

COVID-19 and Tinnitus: An Initiative to Improve Tinnitus Care

International Journal of Audiology

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Abstract

Objective:

To investigate the effects of COVID-19 on individuals with tinnitus and their views to guide future tinnitus care.

Design:

A mixed-methods cross-sectional research design.

Study sample:

An online survey was completed by 365 individuals with tinnitus from Australia and other countries.

Results:

Tinnitus was reported to be more bothersome during the pandemic by 36% of respondents, whereas 59% reported no change and 5% reported less bothersome tinnitus. Nearly half of the respondents had received COVID-19 vaccination(s) and 12% of them reported more bothersome tinnitus while 2% developed tinnitus post-vaccination. Australian respondents spent less time in self-isolation or quarantine and saw fewer change in in-person social contact than respondents from other countries. More than 70% of respondents thought that tinnitus care services were insufficient both before and during the pandemic. Regarding their opinions on how to improve tinnitus care in the future, five themes including alleviation of condition, government policies, reduced barriers, self- and public-awareness, and hearing devices were identified.

Conclusions:

A majority of respondents did not perceive any change in tinnitus perception and one-third of respondents had worsened tinnitus during the pandemic. To improve tinnitus care, better awareness and more accessible resources and management are crucial.

Introduction

Tinnitus is the perception of sounds without an external stimulus (Baguley, McFerran, and Hall 2013). Its prevalence is estimated to be between 10% and 15% and it is more commonly experienced by males and the older population (Baguley, McFerran, and Hall 2013; Lockwood, Salvi, and Burkard 2002). Tinnitus is heterogeneous, with numerous aetiologies, but it is often accompanied by hearing loss (Tonkin 2002) and can be exacerbated by emotional distress and vice versa; chronic stress, anxiety, and depression are frequently reported among tinnitus patients (Mazurek, Boecking, and Brueggemann 2019; Salazar et al. 2019).

After the onset of the COVID-19 pandemic, most countries implemented some form of social restrictions

and lock-down measures throughout 2020 and 2021, including temporary closure of public venues and workplaces and travel restrictions (Thome et al. 2020). Evidence suggests that social restriction measures increased unemployment, mental ill-health, poor sleep, and financial worries (Fisher et al. 2020; Vindegaard and Benros 2020). Medical resources were concentrated on treating COVID-19 patients and therefore significant disruption of non-urgent healthcare services was observed worldwide (Webb et al. 2022). Adoption of telehealth services surged in countries such as Australia, the UK, and the USA (Ohannessian, Duong, and Odone 2020).

There has been an increasing number of reports of tinnitus following COVID-19 exposure. A systematic review

reported that from 18 studies which explored the effects of COVID-19 on individuals with tinnitus, the pooled prevalence of tinnitus in suspected and probable COVID-19 cases was 8% (Beukes et al. 2021c). As tinnitus is a prevalent and debilitating condition and individuals with tinnitus are likely to be exposed to pandemic-related emotional distress, there has been an urgent need to assess potential changes in their tinnitus experience during the pandemic to provide better support and care in the future.

A few studies have utilized surveys to explore the effects of COVID-19 on individuals with tinnitus. Beukes et al. (2020) conducted the first large-scale survey to address such issues and 3400 responses were collected across 48 countries. They measured the respondents' degree of tinnitus distress using the Tinnitus Handicap Inventory-Screening version (THI-S) and asked questions regarding COVID-19 symptoms and medication, social restrictions, and coping strategies. Thirty-two percent of respondents reported more bothersome tinnitus, potentially due to isolation, poorer sleep quality, and worsened mental health. Meanwhile, 67% of respondents reported no change in tinnitus and 1% reported less bothersome tinnitus. Fifteen percent to 34% of respondents showed higher level of anxiety, depression and/or irritability and tinnitus was reported to be significantly more bothersome in these individuals. For those who experienced COVID-19 symptoms, 40% reported tinnitus exacerbation and seven individuals mentioned initiation of tinnitus symptoms after being diagnosed with COVID-19. Schlee et al. (2020) conducted an online survey of tinnitus patients in Germany with an aim to measure the patients' tinnitus distress level and the impact of COVID-19 on their emotional state. Even though an elevated stress level was reported by those who perceived more bothersome tinnitus, only a slight increase in tinnitus distress was seen. Aazh, Danesh, and Moore (2021) conducted a retrospective survey study of tinnitus patients in the UK before and during the implementation of lock-down measures. The Visual Analog Scale (VAS) was used to measure patients' tinnitus loudness, annoyance, and effect on life. Data were collected from two groups of tinnitus patients, one during lock-down in 2020 and another one before lock-down in 2019. The authors concluded that the ratings of tinnitus severity between the two groups were not significantly different, and thus any change in mental health during lock-down was not a significant contributing factor to changes in tinnitus symptoms.

In these studies, vaccination-related questions were not asked and the Australian population was only marginally represented. Because there are international differences in duration of lock-down, degree of restrictions, and incidence and mortality rates related to COVID-19, this study aimed to examine the functional and emotional

challenges of individuals with tinnitus in Australia throughout the pandemic and obtain their opinions on the accessibility and provision of tinnitus care.

