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To cite this article: Abby McCormack, Mark Edmondson-Jones, Heather Fortnum, Piers D Dawes, Hugh Middleton, Kevin J Munro & David R Moore (2015) Investigating the association between tinnitus severity and symptoms of depression and anxiety, while controlling for neuroticism, in a large middle-aged UK population, *International Journal of Audiology*, 54:9, 599-604, DOI: [10.3109/14992027.2015.1014577](https://doi.org/10.3109/14992027.2015.1014577)

To link to this article: <https://doi.org/10.3109/14992027.2015.1014577>



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Published online: 13 Mar 2015.



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## Original Article

# Investigating the association between tinnitus severity and symptoms of depression and anxiety, while controlling for neuroticism, in a large middle-aged UK population

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## Abstract

**Objective:** Clinical studies indicate increased risk for depression and anxiety among tinnitus patients. However population data are scarce, and no studies have controlled for neuroticism. We examined associations between tinnitus and symptoms of depression and anxiety in a large UK population, controlling for neuroticism, to explore whether neuroticism, as previously reported, fully explains the association between symptoms of depression and anxiety, and tinnitus. **Design:** We used the UK Biobank resource. **Study sample:** 171 728 participants answered hearing questions. **Results:** Using generalized linear modelling, we examined associations between tinnitus (mild to severe) and symptoms of depression and anxiety. Controlling for neuroticism, patients with severe tinnitus were at increased risk of depression (odds ratio (OR) = 1.27) and anxiety (OR = 1.11) symptoms, compared to those without tinnitus. **Conclusions:** Although it is not possible to determine whether tinnitus is a predisposing factor to depression, these results suggest an association. We suggest further exploration to determine the clinical significance of this association. Early psychosocial intervention aimed at reducing anxiety and depression in patients at increased risk might influence the extent to which tinnitus is experienced as troubling, and therefore psychological distress associated with it. Likewise, with tinnitus patients, assessment for anxiety/depression should be considered.

**Key Words:** Tinnitus; demographics/epidemiology; psycho-social/emotional; aging

Tinnitus is the perception of sound (e.g. tones, buzzing, or ringing) in the ears or head when no corresponding external sound stimuli are present. Around a quarter of adults experience tinnitus at any one time (Shargorodsky et al, 2010). It is difficult to measure objectively, and is typically subjectively rated by patients according to the difficulty it imposes (e.g. disruption with sleep, and/or normal daily activities). Although tinnitus is often comorbid with hearing loss, the perceived severity of tinnitus is more closely correlated with psychological factors than with audiometric measures (Erlandsson et al, 1992). Research on the risk factors associated with tinnitus suggests that severity is associated with anxiety and depression symptoms amongst others. Holgers and colleagues (Holgers et al, 2005) conducted standardized diagnostic interviews for psychiatric diagnosis, including anxiety and depression (based on DSM III-R) of 82 patients two years after the first tinnitus consultation. They found a high comorbidity of depression and anxiety disorders in tinnitus patients, especially in those with severe tinnitus. Several other studies have demonstrated a link between tinnitus and depression (Weber et al, 2008; Zöger et al,

2006), although there is inconsistency in the literature with some studies suggesting no association (Ooms et al, 2011; Figueiredo et al, 2011). The majority of these studies focused on clinical populations or had relatively small sample sizes, and this may explain the inconsistency. There is some evidence from population-based studies to support an association between tinnitus, mental health, and quality of life. The US National Health and Nutrition Examination Survey (NHANES) of adults aged 20–39 years (Shargorodsky et al, 2010), and adults aged 70–85 years (Loprinzi et al, 2013) found that adults with tinnitus were more likely to be depressed. It remains uncertain whether the reported association between tinnitus and depression represents a causal association, and if so, whether tinnitus causes depression or whether depression causes sufferers to perceive tinnitus as being more bothersome. If it is the case that tinnitus is associated with depression and other mental health problems, it may be that personality traits play their part in this by biasing towards a particularly aversive appreciation of tinnitus. Psychopathological symptoms of depression and anxiety are undoubtedly associated with

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(Received 17 June 2014; accepted 26 January 2015)

