sugar	tinnitus	0.81	0.43	1.53
Diana Tang 2021a	2nd quartile (>91.0–120.1)	sugar	tinnitus	0.64	0.4	1.01
Diana Tang 2021b	3rd quartile (>120.1–154.0)	sugar	tinnitus	0.94	0.61	1.47
Diana Tang 2021c	4th quartile (>154.0–350.8)	sugar	tinnitus	0.7	0.44	1.12
Piers Dawes 2020a	quintile 2	sugar	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	sugar	tinnitus	1.01	0.89	1.13
Piers Dawes 2020c	quintile 4	sugar	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	sugar	tinnitus	1.06	0.9	1.26
Christopher Spankovich 2017	direct	variety	Persistent tinnitus	0.95	0.61	1.5
Carlotta Micaela Jarach 2023a	900-1050g/week	vegetable	tinnitus	0.77	0.38	1.56
Carlotta Micaela Jarach 2023b	≥1200g/week	vegetable	tinnitus	0.75	0.4	1.41
Christopher Spankovich 2017	direct	vegetable	Persistent tinnitus	1.25	0.9	1.79
Diana Tang 2021a	2nd quartile (>7.2–9.7)	vegetable	tinnitus	1.32	0.82	2.11
Diana Tang 2021b	3rd quartile (>9.7–12.3)	vegetable	tinnitus	0.97	0.60	1.56
Diana Tang 2021c	4th quartile (>12.3–54.5)	vegetable	tinnitus	1.19	0.75	1.89
Abby McCormack 2014	direct	vegetable and fruit	Transient tinnitus	1.000	1.000	1.010
Abby McCormack 2014a	direct	vegetable and fruit	Persistent tinnitus	1.010	1.000	1.010
Abby McCormack 2014b	direct	vegetable and fruit	Bothersome tinnitus	1.010	1.000	1.020
Carlotta Micaela Jarach 2023a	>1 liter/per day	water	tinnitus	0.84	0.43	1.65
Doh Young Lee 2018	direct	water	tinnitus	1.003	0.992	1.014

eTable 3. Evaluation of Risk of Bias Using Newcastle-Ottawa Scale (NOS) for Observational Studies

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Total
Carlotta Micaela Jarach 2023	*	*	*	*	*	*	*	*		8
Diana Tang 2021	*	*	*		*	*	*	*	*	8
Milena Tomanic 2020	*	*	*				*			4
Piers Dawes 2020	*	*	*		*	*	*			6
Sang-Yeon Lee 2019	*	*	*		*	*	*			6
Doh Young Lee 2018	*	*	*		*	*	*			6
Sang-Youp Lee 2018	*	*	*		*	*	*			6
Christopher Spankovich 2017	*	*	*		*	*	*			6
Abby McCormack 2014	*	*	*		*	*	*			6
Jordan T Glicksman 2014	*	*	*		*	*	*		*	7

eTable 4. Literature screening process

Title	Author	Whether to include
The Role of Diet in Tinnitus Onset: A Hospital-Based Case-Control Study from Italy.	Carlotta Micaela Jarach 2023	YES
Associations between intake of dietary flavonoids and the 10-year incidence of tinnitus in older adults.	Diana Tang 2022	YES
Dietary Fibre Intake and the 10-Year Incidence of Tinnitus in Older Adults.	Diana Tang 2021	YES
Relationship Between Diet, Tinnitus, and Hearing Difficulties.	Piers Dawes 2020	YES
Association of Chocolate Consumption with Hearing Loss and Tinnitus in Middle-Aged People Based on the Korean National Health and Nutrition Examination Survey 2012-2013.	Sang-Yeon Lee 2019	YES
Relationship Between Diet and Tinnitus: Korea National Health and Nutrition Examination Survey.	Doh Young Lee 2018	YES
Association of Coffee Consumption with Hearing and Tinnitus Based on a National Population-Based Survey	Sang-Youp Lee 2018	YES
Relationship between dietary quality, tinnitus and hearing level: data from the national health and nutrition examination survey, 1999-2002.	Christopher Spankovich 2017	YES
Association of dietary factors with presence and severity of tinnitus in a middle-aged UK population.	Abby McCormack 2014	YES
A prospective study of caffeine intake and risk of incident tinnitus	Jordan T. Glicksman 2014	YES
The effect of MemoVigor 2 on recent-onset idiopathic tinnitus: a randomized double-blind placebo-controlled clinical trial.	Dimitrios G Balatsouras 2024	No
The effects of dietary and physical activity interventions on tinnitus symptoms: An RCT.	Ümüş Özbey-Yücel 2023	No

Effectiveness of Tinnitan Duo in Subjective Tinnitus with Emotional Affectation: A Prospective, Interventional Study.	Jennifer Knäpper 2023	No
Hyperlipidemia and its relation with tinnitus: Cross-sectional approach.	A Musleh 2022	No
Diet Quality and the Risk of Impaired Speech Reception Threshold in Noise: The UK Biobank cohort	Humberto Yévenes-Briones 2022	No
The effect of caffeine on tinnitus: Randomized triple-blind placebo-controlled clinical trial.	Alleluia Lima Losno Ledesma 2021	No
The effects of diet and physical activity induced weight loss on the severity of tinnitus and quality of life: A randomized controlled trial.	Ümüş Özbey-Yücel 2021	No
Dietary Factors and Tinnitus among Adolescents.	Milena Tomanic 2020	No
Restriction of salt, caffeine and alcohol intake for the treatment of Ménière's disease or syndrome.	Kiran Hussain 2018	No
The effect of supplemental dietary taurine on tinnitus and auditory discrimination in an animal model.	Thomas J Brozoski 2010	No
Low energy diet and intracranial pressure in women with idiopathic intracranial hypertension: prospective cohort study.	Alexandra J Sinclair 2010	No
Caffeine abstinence: an ineffective and potentially distressing tinnitus therapy.	Lindsay St Claire 2010	No
The role of endogenous Antisecretory Factor (AF) in the treatment of Meniere's Disease: A two-year follow-up study. Preliminary results.	Pasquale Viola 2020	No
Caffeine intake and Meniere's disease: Is there relationship?	Inés Sánchez-Seller 2018	No
Tinnitus features according to caffeine consumption.	Ricardo Rodrigues Figueiredo 2021	No
The Influence of Diet on Tinnitus Severity: Results of a Large-Scale, Online Survey	Steven C. Marcrum 2022	No

BMJ Open

Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-091507.R3
Article Type:	Original research
Date Submitted by the Author:	07-Feb-2025
Complete List of Authors:	Zhang, Mengni; Chengdu University of Traditional Chinese Medicine, Wang, Xiaocui ; Hospital of Chengdu University of Traditional Chinese Medicine Zhang, Shipeng; Hospital of Chengdu University of Traditional Chinese Medicine, He, Xinyi; Chengdu University of Traditional Chinese Medicine Chen, Xi; Hospital of Chengdu University of Traditional Chinese Medicine Wang, Lu ; Hospital of Chengdu University of Traditional Chinese Medicine Fu, Li ; Hospital of Chengdu University of Traditional Chinese Medicine wang, hanyu; Chengdu University of Traditional Chinese Medicine Fu, Qinwei; Hospital of Chengdu University of Traditional Chinese Medicine jiang, yanjie; Nanjing University of Chinese Medicine Li, Xinrong; Hospital of Chengdu University of Traditional Chinese Medicine Zhang, Qinxiu; Chengdu University of Traditional Chinese Medicine, Hospital of Chengdu University of Traditional Chinese Medicine; Chengdu University of Traditional Chinese Medicine, School of Medical and Life Sciences
Primary Subject Heading:	Ear, nose and throat/otolaryngology
Secondary Subject Heading:	Nutrition and metabolism
Keywords:	OTOLARYNGOLOGY, NUTRITION & DIETETICS, Meta-Analysis, Neurotology < OTOLARYNGOLOGY

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Association of fifteen common dietary factors with tinnitus: a systematic review and meta-analysis of observational studies

Abstract

Objective A systematic analysis was conducted to investigate the association between tinnitus incidence and daily dietary patterns.

Design Systematic review and meta-analysis using the Grading of Recommendation, Assessment, Development, and Evaluation (GRADE) approach.

Data sources The PubMed, Embase, Web of Science, and Cochrane Library databases were searched from their inception to May 25, 2024.

Eligibility criteria for selecting studies We included observational studies from peer–reviewed English–language journals that examined tinnitus presence or severity in adults aged 18 years or older, including associated prevalence estimates.

Data extraction and synthesis Data extraction was independently conducted by two evaluators, who assessed research bias using the Agency for Newcastle-Ottawa Scale (NOS) and applied evidence classification criteria for aggregate grade strength assessment. This study adhered to the guidelines of the Preferred Reporting Project (PRISMA) and Meta-Analysis of Epidemiological Observational Studies (MOOSE), as well as the PROSPERO Registry protocols. A mixed-effects model combined maximum adjusted estimates, with heterogeneity measured using the I^2 statistic. Sensitivity analysis validated the robustness of the analysis, and publication bias was assessed qualitatively and quantitatively.

Results A total of 10 retrospective studies were identified and included in this analysis, with the last eight studies incorporated into the meta-analysis. Fifteen dietary factors were examined. Fruit intake, dietary fiber, caffeine, and dairy product consumption were negatively correlated with tinnitus incidence (OR = 0.649, [95% CI 0.532, 0.793], p<0.0001), (OR = 0.918, [95% CI 0.851, 0.990], p = 0.03), (OR = 0.898, [95% CI 0.862, 0.935], p <0.00001), (OR = 0.827, [95% CI, 0.766 to 0.892], p <0.00001), respectively. A sensitivity analysis confirmed the robustness of the findings.

Conclusions This systematic review and meta-analysis suggest a link between particular dietary elements and a lower incidence of tinnitus.

PROSPERO registration number CRD42023493856

Keywords: Diet; Tinnitus; Food intake; Nutrition; Odds ratio

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This study conducted a thorough literature screening, assessed the quality of the literature based on international standards, and excluded articles with a high risk of bias.
- This review involves a large population base, improving its representation of fundamental population characteristics and ensuring relatively reliable outcomes.
- There was minimal heterogeneity among the studies regarding the main observations, ensuring the solidity of the findings.
- The relatively small number of included articles may have led to certain conventionally accepted beneficial dietary factors (such as vegetables and eggs) not demonstrating significant differences. In addition, owing to the limited data in the original literature, a dose-effect meta-analysis cannot be supported.
- The majority of the included articles were cross-sectional studies, underscoring the necessity for further cohort studies or Mendelian randomization studies to investigate causal relationships and provide additional clinical evidence for the dietary prevention of tinnitus.

Introduction

Tinnitus, characterized by perceived sounds such as buzzing, cicadas, or electric currents, occurs without external auditory stimuli [1]. It is associated with distress, depression, anxiety, stress, and, in severe cases, suicide, significantly affecting overall quality of life[2 3]. Recent epidemiological data suggest a global pooled prevalence of about 14.4% in adults and 13.6% in children and adolescents[4]. The notable prevalence of tinnitus and its substantial impact on life and mental well-being have increasingly become significant medical and societal concerns[5].

The origins of tinnitus remain elusive and involve a range of factors. Some researchers have suggested neural dysfunction or circulatory issues in the inner ear, abnormal neuronal activity in central auditory pathways, and irregular activity in nonauditory brain regions such as the anterior insula, anterior cingulate cortex, and thalamus[6]. In clinical practice, treatments for tinnitus management include psychological counseling, cognitive-behavioral therapy, tinnitus retraining therapy, sound therapy, surgery, pharmacological interventions, and nonpharmacological interventions (including electrical stimulation, repetitive transcranial magnetic stimulation, nerve block, bimodal neuromodulation, tinnitus retraining therapy, etc.), as well as hearing aids and cochlear implants for patients with relevant hearing loss[7 8]. Owing to an incomplete understanding of central neuropathological mechanisms, no single treatment universally meets the needs of all patients[9 10].

Diet can have a significant impact on tinnitus, but it remains uncertain which specific foods worsen or relieve tinnitus symptoms. Diet is an uncertain factor for tinnitus, as mentioned in the James Lind Alliance prioritization statement. Optimizing nutritional intake is an essential part of multidimensional efforts to prevent and treat chronic diseases. In recent years, there has been an increase in interest and need for nutritional treatment programs for tinnitus[11], as evidenced by various population-based studies found in lately publications[12-15]. A population study investigating the correlation between diet and tinnitus among UK adults revealed a decrease in tinnitus incidence with increased fruit and vegetable consumption. Conversely, avoiding dairy was linked to a greater risk of tinnitus. On the other hand, abstaining from eggs, adding fish to the diet, and consuming caffeinated beverages are suggested to potentially lower the risk of tinnitus [2]. Another study in British adults revealed that greater fat intake was associated with a greater likelihood of experiencing tinnitus[16]. Similarly, Lee and Kim identified risk factors for tinnitus, including low water, protein, riboflavin, and niacin intake, although this was unrelated to fruit and vegetable consumption[17]. It is thought that the intake of high-quality nutrients through food can have a positive effect on the hearing system by improving blood flow to the cochlea, reducing oxidative damage and reducing inflammation. In contrast, high saturated fat intake may increase the risk of tinnitus through cardiovascular pathways[11 16]. Tang et al.[18] reported that inadequate fruit fiber (<3.6 g/day) and grain fiber (<4.2 g/day) intake were linked to a 65% and 54% increased risk of developing tinnitus over the next decade, respectively. Conflicting results have hindered researchers' ability to understand the potential benefits of diet; hence, a systematic review on the relationship between diet and tinnitus is needed.

To date, there has not been a comprehensive examination through systematic reviews or meta-analyses regarding the link between typical dietary patterns and tinnitus. Our objective was to systematically explore this association while accounting for potential confounding variables. This study aimed to provide clinical evidence to inform the development of dietary prevention approaches for tinnitus.

Method

According to the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA), a set of evidence-based standards for the research quality of systematic reviews, which apply to published reviews of literature that contain primary data sources and aim to improve the scientific rigor of systematic reviews[19], the protocol for this study was appropriately registered on PROSPERO under the registration number CRD42023493856. Additionally, our reporting is guided by the Meta-analysis of Observational Studies in Epidemiology (MOOSE) standards for epidemiological observational studies, which were developed by a group of experts to improve the quality and transparency of meta-analysis and systematic evaluation of observational studies, contributing to the scientific validity and credibility of such studies, as referenced [20]. **Supplemental eTable 1** contains the MOOSE listings, whereas Supplemental 2 outlines the PRISMA instructions.

Search Strategy

We developed an inclusive search strategy covering diet-related and tinnitus-related subjects to capture pertinent literature from the PubMed, Embase, Web of Science, and Cochrane Library databases. The research design was limited to systematic evaluation. There were no language restrictions imposed on the search, and we considered articles published before May 25, 2024. We used special translation software for publications in unknown languages.

The search strategy was designed to identify studies linking tinnitus and diet, and two specific terms, 'Tinnitus' and 'Diet', from the Medical Subject Headings (MeSH) Major Topic were identified. The databases were systematically explored via a blend of MeSH terms, keywords, and various text word variations related to diet, following the guidance outlined by the Scottish Intercollegiate Guidelines Network: ((tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR variety OR caffeine OR carbohydrate OR protein). The search strategy for each database is described in **Supplemental Search Strategy**. The screening process is depicted in **Figure 1.**

The following inclusion criteria were applied: (1) inclusion of cohort, case-control, or cross-sectional studies; (2) inclusion of all individuals in the study population; (3) consideration of various dietary intakes; and (4) investigation of tinnitus as a study outcome provided effect sizes or other data on the association between dietary intake and tinnitus as an outcome. The exclusion criteria were as follows: (1) studies involving therapeutic interventions; (2) randomized controlled trials, animal experiments, cell studies, case reports, literature, and incomplete or invalid sources, and the original literature lacked sufficient data to calculate the risk ratio for tinnitus (some publications do not report effect sizes but instead allow the raw data to be used to calculate them. In these cases, RevMan (version 5.3) was used to calculate the OR).

Data collection

In **Table 1,** data compilation was conducted by two reviewers (SZ, MZ), including authors' names, participant counts, age spans, survey/diagnosis specifics, and information on food and tinnitus. Given that dietary intake is a continuous variable, some researchers have typically performed stratified comparisons on the basis of regional intake standards and researchers' characteristics. This strategy aimed to explore the impact of varying levels of increased intake on tinnitus incidence. For most continuous variables associated with food intake, adjusted OR values were assimilated in the meta-analysis when stratified according to dose intake, with the exclusion of the reference group. In cases of direct comparison, the singular adjusted OR value was integrated. Further insights into the odds ratios (ORs) are provided in **Supplemental eTable 2**.

Literature quality evaluation

The assessment of individual study quality was conducted by two reviewers (SZ and MZ) via a modified version of the Newcastle-Ottawa Scale. Previous studies were categorized as having a high (<5 stars),

Table 1: Basic information to be incorporated into the article.