Methods

Study design and ethics

This study adopted a mixed-methods approach and cross-sectional research design. Ethical approval was obtained from Flinders University Human Research Ethics Committee (Project ID: 2857) prior to the start of data collection.

Survey development

Survey questions were brainstormed by the research team (BM, NL, BK, DD, GSS) based on themes surrounding tinnitus, COVID-19 pandemic-related factors which could have changed respondents' tinnitus experience, and their suggestions on improving tinnitus care. Ninety-seven questions were generated for the final survey, 93 closed-ended and four open-ended. Although only four questions were completely open-ended, respondents were given opportunities to freely express their additional opinions in the text boxes when choosing answers to some of the closed-ended questions. The Ida Institute's Tinnitus Thermometer was included in the survey to gauge the extent to which the respondents were bothered by their tinnitus. The Tinnitus Thermometer is a visual analog scale numbered from 0 (no tinnitus) to 10 (worst possible tinnitus) complemented with five smiley face emoticons which is used to rate how much tinnitus is bothering the respondent at the time of assessment (Ida Institute 2021). The estimated time needed to complete the survey was approximately 20 to 25 minutes.

The questions in the survey were categorized as described below:

1. Demographic information including age, gender, and the country they spent the most time in over the past year (three questions).
2. Tinnitus history and characteristics as adapted from the Tinnitus Sample Case History Questionnaire (TSCHQ) (seven questions) (Landgrebe et al. 2010).
3. The severity and effects of tinnitus during the COVID-19 pandemic were evaluated with the use of the Tinnitus Functional Index (TFI) and the overall TFI score was used for analysis (Meikle et al. 2012). A higher score indicates greater tinnitus severity and the maximum possible score was 100. The Tinnitus Thermometer was integrated into the question "How bothered or upset have you been because of your tinnitus?" in the TFI (25 questions).
4. Change in tinnitus perception since the pandemic outbreak was investigated by asking respondents to compare their current tinnitus loudness, annoyance,

and the extent they were bothered or upset by tinnitus to the start of the pandemic (three questions).

5. Anxiety and depression level during the pandemic was measured using the Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith 1983). Anxiety and Depression scores were calculated separately. A higher score represents more anxiety or depression. For both subscale scores, the maximum possible score is 21 and a score below 8 indicates no risk of anxiety or depression disorders (14 questions).
6. Information regarding COVID-19 symptoms, medication, and vaccination (11 questions).
7. Pandemic-related lifestyle changes in multiple areas, such as self-isolation and social contact, employment status, diet and exercise, and access to healthcare (23 questions).
8. Experience on teleaudiology services and tinnitus smartphone apps (two open-ended questions).
 - a. You mentioned that you have tried tinnitus smartphone apps. Please tell us which app you used and if there is anything you would like to share with us about your experience? (e.g., Did you like it? Will you keep using this app? What features would you like to see included?)
 - b. You mentioned that you have had virtual meetings with an audiologist/clinician. Is there anything you would like to share with us about your experience?
9. Considerations before trying a tinnitus treatment (two questions).
10. Thoughts on the availability of tinnitus healthcare services before and during the pandemic, and the accessibility of reliable tinnitus information (five questions).
11. Other untouched issues about tinnitus experience during the pandemic and how they would like tinnitus care to be improved (two open-ended questions).
 - a. Is there anything else you would like to share regarding your tinnitus experience during the COVID-19 pandemic?
 - b. How would you like to see tinnitus care improve in the future?

A two-stage review process was performed before launching the survey. The survey was first reviewed by three tinnitus researchers to determine the relevance and appropriateness of questions. It was subsequently reviewed by three tinnitus patients to check whether the questions were readily understandable. Both groups of reviewers were also asked to state the time taken to complete the survey and suggest any missing or duplicated items. The depth, logic and flow of the survey were improved after the review process.

The final survey was created using Qualtrics (<https://www.qualtrics.com>). Skip logic was applied to a screening question at the beginning to exclude individuals who did not experience tinnitus, and display logic was applied to follow-up questions so that they would be shown if specific conditions were met.

Survey distribution

This study targeted individuals experiencing tinnitus aged 18 years or above. The survey was distributed via tinnitus researchers and tinnitus organizations in Australia, the UK, and the USA via social media (Twitter, LinkedIn) and the organizations' newsletters. A flyer was designed to facilitate the recruitment process and its printed copies were displayed in Flinders University and a number of audiology clinics in Adelaide. The data collection period was from 7th April 2021 to 10th August 2021. Online written participant consent was sought before commencing the survey.

Data analysis

Responses that did not fit the inclusion criteria (i.e., not willing to give consent and/or not experiencing tinnitus) were excluded from data analysis. Both quantitative and qualitative analyses were conducted. Descriptive analysis (e.g., mean, standard deviation) was performed using IBM SPSS Statistics (Version 27). The v2 test was utilized to determine the relationships between categorical variables. Due to the use of multiple comparisons, the p-value was adjusted to 0.01 to be considered statistically significant and was derived via Bonferroni correction. Logistic regression analysis was performed using Stata/BE (Version 17) to establish the best predictors of worsened tinnitus perception during the pandemic from a range of factors including age, gender, country of residence, COVID-19 symptoms and vaccination, self-isolation duration, change in employment status, change in social contact, and access to regular tinnitus care. A two-stage analytic approach was used. Bootstrapped stepwise backwards logistic regression using 500 bootstrap samples was first undertaken to provide an initial set of potential candidate predictor variables. Any variable selected 250 times or more was then entered into the second stage. The second stage consisted of a standard step-wise backwards logistic

Table 1. Demographic Information of Respondents.

