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Virtual clinic for hearing loss and non-pulsatile tinnitus: initial experience of 210 cases

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Abstract

Objective. Patients with hearing loss and tinnitus face lengthy waits to be seen in the ENT clinic. SHOEBOX Audiometry is an iPad-based, audiometric screening tool. A virtual hearing loss and non-pulsatile tinnitus clinic involving an ENT specialist virtually assessing cases based on the SHOEBOX audiogram, a patient symptom questionnaire and the primary care referral letter were implemented. This service evaluation explored the outcomes of the virtual clinic in reducing the need for a face-to-face ENT appointment.

Method. This was a retrospective service evaluation of the first six months of the virtual hearing loss and non-pulsatile tinnitus clinic.

Results. A total of 210 patients were included: 34.8 per cent (73) were discharged without requiring audiologist assessment or an ENT appointment, 51.9 per cent (109) required formal audiological assessment, 36.7 per cent (77) required imaging and only 13.8 per cent (29) required a face-to-face ENT appointment.

Conclusion. A virtual hearing loss and non-pulsatile tinnitus clinic minimised the number of patients requiring a traditional face-to-face clinic appointment within ENT.

Main Article

Venkat Reddy takes responsibility for the integrity of the content of the paper

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Introduction

In the UK, approximately 11 million people suffer from some degree of hearing loss, and 7 million people suffer from tinnitus.[1,2] These symptoms can have a profound impact on quality of life[3,4] and are associated with poor mental health and unemployment.[5] Unaddressed hearing loss impacts on cognitive function and communication skills[6,7] alongside psychosocial effects, such as social isolation and loneliness.[8]

There is significant demand for secondary care assessment of patients with hearing loss and non-pulsatile tinnitus, who may face lengthy waits to be seen in ENT clinics, and this was exacerbated during the coronavirus (Covid-19) pandemic.[9] These presentations rarely have surgical disease requiring intervention and typically do not demonstrate significant clinical findings.[10]

At the outset of the Covid-19 pandemic, ENT clinics prioritised patients with urgent presentations, leading to a significant backlog of patients who continued to be referred with hearing loss and/or non-pulsatile tinnitus. Combined with a chronic shortage of audiologists supporting ENT services in our department, waiting times for some patients requiring a traditional face-to-face ENT appointment with audiology assessment reached 12 months since referral.

Following a risk assessment of potential harm to patients from delay of diagnosis for tumours of the cerebellopontine angle or internal auditory meatus, a virtual clinic for hearing loss and non-pulsatile tinnitus was proposed. This was subjected to our institutional governance processes and reviewed by the planned care commissioning team and primary care partners with an outcome in support of implementation.

The virtual clinic for hearing loss and non-pulsatile tinnitus is an enhanced triage process to identify patients with hearing loss and/or non-pulsatile tinnitus who do not require a face-to-face ENT appointment. An ENT clinician vets the primary care referral letter for suitability for the virtual clinic based on the presenting complaints, relevant past medical or surgical history, and the referrer's otoscopy findings.

Inclusion criteria for the virtual clinic for hearing loss and non-pulsatile tinnitus were: ≥16 years of age; subjective bilateral hearing loss and/or tinnitus that did not fulfil the criteria for direct referral to audiology (they would see patients ≥50 years of age); subjective asymmetrical sensorineural hearing loss; and subjective unilateral non-pulsatile tinnitus.

Exclusion criteria for the virtual clinic for hearing loss and non-pulsatile tinnitus were: cognitive, motor or visual impairment that may preclude use of an iPad®; patients who had been referred back to ENT having previously been fully medically assessed (redirected to audiology or hearing therapy where appropriate); and symptoms that required a face-to-face appointment (conductive hearing loss, pulsatile tinnitus, vertigo or dizziness, pain, discharge, infections, abnormal ear examination, and history of ear disease, surgery or ear injury).

Patients were invited for an appointment to have a screening audiogram overseen by a healthcare assistant in a quiet setting. SHOEBOX Audiometry (Ottawa, Canada)[11] is a

portable, tablet-based (iPad), user-operated audiometric screening tool that may reduce the need for some patients to be formally assessed by an audiologist. Calibrated headphones (using American National Standards Institute S3.6-2004 standards) are used with the iPad which employs the modified Hughson-Westlake procedure to produce a screening pure tone audiogram. The patient is instructed to drag objects on-screen to either 'audible' or 'inaudible' bins, while a fixed tone is played.[12] SHOEBOX has been shown to possess good test performance with a negative predictive value and sensitivity of approximately 90 per cent for hearing loss, demonstrated in multiple comparative validation studies compared with the 'gold standard' of formal audiometry.[12–15]

The patient is asked to complete a patient questionnaire regarding their symptoms, expectations, whether they would be keen to be referred on to other services, and to establish safety and consent for magnetic resonance imaging (MRI) of the internal auditory meati if indicated.