Author	Total	Age	Time frame	Data from	Study design	Diet recording method	Disease diagnosis	Type of diet
Jarach 2023	383	40–65	2016–2019	The Mario Negri Institute in Milan (Italy) , Monza e Brianza, Italy	case control	Self-designed questionnaire	Interviewer administered a questionnaire and the Italian-validated version of the tinnitus handicap inventory	coffee, eggs, butter, meat, fish, cheese, fruit, vegetable, varied diet, dairy, milk
Tang 2022	1217	>50	1997－2009	Blue Mountains Hearing Study	cohort	Semiquantitative food frequency questionnaire, FFQ	Audiologist administered questionnaire	dietary flavonoids
Tang 2021	1730	>50	1997–2009	Blue Mountains Hearing Study	cohort	Semiquantitative food frequency questionnaire, FFQ	Audiologist administered questionnaire	carbohydrate, sugar, fiber, fruit, vegetable
Dawes 2020	34576	30–69	2006–2010	UK Biobank resource (Collins 2012).	cross-sectional	Dietary assessment was based on the Oxford Web-Q	An epidemiologic method of hearing investigation	fiber, fat, sugar
Lee 2019	3575	40–64	2012–2013	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	chocolate
Lee 2018	7621	40–80	2013–2015	The sixth Korea National Health and Nutrition Examination Survey (KNHANES)	cross-sectional	Diet was assessed with a semiquantitative food-frequency questionnaire	Self-designed questionnaire	water, protein, fat, carbohydrate, fiber
Lee 2018	13448	>19	2009－2012	The sixth Korea National Health and Nutrition Examination Survey	cross-sectional	Food-frequency questionnaire (FFQ)	Self-designed questionnaire	coffee
Spankovich 2017	2176	20–69	1999–2002	NHANES	cross-sectional	Dietary recall interviews were conducted during 1999–2002 NHANES MEC evaluations.	Self-designed questionnaire	fat, fruit, vegetable, meat, varied diet
McCormack 2014	171722	40–69	2006–2010	UK Biobank resource (Collins 2012).	cross-sectional	The UK Biobank touchscreen questionnaire	Self-designed questionnaire	fruit, vegetable, fish, egg, sugar, coffee, dairy
Glicksman 2014	65085	30–44(registered)	1991–2009	The Nurses' Health Study II	cross-sectional	Extensively validated semiquantitative food frequency questionnaires	Self-designed questionnaire	coffee

moderate (5–7 stars), or low (≥8 stars) risk of bias (see eTable 3 in the Supplement).

Statistical analysis

Data analysis was performed via RevMan (version 5.3) and Stata (version 15.0). Mixed-effect models were utilized to aggregate maximally covariate-adjusted odds ratios (ORs) across all studies. In current practice, odds ratios (ORs), relative risks (RRs), and hazard ratios (HRs) are about equal when events occur infrequently. For this situation, it is acceptable to include OR, RR, and HR in the same meta-analysis. In cases where the P value of the Q test was <0.10 or the I^2 statistic exceeded 50%, we conducted an assessment to determine significant interstudy heterogeneity. For observational studies, maximally covariate-adjusted estimates were strongly prioritized. If a study employed an analytical method incongruent with synthesis for the majority of other studies, we either converted the effect estimate to the appropriate combined ratio or excluded the study from the meta-analysis.

In cases of considerable heterogeneity in the analysis with significant differences, meta-regression was used to explore the source of heterogeneity (please note that meta-regression was considered when the data included in the analysis were greater than 10). We visually assessed the asymmetry of the funnel plot and used Egger's bias to detect possible publication bias, with estimation of missing studies conducted via eMethods if publication bias was suspected (please note that publication bias analysis was considered when the data included in the analysis were greater than 6). Moreover, we conducted a sensitivity analysis of the pooled results employing a one-by-one exclusion method.

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Results

The literature screening process is shown in **Supplemental eTable 4**. Ten articles were found in the search[2 16-18 21-26]. Among these, two articles delved into individual dietary factors, namely, chocolate [23] and flavonoids [22], which were not investigated in other studies. While these two articles were included in the narrative review, they were excluded from the meta-analysis. The remaining eight articles composed the dataset for the meta-analysis.

Fifteen common dietary factors were analyzed, and dietary sources were assessed via validated nutrition/diet questionnaires. The combined findings revealed that four diets (caffeine, fruit, dietary fiber, and dairy products) were negatively associated with the incidence of tinnitus; that is, the higher the intake of caffeine, fruit, dietary fiber, and dairy products was, the lower the prevalence of tinnitus.

A meta-analysis of dietary factors

The meta-analysis included eight studies with a total of 301,533 people and analyzed 15 dietary factors, as shown **in Figure 2**: carbohydrates (2/8, **Supplemental eFigure 1**), caffeine (4/8, **Supplemental eFigure 2**), varied diets (2/8, **Supplemental eFigure 3**), eggs (2/8, **Supplemental eFigure 4**), fruits (3/9, **Supplemental eFigure 5**), fibers (2/8, **Supplemental eFigure 6**), fat (3/8, **Supplemental eFigure 7**), margarine (2/8, **Supplemental eFigure 8**), meat (2/8, **Supplemental eFigure 9**), sugar (4/8, **Supplemental eFigure 10**), protein (2/8, **Supplemental eFigure 11**), fish (3/8, **Supplemental eFigure 12**), vegetables (4/8, **Supplemental eFigure 13**), water (3/8, **Supplemental eFigure 14**), and dairy (2/8, **Supplemental eFigure 15**). The summary results are depicted **in Figure 2**. The intake of dairy products, fruits, dietary fiber, and caffeine was negatively correlated with the prevalence of tinnitus: 0.827 for dairy [95% CI 0.766–0.892], $I^2 = 0\%$, $p < 0.00001$; 0.649 for fruit [95% CI 0.532–0.793], $I^2 = 0\%$, $p < 0.0001$; 0.918 for fiber [95% CI 0.851–0.990], $I^2 = 63\%$, $p = 0.03$; and 0.898 for caffeine [95% CI 0.862–0.935], $I^2 = 23\%$, $p < 0.003$. Protein intake increased the risk of tinnitus (OR = 1.002 [95% CI 1.001–1.004], $I^2 = 0\%$, $p = 0.009$). No associations were found between other dietary factors and tinnitus.

Sensitivity analysis

We conducted sensitivity analyses for various dietary intakes on the basis of predefined analysis criteria (requiring data from the included articles to exceed 6). Contradictory outcomes were noted in the aggregated results for caffeine **(**refer to **Supplemental eFigure 16)**, with the analysis attributing these contradictions to data within the same article (Abby McCormack 2014). Sequential exclusion of fruit **(**refer to **Supplemental eFigure 17)** and dietary fiber **(**refer to **Supplemental eFigure 18)** maintained the statistical significance of the combined odds ratio. Successive exclusion of summary results for vegetables **(**refer to **Supplemental eFigure 19)** and sugar **(**refer to **Supplemental eFigure 20)** revealed no contradictory outcomes in the combined odds ratio, thus ensuring the robustness of the meta-analysis results. The comprehensive sensitivity analysis revealed the relative robustness of the meta-analysis results, confirming the associations of fruit and dietary fiber intake with the prevalence of tinnitus. No significant associations between other dietary intakes and tinnitus were found.

Publication bias

The funnel plot and Egger test findings for caffeine, fruit, vegetables, diet, sugar, and fat indicated the presence of publication bias (**Supplemental eFigure 21 – 26**). We performed a supplementary analysis using the shear compensation method, which yielded consistent results that suggest that publication bias did not impact the main outcome.

Discussion

In this systematic review and meta-analysis involving eight observational studies (comprising a total of 301,533 participants), we discovered that increased dietary consumption of fruit, dietary fiber, dairy products, and caffeine was associated with a reduced occurrence of tinnitus. These reductions were 35.1% (20.7%–46.8%) for fruit intake, 9.2% (1%–14.9%) for dietary fiber, 17.3% (10.8%–23.4%) for dairy products, and 10.2% (6.5%–13.8%) for caffeine intake. These results were consistently supported by the sensitivity analysis.

The association between caffeine intake and tinnitus remains contentious. Our findings indicate that caffeine has a positive effect on tinnitus incidence. Some suggest that caffeine might effectively decrease tinnitus incidence, possibly because of its anxiety-reducing effects. Conversely, some scholars argue that individuals with tinnitus often experience insomnia, in which caffeine consumption could worsen, thus exacerbating tinnitus symptoms. Recent observational studies [27,28] have revealed no link between caffeine consumption and depression or anxiety levels. Furthermore, additional dose analysis revealed a J-pattern association between caffeine intake and psychiatric disorders, with about 2–3 cups per day associated with decreased risk [29]. Caffeine, which acts as a nonselective adenosine receptor antagonist, can mitigate anxiety when it is ingested at a daily dose of 10 mg/kg [30]. Genetic analysis also suggested a correlation between caffeine consumption and reduced tinnitus incidence [31]. This effect is achieved through adenosine receptor blockade, dopamine release promotion, acetylcholinesterase activity inhibition, and sympathetic nerve stimulation.

The results of most studies[16 18 25 32] showed that dietary fiber and fruit intake have a positive impact on reducing the occurrence of tinnitus, and the findings of our meta-analysis clarify this reliably and comprehensively by integrating and analyzing the results of all relevant studies. Some scholars have proposed that dietary fiber is associated with increased insulin sensitivity[33]. Studies indicate that hyperinsulinemia resulting from low insulin sensitivity could disturb the inner ear environment, potentially increasing tinnitus risk [34 35]. Conversely, research suggests that fiber and dairy products might enhance blood vessel function[36], a factor correlated with tinnitus. Abnormal microcirculation, for example, contributes to a sustained reduction in ear blood flow, potentially leading to cochlear damage and increasing tinnitus risk [18].

Our combined analysis revealed no correlation between vegetable consumption and tinnitus. Identifying the source of heterogeneity was difficult because of the limited number of articles. Nevertheless, sensitivity analyses reaffirmed the strength of our conclusions. Vegetables and fruits, which are rich in diverse vitamins and minerals crucial for maintaining health, have been shown to improve ear microcirculation, alleviate tinnitus, and offer additional benefits [17 32]. Future studies are expected to provide clearer results.

The body has three main sources of energy: carbohydrates (sugars), fats and proteins. Our findings indicate that protein do not increase the occurrence of tinnitus (OR = 1.002, [95% CI 1.001–1.004], p = 0.009). Protein is a crucial nutrient that requires daily consumption and plays a vital role in supporting neuronal activity and neural development[37 38]. Inadequate protein intake can lead to ototoxic side effects and impair the neural function of the auditory system[39]. Dawes et al. demonstrated that a higher intake of dietary pattern factor 3 (high protein) was linked to a reduced likelihood of tinnitus[16]. Although low-protein diets may affect auditory vestibular function, no studies have specified the necessary amount of protein in the diet. Our analysis revealed links between protein intake and tinnitus risk. Moreover, high-protein diets have been shown to induce oxidative stress in the cerebral cortex and hypothalamus of rats[40]. Hence, further research on the relationship between protein dosage and tinnitus is warranted in the future.

Sugar is an essential daily component, in line with our analysis, no significant effect of sugar intake on tinnitus incidence was observed (OR = 0.997 [95% CI 0.967, 1.027]). High sugar consumption is typically associated with an unhealthy lifestyle. Proinflammatory foods, including sugary items, are often associated with increased systemic inflammation and microvascular damage, particularly microischemic events[41]. Elevated blood glucose levels can harm small blood vessels and nerves in the inner ear, leading to pathological alterations in outer hair cells and spiral ganglion cells. This can result in nerve tissue ischemia and hypoxia, leading to nerve damage[39]. Conversely, Spankovich et al. demonstrated that high carbohydrate intake can prevent hearing loss in older adults[42]. Tang et al. reported a 45% decrease in tinnitus risk for participants in the fourth quartile compared with the first quartile of carbohydrate intake [18].

Both excessive and insufficient dietary intake may have adverse effects on tinnitus, underscoring the need for a dose-response analysis of diet, which would provide valuable insights for preventing dietary tinnitus. Several studies have suggested that increasing the score of healthy foods, such as fruits, vegetables, legumes, nuts, fish, and dairy products, may lower the risk of cardiovascular disease and mortality[43-45]. Each one-fifth increase in the healthy diet score was associated with a corresponding decrease in overall mortality rate (HR = 0.92; 0.90–0.93), severe cardiovascular disease (HR = 0.94; 95% CI: 0.93–0.95), myocardial infarction (HR = 0.94; 0.92–0.96), stroke (HR = 0.94; 0.89–0.99), and death or cardiovascular disease (HR = 0.93; 0.92–0.94[46]).

The outcomes of our analysis did not support a notable connection between fat intake and tinnitus risk, although there was a discernible upward trend. Moreover, high-fat diets contribute to obesity and can lead to insulin resistance[47]. Conversely, adopting a low-fat/low-cholesterol diet might aid in reducing blood cholesterol and triglyceride levels, potentially alleviating tinnitus symptoms[48]. Future studies are needed to verify the relationship between fat and tinnitus.

A recent study revealed that increased levels of dietary variety, including quantity, evenness, and quality, were inversely linked to the risk of depressive symptoms, especially among women and older adults[49]. This could offer relief for tinnitus patients. Moreover, dietary variety is believed to be correlated with insulin resistance[50]. Given the protective effects of various diets on human health, further exploration of dietary variety is necessary to validate significant associations. Our pooled analysis indicated that a varied in diet was not significantly linked to a reduced tinnitus incidence (OR = 0.653 [95% CI 0.410, 1.038]) based on the currently available evidence.

We found only one study that investigated the impact of chocolate and flavonoids on the onset of tinnitus [23], but it did not provide sufficient data for a meta-analysis. Flavonoids, which are abundant in fruits and vegetables, offer antioxidant, anti-inflammatory, and vascular health benefits, which align with the pathophysiology of age-related hearing loss and tinnitus[51]. Additionally, flavonoids interact with signaling cascades involving protein and lipid kinases, inhibiting neuronal death induced by neurotoxicants such as oxygen radicals and promoting neuronal survival and synaptic plasticity[52]. Despite the hypothesis that dietary flavonoids might protect against tinnitus development over a 10-year period, Tang et al. [51]. did not support this idea. However, it is important to note that this study has limitations, such as insufficient data collection.

Chocolate is a globally consumed product renowned for its high phenolic compound content (flavonoids are a subclass of polyphenols) [53]. A study by Lee et al. indicated that chocolate consumption is not linked to tinnitus or tinnitus-related issues[23]. An animal study demonstrated that polyphenols alleviate oxidative stress in the cochlea by suppressing apoptotic signaling pathways[54]. Nonetheless, excessive chocolate consumption can have adverse effects on brain hyperexcitability[55]. Future investigations into the association between chocolate consumption and tinnitus should consider the intake dosage.

This systematic review and meta-analysis represents the first attempt to explore the epidemiological link between diet and tinnitus. While we examined the relationships between fruit, dietary fiber, and caffeine intake and a reduced incidence of tinnitus, it remains inconclusive whether a causal relationship exists.

Conclusion

Diet-based strategies for tinnitus prevention are anticipated to play a significant role in chronic tinnitus management. Existing evidence suggests that consuming fruit, dietary fiber, caffeine, and dairy may be associated with a reduced incidence of tinnitus. The primary underlying mechanisms may involve the protective effects of these diets on blood vessels and nerves, as well as their anti-inflammatory and antioxidant properties. However, it is crucial to interpret our findings cautiously because of the overall low quality of the evidence available. In the future, further well-designed, large-scale, cross-population cohort studies are warranted to complement and verify the relationship between dietary intake and tinnitus. Additionally, focusing on the dosage and categorization of each dietary intake would provide valuable insights.

Author Contribution

All authors contributed to the study's conception and design. SZ, MZ, XW, YJ conducted data collection and analysis. SZ, QZ designed the test plan. QF as the paper guide, control the quality of the paper, XH, XL, XW, HW drew the chart. XC, LW, LF completed the writing of the test plan. XL and QZ revised the manuscript. QZ is responsible for the overall content as the guarantor.

Author Declaration

The author has no direct conflict of interest.

Ethical Approval

The article belongs to the review category and does not require the approval of the ethics committee.