ISSN 1499-2027 print/ISSN 1708-8186 online  
DOI: 10.3109/14992027.2015.1014577

neuroticism (Muris et al, 2005), and it is generally accepted that this personality trait predisposes individuals to other psychopathological conditions such as emotional disorders, psychotic experiences, and substance abuse (Ormel et al, 2013). As a personality trait neuroticism is conceived of as a stable and enduring psychological attribute. It has strong inheritability suggesting a molecular contribution, it is normally distributed in random population samples and it is reliably consistent across time and measurement scales (Matthews et al, 2003). It is considered to contribute vulnerability to the development of psychological disorders (Clark et al, 1994), so that people high in neuroticism have less psychological resilience and are more likely to feel anxious or depressed about symptoms of ill health. Thus neuroticism may play a role in mediating the impact of severity of tinnitus on psychological well-being (Milerová et al, 2013), and the association between tinnitus and psychopathological states such as depression and anxiety may also be mediated by it.

In a previous study, we reported that higher levels of neuroticism are associated with reports of more severe or bothersome tinnitus (McCormack et al, 2014). In the present paper, we examined the association between tinnitus and symptoms of depression and anxiety in a large sample of UK adults aged 40 to 69 years, while controlling for neuroticism symptoms in order to explore whether a shared association with neuroticism might fully explain any observed association between tinnitus and symptoms of anxiety and depression. Our hypothesis was that if increased neuroticism conveys vulnerability to psychological distress associated with symptoms of being unwell, then the level of neuroticism would substantially impact on the association between tinnitus and manifestations of anxiety/depression.

## Method

### UK Biobank

UK Biobank is a large long-term ‘whole body’ study which was set up to support a diverse range of research intended to improve the prevention, diagnosis, and treatment of illness, and the promotion of health throughout society (Allen et al, 2012). The resource was established to facilitate research into the causes of disease in

middle and older age (Collins, 2012). Over 500 000 participants aged between 40–69 years attended one of 22 assessment centres located in England, Scotland, and Wales, in 2006–2010. The assessment involved collecting information relating to socio-demographics, lifestyle and environment, medical history, as well as biological samples (blood, saliva, and urine) and physiological measures. Only around a third of participants, recruited in the latter part of the study, were asked questions relating to hearing and tinnitus; we have restricted our analyses to these participants.

### Procedure

Participants attended their nearest assessment centre and gave informed consent. They completed a single assessment of approximately 90 minutes duration. This included completing automated touchscreen questionnaire on lifestyle, environment and medical history; and physical measures including hearing and visual acuity. Detailed information on the procedure adopted by Biobank and on the additional data collected can be found elsewhere: <http://www.ukbiobank.ac.uk/>.

The variables considered in this paper relate to data collected from the UK Biobank touchscreen questionnaire on tinnitus and mental health.

### Outcome measures

Not all the symptoms of depression and anxiety as defined in the Diagnostic and Statistical Manual IV (DSM) (American Psychiatric Association, 1994) were assessed in UK Biobank, possibly as a result of time constraints; and hence a comprehensive evaluation of depression and/or anxiety cannot be made. The symptoms included are listed in Table 1.

Responses in bold in the final column of Table 1 were coded as ‘yes’ to experiencing the symptom. An overall measure of ‘depression symptoms’ and an overall measure of ‘anxiety symptoms’ were created on a continuous interval scale, based on the number of ‘yes’ responses. Depression score ranged from 0 to 6, and anxiety ranged from 0 to 5.

**Table 1.** Symptoms of depression and anxiety within UK Biobank.

<i>Symptom</i>	<i>Measure of depression and/or anxiety</i>	<i>Question</i>	<i>Responses (bold responses indicate positive response)</i>
Frequency of depressed mood in last two weeks	Depression	Over the past two weeks, how often have you felt down, depressed or hopeless?	Not at all Several days <b>More than half the days</b>
Frequency of tiredness / lethargy in last two weeks	Depression/Anxiety	Over the past two weeks, how often have you felt tired or had little energy?	<b>Nearly every day</b>
Frequency of unenthusiasm/disinterest in last two weeks	Depression	Over the past two weeks, how often have you had little interest or pleasure in doing things?	Do not know Prefer not to answer
Frequency of tenseness/restlessness in last two weeks	Depression/Anxiety	Over the past two weeks, how often have you felt tense, fidgety, or restless?	
Sleeplessness/insomnia	Depression/Anxiety	Do you have trouble falling asleep at night or do you wake up in the middle of the night?	Never/rarely Sometimes <b>Usually</b> Prefer not to answer
Guilty feelings	Depression	Are you often troubled by feelings of guilt?	<b>Yes</b>
Worrier/anxious feelings	Anxiety	Are you a worrier?	No
Irritability	Anxiety	Are you an irritable person?	Do not know Prefer not to answer