Cases are then booked into a virtual clinic, with the ENT clinician reviewing the referral letter, patient questionnaire, severity score from 0–10 regarding their perceived severity of hearing loss and tinnitus, and the SHOEBOX audiogram to produce a report summarising the history, SHOEBOX audiogram findings and our recommendations. The report is based on a Microsoft Word® document template including free-text fields and multiple blocks of patient information that can be edited as appropriate to the case. The report is sent to the referring primary care physician and the patient, with signposting to relevant self-referral services, including hearing therapy and counselling, and appropriate patient information regarding communication tactics, tinnitus, justification for imaging and what to expect. An explanation as to what to expect next and the rationale for the decision made is provided for patients referred for further evaluation. The outcomes of the virtual clinic for hearing loss and non-pulsatile tinnitus are as follows: discharged with advice including access to hearing therapy where appropriate; referral to audiology for formal assessment and/or onward referral to hearing therapy if required; MRI of internal auditory meati requested to exclude vestibular schwannoma; and face-to-face ENT appointment.

The aim of this study was to explore the performance of the virtual clinic for hearing loss and non-pulsatile tinnitus in terms of the proportion of patients who are discharged without requiring a face-to-face ENT appointment.

Materials and methods

A retrospective service evaluation was conducted on consecutive patients presenting to the virtual clinic for hearing loss and non-pulsatile tinnitus from June 2020 to January 2021. Patient records including the virtual review report, investigations, interventions and follow-up appointments were reviewed. All patients were followed through the virtual clinic for hearing loss and non-pulsatile tinnitus process until the clinical episode was complete. Data extracted included patient demographic data, presenting complaint, SHOEBOX audiometric screening result (graded as normal (≤25 dB), mild (26–50 dB), moderate (51–70 dB), severe (71–90 dB) or profound (>90 dB)), outcomes of the consultation (discharge, referral for formal audiological assessment, and/or onward referral to hearing therapy, imaging or face-to-face review).

Data were recorded on a Microsoft Excel® spreadsheet. Descriptive statistics were used to describe demographic data, presentations and outcomes. The study was registered with our institutional quality improvement department. As this was a retrospective service evaluation, ethical approval was not required.

Results

A total of 228 patients were vetted as appropriate for the virtual clinic for hearing loss and non-pulsatile tinnitus based on referral information. Eighteen patients (7.9 per cent) were subsequently excluded as they were unable to use the SHOEBOX audiometer due to cognitive or physical impairment and so were booked for a traditional face-to-face appointment with audiologist support.

The study population of 210 patients was composed of 106 females and 104 males, with an age range of 16–86 years. The age and sex distributions are demonstrated in Figure 1. In terms of the frequency of presenting complaints, 41.9 per cent ($n = 88$ of 210) had hearing impairment, 40 per cent ($n = 84$ of 210) had hearing impairment and tinnitus, and 18.1 per cent ($n = 38$ of 210) had tinnitus. The distribution of presenting complaints by sex is shown in Figure 2.

The mean average patient-reported symptom severity scores, on a scale of 0 to 10, were 6.19, 5.60, 7.31, 6.24 and 7.42 for unilateral hearing loss, bilateral hearing loss, unilateral tinnitus, bilateral tinnitus, and mixed hearing loss and

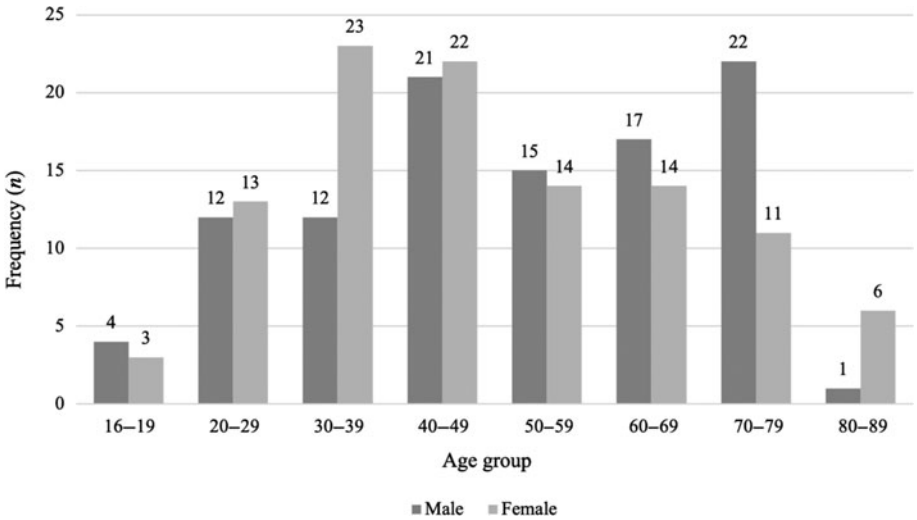

Figure 1. Cohort population by age group and sex.

