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A systematic review of the reporting of tinnitus prevalence and severity

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ABSTRACT

Introduction: There is no standard diagnostic criterion for tinnitus, although some clinical assessment instruments do exist for identifying patient complaints. Within epidemiological studies the presence of tinnitus is determined primarily by self-report, typically in response to a single question. Using these methods prevalence figures vary widely. Given the variety of published estimates worldwide, we assessed and collated published prevalence estimates of tinnitus and tinnitus severity, creating a narrative synthesis of the data. The variability between prevalence estimates was investigated in order to determine any barriers to data synthesis and to identify reasons for heterogeneity.
Methods: and analysis: A systematic review included all adult population studies reporting the prevalence of tinnitus from January 1980 to July 2015. We searched five databases (Embase, Medline, PsychInfo, CINAHL and Web Of Science), using a combination of medical subject headings (MeSH) and relevant text words. Observational studies including cross-sectional studies were included, but studies estimating the incidence of tinnitus (e.g. cohort studies) were outside the scope of this systematic review.
Results: The databases identified 875 papers and a further 16 were identified through manual searching. After duplicates were removed, 515 remained. On the basis of the title, abstract and full-text screening, 400, 48 and 27 papers respectively were removed. This left 40 papers, reporting 39 different studies, for data extraction. Sixteen countries were represented, with the majority of the studies from the European region (38.5%). Publications since 2010 represented half of all included studies (48.7%). Overall prevalence figures for each study ranged from 5.1% to 42.7%. For the 12 studies that used the same definition of tinnitus, prevalence ranged from 11.9% to 30.3%. Twenty-six studies (66.7%) reported tinnitus prevalence by different age groups, and generally showed an increase in prevalence as age increases. Half the studies reported tinnitus prevalence by gender. The pattern generally showed higher tinnitus prevalence among males than females. There were 8 different types of definitions of tinnitus, the most common being *"tinnitus lasting for more than five minutes at a time"* (34.3%). Only seven studies gave any justification for the question that was used, or acknowledged the lack of standard questions for tinnitus. There is widespread inconsistency in defining and reporting tinnitus, leading to variability in prevalence estimates among studies. Nearly half of the included studies had a high risk of bias and this limits the generalisability of prevalence estimates. In addition, the available prevalence data is heterogeneous thereby preventing the ability to pool the data and perform meta-analyses. Sources of heterogeneity include different diagnostic criteria, different age groups, different study focus and differences in reporting and analysis of the results. Heterogeneity thus made comparison across studies impracticable.
Conclusion: Deriving global estimates of the prevalence of tinnitus involves combining results from studies which are consistent in their definition and measurement of tinnitus, survey methodology and in the reporting and analysis of the results. Ultimately comparison among studies is unachievable without such consistency. The strength of this systematic review is in providing a record of all the available, recent epidemiological data in each global region and in making recommendations for promoting standardisation.

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Contents

1. Introduction

Tinnitus is a common complaint defined as a sound in the head or ears that occurs in the absence of any external acoustical source (Baguley et al., 2013). Many tinnitus patients are not bothered by the sound and do not seek medical help. For others, it can impact on quality of life (Nondahl et al., 2007) and cause debilitating problems such as depression, anxiety, frustration and insomnia.

Understanding the prevalence of a condition in a defined population is important for improvement of health and prevention of that condition (Moller, 2011). Epidemiological data can be utilised to provide up-to-date tinnitus prevalence estimates globally. Estimates of tinnitus are essential for setting the priorities of interventions, selection of strategies for implementation, and monitoring of programmes at both national and global level (Pascolini and Smith, 2009). However, standardisation in defining the condition and in collecting and analysing the data is essential in order to be able to pool prevalence data together, thereby increasing confidence in the prevalence estimate.

With respect to the epidemiology of hearing loss, Duijvestijn and colleagues (Duijvestijn et al., 1999) found that the different definitions of hearing impairment partly explain the variation in prevalence figures of hearing impairment found in the literature. In a Dutch sample of 1041 participants aged 55 years and older, prevalence of hearing impairment was calculated based on nine criteria including: participant's subjective impression, five Dutch and international audiometric definitions, consultation of a General Practitioner, referral to an ENT specialist and hearing aid possession. Due to these different criteria, prevalence figures ranged from 6% to 30% for women and from 10% to 49% for men. This variability was observed despite the World Health Organisation defining grades of hearing impairment and recommending standard ways for collection and analysis of data (World Health Organisation, 1991). For example, it is recommended that epidemiological surveys of hearing impairment should follow the WHO Ear and Hearing Disorders Survey Protocol (World Health Organisation, 1999).

No such standardisation exists for tinnitus. Therefore, there remain some uncertainties about its true prevalence. This systematic review aimed to provide a greater understanding of the recording and reporting of tinnitus prevalence, and what is the 'correct' variability in reported prevalence estimates. A number of epidemiological studies on tinnitus have been conducted in specific population groups, for example, noise exposed workers (Kim and Chung, 2002) or patients attending audiology clinics (Negrila-Mezei et al., 2011). However, to consider what the global prevalence of tinnitus may be, it is important that studies have randomly selected samples and are population based, to allow accurate up-to-date estimates of tinnitus prevalence in the general population.

1.1. Objectives

The objectives of the review were to conduct a world-wide search of the recent published literature reporting tinnitus prevalence and severity figures, to examine the range of prevalence figures for representative samples of the population, and to explore reasons for heterogeneity in reporting. Specifically, our primary research questions were to collate global prevalence estimates for tinnitus and, where possible, to report prevalence by age-bands and gender. Secondary aims were to collate prevalence estimates for bothersome tinnitus, and again to report these prevalence figures by age-bands and gender. A third aim was to examine potential explanations for heterogeneity in prevalence reporting.