### Tinnitus

No validated questionnaires were used to assess hearing or tinnitus, however, two self-report questions on tinnitus were asked: ‘Do you get or 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?’ Current tinnitus was defined as those who responded ‘Yes, now most or all of the time’, ‘Yes, now a lot of the time’ or ‘Yes, now some of the time’. Those with current tinnitus were asked about severity: ‘How much do these noises worry, annoy, or upset you when they are at their worst?’ The response options were ‘not at all’, ‘slightly’, ‘moderately’, or ‘severely’. These questions are consistent with those presented in various other major epidemiological hearing studies, such as the National Study of Hearing (Davis, 1989), the Blue Mountains Hearing Study (Sindhusake et al, 2003), and the Epidemiology of Hearing Loss Study (Nondahl et al, 2010).

### Hearing

All participants were asked about their hearing: ‘Do you have any difficulty with your hearing?’ Responses to this subjective question were included in the analysis. About one third of all participants also completed an objective measure of speech-in-noise (SiN) hearing, the truncated digit triplets test (DTT), in which fifteen (monosyllabic single digit) triplets (e.g. 2–9–5) were presented to each ear via circumaural headphones (Sennheiser D25). Participants first set the volume of stimuli to a comfortable listening level. Digits were then presented in background noise shaped to match the spectrum of the speech stimuli. Noise level was varied adaptively after each triplet, dependent on the participants correct touchscreen response to all three digits, to obtain criterion performance of 50% correct. The speech reception threshold (SRT) was taken as the mean signal-to-noise (SNR) for the last eight triplets played (Dawes et al, 2014).

### Neuroticism symptoms

Neuroticism was assessed by 13 questions (see McCormack et al (2014) for a more detailed analysis of the neuroticism questions) from the Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1964), in which participants responded ‘yes’ or ‘no’. Level of neuroticism was treated as a 4-level factor based on scores of 0–2 (low), 3–5 (low-medium), 6–9 (medium-high), and 10–13 (high).

### Quality of life

Quality of life measures included questions on how satisfied the respondent was with their health. The response options were extremely happy/ very happy/ moderately happy/ moderately unhappy/ very unhappy/ extremely unhappy. This was included because neuroticism scores may also be associated with subjective physical health (Ormel et al, 2004), as is common in other studies reporting quality of life (Eysenck & Eysenck, 1964). This item was dichotomized into happy vs. unhappy.

### Analysis

As hearing-related questions, including the two questions relating to tinnitus, were introduced part-way through sampling, analysis has been restricted to only those participants who were presented with this part of the assessment. Restriction to this subgroup is not expected to introduce any bias, as it depends only on the recruitment order. However, participants had the option of not responding by

choosing ‘do not know’ or ‘prefer not to answer’ to most questions and so non-responses were possible. On inspection of response patterns it is not reasonable to assume that these withheld responses are missing completely at random (MCAR) (Rubin, 2009) but rather missingness patterns appear to be correlated with other data. In order to handle such missing data we used the technique of multiple imputation (MI) by chained equations implemented in the R package mice (Buuren & Groothuis-Oudshoorn, 2011), generating 20 complete datasets. MI models variables for which some data are missing multivariately based on other data. The resulting imputation model is used to simulate a range of distributionally representative datasets from which unbiased inferences can be drawn (Sterne et al, 2009). The number of depression symptoms and the number of symptoms of anxiety were separately analysed using quasibinomial generalized linear modelling to allow for over/under-dispersion resulting from correlation between symptoms. The strength of association between tinnitus (none, no problem, slight, moderate, severe) and number of symptoms of depression or anxiety was estimated allowing for confounding by sex, age group, deprivation (measured on a 0–1 scale according to national deciles), self-reported difficulty hearing, SRT, health satisfaction (happy, unhappy) and level of neuroticism (low, low-medium, medium-high, high). Self-reported difficulty hearing and SRT were controlled for because hearing difficulty is often associated with tinnitus (Hoffman & Reed, 2004) and has also been associated with depression and anxiety (Jones et al, 1984). Health satisfaction was controlled for because it has been found to be associated both with tinnitus and with symptoms of depression and anxiety (Strine et al, 2009). As we expected significant associations with all variables stepwise modelling techniques were not used. P-values are marginal assuming that all other model variables are retained.