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Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

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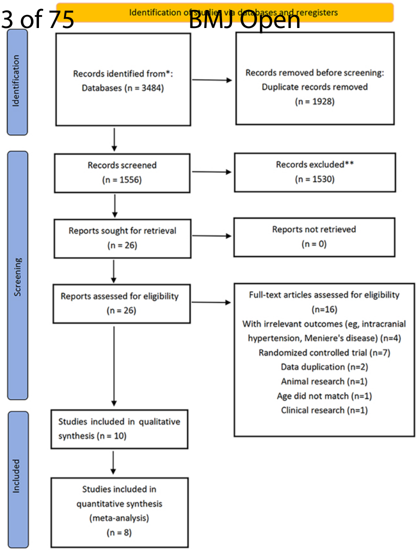
Figure 1: Flow chart

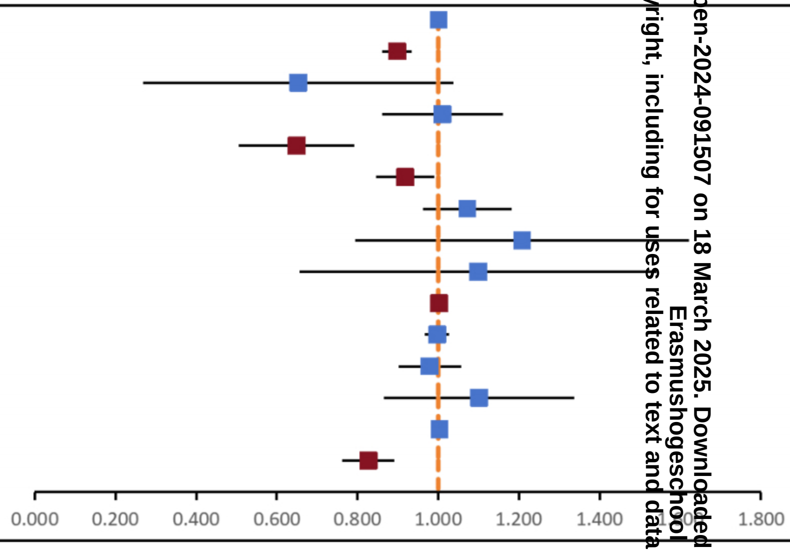
Figure 2: Risk ratio summary of diet and tinnitus incidence



*means: The search results of the four databases according to the pre-specified database search strategy.

**means: The process of selecting articles for title and abstract based on inclusion exclusion criteria.

Type of diet	Study，n	I^2	OR	LOR	UOR	95%CI	Grade	Evidence class
Carbohydrate	2	33.0%	1.001	1.000	1.002		Low	NS
Caffeine	3	23.0%	0.898	0.862	0.935		Low	Class II
Varied diet	2	50.0%	0.653	0.410	1.038		Very low	NS
Egg	2	55.0%	1.010	0.880	1.160		Very low	NS
Fruit	3	0.0%	0.649	0.532	0.793		Moderate	Class II
Fiber	3	63.0%	0.918	0.851	0.990		Low	Class II
Fat	3	73.0%	1.072	0.973	1.181		Very low	NS
Margarine	2	0.0%	1.208	0.900	1.622		Low	NS
Meat	2	0.0%	1.099	0.783	1.542		Low	NS
Protein	2	0.0%	1.002	1.001	1.004		Low	Class III
Sugar	3	0.0%	0.997	0.967	1.027		Low	NS
Fish	3	72.0%	0.979	0.907	1.056		Very low	NS
Vegetable	4	0.0%	1.101	0.907	1.337		Very low	NS
Water	3	0.0%	1.003	0.992	1.014		Low	NS
Dairy	2	0.0%	0.827	0.766	0.892		Low	Class II



The blue or red dots represent OR values, and the black linesrepresent confidence intervals

$p<0.05$ indicates statistical difference.

The evidence classification criteria: Class I (convincing evidence), Class II (highly suggestive evidence), Class III (suggestive evidence), Class IV (weak evidence), and NS (non-significant).

GRADE:Grade of Recommendations Assessment, Development, and Evaluation.

Moderate: The results of current efficacy evaluation are likely to be close to the true value;

Low: The reliability of the current efficacy evaluation results is uncertain;

Very low: The reliability of the current efficacy evaluation results is very uncertain;

Catalogue

Search Strategy

Search Strategy Free text search strategy: Initial search date: 25 May 2024

PubMed 1216

(tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate).

EMBASE 1942

('Tinnitus'/exp OR 'Tinnitus':ab,ti,kw OR 'Ringing-Buzzing'/exp OR 'Ringing-Buzzing':ab,ti,kw OR 'ear buzzing':ab,ti,kw) AND (('Diet'/exp OR 'Diets':ab,ti,kw) OR ('Food'/exp OR 'Food':ab,ti,kw OR 'Foods':ab,ti,kw) OR ('Water'/exp OR 'Water':ab,ti,kw OR 'Hydrogen Oxide':ab,ti,kw) OR ('Milk'/exp OR 'Milk':ab,ti,kw OR 'Cow Milk':ab,ti,kw) OR ('fish'/exp OR 'fish':ab,ti,kw) OR ('vegetable'/exp OR 'vegetable':ab,ti,kw) OR ('Dietary Fiber'/exp OR 'alimentary fiber':ab,ti,kw) OR ('sugar'/exp OR 'sugar':ab,ti,kw) OR ('meat'/exp OR 'meat':ab,ti,kw OR 'sausage':ab,ti,kw) OR ('margarine'/exp OR 'margarine':ab,ti,kw OR 'oleomargarine':ab,ti,kw) OR ('fat'/exp OR 'fat':ab,ti,kw) OR ('egg'/exp OR 'egg':ab,ti,kw) OR ('varietas'/exp OR 'plant variety':ab,ti,kw) OR ('caffeine'/exp OR 'caffeine':ab,ti,kw OR 'coffein':ab,ti,kw) OR ('carbohydrate'/exp OR 'carbohydrate':ab,ti,kw OR 'carbon hydrate':ab,ti,kw OR 'synthetic carbohydrate':ab,ti,kw OR 'saccharide':ab,ti,kw) OR ('protein'/exp OR 'protein':ab,ti,kw))

Web of Science 29

("Tinnitus"(Topic) OR "Tinnitus"(Topic) OR "Ringing-Buzzing"(Topic) OR "Ringing-Buzzing"(Topic) OR "ear buzzing"(Topic)) AND (("Diet"(Topic) OR "Diets"(Topic)) OR ("Food"(Topic) OR "Foods"(Topic)) OR ("Water"(Topic) OR "Hydrogen Oxide"(Topic)) OR ("Milk"(Topic) OR "Cow Milk"(Topic)) OR ("fish"(Topic)) OR ("vegetable"(Topic)) OR ("Dietary Fiber"(Topic) OR "alimentary fiber"(Topic)) OR ("sugar"(Topic)) OR ("meat"(Topic) OR "sausage"(Topic)) OR ("margarine"(Topic) OR "oleomargarine"(Topic)) OR ("fat"(Topic)) OR ("egg"(Topic)) OR ("varietas"(Topic) OR "plant variety"(Topic)) OR ("caffeine"(Topic) OR "coffein"(Topic)) OR ("carbohydrate"(Topic) OR "carbon hydrate"(Topic) OR "synthetic carbohydrate"(Topic) OR "saccharide"(Topic)) OR ("protein"(Topic)))

Cochrane 297

((tinnitus OR Ringing-Buzzing) AND (diet OR food OR water OR milk OR fish OR fruit OR vegetable OR fiber OR sugar OR meat OR margarine OR fat OR egg OR diversity OR caffeine OR carbohydrate) in Title Abstract Keyword

Stata analysis

We used mixed-effects models to pool maximally covariate-adjusted odds ratios (ORs) from each study. Due to the low incidence of events and short follow-up events, OR, RR, and HR were approximately equal, so our results were uniformly expressed in OR. If the P-value of the q test was <0.10 or the I^2 statistic was ≥50%, we assessed and considered the inter-study heterogeneity to be significant. For observational studies, we maximally support covariate-adjusted estimates. If a study uses an analytical method that is incompatible with synthesis for most other studies, we convert the effect estimate to the appropriate combined ratio or exclude the study from the meta-analysis.

Publication bias

If the article heterogeneity is large in the analysis with statistical differences, we will use meta regression to investigate the source of heterogeneity. We assessed the asymmetry of the funnel plot with visual and Egger's bias, and estimated the possible missing studies with eMethods if publication bias is suspected.

Analysis software

We conducted all analyses using stata (version 16) and Review Manager (version 5.3). Unless otherwise specified, we considered a two-sided P value of <0.05 as statistically significant.

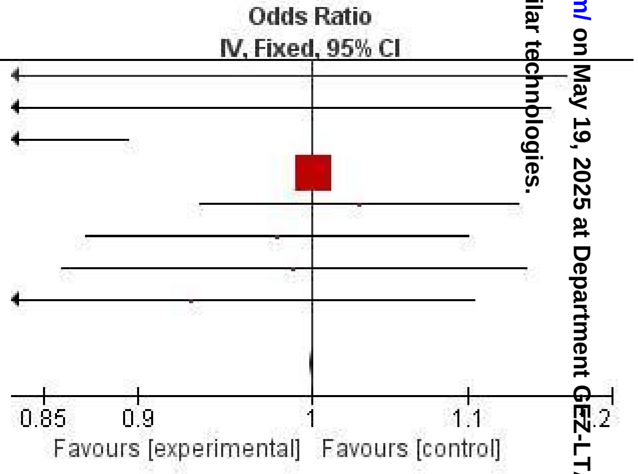
eFigure 1: Forest Plot Showing the Association Between carbohydrate and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.

Carbohydrate: OR=1.00, [95%CI 1.00,1.00], I^2=33%, p=0.05.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Diana Tang 2021a	-0.3011051	0.2326598	0.0%	0.74 [0.47, 1.17]
Diana Tang 2021b	-0.3024573	0.2282614	0.0%	0.74 [0.47, 1.16]
Diana Tang 2021c	-0.597837	0.2483288	0.0%	0.55 [0.34, 0.89]
Doh Young Lee 2018	0.0009995	0.0005102	100.0%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0295588	0.0492101	0.0%	1.03 [0.94, 1.13]
Piers Dawes 2020b	-0.0202027	0.059233	0.0%	0.98 [0.87, 1.10]
Piers Dawes 2020c	-0.0100503	0.0719008	0.0%	0.99 [0.86, 1.14]
Piers Dawes 2020d	-0.0725707	0.0876968	0.0%	0.93 [0.78, 1.10]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 10.46, df = 7 (P = 0.16); I² = 33%
Test for overall effect: Z = 1.95 (P = 0.05)



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              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Diana Tang 2021a     |  0.740       0.469     1.168          0.00
Diana Tang 2021b     |  0.739       0.472     1.156          0.00
Diana Tang 2021c     |  0.550       0.338     0.895          0.00
Doh Young Lee 2018   |  1.001       1.000     1.002         99.97
Piers Dawes 2020a    |  1.030       0.935     1.134          0.01
Piers Dawes 2020b    |  0.980       0.873     1.101          0.01
Piers Dawes 2020c    |  0.990       0.860     1.140          0.01
Piers Dawes 2020d    |  0.930       0.783     1.104          0.00
---------------------+---------------------------------------------------
I-V pooled ES        |  1.001       1.000     1.002        100.00
---------------------+---------------------------------------------------
```

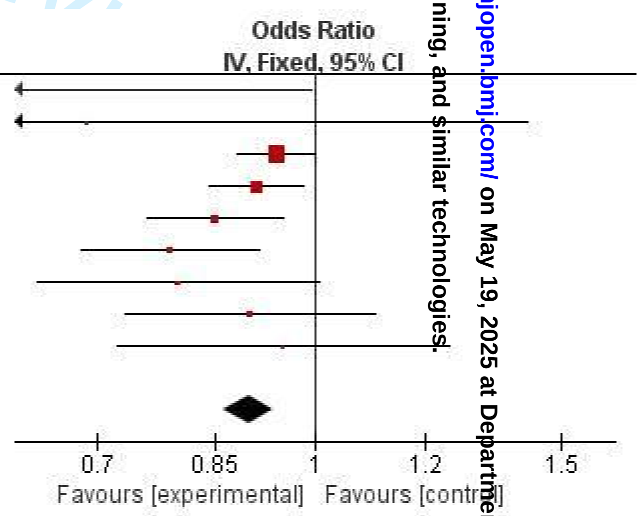
Actually: Carbohydrate: OR=1.001, [95%CI 1.000,1.002]

eFigure 2: Forest Plot Showing the Association Between caffeine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Caffeine: OR=0.90, [95%CI 0.86,0.94], I^2=23% p<0.000001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.7133499	0.3614964	0.3%	0.49 [0.24, 1.00]
Carlotta Micaela Jarach 2023b	-0.3710637	0.36645	0.3%	0.69 [0.34, 1.42]
Jordan T Glicksman 2014a	-0.0618754	0.0326106	40.8%	0.94 [0.88, 1.00]
Jordan T Glicksman 2014b	-0.0943106	0.0393242	28.0%	0.91 [0.84, 0.98]
Jordan T Glicksman 2014c	-0.1625189	0.0569244	13.4%	0.85 [0.76, 0.95]
Jordan T Glicksman 2014d	-0.2357223	0.0743244	7.8%	0.79 [0.68, 0.91]
Sang-Youp Lee 2018	-0.2231435	0.1178662	3.1%	0.80 [0.63, 1.01]
Sang-Youp Lee 2018b	-0.1053605	0.1045972	4.0%	0.90 [0.73, 1.10]
Sang-Youp Lee 2018c	-0.0512933	0.1386774	2.3%	0.95 [0.72, 1.25]
Total (95% CI)			**100.0%**	**0.90 [0.86, 0.94]**

Heterogeneity: Chi² = 10.43, df = 8 (P = 0.24); I² = 23%
Test for overall effect: Z = 5.18 (P < 0.00001)



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              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.490       0.241     0.995          0.33
Carlotta Micaela Jar |  0.690       0.336     1.415          0.32
Jordan T 2014a       |  0.940       0.882     1.002         40.76
Jordan T 2014b       |  0.910       0.842     0.983         28.03
Jordan T 2014c       |  0.850       0.760     0.950         13.38
Jordan T 2014d       |  0.790       0.683     0.914          7.85
Sang-Youp Lee 2018   |  0.800       0.635     1.008          3.12
Sang-Youp Lee 2018   |  0.900       0.733     1.105          3.96
Sang-Youp Lee 2018   |  0.950       0.724     1.247          2.25
---------------------+---------------------------------------------------
I-V pooled ES        |  0.898       0.862     0.935        100.00
---------------------+---------------------------------------------------
```

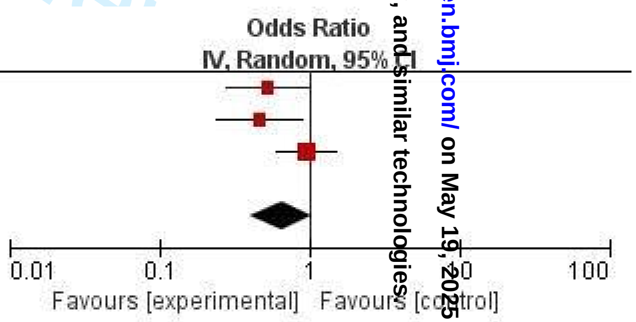
Actually: Caffeine: OR=0.898, [95%CI 0.862,0.935]

eFigure 3: Forest Plot Showing the Association Between diversity and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Diversity: OR=0.65, [95%CI 0.41,1.04], I^2=50% p=0.08.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlotta Micaela Jarach 2023a	-0.6348783	0.3247361	29.9%	0.53 [0.28, 1.00]
Carlotta Micaela Jarach 2023b	-0.7550226	0.3371826	28.7%	0.47 [0.24, 0.91]
Christopher Spankovich 2017	-0.0444	0.2295	41.4%	0.96 [0.61, 1.50]
Total (95% CI)			**100.0%**	**0.65 [0.41, 1.04]**

Heterogeneity: Tau² = 0.09; Chi² = 3.98, df = 2 (P = 0.14); I² = 50%
Test for overall effect: Z = 1.78 (P = 0.08)