2. Method

Methods are reported according to the Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) guidelines (Moher et al., 2009) Subheadings correspond to some of the items in the PRISMA guidelines, as appropriate. A review protocol was registered at PROSPERO (http://www.crd.york.ac.uk/PROSPERO), registration number CRD42013003649.

2.1. Eligibility criteria

For maximum inclusivity we included all human participants, with the only restrictions being adults (≥18 years). Where studies enrolled participants younger than 18 years, data was extracted only for participants who were 18 years and above. All studies needed to report the prevalence of tinnitus occurrence or severity.

All studies, internationally, were considered. The literature search was restricted to articles published on or after 01 January 1980, where the data must also not have been collected pre-1980. This date was chosen because the last major epidemiological study of hearing took place in the early 1980's (National Study of Hearing (Davis, 1995)), and the 35 year timescale replicates the timescale in a similar systematic review compiling epidemiological studies of hearing impairment (Pascolini and Smith, 2009). Publications not in the English language were translated where possible.

For studies based on a representative population sample, a suitable design would be cross-sectional. However, the baseline testing of appropriate cohort studies could also be used for this purpose and might be separately reported in publications. Case-control studies were excluded, as the case/control split is usually atypical of the population from which the sample is taken. Studies that only estimated the incidence of tinnitus were outside the scope of this systematic review. Examples of restricted sampling include noise exposed workers; medical students; veterans with post-traumatic stress disorder, or otology patients. Gender was not considered a criterion for restricted sampling because our aim was to report prevalence figures by gender where possible.

2.2. Search strategy

The electronic research databases Embase, medline, PsychInfo, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Web of Science were searched on 01 July 2015. The search identified articles published from 01 January 1980 to 01 July 2015 inclusive. Hence this date is the upper limit of eligibility in this review. A search strategy was carefully specified to capture all potentially eligible records relating to tinnitus prevalence. We used a combination of Medical Subject Headings (MeSH) and relevant text words wherever possible. An example of the search criteria used for CINAHL is shown in Table 1. We also searched reference lists of those review articles that had been identified in the search. We did not apply any language restrictions.

2.3. Study selection

Once the search had been run, a three-step process reviewed all records according to the eligibility criteria: first by reading the title; second by reading the abstract; and third by reading the full text. The full text was obtained for all potentially relevant records appearing to meet the inclusion criteria or for which there was insufficient information in the title and abstract to make a firm decision. Two review authors performed each key step independently for every record. Any discrepancies at each step were reviewed by a third author and a decision was made after discussion. Where multiple publications from the same study existed, all publications that met the inclusion criteria were included.

2.4. Data extraction

The method for data extraction was developed and piloted on a random selection of 10 studies by two review authors. Uncertainties were resolved by discussion and the data extraction form was modified, to include greater clarification for items to assist the review authors. The final data items included for data extraction were: year of study/publication, location, aim of the study, study design, selection method, sample size, age groups, gender, the question/definition of tinnitus occurrence or severity, and prevalence data reported by age and gender where possible. The data extraction form also included the questions needed to answer risk of bias. For studies that included participants younger than 18 years, only the data for those over 18 years was included. Where age was not available, we contacted the corresponding author by email (without a reminder) to seek clarification. Four authors were contacted to request a breakdown of their data. One replied (Widen and Erlandsson, 2004) with data for 18 years and over, but the other three did not (Jalessi et al., 2013; Mahboubi et al., 2013; Pilgramm et al., 1999), so we could not include the data. Where the year of data collection was not reported in the article, we sought other supporting evidence to make a reasonable estimate as to when this was. This additional information can be found in Supplementary Table S1.

2.5. Risk of bias in individual studies

Bias is typically considered to be a systematic error that can lead to an overestimation or underestimation of the true effect (Higgins and Green, 2011). Biases can vary in magnitude. Some are small and can be considered trivial compared with the observed effect, and some are substantial so that an apparent finding may be entirely due to bias. Differences in risks of bias can help explain variation in the results of the included studies. More rigorous studies are more likely to yield results that are closer to the truth. Because the review question is that of prevalence of tinnitus in the population, the main risk of bias in studies is that of selection bias (i.e. a non-

Table 1
Search criteria for CINAHL.

#	Query
S9	S1 AND S2 AND S5 AND S8
S8	S6 OR S7
S7	middle AND age*
S6	adult* OR adult/OR middle age/
S5	S3 OR S4
S4	?etiology
S3	observational OR epidemiolog* OR epidemiology/OR case control OR case control studies/OR cohort stud* OR prospective studies/OR cohort analy* OR cross section* OR cross sectional studies/OR population OR population/
S2	tinnit*s OR tinnitus/OR (ringing AND ear*) OR (buzzing AND ear*) OR (noise AND ear*)
S1	prevalence OR prevalence/

*Truncation symbol to search all keyword variant endings and plurals which may be relevant for the search.

representative sample). This risk of bias was accounted for during the screening process. Any studies that had restrictive sampling failed the eligibility criteria and were not included in the review. Three other sources of bias were assessed in this review: i) non-response bias (e.g. low response rate), ii) measurement bias (poorly measuring the outcome you are measuring), and iii) analysis bias (poor analysis or reporting decisions). All three are important sources of bias for prevalence studies (Hoy et al., 2012).

First, we addressed non-response bias with the two questions: 'Were non-responders reported or investigated?' and 'Do the authors summarise response rates?'. Second, we addressed measurement bias with the two questions: 'What is the method of tinnitus measurement?' and 'Has the question been validated, used before, or justification for use been given?'. Examples of methods for tinnitus measurement include self report or a published questionnaire such as Tinnitus Handicap Inventory (THI, (Newman et al., 1996). Finally, we addressed analysis bias with the question: 'What is the completeness of data collection/reporting? Namely, is there any missing information or any other questions?' Each risk of bias question scored 2 (fully reported), 1 (partially reported), or 0 (unclear/not reported). Scores for each risk of bias question were added together to give a total score between 0 and 10. A score of 0–3 was considered high risk of bias; 4–6 was considered moderate risk of bias; and 7–10 was considered low risk of bias. The risk of bias assessment was performed by two independent raters. Differences were resolved by discussion among the two raters.