	Total	Australia	Other countries
Number of respondents	365	260 (71.2%)	105 (28.8%)
Gender			
Female	179 (49.0%)	117 (45.0%)	62 (59.1%)
Male	185 (50.7%)	142 (54.6%)	43 (41.0%)
Gender neutral	1 (0.3%)	1 (0.4%)	0
Mean age (years)	57.4 (SD: 15.3)	59.4 (SD: 14.7)	52.6 (SD: 15.6)
Mean tinnitus duration (years)	14.5 (SD: 14.7)	15.3 (SD: 15.3)	11.9 (SD: 12.6)

regression. Thematic analysis was carried out following Graneheim and Lundman (2004) framework to analyze the qualitative data from the four open-ended questions as a complement to the quantitative data. The open-ended responses were first coded into meaning units. Meaning units related to the same sub-theme were grouped and sub-themes were further condensed into themes. Initial data coding was conducted by BM using Microsoft Excel (Version 16.58) and its consistency was cross-checked by NL, BK, and HD. Any inconsistencies identified were resolved by discussion.

Results

Demographic information and tinnitus characteristics

Four hundred seventy-nine responses were collected. Among them, 114 did not fit the inclusion criteria as they neither consented to participate in the survey nor experienced tinnitus. Of the remaining 365 respondents, 329 answered all survey questions and the remaining 36 did not complete the full survey. The age of the 365 respondents ranged from 18 to 90 years with a mean age of 57 years (SD: 15) and as shown in Table 1, there were roughly equal numbers of males and females. Regarding their country of residence over the past year, most respondents lived in Australia (71%), followed by the UK (18%) and the USA (4%). The remaining individuals (7%) resided in 19 countries across North America, South America, Europe, Asia, and Africa. Since this study aimed at providing an Australian perspective on how COVID-19 affected individuals with tinnitus, responses from Australia were compared to those from other countries.

The mean tinnitus duration was 14.5 years (SD: 15) with a range of 0.1 to 75 years, suggesting that the respondents

generally had chronic tinnitus and 14% (N = 51/365) developed tinnitus after the COVID-19 outbreak. Two percent (N = 9/365) believed that the initial onset of their tinnitus was related to COVID-19 infection or vaccination. Sixty-three percent (N = 225/356) and 23% (N = 83/356) of respondents experienced bilateral and unilateral tinnitus respectively, with the remaining 14% (N = 48/356) experiencing tinnitus either inside the head or both inside the ear(s) and the head. Eighty-two percent (N = 293/356) of respondents heard their tinnitus constantly while 18% (N = 63/356) heard it intermittently. Ringing was the most common description of the sound of their tinnitus (57%; N = 203/356), followed by hissing (41%; N = 146/356), buzzing (22%; N = 80/356), and whistling (22%; N = 78/356). On a scale of zero (very low pitch) to ten (very high pitch), the respondents on average rated the pitch of their tinnitus as 7.5.

Tinnitus severity and emotional state

The mean TFI score across all respondents was 50 (SD: 23; range: 0–99), which indicated mild-to-high tinnitus severity following the grading system proposed by Gos et al. (2021). No significant difference was observed between the mean TFI scores of respondents from Australia and other countries, $t(327) = 0.50$, $p = 0.62$.

The mean HADS Anxiety score across all respondents was 7 (SD: 4; range: 0–19) and the mean HADS Depression score was 5 (SD: 4; range: 0–21). No significant difference was observed between the mean HADS Anxiety scores of respondents from Australia (7) and other countries (8), $t(322) = -2.20$, $p = 0.028$. However, for the mean HADS Depression score, Australian respondents had a significantly lower score (4) than those from other countries (6), $t(322) = -3.38$, $p < 0.001$.

Change in tinnitus perception since COVID-19 outbreak

Compared to the start of the COVID-19 pandemic, 35% to 38% of respondents reported an increase in tinnitus loudness, annoyance, or how much they were bothered or upset by their tinnitus as illustrated in Figure 1. No change in tinnitus loudness, annoyance, or how much they were bothered or upset by tinnitus was reported by 58% to 59% of respondents, whereas 4% to 6% reported a decrease in these three aspects. The proportions of respondents reporting an increase in tinnitus loudness [$\chi^2(2, N = 332) = 151.63$, $p < 0.001$], annoyance [$\chi^2(2, N = 332) = 140.34$, $p < 0.001$], and how much they were bothered or upset by tinnitus [$\chi^2(2, N = 332) = 143.88$, $p < 0.001$] were significantly greater than those reporting a decrease. Their country of residence was related to the change in tinnitus loudness [$\chi^2(2, N = 311) = 11.15$, $p = 0.004$], annoyance [$\chi^2(2, N = 311) = 18.85$, $p < 0.001$], and the extent of being bothered or upset [$\chi^2(2, N = 311) = 13.13$, $p = 0.001$]. In general, Australian respondents were less affected than those from other countries in terms of change in tinnitus perception.

