

Tinnitus prevalence in Europe: a multi-country cross-sectional population study

R. Biswas,^{a,b} A. Lugo,^b M.A. Akeroyd,^a W. Schlee,^d S. Gallus,^{b*} and D.A. Hall,^{a,c}

^aHearing Sciences, Division of Clinical Neuroscience, School of Medicine, University of Nottingham, Nottingham, UK

^bDepartment of Environmental Health Sciences, Istituto di Ricerche Farmacologiche Mario Negri IRCCS, Milan, Italy

^cSchool of Social Sciences, Heriot-Watt University Malaysia, Putrajaya, Malaysia

^dDepartment of Psychiatry and Psychotherapy, University of Regensburg, Regensburg, Germany

ABSTRACT

Background Tinnitus prevalence studies report large variability across countries that might be due to inconsistent research methods. Our study aimed to report a single Pan-European estimate for tinnitus prevalence and investigate the effect of individual and country-level characteristics on prevalence. We explored the relationships of healthcare resource use and hearing difficulty with tinnitus symptoms.

Methods Between 2017-2018, a cross-sectional European Tinnitus Survey (ETS) was conducted in 12 European Union nations (Bulgaria, England, France, Germany, Greece, Ireland, Italy, Latvia, Poland, Portugal, Romania, and Spain), using a standardised set of tinnitus-related questions and response options in country-specific languages. We recruited 11,427 adults aged ≥ 18 years.

Findings Prevalence of any tinnitus was 14.7% (14.0% in men and 15.2% in women), ranging from 8.7% in Ireland to 28.3% in Bulgaria. Severe tinnitus was found in 1.2% participants (1.0% in men and 1.4% in women), ranging from 0.6% in Ireland to 4.2% in Romania. Tinnitus prevalence significantly increased with increasing age and worsening of hearing status. Healthcare resource use for tinnitus increased with increasing tinnitus symptom severity.

Interpretation This is the first multinational report of Pan-European tinnitus prevalence using standardised questions. The overall prevalence estimates refine previous findings, although widespread inter-country heterogeneity was noted. The results indicate that more than 1 in 7 adults in the EU have tinnitus. Extrapolating to the overall population, approximately 65 million adults in EU28 have tinnitus, 26 million have bothersome tinnitus and 4 million have severe tinnitus.

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Key words: tinnitus; hearing loss; health resources; epidemiology; survey

Introduction

Tinnitus, a common symptom of clinically heterogeneous pathologies, is defined as the conscious perception of an auditory sensation in the absence of a corresponding external stimulus [1]. In its debilitating form, tinnitus negatively affects emotional health, and social well-being, and can precipitate psychological distress [2], while exerting substantial individual, and societal financial burden [3,4].

No treatment successfully eliminates tinnitus, and heterogeneity regarding aetiology, perception, and distress makes it challenging to demonstrate the reproducible clinical benefit of specific therapies [5,6]. Cognitive behavioural therapy maybe more effective in reducing the negative impact of tinnitus on quality of life when compared to other forms of treatment. However, the certainty is moderate to low [7]. Therefore, it becomes crucial to take adequate preventive measures and health interventions.

Knowledge of the prevalence of a condition helps understand the magnitude of its impact on the population and inform decisions regarding resource allocation and implementation of appropriate interventions. Most studies from Western Europe and the US show a tinnitus prevalence between 10% to 15% [1]. Nonetheless,

*Corresponding author: Dr Silvano Gallus, Laboratory of Life-style Epidemiology, Department of Environmental Health Sciences, Istituto di Ricerche Farmacologiche Mario Negri IRCCS, Via Mario Negri 2; 20156 Milan, Italy

E-mail address: silvano.gallus@marionegri.it (S. Gallus).

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Research in context

Evidence before this study

The risk of developing tinnitus rises with age, and with hearing loss, but the global prevalence of tinnitus remains unknown. This knowledge gap crucially hinders engagement with the pharmaceutical industry in searching for a tinnitus cure, as well as public health programs to reduce risk. A systematic review on tinnitus prevalence and severity published in 2016 reported prevalence estimates ranging from 5% to 43%. The authors could not calculate a single global prevalence estimate for tinnitus due to variability in the assessment question and heterogeneous reporting measures. From the 35 included studies, eight different tinnitus assessment questions were identified. In these questions, the two most commonly used phrases specified the duration ("tinnitus lasting for more than five minutes at a time") and the time frame ("experiencing tinnitus in the last year") of tinnitus. Prevalence studies often seek information on the severity, or bothersomeness of tinnitus symptoms. Most studies used one or more emotional descriptors (i.e., how bothered, annoyed, or worried the symptoms made the individual) to assess tinnitus severity. Again, the variability in defining severity precluded pooling data across studies to create a global prevalence estimate for severe tinnitus. We did a literature search on 08/04/2021 using the terms "tinnitus", "prevalence", "cross-sectional", "population", and "survey", to identify any additional articles. We identified a total of 22 additional articles with information on tinnitus prevalence in the adult population. We noted the heterogeneity in assessment methods. Assessment questions addressing both duration and time frame for tinnitus symptoms narrowed the range of prevalence estimates. No multinational study on tinnitus prevalence reporting a single overall prevalence estimate and comparing between-country differences was identified. No prevalence data were available from Eastern European countries. There is an evident geographical bias in tinnitus prevalence knowledge, given that most work hitherto has been limited to individual countries (or smaller regions) predominantly in Western Europe, Australia, and the US.