2.6. Data synthesis

The main purpose of this systematic review was to collate prevalence estimates for tinnitus prevalence and to provide a narrative synthesis of global estimates. Where possible, a second aim was to collate prevalence estimates for bothersome tinnitus. The third aim was to identify potential explanations for heterogeneity in prevalence figures by considering how studies have recorded and reported data.

3. Results

3.1. Search results

The process of study selection is presented in a flow chart (Fig. 1).

The systematic search of electronic databases identified 875 articles, and a subsequent manual search of bibliographies of included studies identified an additional 16 articles. After duplicates were removed, 515 articles remained. At title screening, 400 articles were removed due to: restricted sampling ($n = 267$); out of scope with the question ($n = 90$); paediatric population aged less than 18 years ($n = 29$); a focus on risk factors for tinnitus ($n = 10$); studies not involving humans ($n = 2$); and out of the date range ($n = 2$). The abstract screen removed 48 articles for similar reasons: restricted sampling ($n = 20$), out of scope ($n = 27$), paediatric population aged less than 18 years ($n = 1$). Some examples of restricted sampling include populations such as patients with an otology issue; tinnitus patients only; noise-exposed workers; college students from a medical school; and veterans with post-traumatic stress disorder.

After the initial title and abstract screening, 67 articles remained and the full text was retrieved. Twenty seven of the full texts were excluded. Reasons were insufficient data for reporting prevalence ($n = 14$), restricted sampling ($n = 4$), out of scope ($n = 3$), paediatric population aged less than 18 years ($n = 1$), focus on risk factors ($n = 3$), out of date range ($n = 2$). This left 40 articles included in the review for data extraction, reporting 39 different studies. Multiple papers from the same study are included because they provide relevant information for data extraction. Specifically, two papers from the National Study of Hearing (Davis, 1989, 1995) and two papers reporting data from UK Biobank (Dawes et al., 2014; McCormack et al., 2014) are included. These have each been consolidated into one entry. One book chapter (Hoffman and Reed, 2004) reports data for two large-scale studies in the US: the 1990 National Health Interview Survey (NHIS) and the 1994–1995 NHIS and so have been reported as two entries. For clarity, four other studies (Adams and Marano, 1995; Adams et al., 1999; Benson and Marano, 1998; Ries, 1994) also report data from the NHIS for different time periods so these have been reported as separate entries rather than consolidated into one. There are also three papers from the Beaver Dam study (Nondahl et al., 2002, 2011, 2007). These have not been consolidated because they each report data from different study periods. Two papers from the Nord-Trondelag Hearing Loss Study survey are also reported separately because one reports tinnitus prevalence (Engdahl et al., 2012) and the other reports tinnitus severity (Krog et al., 2010).

3.2. Study characteristics

The characteristics of the 39 included studies are reported in Table 2. This gives details of the year(s) of data collection, city and country, sample size, age, and gender. As the aim was to look at global prevalence figures of tinnitus, the studies have been presented by World Health Organisation (WHO) regions and the countries within each region are listed in alphabetical order. The majority of the studies were from the European region (15/39, 38.5%), followed by the Region of the Americas (12/39, 30.8%), and the Western Pacific Region (10/39, 25.6%), and one each from South East Asia Region (1/39, 2.6%), and African Region (1/39, 2.6%). Sixteen different countries are represented. Studies published since 2010 represented half of all studies (19/39, 48.7%), followed by 2000s (10/39, 25.6%), then 1990s (8/39, 20.5%), then 1980s (2/39, 5.1%).

Six studies (Cho et al., 2010; Davis, 1989, 1995; Hannaford et al., 2005; Park et al., 2014; Shargorodsky et al., 2010; Xu et al., 2011) included participants younger than 18 years old, but we report data only for those over 18 years old. Studies had an age range of a single age (Welch and Dawes, 2008) to 81-year age range (Engdahl et al., 2012; Krog et al., 2010). Sample size ranged from 498 (Gibrin et al., 2013) to 172,621 (Dawes et al., 2014; McCormack et al., 2014). Four studies did not report the sample size (Adams and Marano, 1995; Adams et al., 1999; Benson and Marano, 1998; Ries, 1994). All studies examined prevalence of tinnitus in males and females, except one study (Parving et al., 1993) which only considered males. Seventeen studies did not report the numbers of males and females.

3.3. Prevalence

Table 3 summarises the data by displaying the overall prevalence figures for each included study. The interested reader is referred to Supplementary Table S2 which provides full details of all prevalence rates for current tinnitus and bothersome tinnitus for all studies, split by age and gender.