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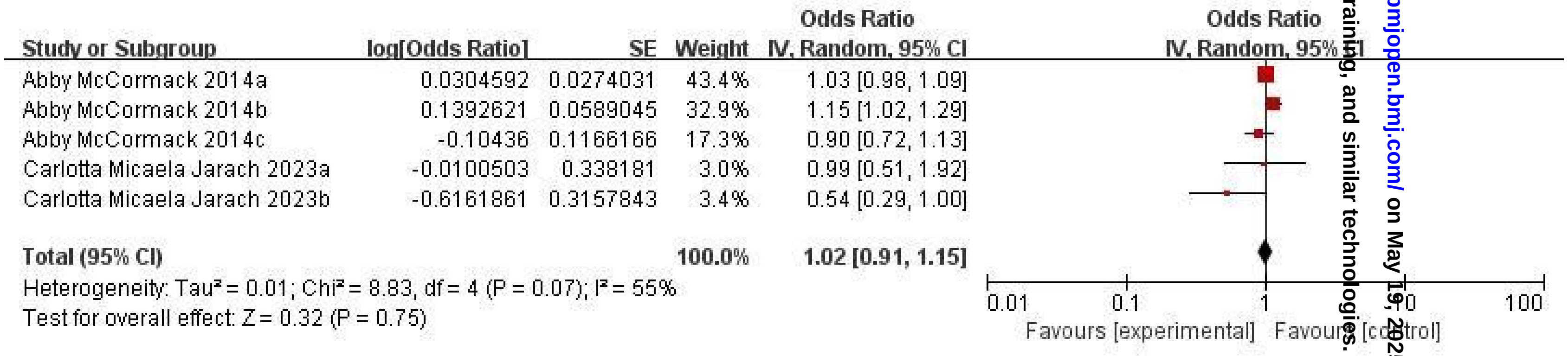
           Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.530       0.280     1.002          29.86
Carlotta Micaela Jar |  0.470       0.243     0.910          28.60
Christopher Spankovi |  0.950       0.606     1.490          41.54
---------------------+---------------------------------------------------
D+L pooled ES        |  0.653       0.410     1.038         100.00
---------------------+---------------------------------------------------
```

Actually: diversity: OR=0.653, [95%CI 0.410, 1.038].

eFigure 4: Forest Plot Showing the Association Between egg and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Egg: OR=1.02, [95%CI 0.91,1.15], I^2=55% p=0.75.



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           Study       |     ES    [95% Conf. Interval]     % Weight
-----------------------+---------------------------------------------------
Abby McCormack 2014    |  1.031       0.926      1.148         36.13
Abby McCormack 2014a   |  1.149       1.024      1.290         35.00
Abby McCormack 2014b   |  0.901       0.717      1.133         20.41
Carlotta Micaela Jar   |  0.990       0.510      1.921          3.97
Carlotta Micaela Jar   |  0.540       0.291      1.003          4.50
-----------------------+---------------------------------------------------
D+L pooled ES          |  1.010       0.880      1.160        100.00
-----------------------+---------------------------------------------------
```

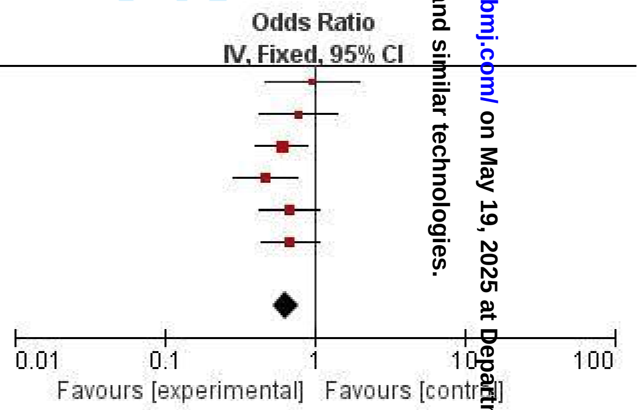
Actually: diversity: OR=1.010, [95%CI 0.880, 1.160].

eFigure 5: Forest Plot Showing the Association Between fruit and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fruit: OR=0.65, [95%CI 0.53,0.79], I^2=0% p<0.0001.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.040822	0.3655756	7.7%	0.96 [0.47, 1.97]
Carlotta Micaela Jarach 2023b	-0.2484614	0.3083197	10.9%	0.78 [0.43, 1.43]
Christopher Spankovich 2017	-0.4942963	0.2033897	25.0%	0.61 [0.41, 0.91]
Diana Tang 2021a	-0.7550226	0.2457749	17.1%	0.47 [0.29, 0.76]
Diana Tang 2021b	-0.3856625	0.230163	19.5%	0.68 [0.43, 1.07]
Diana Tang 2021c	-0.3710637	0.2290667	19.7%	0.69 [0.44, 1.08]
Total (95% CI)			**100.0%**	**0.65 [0.53, 0.79]**

Heterogeneity: Chi² = 3.43, df = 5 (P = 0.63); I² = 0%
Test for overall effect: Z = 4.24 (P < 0.0001)



```
. metan logrr selogrr, label(namevar=author) fixed eform

           Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.960       0.469     1.965          7.74
Carlotta Micaela Jar |  0.780       0.426     1.427         10.88
Christopher Spankovi |  0.610       0.409     0.909         25.01
Diana Tang 2021a     |  0.470       0.290     0.761         17.13
Diana Tang 2021b     |  0.680       0.433     1.068         19.53
Diana Tang 2021d     |  0.690       0.440     1.081         19.72
---------------------+---------------------------------------------------
I-V pooled ES        |  0.649       0.532     0.793        100.00
---------------------+---------------------------------------------------
```

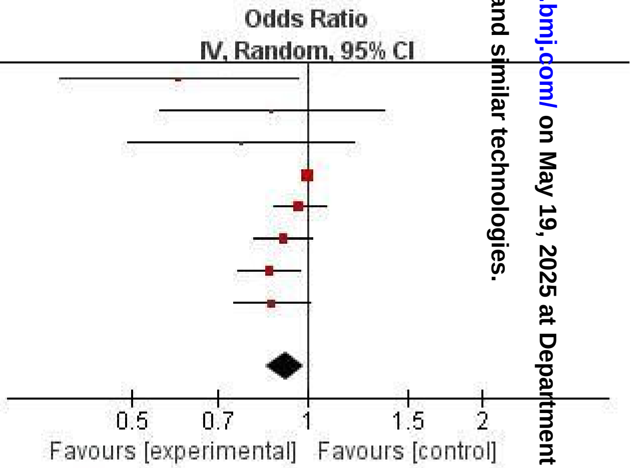
Actually: fruit: OR=0.649, [95%CI 0.532, 0.793].

eFigure 6: Forest Plot Showing the Association Between fiber and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis.
Fiber: OR=0.92, [95%CI 0.85,0.99], I^2=63% p=0.03.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Diana Tang 2021a	-0.5108256	0.243222	2.3%	0.60 [0.37, 0.97]
Diana Tang 2021b	-0.1392621	0.2282217	2.6%	0.87 [0.56, 1.36]
Diana Tang 2021c	-0.2613648	0.2306047	2.5%	0.77 [0.49, 1.21]
Doh Young Lee 2018	0.003992	0.0022879	27.8%	1.00 [1.00, 1.01]
Piers Dawes 2020a	-0.0304592	0.0527859	18.3%	0.97 [0.87, 1.08]
Piers Dawes 2020b	-0.0943106	0.0588071	16.9%	0.91 [0.81, 1.02]
Piers Dawes 2020c	-0.1508229	0.0622392	16.1%	0.86 [0.76, 0.97]
Piers Dawes 2020d	-0.1392621	0.0759266	13.4%	0.87 [0.75, 1.01]
Total (95% CI)			**100.0%**	**0.92 [0.85, 0.99]**

Heterogeneity: Tau² = 0.01; Chi² = 19.09, df = 7 (P = 0.008); I² = 63%
Test for overall effect: Z = 2.21 (P = 0.03)



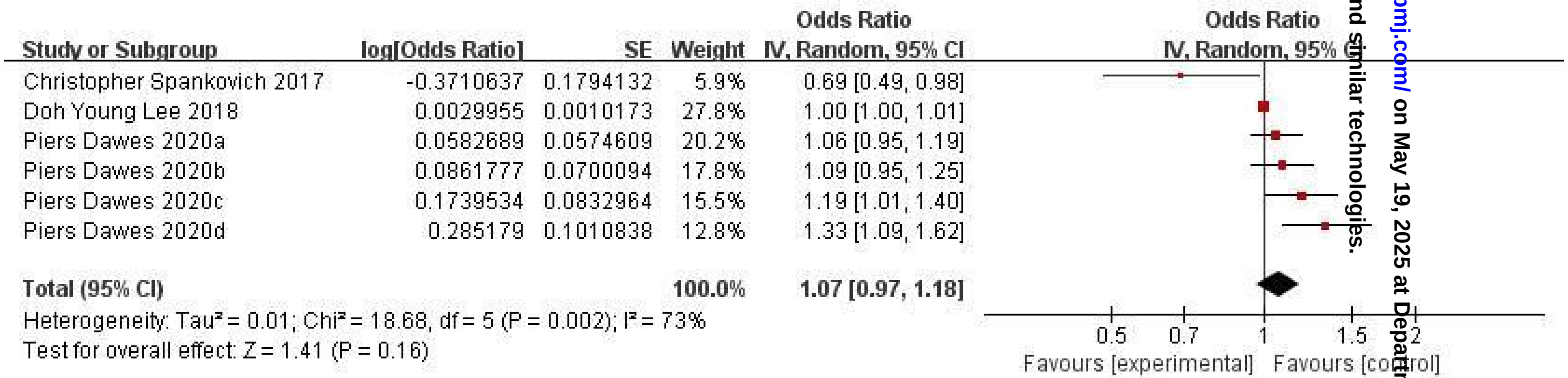
```
. metan logrr selogrr, label(namevar=author) random eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Diana Tang 2021a     |  0.600       0.372     0.966          2.31
Diana Tang 2021b     |  0.870       0.556     1.361          2.59
Diana Tang 2021d     |  0.770       0.490     1.210          2.54
Doh Young Lee 2018   |  1.004       1.000     1.009         27.81
Piers Dawes 2020a    |  0.970       0.875     1.076         18.30
Piers Dawes 2020b    |  0.910       0.811     1.021         16.90
Piers Dawes 2020c    |  0.860       0.761     0.972         16.14
Piers Dawes 2020d    |  0.870       0.750     1.010         13.40
---------------------+---------------------------------------------------
D+L pooled ES        |  0.918       0.851     0.990        100.00
---------------------+---------------------------------------------------
```

Actually: fruit: OR=0.918, [95%CI 0.851, 0.990].

eFigure 7: Forest Plot Showing the Association Between fat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Fat: OR=1.07, [95%CI 0.97,1.18], I^2=73% p=0.16.



```
. metan logrr selogrr, label(namevar=author) random eform

          Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Christopher Spankovi |  0.690       0.485     0.981          5.95
Doh Young Lee 2018   |  1.003       1.001     1.005         27.75
Piers Dawes 2020a    |  1.060       0.947     1.186         20.17
Piers Dawes 2020b    |  1.090       0.950     1.250         17.81
Piers Dawes 2020c    |  1.190       1.011     1.401         15.50
Piers Dawes 2020d    |  1.330       1.091     1.621         12.82
---------------------+---------------------------------------------------
D+L pooled ES        |  1.072       0.973     1.181        100.00
---------------------+---------------------------------------------------
```

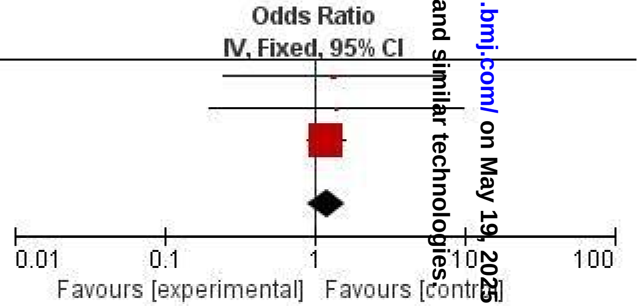
Actually: fat: OR=1.072, [95%CI 0.973, 1.181].

eFigure 8: Forest Plot Showing the Association Between margarine and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Margarine: OR=1.21, [95%CI 0.90,1.63], I^2=0% p=0.20.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3001046	0.8652602	3.0%	1.35 [0.25, 7.36]
Carlotta Micaela Jarach 2023b	0.3364722	0.9974543	2.3%	1.40 [0.20, 9.89]
Milena Tomanic 2020	0.1856494	0.154809	94.7%	1.20 [0.89, 1.63]
Total (95% CI)			**100.0%**	**1.21 [0.90, 1.63]**

Heterogeneity: Chi² = 0.04, df = 2 (P = 0.98); I² = 0%
Test for overall effect: Z = 1.28 (P = 0.20)



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  1.350       0.248     7.359          3.01
Carlotta Micaela Jar |  1.400       0.198     9.889          2.27
Milena Tomanic 2020  |  1.200       0.887     1.624         94.72
---------------------+---------------------------------------------------
I-V pooled ES        |  1.208       0.900     1.622        100.00
---------------------+---------------------------------------------------
```

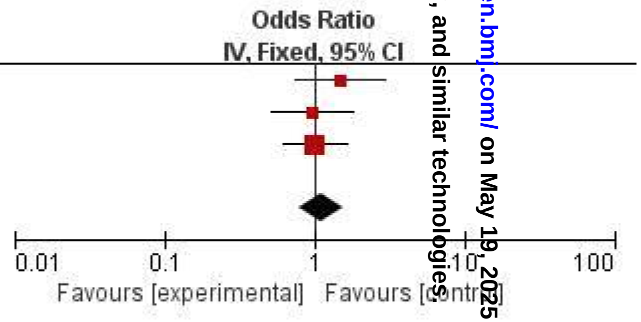
Actually: margarine: OR=1.208, [95%CI 0.900, 1.622].

eFigure 9: Forest Plot Showing the Association Between meat and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Meat: OR=1.10, [95%CI 0.78,1.54], I^2=0% p=0.59.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	0.3987761	0.3484928	24.6%	1.49 [0.75, 2.95]
Carlotta Micaela Jarach 2023b	-0.0304592	0.3287067	27.6%	0.97 [0.51, 1.85]
Christopher Spankovich 2017	0.0099503	0.2496967	47.8%	1.01 [0.62, 1.65]
Total (95% CI)			**100.0%**	**1.10 [0.78, 1.54]**

Heterogeneity: Chi² = 1.02, df = 2 (P = 0.60); I² = 0%
Test for overall effect: Z = 0.55 (P = 0.59)



```
. metan logrr selogrr, label(namevar=author) fixed eform

           Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  1.490       0.753     2.950         24.56
Carlotta Micaela Jar |  0.970       0.509     1.847         27.60
Christopher Spankovi |  1.010       0.619     1.648         47.84
---------------------+---------------------------------------------------
I-V pooled ES        |  1.099       0.783     1.542        100.00
---------------------+---------------------------------------------------
```

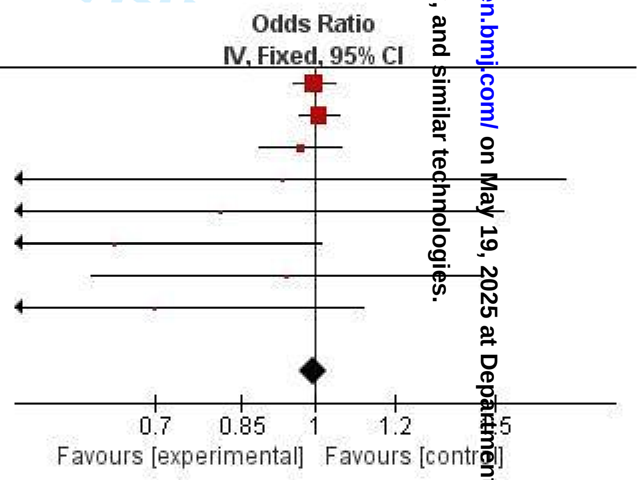
Actually: meat: OR=1.099, [95%CI 0.783, 1.542].

eFigure 10: Forest Plot Showing the Association Between sugar and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Sugar: OR=1.00, [95%CI 0.97,1.03], I^2=0% p=0.84.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Abby McCormack 2014a	0	0.0230439	44.3%	1.00 [0.96, 1.05]
Abby McCormack 2014b	0.0099503	0.0233327	43.2%	1.01 [0.96, 1.06]
Abby McCormack 2014c	-0.0294288	0.0469906	10.7%	0.97 [0.89, 1.06]
Carlotta Micaela Jarach 2023a	-0.0725707	0.3247361	0.2%	0.93 [0.49, 1.76]
Carlotta Micaela Jarach 2023b	-0.210721	0.3237852	0.2%	0.81 [0.43, 1.53]
Diana Tang 2021a	-0.4462871	0.236286	0.4%	0.64 [0.40, 1.02]
Diana Tang 2021b	-0.0618754	0.2243772	0.5%	0.94 [0.61, 1.46]
Diana Tang 2021c	-0.356675	0.2383442	0.4%	0.70 [0.44, 1.12]
Total (95% CI)			**100.0%**	**1.00 [0.97, 1.03]**

Heterogeneity: Chi² = 6.89, df = 7 (P = 0.44); I² = 0%
Test for overall effect: Z = 0.20 (P = 0.84)