Table 2. Logistic regression analysis of best predictors of worsened tinnitus perception.

	Odds ratio	95% CI	p
Increased tinnitus loudness			
Gender			
Male	1.00	/	/
Female	1.82	1.14-2.90	0.012
Decreased social contact (colleagues)			
No	1.00	/	/
Yes	2.34	1.43-3.82	0.001
Increased tinnitus annoyance			
Age (years)	0.97	0.95-0.99	0.002
Decreased social contact (colleagues)			
No	1.00	/	/
Yes	2.35	1.41-3.91	0.001
More bothered/upset by tinnitus			
Age (years)	0.98	0.96-0.99	0.005
Decreased social contact (colleagues)			
No	1.00	/	/
Yes	2.16	1.30-3.59	0.003
Decreased access to regular tinnitus care			
No	1.00	/	/
Yes	2.50	1.18-5.29	0.017

Table 2 summarizes the outcome of the logistic regression analysis for establishing the best predictors of worsened tinnitus perception during the pandemic. Only the variables which entered the second stage (i.e., standard stepwise backwards logistic regression) and were statistically significant were included in the table. Having decreased social contact with colleagues was a best predictor for all three outcomes (i.e., increased tinnitus loudness, annoyance, and the extent of being bothered or upset). Female respondents had 1.8 times the odds of experiencing louder tinnitus during the pandemic than

male respondents. For each one-year increase of age, there was approximately a 3% decrease in the odds of the respondents showing increase in being annoyed, bothered or upset by their tinnitus. Those with reduced access to regular tinnitus care also had 2.5 times the odds of being more bothered or upset by their tinnitus than those whose regular tinnitus care was not affected.

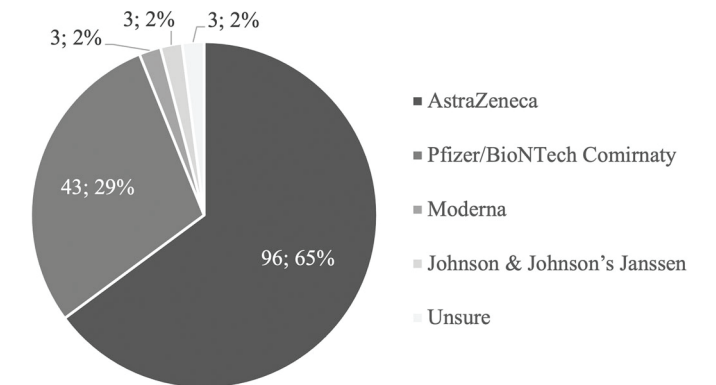


Figure 2. Types of COVID-19 vaccines received by 148 respondents

COVID-19 symptoms and vaccination

Twenty-six percent (N = 84/327) experienced COVID-19 symptoms such as fever, dry cough, difficulty breathing, and loss of taste or smell. Nineteen percent (N = 16/84) of those had more bothersome tinnitus, as a respondent explained: “blocked ears/eustachian tubes make it worse” (female, 55 years, Australia), and 8% (N = 7/84) reported tinnitus initiation since experiencing such symptoms. Two percent of all respondents (N = 7/365) tested positive for COVID-19 and of those three had more bothersome tinnitus, two developed tinnitus after experiencing COVID-19 symptoms, and two perceived no change in tinnitus.

As shown in Figure 2, COVID-19 vaccination was received by 45% (N = 148/327) and most of them received the AstraZeneca vaccine (65%; N = 96/148). Of those who were vaccinated, 12% (N = 18/148) had more bothersome tinnitus and a majority of those received the AstraZeneca vaccine (N = 11/18). Post-vaccination tinnitus initiation was reported by three individuals (2% of vaccinated respondents) and one each received Pfizer/BioNTech, Moderna, and Johnson & Johnson's Janssen vaccine. Improvement of tinnitus was noted by two respondents.

Impact on social contact and employment

Respondents from other countries spent more time in self-isolation or quarantine (Mean: 15.0 weeks; SD: 22) than Australian respondents (Mean: 3.5 weeks; SD: 5.4). Fifteen percent (N = 12/78) of all respondents who were required to self-isolate or quarantine described their tinnitus as more bothersome because of self-isolation or quarantine, e.g., “quieter area at home, it became easier to