Added value of this study

To our knowledge, this is the first study where the same set of cross-culturally adapted tinnitus assessment questions have been used to collect data from representative populations across 12 European Union (EU) member states. These strategically chosen countries represent the socio-cultural and economic diversity of the EU, and the population domain constitutes approximately 80% of the population aged 18 years and above across the 28 EU member states. Prevalence was high for "any" tinnitus, with one in seven adults reporting symptoms. One in 15 adults reported "bothersome" tinnitus, and one in 100 adults reported "severe" tinnitus. Tinnitus symptom severity was confirmed as a major contributor to healthcare resource use, and so bothersome and severe tinnitus are good proxies for the true societal and healthcare burden. Pan-European sampling

provided new insights on geographical variations. Differences in inter-country prevalence were substantial, even within the EU member states. The relatively high tinnitus prevalence in Eastern Europe (i.e. Bulgaria, Poland, Romania, and Latvia) reflects a general pattern of countries with lower GDP reporting a higher prevalence.

Implications of all the available evidence

The estimates measured in this Pan-European study demonstrate the substantial size of the current problem. Given the rise in life expectancy and the increasing aging population, the tinnitus-related burden is predicted to increase over the next decades. Therefore, this knowledge can guide resource allocation for implementing effective measures, and attract various stakeholders, including research funders, industrial and healthcare organisations, to engage in needful endeavours for tackling tinnitus. Since the observed inter-country variations cannot be attributed to methodological variability, future work is urgently needed to understand the underlying reasons and to identify population characteristics that make one group more vulnerable than another.

there is a lack of clear understanding of the proportion of the global population affected by tinnitus and what makes one population group more vulnerable than others. Systematic reviews on tinnitus prevalence indicate large variability and an imprecise understanding of prevalence estimates [8,9], which is a major hindrance affecting resource allocation and financial investment for tinnitus research [5].

Lack of an agreed assessment question, heterogeneous reporting measures, and geographical bias are some crucial issues that plague tinnitus epidemiological research [9]. Being a subjective condition, the impact of tinnitus symptoms depends on its perceived bothersomeness or severity. Therefore, "bothersome" or "severe" tinnitus symptoms are a better predictor for the emotional, societal, and financial burden of tinnitus than "any" tinnitus [3,4]. While epidemiological studies have attempted to distinguish any and severe tinnitus, both these concepts are troubled by lack of standardised assessment precluding comparison across countries and global meta-analysis [9]. Moreover, interpretation of the tinnitus prevalence estimates may be confounded by hearing difficulty which is a known major risk factor for tinnitus [1]. However, few population studies have addressed this directly.

The main objective of the European Tinnitus Survey (ETS) was to measure the prevalence of tinnitus in Europe using standardised methods across countries. For that, we first adapted a set of questions and response options (henceforth, referred to as items) from existing tinnitus survey questionnaires in English, and translated them into 11 European languages [10]. These items were

implemented as the ETS in 12 EU countries to assess the overall, and country-specific prevalence of any, bothersome, and severe tinnitus, and healthcare resources used for tinnitus. To the best of our knowledge, this is the first time that such rigour in across-country and across-language comparison has been done. Additionally, we investigated the effect of selected individual and country-level variables on tinnitus prevalence. We also examined the effect of tinnitus severity on healthcare resource use and assessed the proportion of individuals in whom tinnitus and hearing difficulty co-exist.

Methods

Study population and sample selection

We used cross-sectional data from a population-based survey conducted between June 2017 and October 2018, across 12 strategically selected countries from European Union (Bulgaria, England, France, Germany, Greece, Ireland, Italy, Latvia, Poland, Portugal, Romania, and Spain), representing geographical, legislative, and cultural variations across the EU. The fieldwork was conducted by Doxa, the Italian branch of the Worldwide Independent Network Gallup International Association, and its European partners. The survey methodology is similar to that of another multi-country survey, the TackSHS survey (Tackling Second-Hand Tobacco Smoke and e-cigarette emission), coordinated by the team at the Istituto di Ricerche Farmacologiche Mario Negri IRCCS (Mario Negri Institute; Milan, Italy) [11].

In each country, we recruited a sample of approximately 1,000 individuals aged 18 years and older, representative of the general population in terms of age, sex, and habitat (i.e., geographic area and/or size of a municipality). Trained interviewers conducted a face-to-face, computer-assisted personal interviewing (CAPI) survey in the 12 countries. This study was approved by the ethics committee of Mario Negri Institute (ethics

committee of Fondazione IRCCS Istituto Neurologico Carlo Besta, Milan, Italy) who notified that no preventative evaluation was required for the present study since anonymous data were collected (File number 37/2017). Details on the survey characteristics were provided to all participants by suitably qualified professionals through a structured information sheet, and all the participants provided their consents by checking the electronic field in the CAPI questionnaire. The procedures for recruitment of subjects, data collection, storage, and protection (based on anonymous identification code) are in accordance with the current country-specific legislations. The ETS protocol has been registered in clinicaltrials.gov (ID: NCT04892095). Further details of the study methods are provided in [supplementary material 1](#).