```
. metan logrr selogrr, label(namevar=author) fixed eform

            Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  1.000       0.956     1.046          44.34
Abby McCormack 2014a |  1.010       0.965     1.057          43.25
Abby McCormack 2014b |  0.971       0.886     1.065          10.66
Carlotta Micaela Jar |  0.930       0.492     1.758           0.22
Carlotta Micaela Jar |  0.810       0.429     1.528           0.22
Diana Tang 2021a     |  0.640       0.403     1.017           0.42
Diana Tang 2021b     |  0.940       0.606     1.459           0.47
Diana Tang 2021c     |  0.700       0.439     1.117           0.41
---------------------+---------------------------------------------------
I-V pooled ES        |  0.997       0.967     1.027         100.00
---------------------+---------------------------------------------------
```

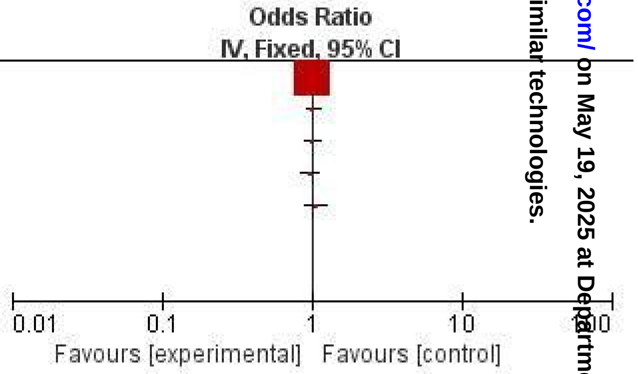
Actually: sugar: OR=0.997, [95%CI 0.967, 1.027].

eFigure 11: Forest Plot Showing the Association Between protein and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis.
Fish: OR=1.00, [95%CI 1.00,1.00], I^2=0% p=0.009.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Doh Young Lee 2018	0.001998	0.0007634	99.9%	1.00 [1.00, 1.00]
Piers Dawes 2020a	0.0198026	0.0546964	0.0%	1.02 [0.92, 1.14]
Piers Dawes 2020b	0.0099503	0.060906	0.0%	1.01 [0.90, 1.14]
Piers Dawes 2020c	-0.0304592	0.0680814	0.0%	0.97 [0.85, 1.11]
Piers Dawes 2020d	0.0582689	0.0858348	0.0%	1.06 [0.90, 1.25]
Total (95% CI)			**100.0%**	**1.00 [1.00, 1.00]**

Heterogeneity: Chi² = 0.78, df = 4 (P = 0.94); I² = 0%
Test for overall effect: Z = 2.62 (P = 0.009)



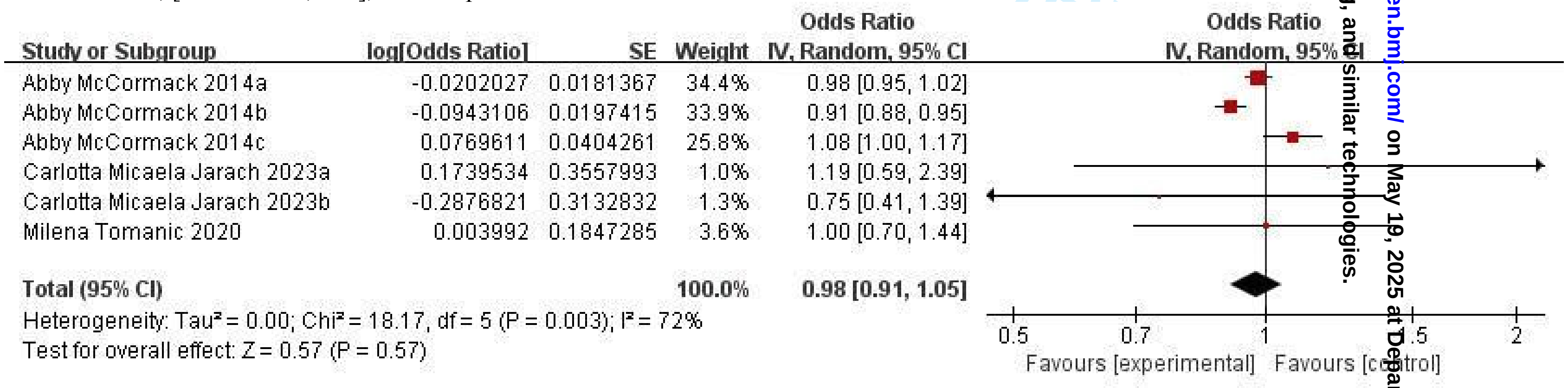
```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Doh Young Lee 2018   |  1.002       1.001     1.004          99.94
Piers Dawes 2020a    |  1.020       0.916     1.135           0.02
Piers Dawes 2020b    |  1.010       0.896     1.138           0.02
Piers Dawes 2020c    |  0.970       0.849     1.108           0.01
Piers Dawes 2020d    |  1.060       0.896     1.254           0.01
---------------------+---------------------------------------------------
I-V pooled ES        |  1.002       1.001     1.004         100.00
---------------------+---------------------------------------------------
```

Actually: protein: OR=1.002, [95%CI 1.001, 1.004].

eFigure 12: Forest Plot Showing the Association Between fish and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta-analysis. Fish: OR=0.98, [95%CI 0.91,1.05], I^2=72% p=0.57.



```
. metan logrr selogrr, label(namevar=author) random eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  0.980       0.946     1.015          35.43
Abby McCormack 2014a |  0.910       0.875     0.946          34.93
Abby McCormack 2014b |  1.080       0.998     1.169          27.04
Carlotta Micaela Jar |  1.190       0.593     2.390           1.14
Carlotta Micaela Jar |  0.750       0.406     1.386           1.46
---------------------+---------------------------------------------------
D+L pooled ES        |  0.979       0.907     1.056         100.00
---------------------+---------------------------------------------------
```

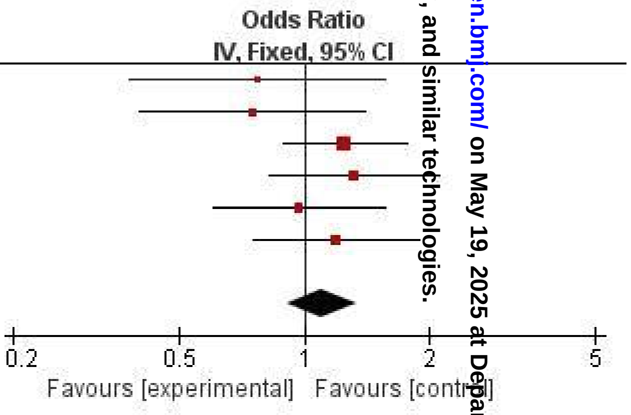
Actually: fish: OR=0.979, [95%CI 0.907, 1.056].

eFigure 13: Forest Plot Showing the Association Between vegetable and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Vegetable: OR=1.10, [95%CI 0.91,1.34], I^2=0% p=0.33..

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.2613648	0.3602729	7.6%	0.77 [0.38, 1.56]
Carlotta Micaela Jarach 2023b	-0.2876821	0.321398	9.5%	0.75 [0.40, 1.41]
Christopher Spankovich 2017	0.2231435	0.1754021	31.9%	1.25 [0.89, 1.76]
Diana Tang 2021a	0.2776318	0.2411069	16.9%	1.32 [0.82, 2.12]
Diana Tang 2021b	-0.0304592	0.2437529	16.5%	0.97 [0.60, 1.56]
Diana Tang 2021c	0.1739534	0.2357803	17.7%	1.19 [0.75, 1.89]
Total (95% CI)			**100.0%**	**1.10 [0.91, 1.34]**

Heterogeneity: Chi² = 3.88, df = 5 (P = 0.57); I² = 0%
Test for overall effect: Z = 0.98 (P = 0.33)



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.770       0.380     1.560          7.56
Carlotta Micaela Jar |  0.750       0.399     1.408          9.50
Christopher Spankovi |  1.250       0.886     1.763         31.89
Diana Tang 2021a     |  1.320       0.823     2.117         16.88
Diana Tang 2021b     |  0.970       0.602     1.564         16.52
Diana Tang 2021c     |  1.190       0.750     1.889         17.65
---------------------+---------------------------------------------------
I-V pooled ES        |  1.101       0.907     1.337        100.00
---------------------+---------------------------------------------------
```

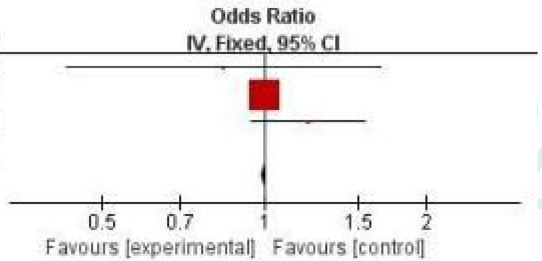
Actually: vegetable: OR=1.101, [95%CI 0.907, 1.337].

eFigure 14: Forest Plot Showing the Association Between water and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Water: OR=1.00, [95%CI 0.99,1.01], I^2=20% p=0.55.

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Fixed, 95% CI
Carlotta Micaela Jarach 2023a	-0.1743534	0.3430473	0.0%	0.84 [0.43, 1.65]
Doh Young Lee 2018	0.0029955	0.0055957	99.8%	1.00 [0.99, 1.01]
Milena Tomanic 2020	0.1889661	0.1243716	0.2%	1.21 [0.95, 1.54]
Total (95% CI)			**100.0%**	**1.00 [0.99, 1.01]**

Heterogeneity: Chi² = 2.50, df = 2 (P = 0.29); I² = 20%
Test for overall effect: Z = 0.59 (P = 0.55)



```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Carlotta Micaela Jar |  0.840       0.429     1.645           0.03
Doh Young Lee 2018   |  1.003       0.992     1.014          99.77
Milena Tomanic 2020  |  1.210       0.950     1.541           0.21
---------------------+---------------------------------------------------
I-V pooled ES        |  1.003       0.992     1.014         100.00
---------------------+---------------------------------------------------
```

Actually: water: OR=1.003, [95%CI 0.992, 1.014].

eFigure 15: Forest Plot Showing the Association Between dairy and tinnitus.

Black diamonds are the estimated pooled odd ratio (OR) for each random-effects meta-analysis; Red box sizes reflect the relative weight apportioned to studies in the meta- analysis. Dairy: OR=0.83, [95%CI 0.77,0.89], I^2=0% p<0.00001

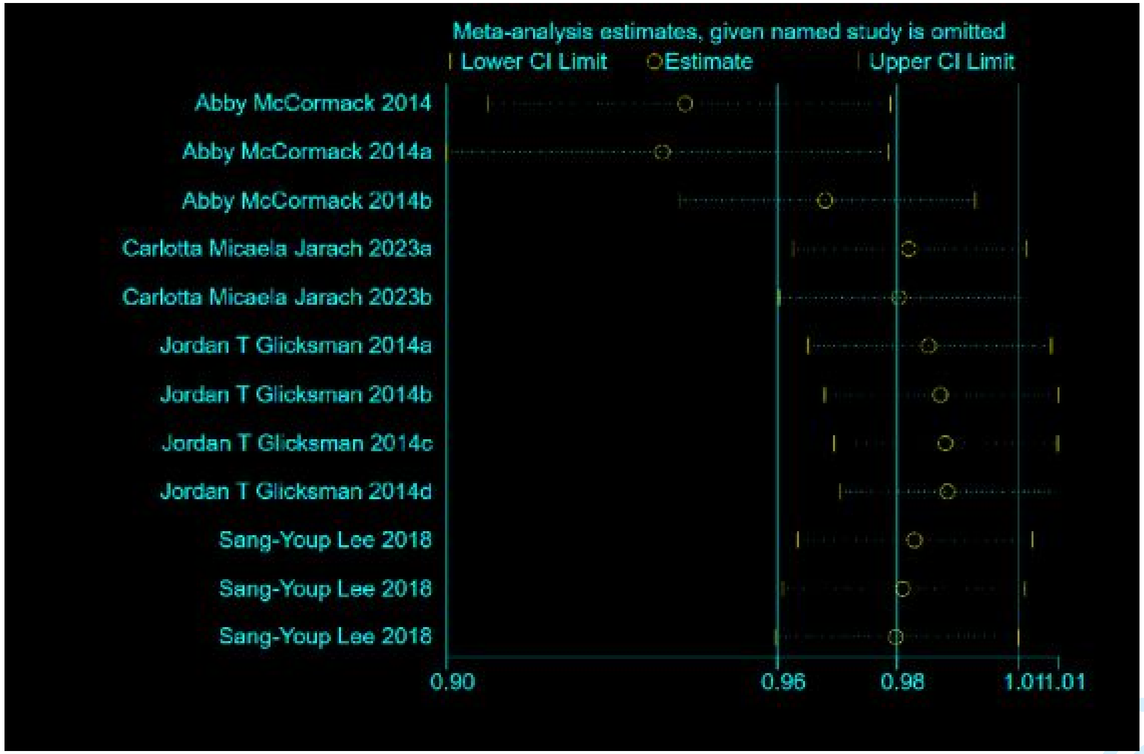
```
. metan logrr selogrr, label(namevar=author) fixed eform

              Study     |     ES    [95% Conf. Interval]     % Weight
---------------------+---------------------------------------------------
Abby McCormack 2014  |  0.847       0.753     0.953          41.62
Abby McCormack 2014a |  0.787       0.702     0.882          44.21
Abby McCormack 2014b |  0.877       0.699     1.100          11.30
Christopher Spankovi |  0.990       0.631     1.552           2.86
---------------------+---------------------------------------------------
I-V pooled ES        |  0.827       0.766     0.892         100.00
---------------------+---------------------------------------------------
```

Actually: dairy: OR=0.83, [95%CI 0.766, 0.892].

eFigure 16: Sensitivity analysis between caffeine and tinnitus.

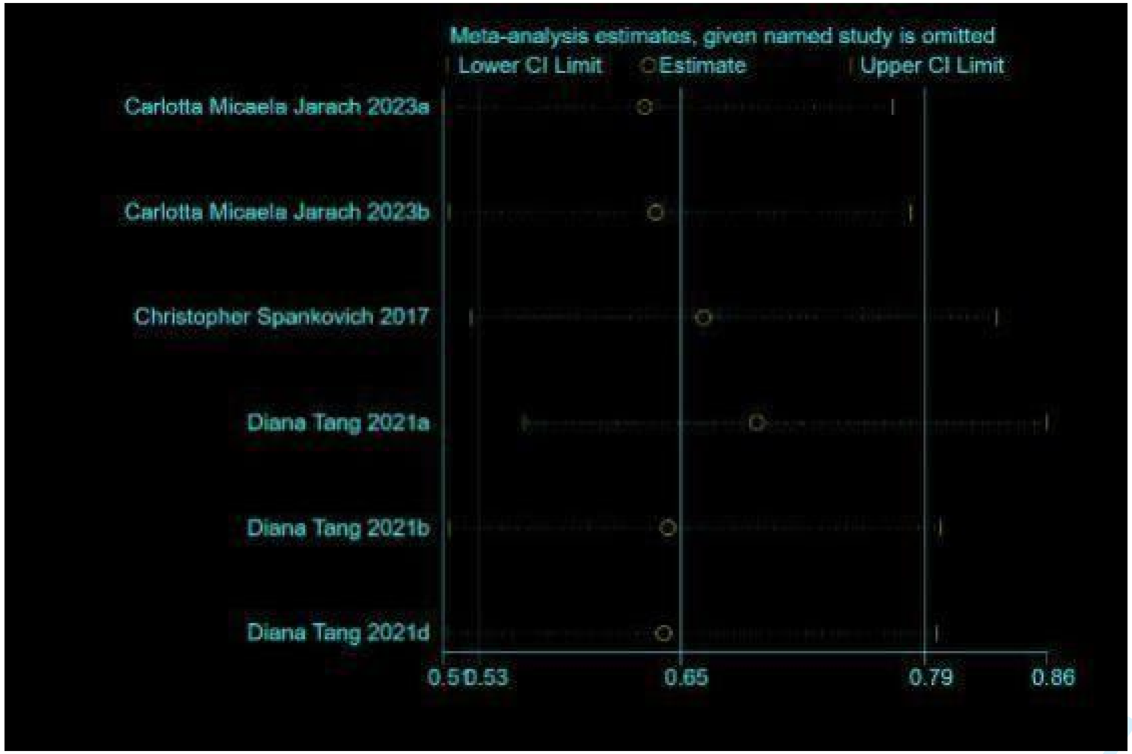
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study at a time, conflicting results emerged and further identification of the source of heterogeneity was needed. It has been confirmed that the main contradiction comes from Abby McCormack 2017, and the sensitivity analysis after removal the reseach did not show contradictory outcome, indicating the robustness of the results.

eFigure 17:Sensitivity analysis between fruit and tinnitus.