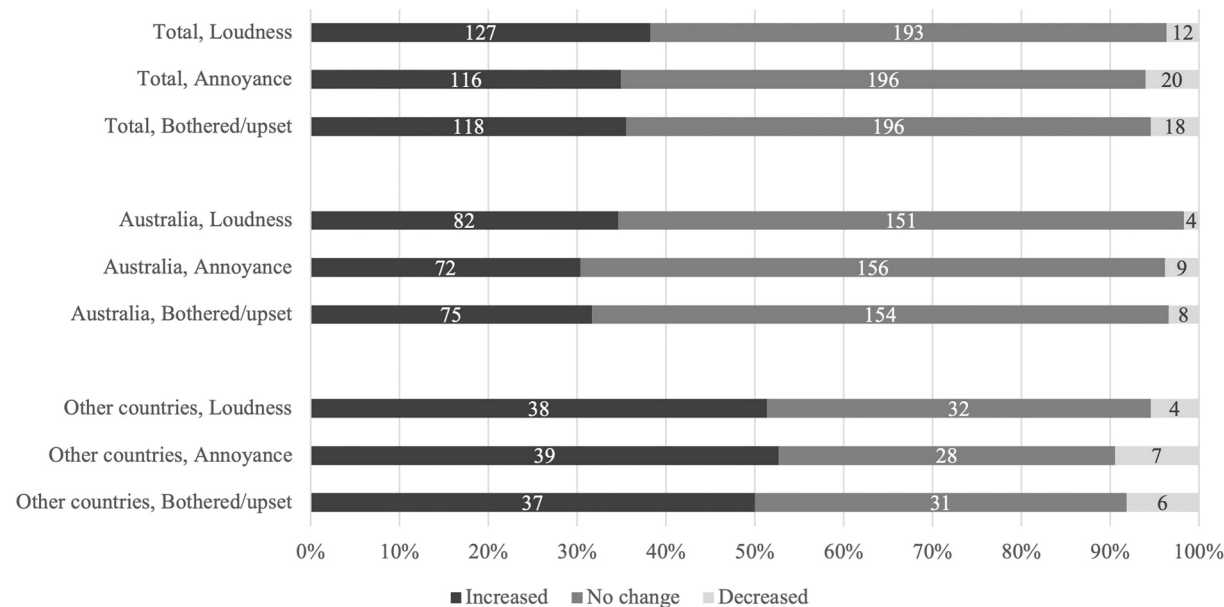


Figure 1. Number of respondents reporting an increase, no change, or decrease in tinnitus loudness, annoyance, and the extent of being bothered or upset by tinnitus since the COVID-19 outbreak.

focus more heavily on tinnitus” (male, 25 years, Australia).

As seen in Figure 3, the amount of in-person social contact with family, friends, and colleagues was more greatly reduced for those living in other countries. Of all respondents who reported changes in social contact, 16% (N = 41/257) reported more bothersome tinnitus and this was supported by statements such as “I used seeing friends and going out as a distraction” (female, 21 years, Canada).

Forty-eight percent (N = 157/326) of respondents experienced changes in employment situation due to COVID-19. Twenty-five percent (N = 81/326) were unemployed, furloughed, worked more remotely, or had reduced working hours. More bothersome tinnitus was reported by 20% (N = 31/157) of those who experienced changes in employment situation, with the most mentioned reasons being changes in soundscape and more frequent use of headsets for meetings. Five respondents (3%) indicated an improvement in tinnitus because of reduced stress and workplace noise.

Experience of teleaudiology services and tinnitus smartphone apps

Only 11% (N = 35/322) of respondents had experience attending virtual appointments with audiologists or clinicians and 37% (N = 13/35) of them thought it was helpful. Examples of positive experience included “it was helpful to understand my hearing loss” (male, 61 years, The UK) and “excellent support from audiologist through Phonak app and appropriate adjustments to hearing aids (were) done remotely” (female, 66 years, The UK).

Regarding tinnitus smartphone apps, 16% (N = 50/322) of respondents used this approach to manage their tinnitus and, of these, 66% (N = 33/50) found the apps helpful. From the 45 open-ended responses collected, Resound Tinnitus Relief was the most mentioned app (N = 14), followed by Calm (N = 4) and Rain Sleep Sounds (N = 3). Those who had positive experience using the apps appreciated the apps’ effectiveness in masking tinnitus and facilitating sleep, and their sound personalization feature. Conversely, negative experience included tinnitus aggravation, lack of suitable sounds for their tinnitus, constant advertising, and high price, e.g., “since my tinnitus is quite broad spectrum rather than a single or very few frequencies, this did not prove particularly useful” (male, 40 years, The UK).

Availability of tinnitus care before/during pandemic

Even though non-urgent healthcare services were disrupted during the pandemic, 78% (N = 249/321) of respondents did not believe that their regular tinnitus care had changed due to the pandemic. Only 5% (N = 16/321) found tinnitus care less accessible and 11

of them reported more bothersome tinnitus, for example: “hospital audiologists not arranging appointments and local British Tinnitus Association group support not being able to hold face-to-face meetings” (Male, 70 years, The UK). Besides, 73% (N = 233/320) and 71% (N = 227/320) of respondents thought that there were insufficient tinnitus care services before and during the pandemic respectively, e.g., a respondent said he had “never heard of any programs” before the pandemic (male, 60 years, Australia). Another respondent said that during the pandemic, “it was near impossible to get a doctor’s appointment for anything, let alone tinnitus” (female, 57 years, The UK).