Definitions of outcomes

In [Table 1](#) the details of three different working definitions of tinnitus are reported, which were estimated as outcome measures.

Definitions of variables

Demographic characteristics included sex (men and women), and age (categorised as 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, ≥ 75 years). Level of education was categorised as country-specific tertiles of schooling years (low, intermediate, and high). Body mass index (BMI) was measured as the weight (in kg)/ height (in meters) [2]. BMI was categorised as: underweight (< 18.5 kg/m²), normal weight (≥ 18.5 kg/m² to < 25 kg/m²), overweight (≥ 25 kg/m² to < 30 kg/m²), and obese (≥ 30 kg/m²) [12]. Marital status categories included married/live-in partner, divorced/separated, widowed, and single. Hearing difficulty was investigated using the question “Do you currently have any other difficulty with your hearing, such as listening to speech in a noisy situation?”. Participants who responded “no difficulty” were included in the

Outcome of interest	Question	Responses marked as positive	Responses marked as negative
Any tinnitus	Over the past year, have you had noises (such as ringing or buzzing) in your head or in one or both ears that lasts for more than five minutes at a time?	Yes, most or all of time / Yes, a lot of the time / Yes, some of the time	No, not in the past year / No, never
Bothersome tinnitus	Over the past year, how much do these noises in your head or ears worry, annoy or upset you when they are at their worst?	Severely / Moderately	Slightly / Not at all
Severe tinnitus	Over the past year, how much do these noises in your head or ears worry, annoy or upset you when they are at their worst?	Severely	Moderately / Slightly/ Not at all
Use of healthcare resources	Over the past year, have you seen your family doctor, or seen a healthcare professional at a clinic or hospital about problems with noises in your head or ears?	One visit/ 2 to 4 visits/ 5 or more visits	Not at all

Table 1: Details of outcome variables with assessment questions and response categories.

no hearing difficulty category (reference), those who responded “yes, slight difficulty” were included in the slight hearing difficulty category, and those who responded “cannot hear at all” / “moderate difficulty” / “severe difficulty” were collectively included in the bothersome hearing difficulty category. The 12 European countries were classified into Northern (England and Ireland), Western (France and Germany), Southern (Italy, Greece, Portugal, and Spain), and Eastern (Bulgaria, Poland, Romania, and Latvia), following United Nations regional groups and the UN standard country codes [13,14]. For each country, information on the gross domestic product (GDP) per capita (in Euros) was derived from the Eurostat data, 2018 [15]. Since there is no standard method available to stratify high income countries into relatively higher and lower income groups, the countries were categorised into lower (Latvia, Romania, Poland, Portugal, Greece, and Bulgaria) and higher (England, France, Germany, Ireland, Italy, and Spain) GDP per capita groups relative to the median GDP per capita for the 12 countries i.e., €21,550.

Statistical analysis

Statistical weights were used to generate representative population estimates for each country (individual weights). Additionally, for the entire sample, we considered country weights, which combined individual weights with an additional weighting factor with each country contributing in proportion to its population aged ≥ 18 years derived from Eurostat [16]. Descriptive statistics were calculated as absolute numbers and proportions. Weighted prevalence estimates were calculated using individual and country weights and reported for any, bothersome, and severe tinnitus. Weighted percentages were also estimated for socio-demographic characteristics, country characteristics, healthcare resource use, and hearing difficulty in subjects with tinnitus. Odds ratios (OR) and their corresponding 95% confidence intervals (CI) were estimated using unconditional multiple logistic models with sex, age, and level of education as adjusting variables. Country weights were used in all logistic regression models. Analyses were performed with SAS 9.4 (SAS Institute; Cary, NC, US).

Role of the funding source

The funders had no role in the study design, data collection, data analysis, data interpretation, writing, or interpretation of the manuscript, and the decision to submit it for publication. The corresponding author had full access to all the data in the study, and had final responsibility for the decision to submit for publication.

Results

Among 11,427 participants (5404 men and 6023 women) aged 18 to 99 years (participants' age was 18 to

64 in Greece, and 18 to 74 years in Latvia), 14.7% reported any tinnitus (14.0% men and 15.2% women), 6.0% reported bothersome tinnitus (5.0% men and 6.6% women), and 1.2% reported severe tinnitus (1.0% men and 1.4% women) (Table 2). The prevalence estimates for any tinnitus ranged from 8.7% in Ireland to 28.3% in Bulgaria, for bothersome tinnitus from 3.4% in Ireland to 11.5% in Bulgaria, and for severe tinnitus from 0.6% in Ireland to 4.2% in Romania (Figure 1A-C). The category of severe tinnitus in each country had small sample sizes ranging from seven individuals with severe tinnitus in Ireland to 35 individuals in Romania. The only statistically reliable pattern by geographical region was that Western European countries had significantly lower odds of any tinnitus compared to Northern European countries (OR was 0.69; 95% CI: 0.52-0.92) (Table 3).

Sex, age, education, BMI, and marital status were the selected individual-level variables on tinnitus prevalence. After adjusting for age and level of education, the OR for women compared to men was statistically significant only for bothersome tinnitus (OR: 1.26; 95% CI: 1.07-1.48) (Table 3). With increasing age, the prevalence of any, bothersome, and severe tinnitus increased (p for trends < 0.001). The ORs for almost all age groups were significantly higher than the reference category, which included subjects aged 18-34 years. The prevalence increased with age for both men and women for all three forms of tinnitus severity (Figure 2).