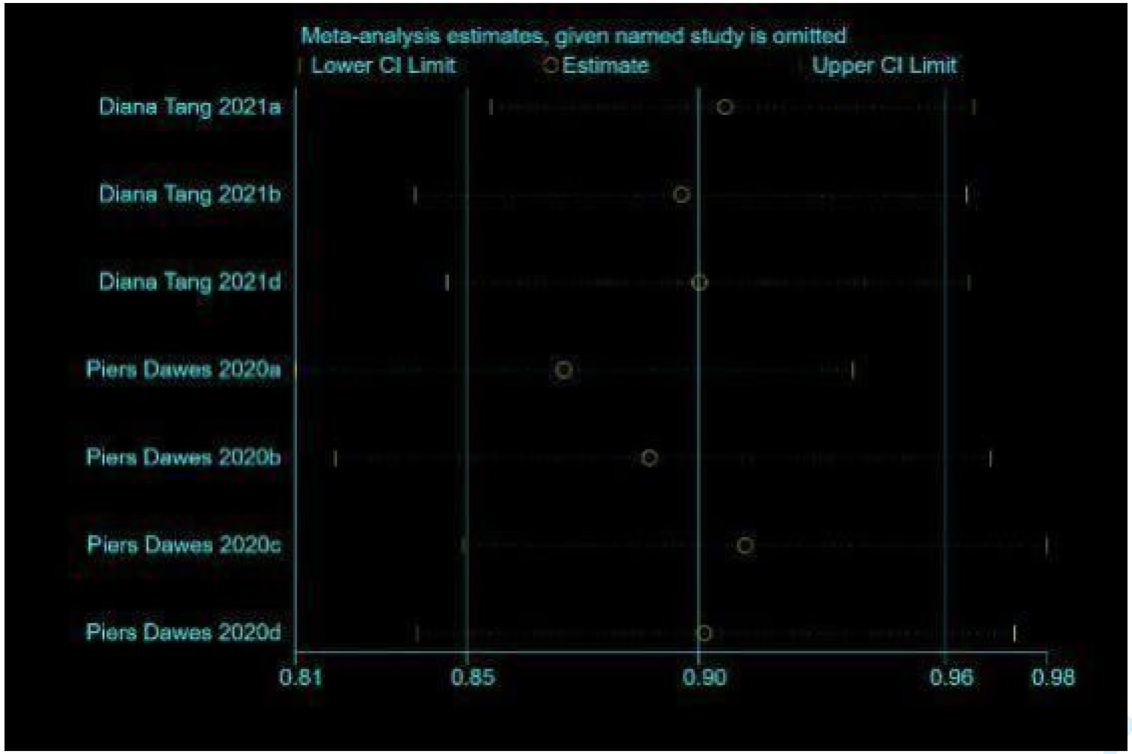
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 18:Sensitivity analysis between fiber and tinnitus.

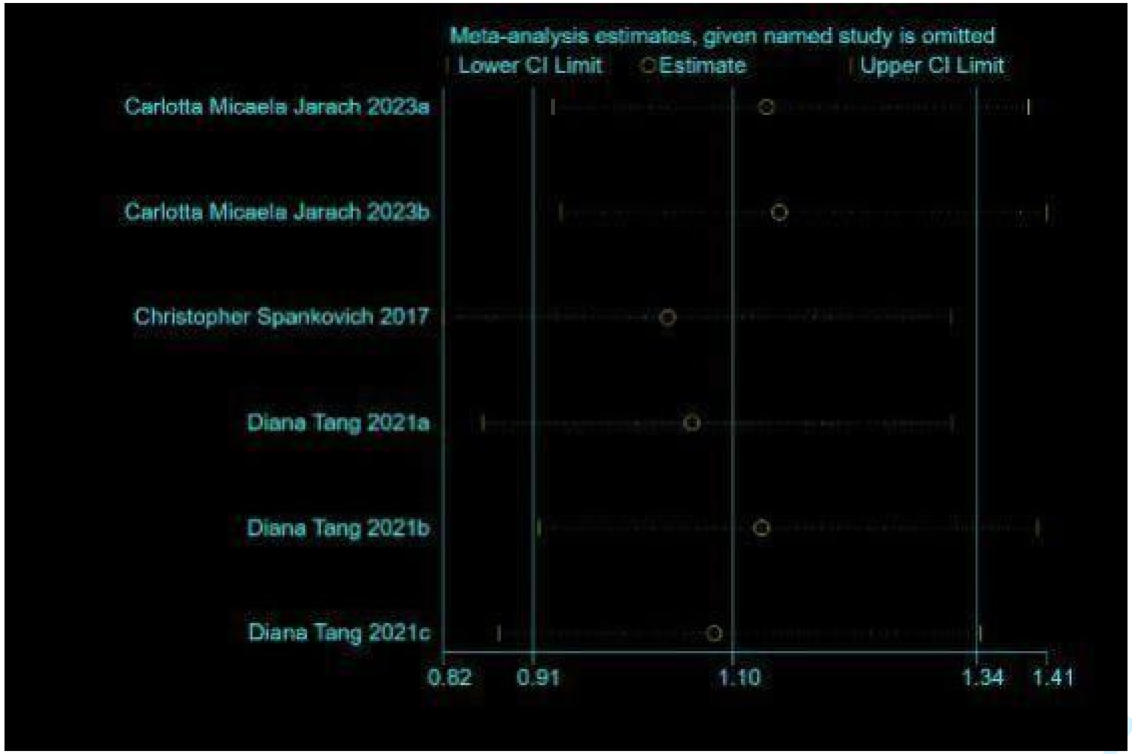
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

eFigure 19:Sensitivity analysis between vegetable and tinnitus.

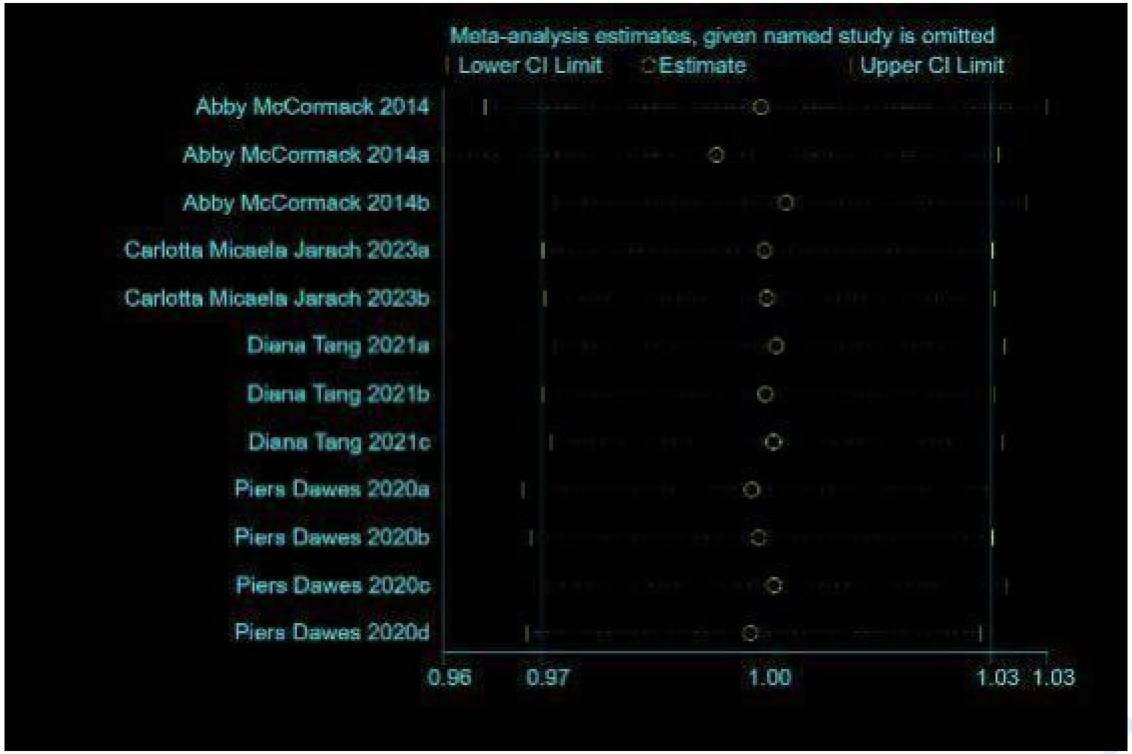
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

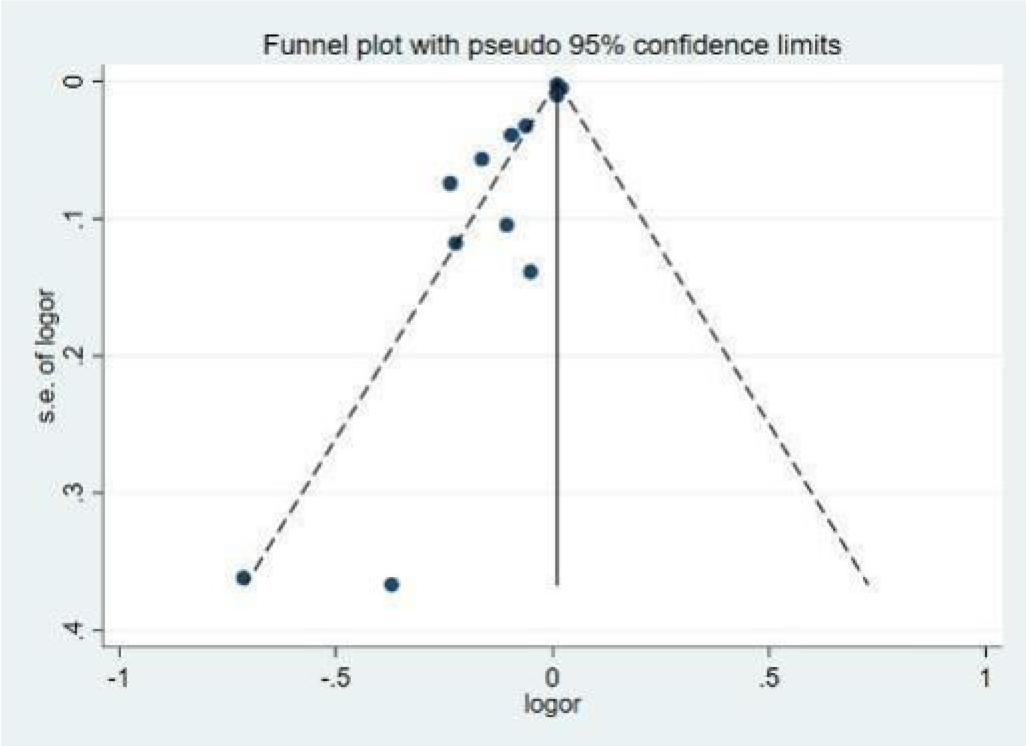
eFigure 20:Sensitivity analysis between sugar and tinnitus.

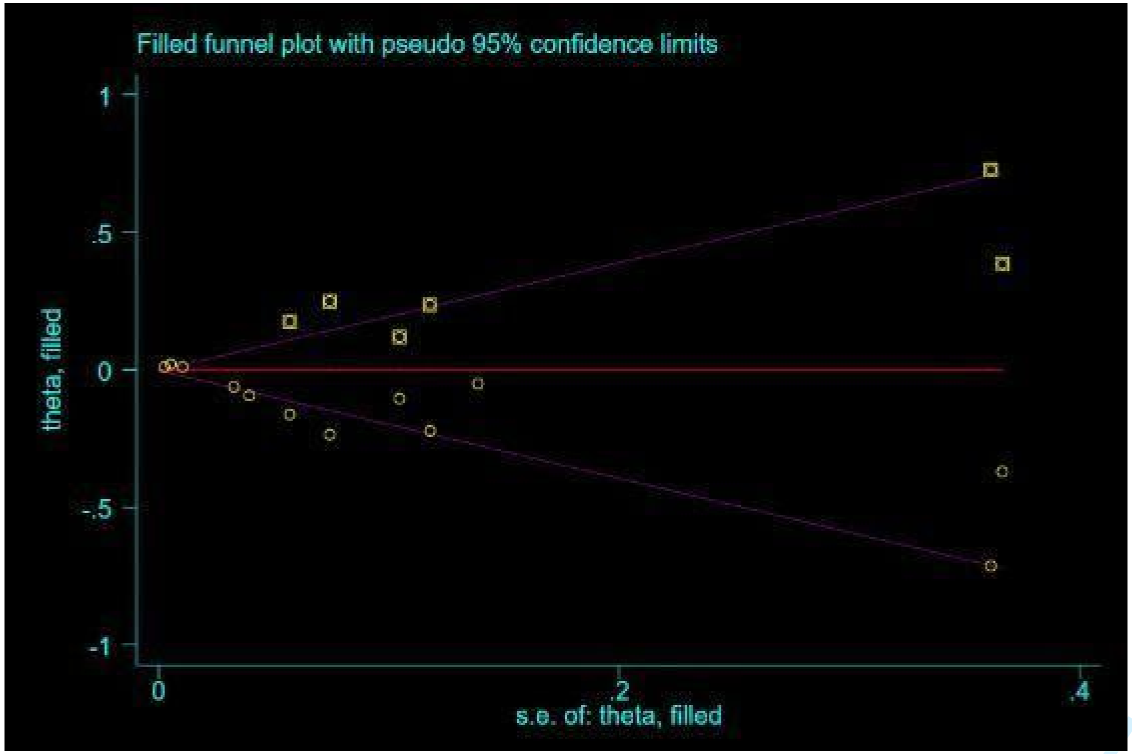
(NOTE: The sensitivity analysis was carried out by one-by-one elimination method for the analysis with more than 6 included articles.)



After deleting one study one by one, there was no contradictory outcome, and the outcome was relatively stable.

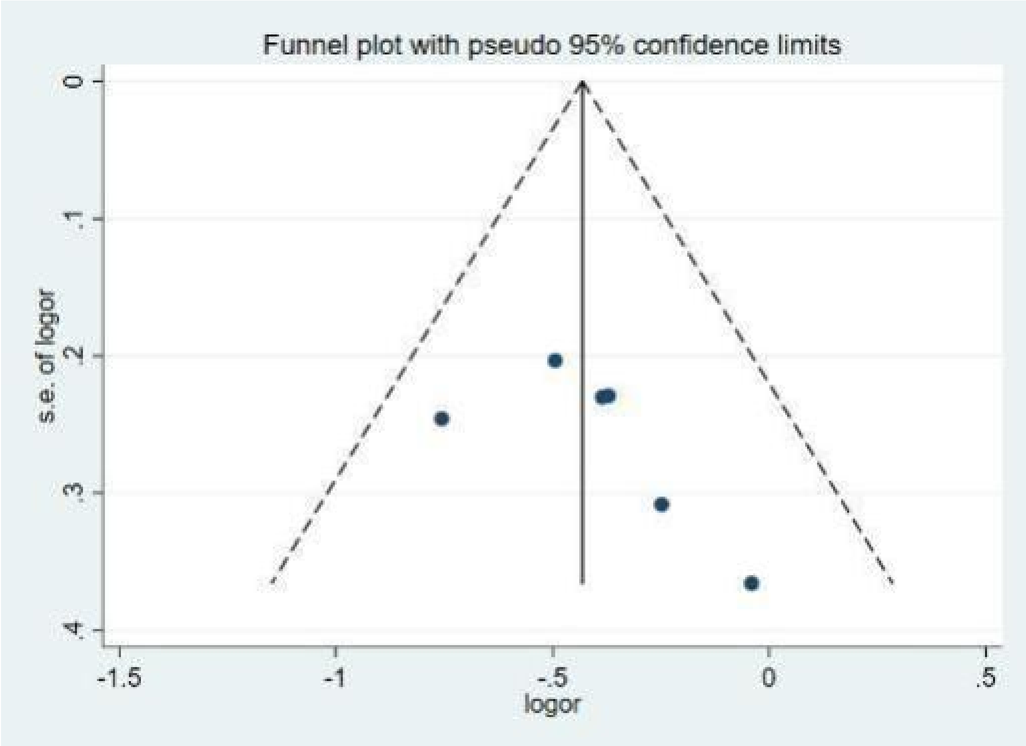
eFigure 21:Publication bias and Egger test on caffeine





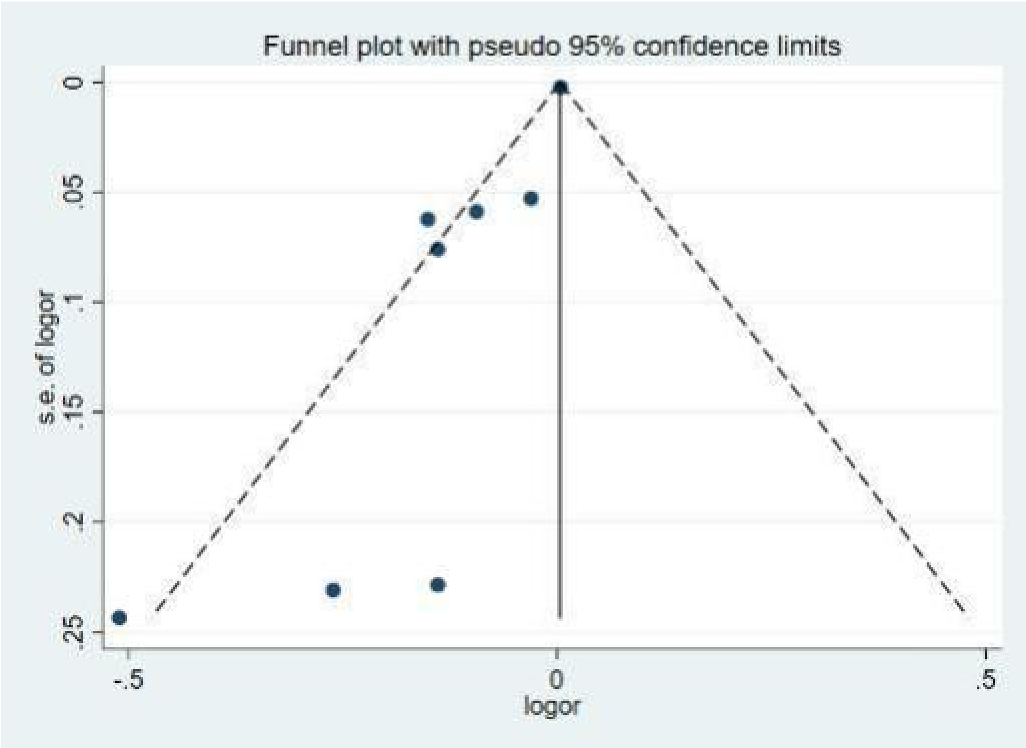
Cut and complement method tips, there was no significant publication bias.