Overall tinnitus prevalence figures for each study ranged from 5.1% (Quaranta et al.,1996) to 42.7% (Gibrin et al., 2013). Tinnitus severity was assessed in 16 studies. The prevalence of bothersome tinnitus ranged from 3.0% (Michikawa et al., 2010) to 30.9% (Kim et al., 2015). Even comparing those studies that used the most common type of tinnitus question ('tinnitus lasting for more than five minutes at a time'), the prevalence figures reported for current tinnitus vary widely from 11.9% (Fujii et al., 2011) to 30.3%

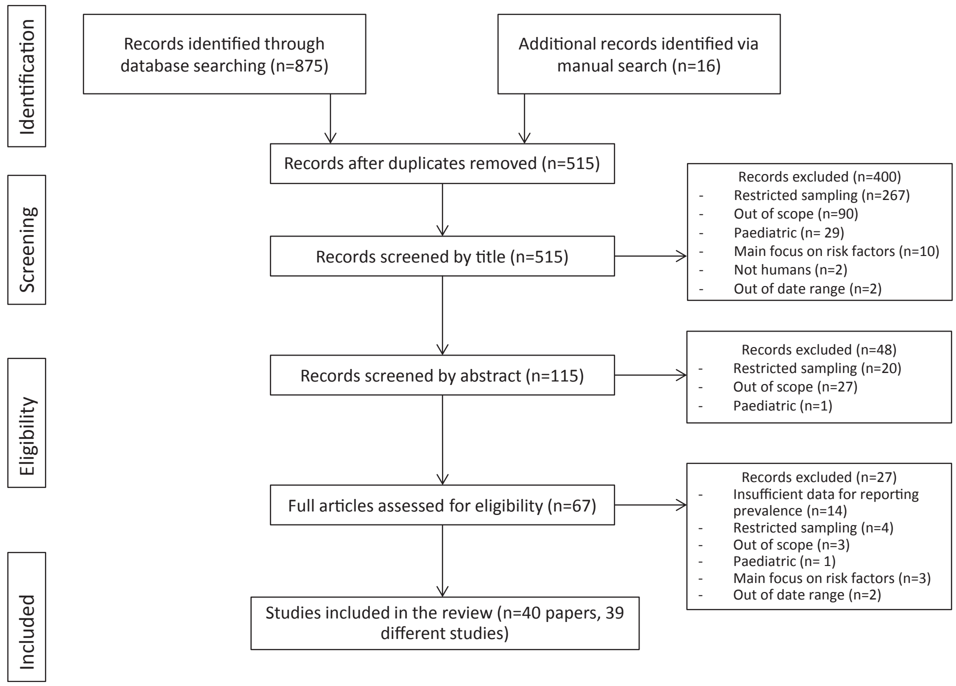

Fig. 1. Flowchart of systematic review according to the PRISMA statement.

(Sindhusake et al., 2003). Out of the 12 studies that used this question, six had similar age bands. Even among these studies there was substantial variability in the prevalence figures reported. For 40–50 year olds, the prevalence of current tinnitus ranged from 11.2% to 25.0% (Davis, 1989, 1995; Fujii et al., 2011; Hasson et al., 2010). For 50–60 year olds, the prevalence ranged from 9.5% to 29.8% (Davis, 1989, 1995; Fujii et al., 2011; Hasson et al., 2010; Johansson and Arlinger, 2003; Xu et al., 2011). For 60–70 year olds, the prevalence ranged from 13.3% to 33.5% (Davis, 1989, 1995; Fujii et al., 2011; Hasson et al., 2010; Johansson and Arlinger, 2003; Sindhusake et al., 2003; Xu et al., 2011). For 70–80 year olds, the prevalence ranged from 15.0% to 31.7% (Davis, 1989, 1995; Fujii et al., 2011; Johansson and Arlinger, 2003; Sindhusake et al., 2003; Xu et al., 2011). Of these 12 studies, five also examined tinnitus severity. The prevalence of bothersome tinnitus ranged from 3.0% (Michikawa et al., 2010) to 30.7% (Hasson et al., 2010), again showing substantial variability.

Twenty-six studies reported tinnitus prevalence or severity by different age groups. But these studies reported age somewhat differently. Some reported age by ten-year age bands (Axelsson and Ringdahl, 1989; Cho et al., 2010; Davis, 1989, 1995; Fujii et al., 2011; Hasson et al., 2010; Johansson and Arlinger, 2003; Nondahl et al., 2002, 2011; Oiticica and Bittar, 2015; Park et al., 2014; Park and Moon, 2014; Shargorodsky et al., 2010; Xu et al., 2011), fifteen-year age bands (Hannaford et al., 2005), or twenty-year age bands (Khedr et al., 2010). Others reported age by a mixture of age bands (Adams and Marano, 1995; Adams et al., 1999; Benson and Marano, 1998; Engdahl et al., 2012; Krog et al., 2010; Michikawa et al., 2010; Ries, 1994; Sindhusake et al., 2003). And some did not report in age bands at all (Baigi et al., 2011; Dawes et al., 2014; Demeester et al., 2007; Gibrin et al., 2013; Hannula et al., 2011; Kim et al., 2015; Lasisi et al., 2010; McCormack et al., 2014; Nondahl et al., 2007; Parving et al., 1993; Quaranta et al., 1996; Sugiura et al., 2008; Widen and Erlandsson, 2004). The most common way of reporting age groups was by decade to decade (i.e. 20–29 and so on), as was the case in twelve different studies (see Supplementary Table S3). The prevalence figures generally show an increase in tinnitus prevalence as age increases. However, some show a peak at around 70 years of age, where the prevalence then starts to decline as age increases. For completeness of reporting, we note that several studies enrolled only people of a single age (Kuttila et al., 2005; Welch and Dawes, 2008).

Approximately half of the studies ($n = 20$) reported tinnitus prevalence by gender, and nine reported tinnitus severity by gender. The majority ($n = 16$, 80%) show a higher prevalence of tinnitus for males than females. However, those studies reporting severity by gender do not show a similar pattern, with half of the studies finding a higher prevalence of tinnitus severity in males, and the other half finding a higher prevalence of tinnitus severity in females, and one study showed the same rate of tinnitus severity for males and females (Welch and Dawes, 2008).