## Results

### Characteristics of the UK Biobank participants

Table 2 shows the characteristics of the study participants and their responses to the auditory questions and the mental health questions. A greater proportion of the participants were female (54% vs. 46% male). The mean age of the sample was 56.7 years. Of those that answered the hearing and tinnitus questions, males were more likely to report subjective difficulty hearing (33%) and current tinnitus (21%) compared to females (23% and 15% respectively). Non-response rates were generally low (< c. 6%) with the exception of some mental health questions. Response rates for all thirteen neuroticism questions (as a set) was 79%.

### Tinnitus as a risk factor for depression

Table 3 shows the results from the two separate generalized linear models with number of depression and anxiety symptoms as the dependent variables. Odds ratios and 95% confidence intervals are shown for the independent variables: sex, age, deprivation, hearing difficulty, SRT, tinnitus (none, no problem, slight, moderate, severe), health-related quality of life, and neuroticism symptoms. While controlling for these variables, tinnitus was associated with depression symptoms and also anxiety symptoms, with strength of association increasing with reported severity.

Table 3 shows that hearing difficulty and SRT were associated with depression and anxiety symptoms, although the odds ratios were small. Neuroticism symptoms were strongly associated with

**Table 2.** Characteristics of UK Biobank participants. Number (item response percentages in brackets) and performance of participants completing each question. Response percentages relate to available data. Mean  $\pm$  sd; % + ve: percent positive responses to each question. Mental health questions show number of questions responded as yes (depression and anxiety symptoms, and neuroticism), responding happy (health-related quality of life).

	Female		Male		All	
	N (%)	Mean $\pm$ sd % positive	N (%)	Mean $\pm$ sd % positive	N (%)	Mean $\pm$ sd % positive
<i>Demographics</i>						
Sex	93 484 (100%)	54%	78 244 (100%)	46%	171 728 (100%)	100%
Age	93 484 (100%)	56.5 $\pm$ 8.0 years	78 244 (100%)	57.0 $\pm$ 8.2 years	171 728 (100%)	56.7 $\pm$ 8.1 years
Townsend deprivation decile	93 338 (>99%)	4.15 $\pm$ 2.70	78 107 (>99%)	4.18 $\pm$ 2.74	171 445 (>99%)	4.17 $\pm$ 2.72
<i>Auditory questions</i>						
Hearing difficulty	87 325 (93%)	23%	74 511 (95%)	33%	161 836 (94%)	27%
SRT (better ear; dB)	87 650 (94%)	-7.4 $\pm$ 1.6 dB	73 305 (94%)	-7.4 $\pm$ 1.8 dB	160 955 (94%)	-7.4 $\pm$ 1.7dB
Current tinnitus	91 284 (98%)	15%	76 182 (97%)	21%	167 466 (98%)	18%
<i>Mental health questions</i>						
Depression symptoms*	81 263 (87%)	0.94 $\pm$ 1.15	69 371 (89%)	0.70 $\pm$ 1.06	150 634 (88%)	0.83 $\pm$ 1.12
Anxiety symptoms*	81 974 (88%)	1.39 $\pm$ 1.13	69 338 (89%)	1.15 $\pm$ 1.13	151 312 (88%)	1.28 $\pm$ 1.13
Health-related quality of life (happy)	92 708 (99%)	86%	77 702 (99%)	86%	170 410 (99%)	86%
Neuroticism	72 501 (78%)	4.77 $\pm$ 3.27	62 830 (80%)	3.97 $\pm$ 3.26	135 331 (79%)	4.40 $\pm$ 3.29

\*Defined in the text.

both depression and anxiety symptoms. Unsurprisingly, those reporting they were unhappy with their health-related quality of life were much more likely to report depression and anxiety symptoms compared with those who were happy with their health-related quality of life. Deprivation was significantly associated with depression and anxiety symptoms, although the association was stronger for depression symptoms, i.e. those who were more deprived were more susceptible to depression symptoms. Age had a significant association with both depression and anxiety symptoms with depression symptoms peaking in participants' 50s and anxiety symptoms

increasing throughout the age range. However, the association with age was relatively small. Males were less likely to report depression and anxiety symptoms compared to females.