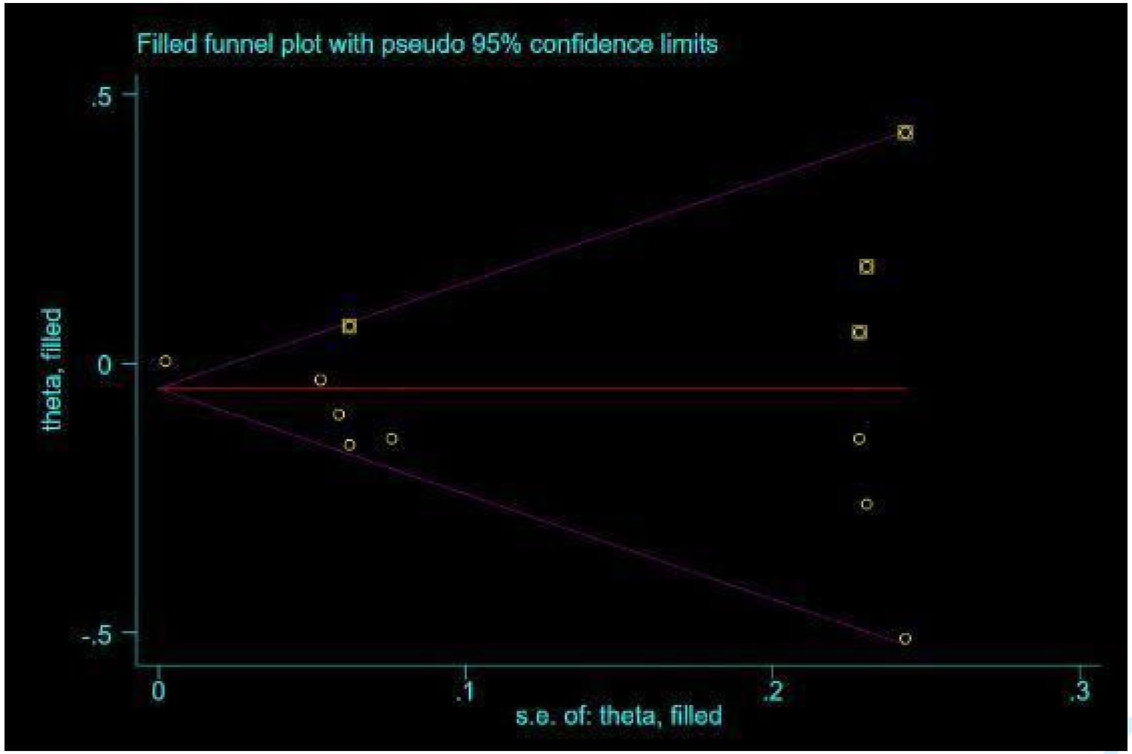
eFigure 22: Publication bias and Egger test on fruit



Egger test: Fruit p=0.205>0.05, there was no significant publication bias.

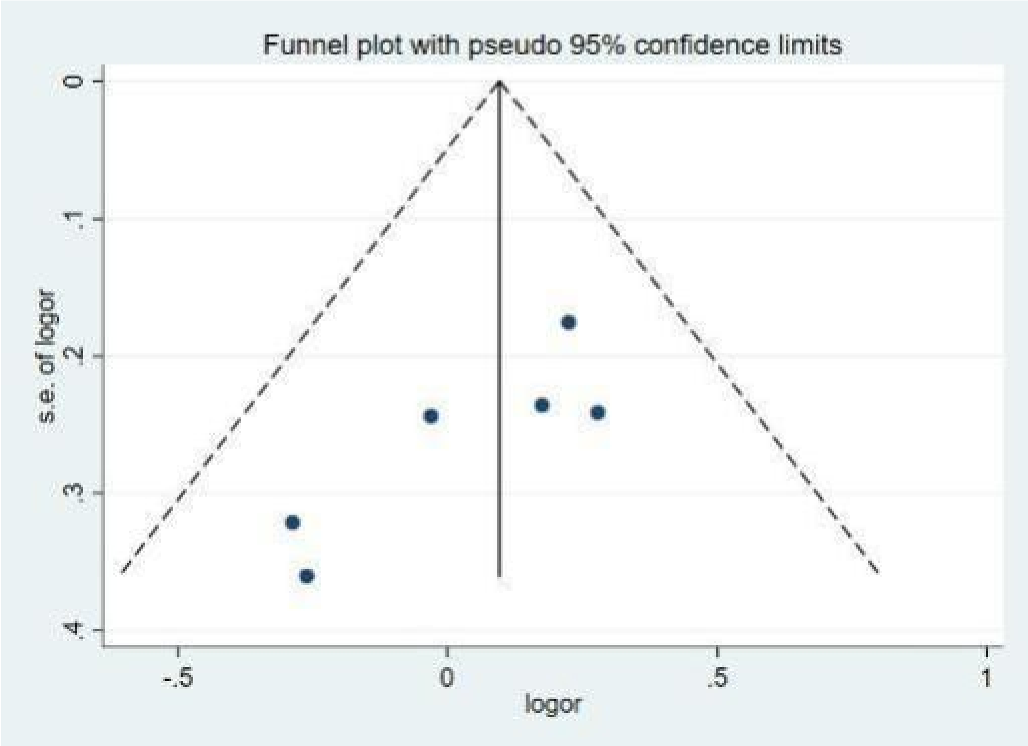
eFigure 23:Publication bias and Egger test on fiber

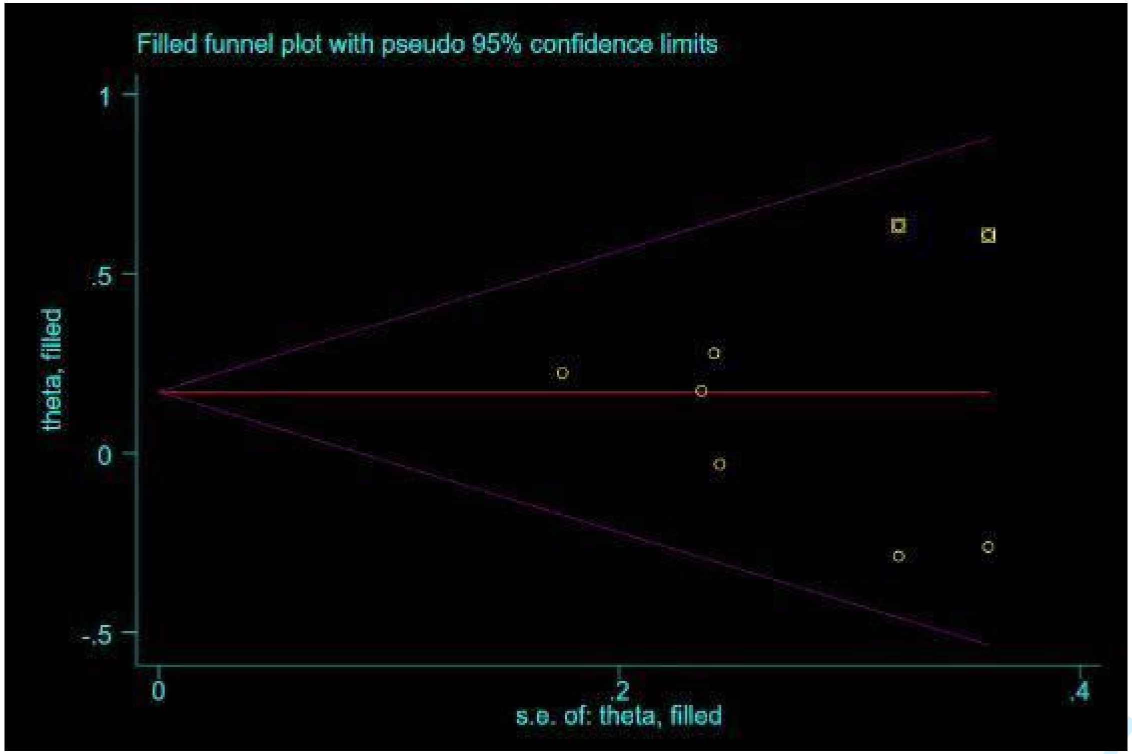




Egger test: Fruit p=0.006<0.05. Cut and complement method tips, there was no significant publication bias.

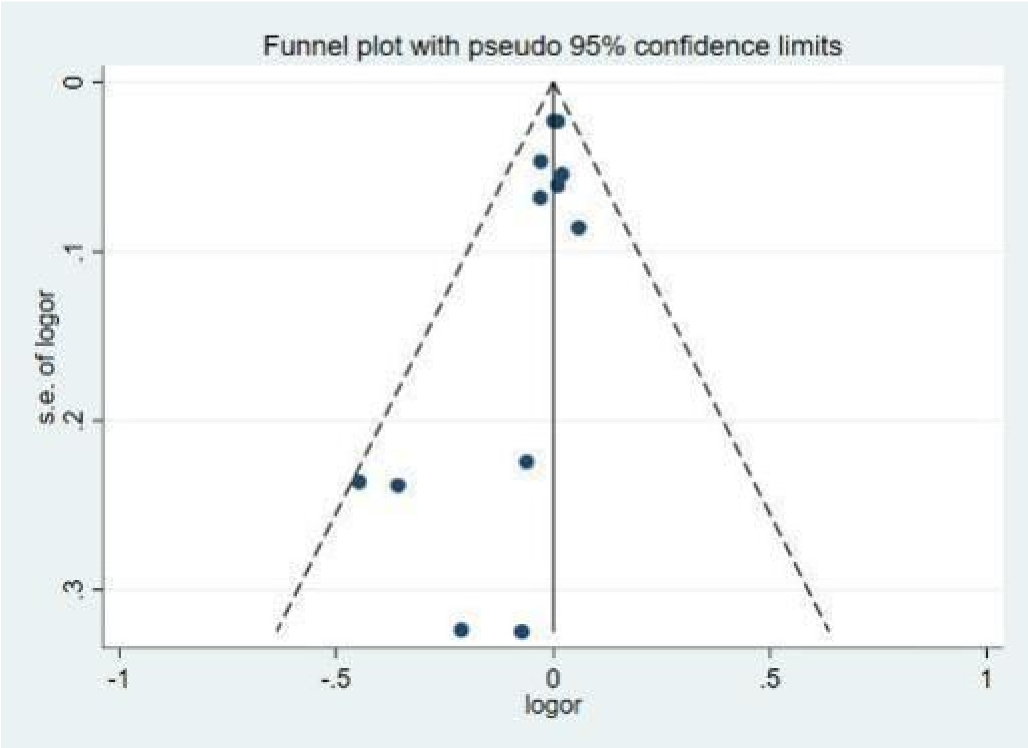
eFigure 24:Publication bias and Egger test on vegetable.

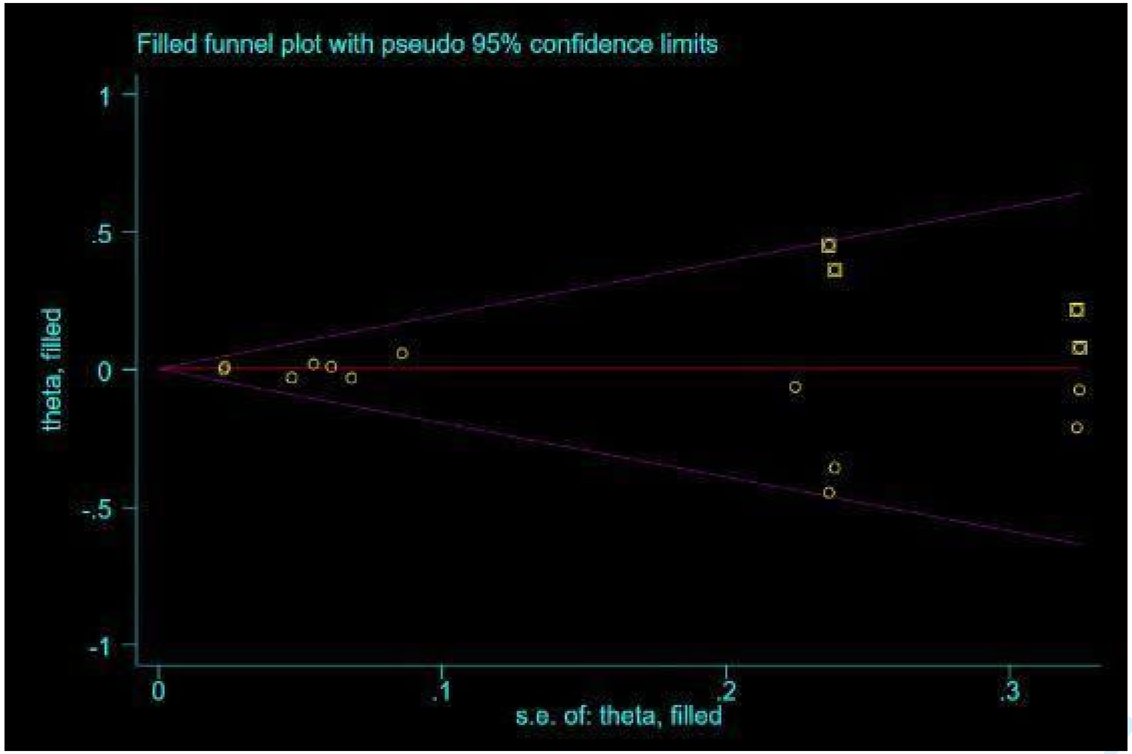




Egger test: Fruit p=0.041<0.05. Cut and complement method tips, there was no significant publication bias.

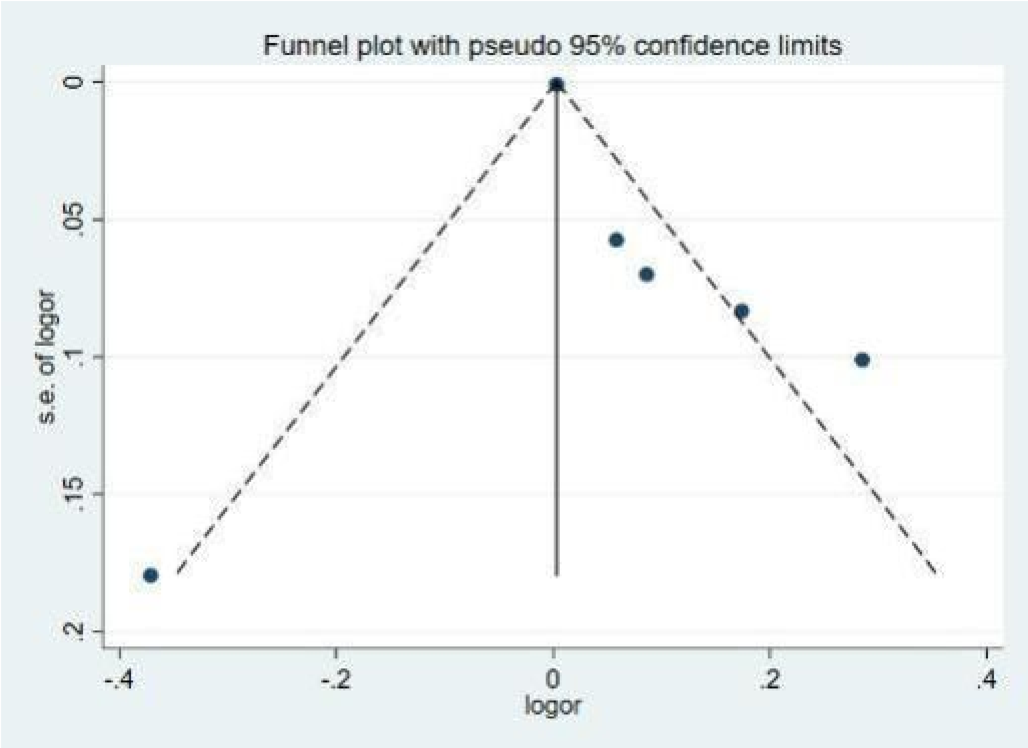
eFigure 25:Publication bias and Egger test on sugar.