Tinnitus information accessibility

Overall, 57% (N = 181/320) of respondents were unaware of where they could go to access reliable tinnitus information. Their country of residence was related to whether they knew where to access such information, $\chi^2(1, N = 320) = 33.01, p < 0.001$. A large proportion of Australian respondents did not know where to get reliable tinnitus information (67%; N = 153/230), while only 31% (N = 28/90) of those from other countries did not know where to find such information. The most mentioned reliable sources the respondents had accessed were the British Tinnitus Association (BTA) (N = 67), government health websites (N = 50), and information brochures (N = 46). They mostly found those sources via Internet search (N = 104) and clinicians’ suggestions (N = 43).

Tinnitus treatment uptake factors

When the respondents were asked to select from a list of factors which might affect their consideration of choosing a tinnitus treatment, the top considerations were the credibility of clinician (N = 184), cost (N = 175), and good reviews from others who have tried the treatment (N = 175). They were also encouraged to suggest factors that were not included in the provided list and four additional factors were identified, as shown in supplementary material Table 1. Professional recommendations based on research evidence, clinicians, and tinnitus associations were deemed important. One participant suggested: “I would like to see good scientific evidence for effectiveness” (Male, 64 years, Australia). The treatment’s ability to effectively relieve or even cure their tinnitus was also important. For example: “Efficacy of treatment is the most important thing. I would pay quite a bit and expend effort if something had a decent chance of reducing my tinnitus” (Female, 48 years, The USA). Some barriers, such as the respondents’ insufficient awareness of new treatments and heavy cost, which prevented them from receiving treatments, needed to be overcome first, e.g., “no idea what is out there really” (Male, 51 years, Australia). Additionally, they were concerned

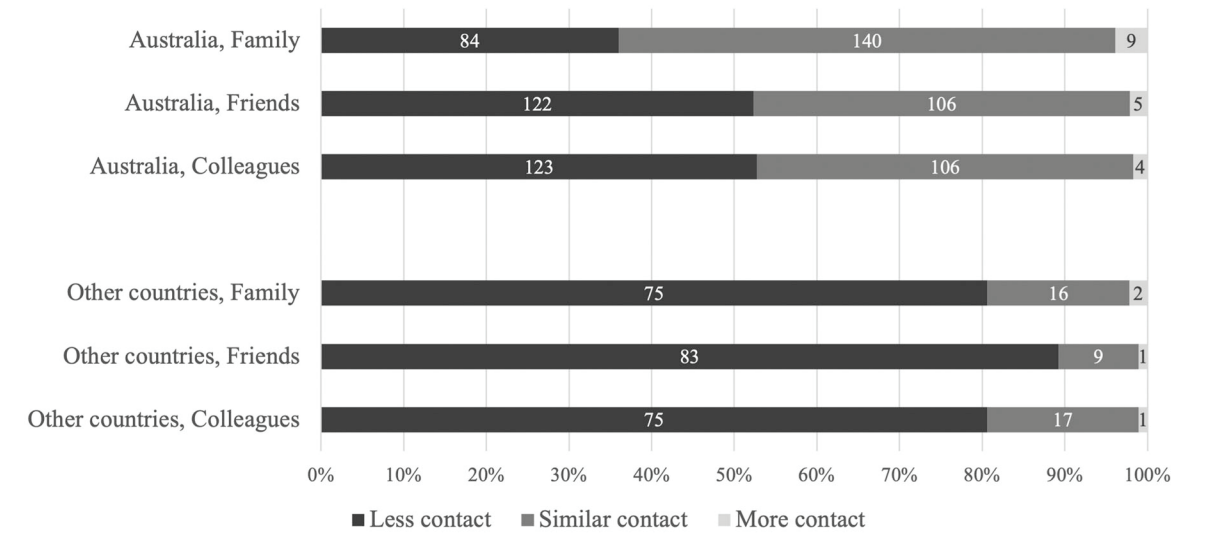


Figure 3. Change in in-person social contact with family, friends, and colleagues during the pandemic.

about whether the treatment would cause physical or psychological damage. For example, side effects were mentioned by a respondent who would consider “how natural it is, or if it involves drugs that are going to put pressure into other organs (i.e., kidneys)” (Female, 33 years, Mexico).

Future of tinnitus care

A total of 250 open-ended responses (180 from Australia and 70 from other countries) were collected regarding respondents’ perceptions on how tinnitus care could be improved. Supplementary material Table 2 shows the five themes generated from the thematic analysis of the respondents’ responses. A considerable number of respondents (N = 67) hoped that a cure could be developed. Many of them thought government policies could be implemented to support scientific research and prohibit scientifically unproven treatments. A need for eliminating barriers such as unsupportive clinicians and low accessibility was indicated, e.g., “every GP and ENT in Australia needs to be trained in how to successfully triage, support and help manage their distressed tinnitus patients. This is not happening at the moment” (female, 63 years, Australia). More tinnitus information should be accessible to patients and the general public in order to raise their awareness and promote prevention of hearing loss and tinnitus. Concerns about hearing devices including patient willingness to use the devices, device appearance, and cost should be addressed as well.

Compared to other countries (19%; N = 13/70), more Australian respondents wished a cure could be developed (30%; N = 54/180). Similarly, more respondents from Australia (19%; N = 35/180) mentioned the need for more information and self-awareness of treatment than those from other countries (10%; N = 7/70). In contrast, less emphasis was put on more funded research (17%),

more supportive and knowledgeable clinicians (18%), and more government support (2%) by Australian respondents than those from other countries (27%, 31%, and 10%, respectively).