## Discussion

This study aimed to examine the association between tinnitus severity and symptoms of depression and anxiety, while controlling for neuroticism, in a cross-sectional sample of UK adults aged 40 to 69 years.

**Table 3.** Generalized linear modelling of reporting depression symptoms and anxiety symptoms (reference levels shown in brackets).

Variable	Depression symptoms		Anxiety symptoms	
	Odds ratio (95% CI)	p	Odds ratio (95% CI)	p
Sex (female)	0.87 (0.86–0.88)	<0.001	0.93 (0.93–0.94)	<0.001
Age at recruitment (40–44)				
45–49	1.03 (1.01–1.04)	0.001	1.01 (1.00–1.03)	0.106
50–54	1.06 (1.04–1.08)	<0.001	1.05 (1.03–1.06)	<0.001
55–59	1.03 (1.01–1.05)	<0.001	1.05 (1.04–1.07)	<0.001
60–64	0.96 (0.95–0.98)	<0.001	1.06 (1.04–1.07)	<0.001
65–69	0.96 (0.94–0.97)	<0.001	1.06 (1.05–1.08)	<0.001
Deprivation score	1.32 (1.29–1.34)	<0.001	1.04 (1.03–1.05)	<0.001
Hearing difficulty (no)	1.04 (1.03–1.05)	<0.001	1.04 (1.03–1.05)	<0.001
SRT - better ear	1.01 (1.01–1.01)	<0.001	1.00 (1.00–1.00)	0.036
Current tinnitus (none)				
Not problematic	1.05 (1.03–1.08)	<0.001	1.01 (0.99–1.03)	0.203
Slight	1.08 (1.06–1.09)	<0.001	1.03 (1.02–1.04)	<0.001
Moderate	1.16 (1.14–1.19)	<0.001	1.07 (1.05–1.09)	<0.001
Severe	1.27 (1.23–1.33)	<0.001	1.11 (1.07–1.15)	<0.001
Health related quality of life satisfaction (unhappy)	0.63 (0.62–0.64)	<0.001	0.77 (0.76–0.77)	<0.001
Neuroticism (0–2)				
3–5	2.38 (2.34–2.41)	<0.001	2.59 (2.56–2.62)	<0.001
6–9	4.17 (4.11–4.24)	<0.001	4.12 (4.07–4.16)	<0.001
10–13	6.00 (5.90–6.10)	<0.001	5.73 (5.65–5.80)	<0.001

### *Comparison with previous studies*

It is well documented that neuroticism is strongly associated with depression and anxiety symptoms (Muris et al, 2005), and there is some evidence that neuroticism is associated with tinnitus severity (McCormack et al, 2014). However there is less evidence for the link of depression and anxiety symptoms with tinnitus, particularly from large population studies, and inconsistent evidence of an association in clinical studies (Ooms et al, 2011, Figueiredo et al, 2011). Relatively small sample sizes in some of these studies may explain this inconsistency, and furthermore, these studies did not control for the effect of neuroticism. After controlling for neuroticism, this study found that tinnitus (particularly severe tinnitus) remains associated with symptoms of depression, and to a lesser extent, symptoms of anxiety. This supports other population studies (Loprinzi et al, 2013) suggesting there is an association between depression and tinnitus, and evidence from a recent systematic review (Geocze et al, 2013) concluding that the association between depression and tinnitus is reliable. However this is the first study to report this association while also controlling for neuroticism. It is likely that some people are predisposed to both tinnitus and manifestations of depression/anxiety by virtue of their level of neuroticism, but others may develop tinnitus or experience bothersome tinnitus for some other reason such as injury, or noise exposure and this contributes to depression/anxiety symptoms independently of neuroticism levels. However, due to the cross-sectional nature of the study it is not possible to determine causality. It is possible that depression and/or anxiety cause tinnitus to be perceived as bothersome. Further studies would be valuable to further explore potential mechanisms.