Egger test: Fruit p=0.035<0.05. Cut and complement method tips, there was no significant publication bias.

eFigure 26:Publication bias and Egger test on fat.



Egger test: Fat p=0.306>0.05, there was no significant publication bias.

eTable 1. Meta-analysis of Observational Studies in Epidemiology (MOOSE) Checklist

Item No.	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	3-5
2	Hypothesis statement	3-5
3	Description of study outcome(s)	3-5
4	Type of exposure or intervention used	3-5
5	Type of study designs used	-
6	Study population	5
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	6
8	Search strategy, including time period included in the synthesis and keywords	6
9	Effort to include all available studies, including contact with authors	6, 7
10	Databases and registries searched	5,6
11	Search software used, name and version, including special features used (eg, explosion)	8
12	Use of hand searching (eg, reference lists of obtained articles)	6
13	List of citations located and those excluded, including justification	6, Fig 1
14	Method of addressing articles published in languages other than English	7
15	Method of handling abstracts and unpublished studies	6, 7
16	Description of any contact with authors	-
Reporting of methods should include		

17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	8
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	7-8
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	7
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	7
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	7
22	Assessment of heterogeneity	8
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	8
24	Provision of appropriate tables and graphics	Table 1, Fig 1
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	Fig 2, Table 1
26	Table giving descriptive information for each study included	eTable2
27	Results of sensitivity testing (eg, subgroup analysis)	eFig16-20
28	Indication of statistical uncertainty of findings	10,11
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	eFig21-26
30	Justification for exclusion (eg, exclusion of non-English language citations)	Fig 1
31	Assessment of quality of included studies	eTable 5
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	11-19
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	11-19

34	Guidelines for future research	19-20
35	Disclosure of funding source	1

eTable 2: Dietary risk ratio associated with tinnitus

Carlotta Micaela Jarach 2023a	scarce	butter	tinnitus	0.98	0.54	1.77
Carlotta Micaela Jarach 2023b	normal use or high use	butter	tinnitus	0.46	0.23	0.93
Diana Tang 2021a	2nd quartile (>188.4–231.7)	carbohydrate	tinnitus	0.74	0.47	1.17
Diana Tang 2021b	3rd quartile (231.8–280.8)	carbohydrate	tinnitus	0.739	0.47	1.15
Diana Tang 2021c	4th quartile (>280.8–577.7)	carbohydrate	tinnitus	0.55	0.34	0.9
Doh Young Lee 2018	direct	carbohydrate	tinnitus	1.001	0.999	1.001
Piers Dawes 2020a	quintile 2	Carbohydrate	tinnitus	1.03	0.94	1.14
Piers Dawes 2020b	quintile 3	Carbohydrate	tinnitus	0.98	0.88	1.11
Piers Dawes 2020c	quintile 4	Carbohydrate	tinnitus	0.99	0.86	1.14
Piers Dawes 2020d	quintile 5	Carbohydrate	tinnitus	0.93	0.78	1.1
Carlotta Micaela Jarach 2023a	50-100g/week	cheese	tinnitus	1.29	0.63	2.67
Carlotta Micaela Jarach 2023b	100+g/week	cheese	tinnitus	0.85	0.46	1.58
Abby McCormack 2014	direct	coffee	Transient tinnitus	1.020	1.010	1.031
Abby McCormack 2014a	direct	coffee	Persistent tinnitus	1.010	1.010	1.020
Abby McCormack 2014b	direct	coffee	Bothersome tinnitus	1.010	0.990	1.031
Carlotta Micaela Jarach 2023a	2nd quartile (850-1749mg)	coffee	tinnitus	0.49	0.24	0.99
Carlotta Micaela Jarach 2023b	3rd quartile (≥1750mg）	coffee	tinnitus	0.69	0.34	1.43
Jordan T Glicksman 2014a	150-299 mg/day	coffee	tinnitus	0.94	0.88	1
Jordan T Glicksman 2014b	300-449 mg/day	coffee	tinnitus	0.91	0.84	0.98
Jordan T Glicksman 2014c	450-599 mg/day	coffee	tinnitus	0.85	0.76	0.95

Jordan T Glicksman 2014d	600+ mg/day	coffee	tinnitus	0.79	0.[illegible]8	0.91
Sang-Youp Lee 2018	Age 19–39 （Daily）	coffee	tinnitus	0.8	0.[illegible]3	1
Sang-Youp Lee 2018	Age 40-64（Daily）	coffee	tinnitus	0.9	0.[illegible]3	1.1
Sang-Youp Lee 2018	Age >65（Daily）	coffee	tinnitus	0.95	0.[illegible]2	1.24
Abby McCormack 2014	direct	dairy	Transient tinnitus	0.847	0.952	0.752
Abby McCormack 2014a	direct	dairy	Persistent tinnitus	0.787	0.885	0.704
Abby McCormack 2014b	direct	dairy	Bothersome tinnitus	0.877	1.099	0.699
Christopher Spankovich 2017	direct	dairy	Persistent tinnitus	0.99	0.[illegible]1	1.50
Carlotta Micaela Jarach 2023a	16-19	diversity	tinnitus	0.53	0.[illegible]8	1
Carlotta Micaela Jarach 2023b	≥20	diversity	tinnitus	0.47	0.[illegible]4	0.9
Abby McCormack 2014	direct	egg	Transient tinnitus	1.031	1.1[illegible]	0.926
Abby McCormack 2014a	direct	egg	Persistent tinnitus	1.149	1.[illegible]	1.031
Abby McCormack 2014b	direct	egg	Bothersome tinnitus	0.901	1.[illegible]3[illegible]	0.719
Carlotta Micaela Jarach 2023a	1/week	eggs	tinnitus	0.99	0.[illegible]1	1.92
Carlotta Micaela Jarach 2023b	2+/week	eggs	tinnitus	0.54	0.[illegible]9	1
Christopher Spankovich 2017	direct	fat	Persistent tinnitus	0.69	0.49	0.99
Doh Young Lee 2018	direct	fat	tinnitus	1.003	1.001	1.005
Piers Dawes 2020a	quintile 2	fat	tinnitus	1.06	0.[illegible]5	1.19
Piers Dawes 2020b	quintile 3	fat	tinnitus	1.09	0.[illegible]5	1.25
Piers Dawes 2020c	quintile 4	fat	tinnitus	1.19	1.01	1.40
Piers Dawes 2020d	quintile 5	fat	tinnitus	1.33	1.09	1.62
Diana Tang 2021a	2nd quartile (>17.8–23.8)	fiber	tinnitus	0.6	0.[illegible]7	0.96
Diana Tang 2021b	3rd quartile (>23.8–30.6)	fiber	tinnitus	0.87	0.[illegible]6	1.37
Diana Tang 2021d	4th quartile (>30.6–89.3)	fiber	tinnitus	0.77	0.[illegible]9	1.21
Doh Young Lee 2018	direct	fiber	tinnitus	1.004	0.999	1.008
Piers Dawes 2020a	quintile 2	fiber	tinnitus	0.97	0.87	1.07
Piers Dawes 2020b	quintile 3	fiber	tinnitus	0.91	0.81	1.02
Piers Dawes 2020c	quintile 4	fiber	tinnitus	0.86	0.76	0.97
Piers Dawes 2020d	quintile 5	fiber	tinnitus	0.87	0.75	1.01

Abby McCormack 2014	direct	fish	Transient tinnitus	0.980	0.950	1.020
Abby McCormack 2014a	direct	fish	Persistent tinnitus	0.910	0.870	0.940
Abby McCormack 2014b	direct	fish	Bothersome tinnitus	1.080	0.990	1.160
Carlotta Micaela Jarach 2023a	300g/week	fish	tinnitus	1.19	0.59	2.38
Carlotta Micaela Jarach 2023b	≥450g/week	fish	tinnitus	0.75	0.41	1.4
Carlotta Micaela Jarach 2023a	900-1050g/week	fruit	tinnitus	0.96	0.47	1.97
Carlotta Micaela Jarach 2023b	≥1200g/week	fruit	tinnitus	0.78	0.43	1.44
Christopher Spankovich 2017	direct	fruit	Persistent tinnitus	0.61	0.41	0.91
Diana Tang 2021a	2nd quartile (>3.6–6.2)	fruit	tinnitus	0.47	0.29	0.76
Diana Tang 2021b	3rd quartile (>6.2–9.7)	fruit	tinnitus	0.68	0.43	1.06
Diana Tang 2021d	4th quartile (>9.7–43.9)	fruit	tinnitus	0.69	0.44	1.08
Carlotta Micaela Jarach 2023a	scarce	margarine	tinnitus	1.35	0.25	7.43
Carlotta Micaela Jarach 2023b	normal use or high use	margarine	tinnitus	1.4	0.2	9.98
Carlotta Micaela Jarach 2023a	300g/week	meat	tinnitus	1.49	0.75	2.94
Carlotta Micaela Jarach 2023b	≥450g/week	meat	tinnitus	0.97	0.51	1.85
Christopher Spankovich 2017	direct	meat	Persistent tinnitus	1.01	0.62	1.65
Carlotta Micaela Jarach 2023a	2nt quartile (1-6 cops/week)	milk	tinnitus	0.68	0.3	1.52
Carlotta Micaela Jarach 2023b	3rt quartile (7+ cops/week)	milk	tinnitus	0.85	0.46	1.55
Doh Young Lee 2018	direct	protein	tinnitus	1.002	1.001	1.004
Piers Dawes 2020a	quintile 2	protein	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	protein	tinnitus	1.01	0.89	1.13
Piers Dawes 2020c	quintile 4	protein	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	protein	tinnitus	1.06	0.9	1.26
Abby McCormack 2014	direct	sugar	Transient tinnitus	1.000	0.952	1.042
Abby McCormack 2014a	direct	sugar	Persistent tinnitus	1.010	0.971	1.064
Abby McCormack 2014b	direct	sugar	Bothersome tinnitus	0.971	0.885	1.064

Carlotta Micaela Jarach 2023a	2nt quartile (1-7 spoon/week)	sugar	tinnitus	0.93	0.49	1.75
Carlotta Micaela Jarach 2023b	3rt quartile (8+ spoon/week)	sugar	tinnitus	0.81	0.43	1.53
Diana Tang 2021a	2nd quartile (>91.0–120.1)	sugar	tinnitus	0.64	0.4	1.01
Diana Tang 2021b	3rd quartile (>120.1–154.0)	sugar	tinnitus	0.94	0.61	1.47
Diana Tang 2021c	4th quartile (>154.0–350.8)	sugar	tinnitus	0.7	0.44	1.12
Piers Dawes 2020a	quintile 2	sugar	tinnitus	1.02	0.92	1.14
Piers Dawes 2020b	quintile 3	sugar	tinnitus	1.01	0.89	1.13
Piers Dawes 2020c	quintile 4	sugar	tinnitus	0.97	0.85	1.11
Piers Dawes 2020d	quintile 5	sugar	tinnitus	1.06	0.9	1.26
Christopher Spankovich 2017	direct	variety	Persistent tinnitus	0.95	0.61	1.5
Carlotta Micaela Jarach 2023a	900-1050g/week	vegetable	tinnitus	0.77	0.38	1.56
Carlotta Micaela Jarach 2023b	≥1200g/week	vegetable	tinnitus	0.75	0.4	1.41
Christopher Spankovich 2017	direct	vegetable	Persistent tinnitus	1.25	0.9	1.79
Diana Tang 2021a	2nd quartile (>7.2–9.7)	vegetable	tinnitus	1.32	0.82	2.11
Diana Tang 2021b	3rd quartile (>9.7–12.3)	vegetable	tinnitus	0.97	0.60	1.56
Diana Tang 2021c	4th quartile (>12.3–54.5)	vegetable	tinnitus	1.19	0.75	1.89
Abby McCormack 2014	direct	vegetable and fruit	Transient tinnitus	1.000	1.000	1.010
Abby McCormack 2014a	direct	vegetable and fruit	Persistent tinnitus	1.010	1.000	1.010
Abby McCormack 2014b	direct	vegetable and fruit	Bothersome tinnitus	1.010	1.000	1.020
Carlotta Micaela Jarach 2023a	>1 liter/per day	water	tinnitus	0.84	0.43	1.65
Doh Young Lee 2018	direct	water	tinnitus	1.003	0.992	1.014

eTable 3. Evaluation of Risk of Bias Using Newcastle-Ottawa Scale（NOS) for Observational Studies

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Total
Carlotta Micaela Jarach 2023	*	*	*	*	*	*	*	*		8
Diana Tang 2021	*	*	*		*	*	*	*	*	8
Milena Tomanic 2020	*	*	*				*			4
Piers Dawes 2020	*	*	*		*	*	*			6
Sang-Yeon Lee 2019	*	*	*		*	*	*			6
Doh Young Lee 2018	*	*	*		*	*	*			6
Sang-Youp Lee 2018	*	*	*		*	*	*			6
Christopher Spankovich 2017	*	*	*		*	*	*			6
Abby McCormack 2014	*	*	*		*	*	*			6
Jordan T Glicksman 2014	*	*	*		*	*	*		*	7

eTable 4. Literature screening process

Title	Author	Whether to include
The Role of Diet in Tinnitus Onset: A Hospital-Based Case-Control Study from Italy.	Carlotta Micaela Jarach 2023	YES
Associations between intake of dietary flavonoids and the 10-year incidence of tinnitus in older adults.	Diana Tang 2022	YES
Dietary Fibre Intake and the 10-Year Incidence of Tinnitus in Older Adults.	Diana Tang 2021	YES
Relationship Between Diet, Tinnitus, and Hearing Difficulties.	Piers Dawes 2020	YES
Association of Chocolate Consumption with Hearing Loss and Tinnitus in Middle-Aged People Based on the Korean National Health and Nutrition Examination Survey 2012-2013.	Sang-Yeon Lee 2019	YES
Relationship Between Diet and Tinnitus: Korea National Health and Nutrition Examination Survey.	Doh Young Lee 2018	YES
Association of Coffee Consumption with Hearing and Tinnitus Based on a National Population-Based Survey	Sang-Youp Lee 2018	YES
Relationship between dietary quality, tinnitus and hearing level: data from the national health and nutrition examination survey, 1999-2002.	Christopher Spankovich 2017	YES
Association of dietary factors with presence and severity of tinnitus in a middle-aged UK population.	Abby McCormack 2014	YES
A prospective study of caffeine intake and risk of incident tinnitus	Jordan T. Glicksman 2014	YES
The effect of MemoVigor 2 on recent-onset idiopathic tinnitus: a randomized double-blind placebo-controlled clinical trial.	Dimitrios G Balatsouras 2024	No
The effects of dietary and physical activity interventions on tinnitus symptoms: An RCT.	Ümüş Özbey-Yücel 2023	No

Effectiveness of Tinnitan Duo in Subjective Tinnitus with Emotional Affectation: A Prospective, Interventional Study.	Jennifer Knäpper 2023	No
Hyperlipidemia and its relation with tinnitus: Cross-sectional approach.	A Musleh 2022	No
Diet Quality and the Risk of Impaired Speech Reception Threshold in Noise: The UK Biobank cohort	Humberto Yévenes-Briones 2022	No
The effect of caffeine on tinnitus: Randomized triple-blind placebo-controlled clinical trial.	Alleluia Lima Losno Ledesma 2021	No
The effects of diet and physical activity induced weight loss on the severity of tinnitus and quality of life: A randomized controlled trial.	Ümüş Özbey-Yücel 2021	No
Dietary Factors and Tinnitus among Adolescents.	Milena Tomanic 2020	No
Restriction of salt, caffeine and alcohol intake for the treatment of Ménière's disease or syndrome.	Kiran Hussain 2018	No
The effect of supplemental dietary taurine on tinnitus and auditory discrimination in an animal model.	Thomas J Brozoski 2010	No
Low energy diet and intracranial pressure in women with idiopathic intracranial hypertension: prospective cohort study.	Alexandra J Sinclair 2010	No
Caffeine abstinence: an ineffective and potentially distressing tinnitus therapy.	Lindsay St Claire 2010	No
The role of endogenous Antisecretory Factor (AF) in the treatment of Meniere's Disease: A two-year follow-up study. Preliminary results.	Pasquale Viola 2020	No
Caffeine intake and Meniere's disease: Is there relationship?	Inés Sánchez-Seller 2018	No
Tinnitus features according to caffeine consumption.	Ricardo Rodrigues Figueiredo 2021	No
The Influence of Diet on Tinnitus Severity: Results of a Large-Scale, Online Survey	Steven C. Marcrum 2022	No