We found a statistically significant inverse relationship between level of education and the three definitions of tinnitus (p for trends were < 0.001). ORs for high compared to low level of education were 0.81 (95% CI: 0.70-0.94) for any tinnitus, and 0.57 (95% CI: 0.46-0.72) for bothersome tinnitus, while no significant OR was observed for severe tinnitus (OR: 0.82; 95% CI: 0.51-1.32). There were no statistically significant relationships between BMI and marital status, and tinnitus, except for widows who reported having significantly greater odds of severe tinnitus (OR: 2.18; 95% CI: 1.32-3.59) compared to married individuals (Table 3).

Pan-European healthcare resource use for tinnitus is shown in Figure 1D. The overall percentage of subjects with tinnitus reporting at least one clinical visit for tinnitus over the past year was 6.8%, with the highest values for Bulgaria at 13.4%, and the least for Greece at 4.1%. Overall, the number of clinic visits increased with tinnitus symptom severity (Figure 3). 2.1% of subjects who were slightly bothered by tinnitus reported 5 or more clinic visits, rising to 7.5% of those moderately bothered, and 26.4% of those severely bothered. This pattern indicates that tinnitus severity is a crucial factor in determining healthcare resource use.

Prevalence of all the three definitions of tinnitus significantly increased with increasing hearing difficulty (p for trend < 0.001). ORs for bothersome hearing difficulty compared to no difficulty were 18.53 (95% CI: 15.55-

Characteristics	N ^b	Any tinnitus		Bothersome tinnitus		Severe tinnitus	
		(%) ^a	95% CI	(%) ^a	95% CI	(%) ^a	95% CI
Total	11427	14.7	13.6, 15.5	6.0	5.3, 6.5	1.2	1.0-1.4
Individual level characteristics							
Sex							
Men	5404	14.0	12.8, 15.2	5.0	4.2, 5.8	1.0	0.7, 1.3
Women	6023	15.2	13.9, 16.4	6.6	5.7, 7.5	1.4	1.0, 1.9
Age groups							
18-34	2935	7.2	5.9, 8.4	1.6	1.0, 2.2	0.3	0.06, 0.6
35-44	2195	10.0	8.2, 11.6	3.5	2.4, 4.5	0.7	0.1, 1.2
45-54	2275	13.3	11.1, 15.4	5.8	4.3, 7.2	1.4	0.7, 2.0
55-64	1992	18.1	15.3, 20.2	6.6	5.2, 8.1	1.3	0.7, 1.8
65-74	1482	26.3	23.2, 29.8	12.0	9.6, 14.4	2.5	1.3, 3.6
>=75	548	30.4	25.7, 35.8	16.1	12.1, 20.0	3.7	1.5, 5.9
Education^b							
Low	4036	19.5	17.9, 21.4	9.6	8.3, 10.9	1.8	1.2, 2.4
Intermediate	4184	11.4	10.2, 12.8	3.5	2.8, 4.2	1.0	0.6, 1.4
High	3204	12.0	10.3, 13.5	3.7	2.9, 4.6	1.0	0.5, 1.4
BMI^b							
Underweight	277	10.2	5.3, 15.0	2.1	0.30, 3.7	0.1	-
Normal	4947	12.4	11.1, 13.7	5.0	4.1, 5.8	1.1	0.7, 1.5
Overweight	3810	16.7	15.1, 18.5	6.8	5.6, 8.0	1.3	0.8, 1.8
Obese	1597	18.2	15.3, 21.0	8.3	6.2, 10.2	2.3	1.2, 3.3
Marital status							
Married or cohabitant	6499	14.5	13.2, 15.6	5.7	4.9, 6.4	1.0	0.6, 1.3
Divorced	1483	16.3	14.0, 19.1	7.4	5.3, 9.3	1.7	0.7, 2.6
Widowed	861	26.6	22.8, 31.6	14.6	11.0, 18.3	4.1	2.0, 6.2
Single	2584	10.2	8.6, 11.9	3.0	2.1, 3.7	0.8	0.3, 1.2
Hearing difficulty^b							
No difficulty	8839	6.5	5.9, 7.1	1.7	1.4, 2.1	0.3	0.2, 0.4
Slight difficulty	1451	39.0	34.7, 42.3	11.7	9.1, 14.2	2.0	0.9, 3.1
Moderate	725	58.7	53.1, 63.6	38.6	33.3, 44.0	7.3	4.3, 10.3
Severe difficulty	190	67.3	57.1, 77.0	50.5	40.1, 60.6	16.9	9.4, 24.5
Cannot hear at all	16	55.2	20.8, 89.5	49.0	15.5, 82.4	43.3	10.6, 76.0
Country-level characteristics							
GDP per capita							
High	5617	13.5	12.4, 14.6	5.4	4.7, 6.3	0.9	0.6, 1.2
Low	5810	17.1	15.5, 18.8	6.6	5.5, 7.7	1.8	1.2, 2.4
Geographic region							
Eastern	3714	19.2	16.5, 22.0	7.8	6.1, 9.6	2.1	1.2, 2.8
Western	1883	12.8	11.3, 14.4	5.7	4.6, 6.8	1.0	0.5, 1.5
Northern	1948	14.8	12.7, 16.9	5.2	3.9, 6.5	0.9	0.3, 1.3
Southern	3882	14.3	12.7, 15.9	5.2	4.3, 6.2	1.2	0.7, 1.6

Table 2: Weighted prevalence estimates and 95% confidence intervals for any, bothersome, and severe tinnitus, overall and according to selected individual-level and country-specific characteristics, across 12 European countries, measured between 2017 and 2018.