3.4. Definitions of tinnitus and tinnitus severity

The main aim for just over half of the studies (22/39) was to assess tinnitus prevalence. Most of the others investigated the epidemiology of hearing disorders in general, or associations between tinnitus and mental health, quality of life, personality, noise, stress or magnetic resonance imaging. There was a wide variation among the studies on the definition of tinnitus that was used to determine prevalence (see Supplementary Table S4). The three studies from the Beaver Dam dataset (Nondahl et al., 2002, 2011, 2007) used the same questions and have been consolidated in Supplementary Table S4. Two studies from the NHIS ((Adams and Marano, 1995; Benson and Marano, 1998) used the same question and have also been consolidated for Supplementary Table S4. The other studies from the NHIS report different questions. It is possible that the wording of questions changed at different study periods. The two studies from the Nord Trondelag Hearing Loss Study ((Engdahl et al., 2012; Krog et al., 2010) also used the same questions and have been reported as one in Supplementary Table S4. Therefore there were 35 different studies defining tinnitus and tinnitus severity and these have been grouped into categories (Table 4) in order to examine the variability in the question asked.

Table 2
Study characteristics of the included studies.

Study ref	Authors and year	Year data collected	City, country	Study design	Sample size	Age groups	Gender
European region							
1	Demeester et al., 2007	1998–2002	Antwerp, Belgium	Cross-sectional	1147	55–65	F = 598, M = 549
2	Parving et al., 1993	1985/1986	Copenhagen, Denmark	Cross-sectional	3387	53–75	Males only
3	Kuttila et al., 2005	NR but after 1996	Finland	Cross-sectional	1720	25, 35, 45, 55, 65	M = 785 (45.6%), F = 935 (53.4%)
4	Hannula et al., 2011	1998–2002	Oulu, Finland	Cross-sectional	850	54–66	M = 383 (45.1%), F = 467 (54.9%)
5	Quaranta et al., 1996	NR but after 1989	Milan, Bari, Padua, Florence and Palermo; Italy.	Cross-sectional	2170	18–80	M = 1127, F = 1043
6	Krog et al., 2010	1995–1997	Nord-Trondelag county of Norway	Cross sectional	51,574	20–101	M = 24,139, F = 27,435
7	Engdahl et al., 2012	1996–1998	Nord-Trondelag county of Norway	Cross-sectional	49,948	20–101	M = 23,374; F = 26,574
8	Hannaford et al., 2005	1998	Scotland	Cross-sectional	11,565	≥30	Numbers of M and F not reported
9	Axelsson and Ringdahl, 1989	1989	Gothenburg, Sweden	Cross-sectional	2378	20–80	F = 1243, M = 1135
10	Johansson and Arlinger, 2003	1999–2000	Sweden	Cross-sectional	590	20–80	M = 260, F = 330
11	Widen and Erlandsson, 2004	NR but after 2004	Goteborg and Vanersborg, Sweden	Cross-sectional	558	18–20	Numbers of M and F not reported
12	Hasson et al., 2010	2008	Sweden	Cross-sectional	11,441	19–70	M = 5086 (45%), F = 6355 (55%)
13	Baigi et al., 2011	2011 (data collected in 2004)	Sweden	Cross-sectional	12,166	18–84	F = 52.8%
14	Davis 1989; Davis 1995	1980–1986	UK	Cross-sectional	24,584	31–99	Numbers of M and F not reported
15	Dawes et al., 2014; McCormack et al., 2014	2006–2010	UK	Cross-sectional	172,621	40–69	Numbers of M and F not reported
Western Pacific region							
16	Sindhusake et al., 2003	1997–1999	Blue Mountains, Sydney, Australia	Cross-sectional	2696	≥55	M = 859, F = 1156
17	Xu et al., 2011	2005–2006	Jiangsu province, China	Cross-sectional	5375	20–93	M = 2508, F = 2867
18	Sugiura et al., 2008	2000–2002	Japan	Cross-sectional	2193	41–82	M = 1152, F = 1107
19	Michikawa et al., 2010	2006	Kurabucki town, Japan	Cross-sectional	1320	≥65	M = 584 (44.2%), F = 736 (55.8%)
20	Fujii et al., 2011	2002	Takayama City, Gifu, Japan	Cohort	14,423	45–79	M = 6450, F = 7973
21	Welch and Dawes 2008	2004–2005	Dunedin, New Zealand	Cohort	970	32	M = 494, F = 476
22	Cho et al., 2010	2008	South Korea	Cross-sectional	4930	≥19	F = 2738, M = 2192
23	Park et al., 2014	2009–2011	South Korea	Cross-sectional	21,893	≥19	Numbers of M and F not reported
24	Park and Moon, 2014	2010–2011	South Korea	Cross-sectional	10,061	≥20	Numbers of M and F not reported
25	Jong Kim et al., 2015	2009–2012	South Korea	Cross-sectional	19,290	≥20	Numbers of M and F not reported
Region of the Americas							
26	Gibrin et al., 2013	NR but after 2009	Brazil	Cross-sectional	498	≥60	Numbers of M and F not reported
27	Oiticica & Bittar, 2015	2012	Sao Paulo, Brazil	Cross-sectional	1960	≥18	Numbers of M and F not reported
28	Hoffman and Reed, 2004	1990	USA	Cross-sectional	53,343	≥20	Numbers of M and F not reported
29	Ries, 1994	1990–1991	USA	Cross-sectional	NR	≥18	Numbers of M and F not reported
30	Adams and Marano, 1995	1994	USA	Cross-sectional		≥18	Numbers of M and F not reported
31	Benson and Marano, 1998	1995	USA	Cross-sectional	NR	≥18	Numbers of M and F not reported
32	Hoffman and Reed, 2004	1994–1995	USA	Cross-sectional	99,435	≥20	M = 41.1%; F = 58.9%
33	Adams et al., 1999	1996	USA	Cross-sectional	NR	≥18	Numbers of M and F not reported
34	Nondahl et al., 2002	1993–1995	Beaver Dam, Wisconsin, USA	Cohort	3753	48–92	Numbers of M and F not reported
35	Nondahl et al., 2007	1998–2000	Beaver Dam, Wisconsin, USA	Cohort	2800	53–97	Numbers of M and F not reported
36	Nondahl et al., 2011	2005–2008	Beaver Dam, Wisconsin, USA	Cohort	3267	21–84	M = 1483, F = 1784