### *Strengths and limitations*

This study is one of few recent studies examining the link between tinnitus severity and mental health measures in a large population sample. However, there are several limitations to be aware of. As data summarizing a wide range of information were collected over a 90 minute period, only limited detail was recorded for each topic. Therefore, detailed information regarding tinnitus characteristics was not available, e.g. duration of tinnitus; whether it was continuous or intermittent, fluctuating or non-fluctuating in loudness, tonal or a ringing sound. These considerations are important as it has been found that patients describing non-fluctuating sounds are more obsessed and disturbed by their symptoms than patients who perceive that the sounds fluctuate (Erlandsson et al, 1992). Additionally, information on the total duration of tinnitus could prove useful as although duration of tinnitus has been found not to be correlated with anxiety and depression levels (Crocetti et al, 2009), shorter duration of tinnitus is associated with a greater negative impact on quality of life (Erlandsson et al, 1992), possibly as a result of having less time to come to terms with their condition and develop successful coping and management strategies. Information on when the tinnitus started is not available in UK Biobank. It is possible that the onset of tinnitus may have coincided with an emotionally stressful period in life and that this association has an impact upon the subjective experience of tinnitus.

Participants in the Biobank study did not complete any previously validated questionnaires to evaluate anxiety and depression levels. The busy UK Biobank assessment protocol could explain why only a few symptoms from the DSM-IV criteria for anxiety and depression were included. Symptoms that were included have been grouped according to what was measured in the UK Biobank data set. Consequently, it is possible that the questions used here

may not correspond with standard clinical measures of depression or anxiety. The lack of a diagnostic tool for assessing depression and anxiety requires caution when interpreting these results. Nevertheless, the results of this study do show that those with severe tinnitus had greater prevalence of symptoms associated with anxiety and depression compared to those without tinnitus.

### *Implications for future research and clinical practice*

The findings from clinical studies on whether there is an association between tinnitus and mental health are inconsistent. Although this study has shown an association with tinnitus, its strength with depression and anxiety symptoms was relatively small. Severe tinnitus showed the strongest association with depression and anxiety symptoms. The weak associations could be due to the limited questions examining depression and anxiety symptoms, or differences in cognition or attention which could also influence how tinnitus is perceived, and these are areas to consider when looking at tinnitus and mental health associations. As the findings do not demonstrate causality, future studies could incorporate a longitudinal design to investigate temporal associations between tinnitus and each of depression and anxiety. A longitudinal study over a two year period found that when depression was treated, depression symptoms were reduced but that this was also associated with a decrease in tinnitus prevalence and even more markedly with tinnitus severity (Hébert et al, 2012). Further research could also include those who have never had tinnitus and those who have had tinnitus in the past to test the hypothesis that if tinnitus is causal for depression/anxiety, then past tinnitus should not be predictive of current depression. Other study designs such as prospective cohort studies could help disentangle the association between tinnitus and depression and anxiety, by following a cohort of individuals over a period of time. Langenbach and colleagues (Langenbach et al, 2005) set out to identify psychosocial and personality factors at the outset of tinnitus which may be important to explain later tinnitus-related distress in a prospective design. They found that patients with higher levels of anxiety, lower levels of life satisfaction and sleeping difficulties, at first presentation shortly after the onset of tinnitus, have a higher risk of developing tinnitus related distress; although the small sample size limits the generalizability of the results. These suggestions should help develop a better understanding of the relationship between tinnitus and mental health.

## **Conclusions**

Tinnitus is a rather prevalent condition, and can be distressing for a substantial proportion of people, although the true extent of distress caused by tinnitus is difficult to determine. After controlling for neuroticism, we have shown that those with tinnitus, particularly bothersome tinnitus, were still more likely to report depression and anxiety symptoms than those without tinnitus. Although it is not possible to determine whether tinnitus is a predisposing factor to depression, these results do suggest an association; and is therefore worth exploring further, by taking into account the limitations noted above, to determine how clinically significant this association is. It is also possible that high depression and/or anxiety symptoms limit a person's ability to cope with tinnitus and thus they perceive it as more bothersome compared to people with low levels of depression or anxiety. Therefore, early psychosocial intervention aimed at reducing anxiety and depression, in patients at risk may prevent the development of chronic tinnitus and the related psychological

distress and may also improve quality of life. It is possible that if the depression is treated and depression symptoms are reduced, then the severity of tinnitus might also be reduced. Clinicians treating people for anxiety/depression should bear in mind that tinnitus may be a contributing factor, and there are audiological interventions (such as noise masker, hearing aid) that might be helpful for these patients. Likewise, clinicians treating tinnitus patients should also consider assessment for anxiety and/or depression.

## Acknowledgements

This work was supported by a grant from National Institute for Health Research (NIHR). We thank UK Biobank for the data collection. However, the views expressed in this paper are those of the authors alone and not necessarily those of UK Biobank.

**Declaration of interest:** The authors declare no conflicts of interest.

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