BMI, body mass index, GDP, gross domestic product

^a Country weight was applied, which combines individual weight with an additional weighting factor, with each country contributing in proportion to its population aged 18 years and above.

^b Sample size (N) is the unweighted number of survey participants. The numbers for education, BMI and hearing difficulty do not add up to the total because of missing values.

22.08) for any tinnitus, 33.21 (95% CI: 26.37-41.82) for bothersome tinnitus, and 30.03 (95% CI: 18.77-48.04) for severe tinnitus (Table 3). Healthcare resource use was 8.2% in countries with lower GDP per capita, and 6.3% in those with higher GDP per capita, and it was

8.9% in Eastern, 6.2% in Western, 5.7% in Northern, and 6.7% in Southern European countries (Figure 1E). Countries with a lower GDP per capita had significantly higher prevalence of any (OR: 1.38; 95% CI: 1.23-1.54), bothersome (OR: 1.26; 95% CI: 1.06-1.48), and severe

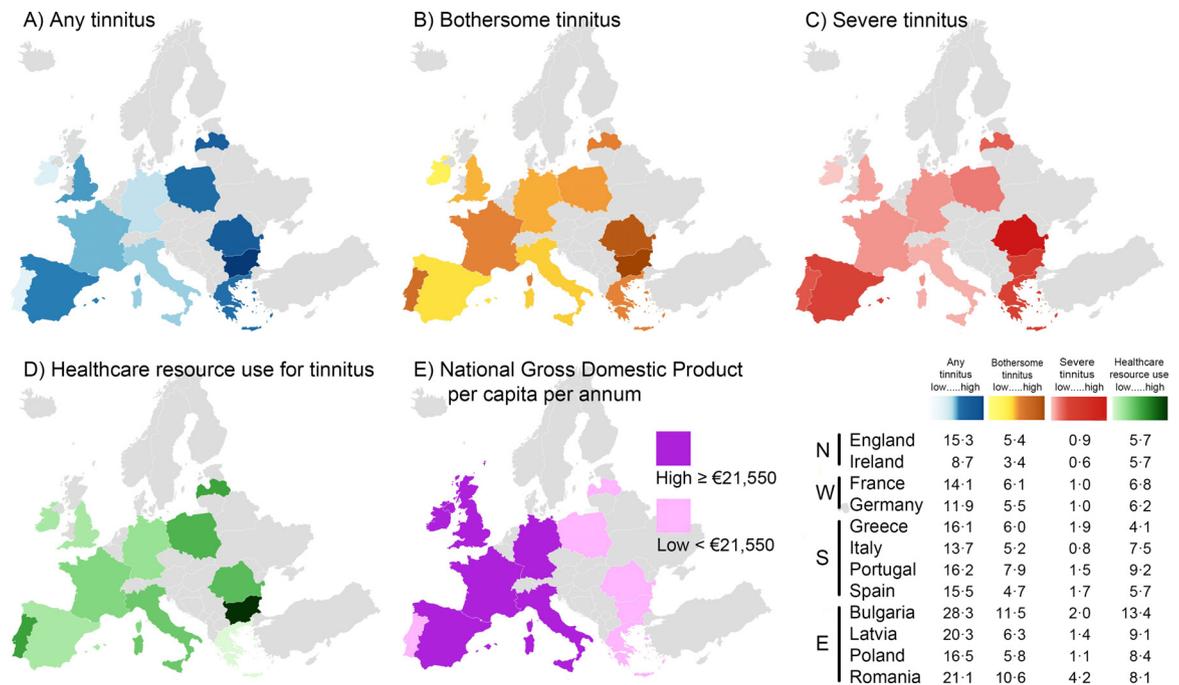


Figure 1. Colour gradient map of (A) prevalence of any tinnitus, (B) prevalence of bothersome tinnitus, (C) prevalence of severe tinnitus, (D) healthcare resource use for tinnitus, and (E) national GDP per capita per annum. Data are for 12 European countries, measured between 2017 and 2018. The darker the colour the greater the values, and numeric values are reported in the bottom right panel.

tinnitus (OR: 2.07; 95% CI: 1.48-2.90) compared to higher GDP per capita (Table 3).

Discussion

The ETS is the first study of its kind where multinational data on tinnitus was collected using the same standardised survey questions and response options across countries. The data showed an overall prevalence of any tinnitus of 14.7%, which is at the upper end of the expected 10-15% range found in previous studies [1]. The prevalence for bothersome tinnitus was less than half for any tinnitus at 6%, and that of severe tinnitus was 1.2%, which is less than one out of ten subjects with any tinnitus. The variability in tinnitus prevalence was widespread, with the Eastern European countries showing consistently higher prevalence for all three working definitions of tinnitus, and Western European countries having the lowest prevalence of any tinnitus. Age and hearing difficulty were directly related to tinnitus prevalence. Healthcare resource use varied between countries, and a higher prevalence of tinnitus and higher GDP per capita resulted in greater resource use. Tinnitus symptom severity played a crucial factor in determining tinnitus-related healthcare resource use with an increasing number of clinical visits with increased symptom severity. GDP per capita and level of education were inversely related to tinnitus

prevalence. Sex differences were inconsistent, and no significant relationship was found between BMI and marital status, and tinnitus.