(continued on next page)

Table 2 (*continued*)

Study ref	Authors and year	Year data collected	City, country	Study design	Sample size	Age groups	Gender
37	Shargorodsky et al., 2010	1999–2004	USA	Cross-sectional	14,178	≥20	Numbers of M and F not reported
South East Asia region							
38	Khedr et al., 2010	2008–2009	Assiut, Egypt	Cross-sectional	8484	≥18	Numbers of M and F not reported
African region							
39	Lasisi et al., 2010	2008	Nigeria	Cohort	1302	≥65	M = 552 (42.4%), F = 750 (57.6%)

Table 3
Overall prevalence figures for each study.

Study reference	Age	Sample size (n =)	Current tinnitus			Bothersome tinnitus		
			Female (%)	Male (%)	Overall (%)	Female (%)	Male (%)	Overall (%)
1	55–65	1147	–	–	19.3 (n = 221)	–	–	–
2	53–75	3387	–	17 (n = 576)	17 (n = NR)	–	3 (n = 101)	3 (n = 101)
3	25–65	F = 913; M = 763; All = 1676	15 (n = 137)	16 (n = 122)	15 (n = 259)	–	–	–
4	54–66	F = 467; M = 383; All = 850	–	–	29.2 (n = 248)	–	–	–
5	18–80	2170	–	–	14.5	–	–	–
6	20–101	F = 26,574; M = 23,374; All = 49,948	–	–	–	6.9 (n = 1887)	11.7 (n = 2812)	9.3 (n = NR)
7	20–101	F = 26,574; M = 23,374; All = 49,948	12.1 (n = 3215)	16.4 (n = 3833)	14.3 (n = NR)	–	–	–
8	≥30	–	21 (n = NR)	23 (n = NR)	22 (n = NR)	–	–	–
9	20–79	F = 1243; M = 1135; All = 2378	12.1 (n = 150)	16.5 (n = 187)	14.2 (n = 337)	18 (n = 27)	16.6 (n = 31)	17.2 (n = 58)
10	20–80	F = 330; M = 260; All = 590	8.9 (N = 29)	17.6 (N = 46)	13.2 (N = 78)	–	–	–
11	18–20	558	–	–	9 (n = 52)	–	–	–
12	19–70	–	23.7 (n = NR)	32.5 (n = NR)	27.8 (n = NR)	–	–	30.7 (n = 943)
13	18–84	12,166	–	–	16.6 (n = NR)	–	–	–
14	31–99	–	–	–	15.2 (n = NR)	–	–	–
15	40–69	–	14.1 (n = NR)	18.4 (n = NR)	16.2 (n = NR)	3.5 (n = NR)	4.1 (n = NR)	3.8 (n = NR)
16	55–89	F = 1156; M = 859; All = 2015	28.6 (n = 330)	32.2 (n = 272)	30.3 (n = 602)	19.1 (n = 221)	10.3 (n = 88)	16.2 (n = 326)
17	20–93		21.4 (n = NR)	19.6 (n = NR)	20.7 (n = NR)	–	–	–
18	41–82	2193	336 (n = NR)	407 (n = NR)	33.8 (743)	–	–	–
19	≥65	F = 736; M = 584; All = 1320	19 (n = 140)	18 (n = 105)	18.6 (n = 245)	3.4 (n = 25)	2.6 (n = 15)	3.0 (n = 40)
20	45–79	F = 7973; M = 6450; All = 14,423	10.7 (n = 857)	13.2 (n = 853)	11.9 (n = 1710)	20.2 (n = 173)	21.9 (n = 187)	21.1
21	32	F = 476; M = 494; All = 970	5.5 (n = 26)	8.1 (n = 40)	6.8 (n = 66)	8.7 (n = 18)	8.7 (n = 20)	8.7 (n = 38)
22	19–80	–	23 (n = NR)	16.9 (n = NR)	20.5 (n = NR)	–	–	–
23	≥19	–	21.7 (n = NR)	17.7 (n = NR)	19.7 (n = NR)	30.2 (n = NR)	28.3 (n = NR)	29.2 (n = NR)
24	≥20	10,061	22.8 (n = 1300)	19.5 (n = 849)	21.4 (2149)	7.7 (n = 441)	6.8 (n = 295)	7.3 (n = 736)
25	≥20	19,290	–	–	20.7 (n = 4234)	–	–	30.9 (n = 1434)
26	≥60	498	–	–	42.7 (n = 213)	–	–	–
27	≥18	1960	–	–	22 (n = 430)	–	–	–
28	≥20	59,343	–	–	–	–	–	9.7
29	≥18	–	–	–	12.2 (n = NR)			
30	≥18	–			6.1 (n = NR)	–	–	–
31	≥18	–	–	–	5.1 (n = NR)	–	–	–
32	≥20	99,435	–	–	5.4	–	–	–
33	≥18	–	–	–	6.2 (n = NR)	–	–	–
34	48–92	F = 2155; M = 1582; All = 3737				7.8 (n = 168)	8.8 (n = 139)	8.2 (n = 306)
35	53–97	F 1606 M 1143 Missing 51 All 2800	–	–	24.6 (675)	–	–	9.4 (n = 258)
36	21–84	F = 1784; M = 1483; All = 3267				9.4 (n = NR)	11.9 (n = NR)	10.6 (n = NR)
37	≥30	F = 7387; M = 6791; All = 14,178	24.6 (n = NR)	26.1 (n = NR)	25.4 (n = NR)	–	–	–
38	≥20	–	–	–	10.1 (n = NR)	–	–	–
39	≥65	F = 750; M = 552	14.7 (n = 110)	13.4 (n = 74)	14.1 (n = 184)	–	–	–

There were eight different types of questions or definitions of tinnitus. Two studies did not report the question at all (Gibrin et al., 2013; Ries, 1994).