Discussion

The aim of the current study was to examine the perspectives of individuals with tinnitus on their functional and emotional challenges throughout the pandemic and to obtain their opinions on the provision of new and accessible tinnitus care. In this study, 36% of respondents reported more bothersome tinnitus since the COVID-19 outbreak, 59% reported no change and 5% reported less bothersome tinnitus. This is consistent with the findings of Beukes et al. (2020) that 32% of respondents reported more bothersome tinnitus during the pandemic, 67% reported no change and 1% reported less bothersome tinnitus. However, Aazh, Danesh, and Moore (2021) reported different results as the ratings of tinnitus loudness, annoyance, and effect on life between the groups of patients seen before and during COVID-19 lockdown did not differ significantly. The authors questioned the reliability of the results reported by Beukes et al. (2020) as respondents might be unable to judge whether their changes in tinnitus perception were due to changes in tinnitus itself, or changes in tinnitus-related symptoms, e.g., poorer sleep quality. Aazh, Danesh, and Moore (2021) suggested that tinnitus-related symptoms could be worsened by the pandemic even for individuals without tinnitus (e.g., having sleep disturbances). Therefore, respondents might have mistakenly attributed their worsened tinnitus to worsened tinnitus-related symptoms instead of tinnitus itself. The authors also suggested that bias might be introduced as respondents were asked to compare their tinnitus severity before and during the pandemic, and it might have made them

believe that there were expected to be differences, and to answer accordingly. Taking these suggestions into consideration, readers should be mindful that caution is needed in the interpretation of the results of this study.

A relationship between respondents' country of residence and change in tinnitus perception was revealed in our study. Nevertheless, logistic regression analysis suggested that country of residence was not the best predictor of worsened tinnitus perception during the pandemic. Instead, female gender, younger age, less access to regular tinnitus care, and less social contact with colleagues were the best predictors of worsened tinnitus perception during the pandemic. Despite the above findings, Australian respondents were found to be less affected than those living in other countries. Some of the factors that might have contributed to this difference between countries are the nationwide pandemic severity, duration of self-isolation, and amount of social contact, and these factors are discussed below.

Compared to other developed countries, such as the UK or the USA, Australia had a remarkably slower spread of the virus and a lower death toll (i.e., 30 deaths per 100,000 population in Australia versus 260 per 100,000 in the UK and 300 per 100,000 in the USA as at May 2022) (World Health Organization 2022). Furthermore, in this study, the duration of self-isolation or quarantine was on average four times longer in other countries than in Australia. Australian respondents were also less affected in terms of reduction in in-person social contact. Self-isolation has been associated with loneliness, stress, depression, and anxiety-induced insomnia (Brooks et al. 2020). These psychological factors are known to have a bidirectional relationship with tinnitus and tinnitus can be exacerbated by worsening emotional state during isolation (Wallh usser-Franke et al. 2012). With less emotional burden stemming from worries about the pandemic and self-isolation, Australians could have perceived less change in their tinnitus. Despite the low mean HADS Anxiety and Depression scores measured among the Australian respondents, they indicated that there should be more focus on wellbeing and quality of life and more mental health support, and the importance of this finding should not be overlooked.

Reports of hearing loss and tinnitus after COVID-19 infection have been emerging (Beukes et al. 2021c; Saniasiaya 2021). Proposed mechanisms behind such observations include infection-induced inflammation and structural damage to the cochlea (Maharaj et al. 2020). Among the seven respondents in this study who had tested positive for COVID-19, three had more bothersome tinnitus and two developed tinnitus after experiencing COVID-19 symptoms. Beukes et al. (2020) also presented seven anecdotal reports of tinnitus emerging as a new

symptom after COVID-19 contraction. Given COVID-19's high infection rate and virulence, substantial efforts have been directed to clinical trials and deployment of COVID-19 vaccines within a year since it was declared a global pandemic (Lo Re et al. 2021). With such a short development period, the side effects of the vaccines were not fully understood and this might be reflected by the post-vaccination tinnitus reports in this study as well as previous literature. Of the 148 vaccinated respondents, 18 had more bothersome tinnitus and three developed tinnitus following vaccinations. Parrino et al. (2022) described three cases of sudden unilateral tinnitus after receiving Pfizer vaccines. Report from Taiwan also indicated a case of temporary tinnitus following AstraZeneca vaccination (Tseng et al. 2021). Post-vaccination tinnitus is rare and has only been reported as a secondary symptom of sensorineural hearing loss after receiving measles, hepatitis B, swine flu, and rabies vaccines (Okhovat et al. 2015). The hypersensitivity reaction triggered by the vaccines and the resultant inner ear inflammation and damage was postulated to be the cause of sensorineural hearing loss and tinnitus (Okhovat et al. 2015). According to published pharmacosurveillance reports of various COVID-19 vaccines, the occurrence rate of tinnitus was 0.006% to 0.03% which was much lower than the observed rate in this study (2%) (Parrino et al. 2022). Such a difference in the occurrence of post-vaccination tinnitus could be due to this study's small sample size and recruitment pathways. Caution is needed in the interpretation of this finding as post-vaccination tinnitus exacerbation and initiation was reported by a small number of respondents. Nevertheless, given the debilitating consequences of tinnitus, further investigation is required to elucidate the pathogenesis of tinnitus symptoms following vaccination.