This study found substantial inter-country differences in tinnitus prevalence with estimates of any tinnitus ranging between 8.7% in Ireland and 28.3% in Bulgaria, and those of severe tinnitus between 0.6% in Ireland and 4.2% in Romania. The published literature on tinnitus focuses on Western European countries [1]. There is no previous data on tinnitus prevalence in Eastern European countries like Bulgaria, Romania, and Latvia. This study provides the first prevalence information on these countries. Interestingly, these countries had the highest prevalence estimates. In the published literature, heterogeneous assessment methods are identified as one of the most important causes of variability in tinnitus prevalence [9]. The use of culturally adapted questions and response options in this survey, precludes the possibility of variability due to diverse assessment methods. The countries with high tinnitus prevalence also had comparatively lower GDP per capita. Countries with higher GDP per capita are known to allocate more resources to health and safety [17]. Hence, more healthcare resources could be accessible for people with tinnitus along with the availability of more protective measures, leading to reduced prevalence. Previous studies have not investigated the role of country-specific GDP per capita from a tinnitus perspective.

Characteristics	N ^b	OR ^a (95% CI)		
		Any tinnitus ^c	Bothersome Tinnitus ^c	Severe Tinnitus ^c
Sex				
Men	5404	Ref	Ref	Ref
Women	6023	1.03 (0.93-1.15)	1.26 (1.07-1.48)	1.36 (0.97-1.92)
Age groups				
18-34	2935	Ref	Ref	Ref
35-44	2195	1.42 (1.17-1.74)	2.22 (1.54-3.21)	2.04 (0.90-4.65)
45-54	2275	2.05 (1.70-2.47)	3.62 (2.58-5.08)	4.26 (2.05-8.86)
55-64	1992	2.74 (2.28-3.31)	3.85 (2.73-5.42)	3.73 (1.74-7.99)
65-74	1482	4.57 (3.77-5.54)	6.83 (4.87-9.58)	7.49 (3.59-15.63)
>=75	548	5.68 (4.53-7.11)	9.20 (6.40-13.23)	11.86 (5.48-25.67)
P for trend		<0.001	<0.001	<0.001
Education^d				
Low	4036	Ref	Ref	Ref
Intermediate	4184	0.80 (0.70-0.91)	0.53 (0.43-0.65)	0.91 (0.60-1.39)
High	3204	0.81 (0.70-0.94)	0.57 (0.46-0.72)	0.82 (0.51-1.32)
P for trend		<0.001	<0.001	<0.001
BMI^d				
Underweight	277	0.93 (0.63-1.37)	0.51 (0.23-1.14)	0.11 (0.00-4.12)
Normal	4947	Ref	Ref	Ref
Overweight	3810	1.17 (1.03-1.32)	1.09 (0.91-1.32)	0.95 (0.64-1.40)
Obese	1597	1.17 (0.98-1.38)	1.20 (0.95-1.53)	1.44 (0.91-2.29)
Marital status				
Married or cohabitant	6499	Ref	Ref	Ref
Divorced	1483	0.88 (0.75-1.04)	0.98 (0.78-1.24)	1.30 (0.80-2.11)
Widowed	861	1.07 (0.87-1.31)	1.28 (0.98-1.66)	2.18 (1.32-3.59)
Single	2584	0.97 (0.83-1.15)	0.81 (0.62-1.06)	1.35 (0.78-2.31)
Hearing difficulty^d				
No difficulty	8839	Ref	Ref	Ref
Slight difficulty	1451	7.77 (6.72-8.99)	6.27 (4.94-7.96)	5.41 (3.14-9.33)
Bothersome hearing difficulty	931	18.53 (15.55-22.08)	33.21 (26.37-41.82)	30.03 (18.77-48.04)
P for trend		<0.001	<0.001	<0.001
GDP per capita				
High	5617	Ref	Ref	Ref
Low	5810	1.38 (1.23-1.54)	1.26 (1.06-1.48)	2.07 (1.48-2.90)
Geographic regions				
Eastern	3714	1.22 (0.88-1.68)	1.27 (0.82-1.98)	1.88 (0.82-4.33)
Western	1883	0.69 (0.52-0.92)	0.88 (0.60-1.31)	0.93 (0.43-2.01)
Northern	1948	Ref	Ref	Ref
Southern	3882	0.79 (0.59-1.05)	0.80 (0.54-1.20)	1.08 (0.50-2.35)

Table 3: Odd ratios (OR) and corresponding 95% confidence intervals (CI) for any, bothersome, and severe tinnitus according to selected individual-level and country-specific characteristics. 12 European countries, 2017-2018.

BMI, body mass index; CI, confidence interval; GDP, gross domestic product; OR, odds ratio; Ref, Reference category

Statistically significant ORs at 0.05 level are in bold

^a ORs and the corresponding 95% CIs were estimated using unconditional multiple logistic regression adjusting for sex, age and level of education.

^b Sample size (N) is the unweighted number of survey participants.