The most common type of definition was 'tinnitus lasting for more than five minutes at a time' (n = 12/35, 34.3% of studies). Most of these questions referred to 'nowadays', but some did not clarify a time frame. The second most common definition was 'experiencing tinnitus in the last year' (n = 9/35, 25.7% of studies). Only 7 studies gave any justification for the question that was used, or acknowledged the lack of standardisation. When we consider only the 20 studies that reported tinnitus prevalence as a main aim, four different types of questions were used. The two most common types of definition were the same (i.e. 'tinnitus lasting for more than five minutes at a time' and 'experiencing tinnitus in the last year').

Questions also had very different response options. The majority of the questions had a response option of 'yes' or 'no' (n = 24). Other response options included words such as 'occasional', 'seldom', 'rarely', 'sometimes', 'often', 'recurrent', 'most of the time', 'always', 'yes in the past'. Some studies did not report the response options (Gibrin et al., 2013; Khedr et al., 2010; Quaranta et al., 1996; Ries, 1994).

Severity of tinnitus symptoms was assessed in 13 different studies. There was substantial variability in how studies assessed tinnitus severity. Most of them (8/13 = 61.5%) measured severity by how bothered or annoyed the person was by their tinnitus. Three

Table 4
Number of studies of tinnitus prevalence and severity by type of question.

Tinnitus prevalence	No. of studies	Study reference
Tinnitus lasting for more than 5 min at a time	12/35 = 34.3%	1, 2, 4, 5, 8, 10, 12, 14, 15, 16, 17, 20
Do you have tinnitus?	5/35 = 14.3%	9, 13, 27, 38, 39
Do you have permanent tinnitus all the time?	1/35 = 2.9%	11
Do you have recurrent tinnitus (once a month or more)	1/35 = 2.9%	3
Are you bothered by ringing in the ears?	1/35 = 2.9%	(6 & 7)[a]
Within the last year have you experienced tinnitus?	9/35 = 25.7%	19, 21, 22, 23, 24, 25, 30, (34, 35 & 36)[a], 37
Have you experienced tinnitus	1/35 = 2.9%	18
Tinnitus for the past 3 months	2/35 = 5.7%	(31 & 33)[a], 32
Not reported	2/35 = 5.7%	26, 29
Tinnitus severity		
Sleeping/concentrating	3/35 = 10.3%	2, 19, (34, 35 & 36)[a]
Bothered/annoyed/worried	8/35 = 22.9%	(6 & 7)[a], 12, 15, 16, 21, 24, 25, 28
Ability to lead a normal life	2/35 = 5.7%	9, 20

[a] Study reference 6 and 7 are from the Nord Trondelag Hearing Loss Study, Sweden; 31 and 33 are from the National Health Interview Survey, USA; 34, 35 and 36 are from the BeaverDam study; USA.

(23.1%) measured severity by how much tinnitus affected a person's sleep or concentration, and two (15.4%) assessed severity by the person's ability to lead a normal life.

3.5. Risk of bias

Studies were considered to have a high, moderate or low risk of bias in terms of the consolidated score out of 10. A high risk of bias was found in 15 studies, a moderate risk of bias in 20 studies, and a low risk of bias in four studies. Full details of scoring across the three types of bias are given in Appendix 1.

4. Discussion

This review is the first systematic approach to identifying and collating data about the global prevalence of tinnitus, combined with a narrative synthesis to explain the findings and to bring an international perspective on factors relating to heterogeneity. We summarise the key findings of this study from the population-based studies. The paper highlights where studies have been conducted globally; the specific questions and definitions that have been used to assess the prevalence of tinnitus; how many studies report by gender and age bands, and which age bands are most commonly used; and provides a narrative synthesis on the prevalence rates for tinnitus and bothersome tinnitus.

The available prevalence data is very diverse thereby preventing the ability to pool the data and perform meta-analyses. It is not possible to compare prevalence rates across studies due to a number of factors: location bias; inconsistency in the definition that is used for current tinnitus and tinnitus severity; a distinction in the literature between those interested in current tinnitus, and those interested in current bothersome tinnitus and reporting by different age bands. These points will be discussed in turn.

4.1. Location bias

We found 39 studies from 16 different countries using a detailed search of electronic databases and manual searches. However, these studies were unevenly distributed, with the majority from the European region (15), followed by the region of the Americas (12) and the Western Pacific Region (10). Only one study was from the African Region and the South-East Asia Region, and no studies were from the Eastern Mediterranean Region. This leads to possible location bias or publication bias in which the majority of published work is from developed countries. Regions where there are more developing or third world countries are under-represented in this review. This has implications when considering the global prevalence of tinnitus and makes it futile to do so.

4.2. Definitions used for current tinnitus and for tinnitus severity

While there is no single agreed upon definition of tinnitus for research purposes, many population studies have attempted to estimate the prevalence of tinnitus. Our review identified eight different questions that assessed the prevalence of tinnitus, and three that assessed tinnitus severity. Many of these questions also had different response options, making comparison impossible. Even among those studies asking a similar question to assess tinnitus prevalence there were vast differences in the reported figures. When we looked at the studies reporting tinnitus prevalence and severity by gender our findings do support the general theory that prevalence of tinnitus increases with age and is more prominent in males than females (Moller, 2011). This conclusion does not change when the risk of bias is considered. However, these results should be interpreted with caution due to the reasons stated above.