In this study, a greater proportion of Australian respondents (67%) were unaware of where they could go to access reliable tinnitus information than respondents from other countries (31%) and this was supported by statements such as "more frequent information in news, TV, radio, etc." (male, 62 years, Australia). This finding reflects the fact that currently Australian tinnitus associations are not gaining enough publicity and although tinnitus information is available on their websites, it is not effectively conveyed to individuals with tinnitus. Australian tinnitus healthcare service providers need to more often direct tinnitus patients to tinnitus associations for information and support should the patients need it. Australian tinnitus associations may increase the available tinnitus information both online and in print to suit individuals with different technology competence. As suggested by the respondents, such associations can also increase media exposure to help individuals with tinnitus find available support.

More than 70% of respondents indicated that tinnitus care services were insufficient regardless of the presence of a pandemic. Similar reports have been made by individuals with tinnitus in the USA (Beukes et al. 2021b). This finding suggests that the availability and accessibility of tinnitus treatments was inadequate before COVID-19, and from the qualitative data collected, individuals with tinnitus would like to see improvement in this aspect. Teleaudiology services delivered via virtual appointments and smartphone apps might be useful to enhance treatment accessibility. Although an increased uptake of teleaudiology was seen in some countries after the COVID-19 outbreak (Saunders and Roughley 2021), only 11% and 16% of respondents tried virtual appointments and tinnitus smartphone apps, respectively. As a study demonstrated that there has been a post-pandemic positive change of patients' attitudes towards teleaudiology (Aazh, Swanepoel, and Moore 2021), continuous implementation and promotion of teleaudiology services is important to bridge the gap between service supply and patient demand.

Patients' views on the future of tinnitus care were studied by Beukes et al. (2021a). They generated five themes of suggestions, which mostly overlapped with this study's findings, i.e., experts, therapies, information, research, and prevention. However, the importance of hearing devices was highlighted in this study. Respondents raised concerns about being pressured into buying hearing aids, insufficient hearing aid tinnitus management features, hearing device appearance, cost, and social stigma. These themes provide invaluable information for stakeholders (e.g., clinicians, manufacturers, etc.) to refine service and product delivery and eventually increase patient satisfaction. There is also a need for awareness campaigns targeting stigma of hearing conditions so that stigma barriers are minimized and individuals with tinnitus may be more motivated to choose device-related options that could be beneficial for them.

From the open-ended responses collected in this study, the significance of a systematic approach to tinnitus was underscored. More funding for tinnitus services is required to minimize cost barriers. More training and higher awareness among general practitioners and other health practitioners can facilitate the improvement of referral pathways. More attention should be paid to public health policies and support mechanisms such as tinnitus associations, particularly those in Australia. Public awareness of tinnitus prevention and how to support individuals with tinnitus should be raised. Furthermore, tinnitus-specific research funding is essential for generating scientific evidence to best inform tinnitus care. The systematic approach suggested above is especially important during the pandemic, as individuals with tinnitus may more likely experience worsened tinnitus symptoms

and their accessibility to in-person tinnitus services may have been reduced.

Limitations

Some study limitations should be noted. Firstly, there was possible sampling bias as the survey needed to be filled online and only an English version was available. This might have excluded individuals who were unfamiliar with technology or English language. Also, those whose tinnitus had improved may have been less likely to participate in the survey than those whose tinnitus had worsened. Moreover, the survey was relatively long and most of the respondents required 20 to 25 minutes to complete it. The length of survey might have deterred respondents from answering all questions and reduced the amount of data collected. Additionally, survey distribution was conducted mainly through tinnitus associations and clinics so the sample might be inadequate to represent the general public, especially those who were not in contact with those associations and clinics.

Future directions

Further investigation is required to elucidate the association between receiving the COVID-19 vaccine and tinnitus symptoms. This study provides insights into the needs and concerns of individuals with tinnitus. Hearing healthcare stakeholders including the government, hearing device manufacturers, and clinicians should strive for better tinnitus care focusing on the needs and concerns of individuals with tinnitus. Development of better self- and public-awareness and higher accessibility to tinnitus resources and management are pivotal in the provision of better tinnitus care. Focus groups and semi-structured interviews of consenting respondents in this study will be organized as a continuation to collect more in-depth opinions regarding their tinnitus experience during COVID-19 and future tinnitus care in Australia and we recommend a similar exercise globally. This step will ensure embedding patient voices in research co-design and transforming tinnitus care globally.

Acknowledgments

The authors acknowledge Audiology Australia, Soundfair, British Tinnitus Association, Royal National Institute for Deaf People, Tinnitus Research Initiative as well as three audiology clinics in Adelaide for their help in survey distribution. The authors also acknowledge the tinnitus researchers and tinnitus patients for their help in the survey review.

Disclosure statement

No potential conflict of interest was reported by the author(s).


Funding

This work was funded by the Ida Institute.

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