^c Country weight was applied, which combines individual weight with an additional weighting factor, with each country contributing in proportion to its population aged 18 years and above.

^d The numbers for education, BMI and hearing difficulty do not add up to the total because of missing values.

Since hearing loss and tinnitus are closely related conditions, it seems reasonable to compare our findings with hearing loss prevalence patterns. Looking across countries, tinnitus prevalence followed the same pattern as hearing loss prevalence [18]. This was not true for self-

reported hearing difficulty (See [Supplementary material 2](#)), but such discrepancies are well documented [19,20].

Inconsistent sex differences for tinnitus prevalence were observed. These findings are in alignment with the available literature [9]. Only for bothersome tinnitus

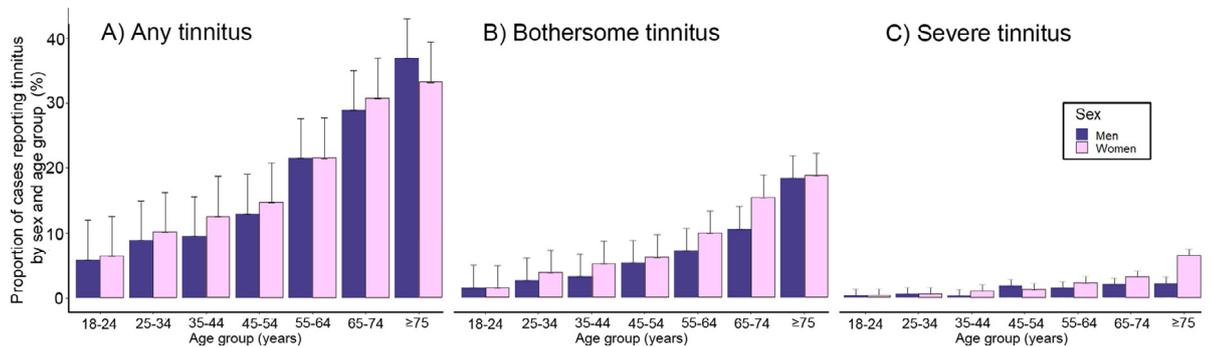


Figure 2. Pan-European distribution of any, bothersome, and severe tinnitus by sex and age groups in deciles.

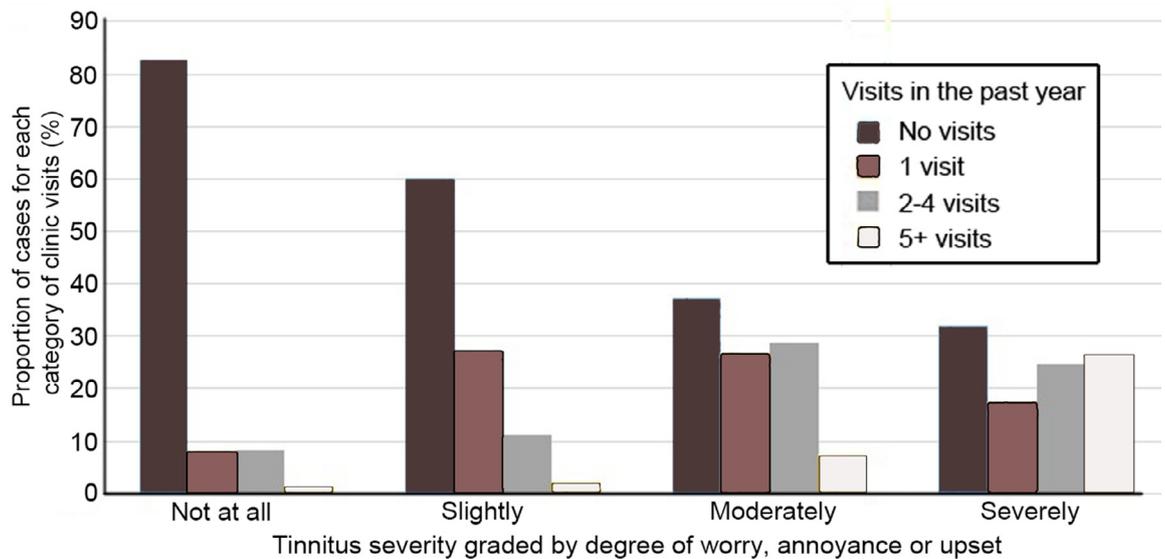


Figure 3. Pan-European pattern of healthcare resource use according to tinnitus severity. ‘Use’ defined by the reported number of visits to the family doctor, or healthcare professional at a clinic or hospital about problems for tinnitus during the past year.

women had a significantly higher prevalence than men. In men, a tendency to downplay or deny the severity of symptoms has been noted, leading to underreporting [21]. For self-reported conditions like tinnitus, it is difficult to conclude if the difference is real or an artefact of behavioural differences, as the reported bothersomeness of tinnitus would depend on difference in attitude and perception. The study results showed an increase in tinnitus prevalence with increasing age and these results are in alignment with previously published literature [8,22]. In their systematic review, McCormack and colleagues reported a peak around 70 years and a decline in prevalence thereafter [9]. In this study, the prevalence of tinnitus showed an increasing trend with age and no decline. However, given that there were relatively lesser number of participants in the 75 years and older category, it is difficult to conclude whether this was a true pattern. A recent meta-analysis reported increased tinnitus likelihood in obese individuals [23].