There was also substantial variability in how studies assessed tinnitus severity. In the clinical literature, there have been some attempts to develop guidelines for the grading of tinnitus severity (Jastreboff and Hazell, 2004; McCombe et al., 2001; Meikle et al., 2012). These are all based on multi-attribute, multi-item questionnaire data because it is well-known that tinnitus severity has many dimensions. This richness of individual experience cannot adequately be captured by a single question, as favoured by epidemiological research.

4.3. Epidemiology of current tinnitus versus current bothersome tinnitus

It is reasonable to assume that distinguishing between current tinnitus and current bothersome tinnitus would be fairly straightforward, but this does not seem to be the case. The questions asked to participants are not always clear cut. Some studies reported prevalence of a tinnitus that was defined as being bothersome, rather than separate figures for current tinnitus, and for bothersome tinnitus (e.g. (Nondahl et al., 2002, 2011). Furthermore, some studies reported bothersome tinnitus as a prevalence rate of the whole population at risk, whereas other studies reported bothersome tinnitus as a prevalence rate of those with current tinnitus. As a result, comparisons between prevalence rates would be misleading.

Among the tinnitus research community there is growing call for standardisation in clinical practice and in clinical trials to allow for meaningful evaluations and comparisons (Hall et al., 2015;

Henry et al., 2003; Langguth et al., 2007). For the same reasons, standardisation is equally important in epidemiological research. However, there has not yet been any proposal for what this epidemiological standard should be. In our review, we found that very few studies acknowledged the lack of standardised questions for tinnitus, or gave any justification for the question they used. We call on the community to make a recommendation for standard questions to define tinnitus and tinnitus severity in epidemiological research.

4.4. Reporting by different age bands

The results also highlight how differently studies report prevalence by age bands. In epidemiological research it is recommended that age grouping should be mid-decade to mid-decade or in five-year age groups (e.g. 20–24, 25–29, 30–34 and so on, or 35–44, 45–54 and so on, but not 20–29, 30–39 or other groups (World Health Organisation, 1999). However, of the 25 studies with more than one age group, only two were reported in this manner (Nondahl et al., 2011; Oiticica and Bittar, 2015). This has implications when comparing prevalence rates between studies if different age categories have been used, as it makes comparison impossible.

4.5. Limitations

The main limitation of the findings of this systematic review is the lack of reliable prevalence data for current and bothersome tinnitus. The risk of bias assessment results showed that more than half of the included studies had a high risk of bias and this limits the generalisability of prevalence estimates. In addition, the available prevalence data is heterogeneous thereby preventing the ability to pool the data and perform meta-analyses. Sources of heterogeneity include different diagnostic criteria, different age groups and variability in sample sizes. A different study focus can lead to differences in reporting and analysis of the results. Consequently, comparison among studies is impracticable.

It is also important to note a further limitation which applies to all systematic reviews. The search strategy in a systematic review aims to be as extensive as possible to maximise sensitivity and to ensure that as many as possible of the relevant studies are included in the review whilst avoiding low precision and being overwhelmed by spurious literature. However, despite the fact we developed a comprehensive and robust search strategy, there is always the possibility that inappropriate indexing may result in a publication being missed.

4.6. Implications for research

One of the most important strengths of this systematic review of the prevalence of tinnitus is in providing a record of all the available, recent epidemiological data in each global region. The inclusion criteria that studies reported epidemiological data for the general population rather than for specific groups of people (e.g. otology patients, medical students etc) allows us to report the prevalence data for different countries. However caution should be taken when relying on these data for the development and implementation of new programs due to the reasons for heterogeneity among the studies listed previously. To move forward with gathering estimates of the current burden of tinnitus, global trends of tinnitus prevalence should be monitored, and comparable epidemiological data is required (Pascolini and Smith, 2009).

This systematic review has confirmed the lack of ability to estimate a global prevalence for tinnitus. Comparing studies is severely compromised by the lack of a standardised definition of tinnitus. A recent study on tinnitus prevalence in Italy, which also compiled previous worldwide surveys on tinnitus prevalence, concluded that comparisons between surveys are difficult to make due to the lack of a standard and validated definition of tinnitus, and heterogeneity in terms of age range of the population studied (Gallus et al., 2015). A recent epidemiological study examining the prevalence of tinnitus in New Zealand found the prevalence was 6% for people aged 14 years and over, and increased with age (Wu et al., 2015). The study also highlights the importance of sex and age in defining a high-risk tinnitus population, and suggests that due to the ambiguity of the way tinnitus is defined, and the heterogeneity in prevalence figures worldwide, that follow-up questions in epidemiological research may be useful. This would help us to understand the frequency of tinnitus experienced by the participant. Assessments such as the Tinnitus Functional Index (TFI) (Meikle et al., 2012), Tinnitus Handicap Inventory (THI (Newman et al., 1996)), or Tinnitus Handicap Questionnaire (THQ (Kuk et al., 1990)) can also help to identify the severity of the tinnitus.

Advances in the epidemiology of tinnitus require a standardised question for the measuring and reporting of tinnitus, as well as in defining tinnitus. Moreover, studies that report prevalence should follow STROBE (Strengthening the Reporting of Observational studies in Epidemiology) reporting guidelines which provide a checklist of items that should be included in publications (http://www.strobe-statement.org). None of the studies in our review indicated that they had followed the STROBE guidelines, although we cannot be certain that they have not. STROBE advises authors to give details of methods of measurement for each variable of interest, which would at least encourage careful consideration of the measurement question(s). Deriving global estimates of the prevalence of tinnitus involves combining results from many surveys which are consistent in the definitions and measurement of tinnitus, the survey methodology and in the reporting and analysis of the results. Ultimately comparison among studies is unachievable without such consistency.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.heares.2016.05.009.

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