Considering the global impact of obesity, it seemed worthwhile to examine whether BMI influences tinnitus prevalence in this multinational data. No significant relationship was observed.

The study findings demonstrate that increased severity of tinnitus symptoms lead to an increased number of clinic visits. This makes sense since those experiencing a bigger problem have greater reason to seek professional help. In this study, the two variables, tinnitus severity and healthcare resource use, were independently rated by the subjects. However, it is interesting to note that other investigators have explicitly defined severe tinnitus according to clinical help seeking behavior [24]. Tinnitus exerts a substantial financial burden on the healthcare system [3,4]. This means that more severe tinnitus requires more financial and personnel involvement, and poses an additional burden on healthcare resources. Therefore, despite any tinnitus affecting more people, perhaps the severe form is more of a

concern given the burden it imposes on global and national healthcare systems.

Strengths

This is a novel approach to collect multi-country data on tinnitus using the same standardised survey questions and response options [10]. For each country, the study sample was representative of the sex, age, and geographic habitat. Hence, the findings are expected to be generalisable to the entire country population. Additionally, the face-to-face interview using CAPI minimises measurement bias that could be introduced using handwritten, or self-administered surveys. The 12 countries included in this survey represent the different socio-economic and cultural variability of the EU countries, and cover approximately 80% of the EU population. Collecting data from all the 28 countries of the EU to ascertain Pan-European prevalence would incur expenses, time, and have feasibility issues. Therefore, this strategic selection of countries is a reasonable approach to assess the Pan-European prevalence of tinnitus.

Limitations

The country-specific sample sizes were relatively limited. The prevalence of any tinnitus is likely to be stable given its relative commonality. But for severe tinnitus, which is a rarer condition, a larger sample size would have provided more stable estimates. Moreover, for Greece and Latvia, the study population was aged 18 to 64 years, and 18 to 74 years, respectively. This lack of recruitment into the older age group (≥ 75) means that the findings in these countries do not represent the whole adult population. For all other countries, adults aged ≥ 75 were recruited, but these were comparatively fewer in number than the other age groups. There were some minor differences in the methodology (for example, sampling methods) across countries and that could potentially introduce small biases.

Future directions

Higher values of tinnitus prevalence are concentrated in specific geographic locations (for example, Eastern Europe), where hearing loss prevalence is also higher [18]. It could be interesting to look at potential genetic and environmental factors leading to such differences. Similarities between statistical maps of genetic variation and geographic maps of population location have been reported in recent studies, and are particularly prominent within Europe where there is a strong correlation between genetic and geographic distance [25,26]. Environmental factors such as, occupational noise exposure, protective hearing devices, noise control regulations, and attitude towards noise, play crucial roles in hearing functions. Exposure to occupational health hazards like industrial noise exposure increases tinnitus risk. The

EU policy framework directive on occupational health and safety has positively impacted the assessment and management of occupational risk factors, and has set common standards across the EU [27]. The countries with high tinnitus prevalence were accessed to the EU in the 2000s, and consequently, came under the EU legislation much later. Future work needs to assess the environmental and occupational noise exposure guidelines in countries with high prevalence of tinnitus and other hearing related conditions.

In their study, Gallus and colleagues found a relatively low tinnitus prevalence in Italy and suggested a potential protective role of the Mediterranean diet [8]. Curhan and colleagues reported a protective role of alternative Mediterranean diet for hearing loss [28]. It might be interesting to examine if there are substantial dietary variations across countries that impact tinnitus prevalence. Apart from measurable determinants, factors like cultural influence and attitude towards a given condition can give rise to differences in measures of estimates. However, they could be challenging to assess and control for in a research setting.

Concluding remarks

The overall population in the EU28 was almost 514 million with approximately 85% adults, aged 18 years and above [29]. Extrapolating our figures indicates that approximately 65 million individuals in the EU28 report any tinnitus, 26 million report bothersome tinnitus, and 4.4 million report severe tinnitus. With limited evidence available for the efficacy of management interventions, there remains an obvious need to evaluate methods to reduce tinnitus-related burden. Resource allocation, policy interventions, stricter regulations, and increased awareness are pertinent to curtail this burden. Heterogeneity affects tinnitus epidemiology, pathophysiology, diagnosis, and treatment. By providing the first estimates of Pan-European tinnitus prevalence, this study starts to resolve questions about global tinnitus prevalence.

Contributors

DAH, WS, and SG conceived and designed the study. SG and AL provided fieldwork supervision for data collection. RB and AL curated the data, and RB did the statistical analysis. RB, DAH, MAA, and SG contributed to data interpretation. RB wrote the first draft of the Article. All authors approved the final version of the Article. RB, AL, and SG had access to the raw data.

Data sharing

Data are available upon reasonable request to the corresponding author.

Declaration of Interests

DAH provides scientific consultancy for Neuromod Devices Ltd and is in receipt of honoraria from Elsevier. WS is the executive director of Lenox UG, consulting. Lenox UG provides scientific consultancy for Pansatori GmbH and realised a project together with Sivantos. WS is a speaker of the Scientific Advisory Board of Pansatori GmbH, and scientific organiser for the Tinnitus Research Initiative (TRI). All other authors declare no competing interests.

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Supplementary materials

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