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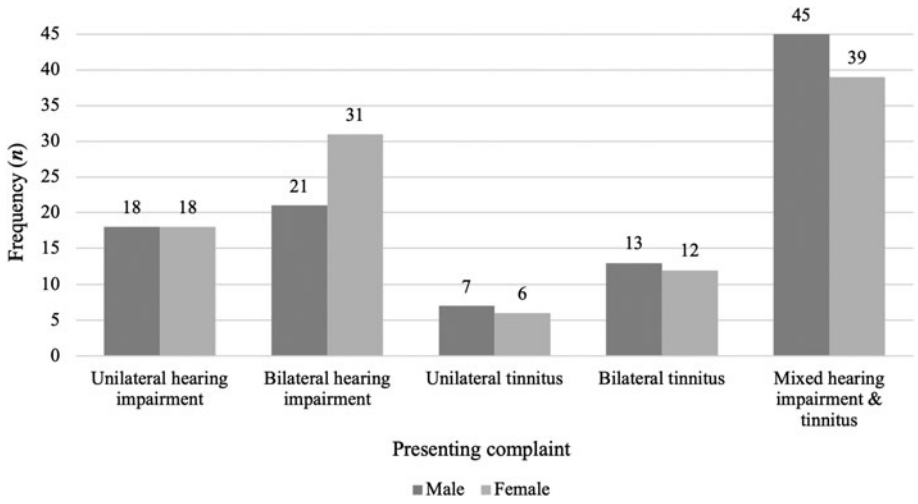

Figure 2. Frequency of each presenting complaint by sex.

tinnitus, respectively. The average cohort-wide symptom severity score was 6.61, with a modal score of 7.

One third (33.3 per cent; $n = 70$ of 210) of those screened with the SHOEBOX audiological assessment had normal hearing. The frequency of hearing impairment categories is demonstrated in Figure 3.

A total of 34.8 per cent of patients ($n = 73$ of 210) were immediately discharged at virtual review with advice and information only, without any further input or management. When broken down by hearing impairment severity as identified by SHOEBOX Audiometry, the virtual clinic was able to immediately discharge 80 per cent ($n = 56$ of 70) of patients with normal hearing and 24 per cent ($n = 13$ of 55) of those with mild impairment. The majority of patients identified as having more significant hearing impairment than this required further investigation (Figure 4).

A total of 51.9 per cent of patients ($n = 109$ of 210) required formal audiological assessment, 36.7 per cent ($n = 77$ of 210) required imaging and only 13.8 per cent ($n = 29$ of 210) required a face-to-face appointment in the ENT clinic. Note that outcome numbers sum to greater than the number of patients (210) passing through the virtual clinic for hearing loss and non-pulsatile tinnitus, alongside percentages summing to greater than 100 per cent. This is explained by multiple outcomes for some patients in many instances (for example, a patient referred for both imaging and audiology and subsequently being referred for a face-to-face evaluation would generate three outcomes for one patient input). The virtual clinic for hearing loss and non-pulsatile tinnitus pathway flow can be depicted using a Sankey diagram (Figure 5). This aids in visualising different patient groups, alongside which patients make up the bulk of referrals for each outcome.

A total of 77 patients (36.7 per cent) underwent MRI to investigate unilateral symptoms, of which 3 patients were diagnosed with vestibular schwannoma or cerebellopontine angle tumours, accounting for 1.43 per cent of all virtual clinic patients. A total of 57.8 per cent of patients referred to audiology received hearing aids ($n = 63$ of 109).

Discussion

This service evaluation details our experience of the virtual clinic for hearing loss and non-pulsatile tinnitus which offers an enhanced triage process to identify patients with hearing loss and/or non-pulsatile tinnitus who do not require a face-to-face ENT appointment. While the literature includes studies of tablet-based audiometry as a lone tool of assessment for hearing, we have demonstrated their utility in addition to a patient questionnaire to streamline existing hearing assessment pathways where resources are lacking for a traditional approach to be undertaken in a timely fashion.

The virtual clinic for hearing loss and non-pulsatile tinnitus facilitated the immediate discharge of 34.8 per cent of all patients presenting for assessment who would have all

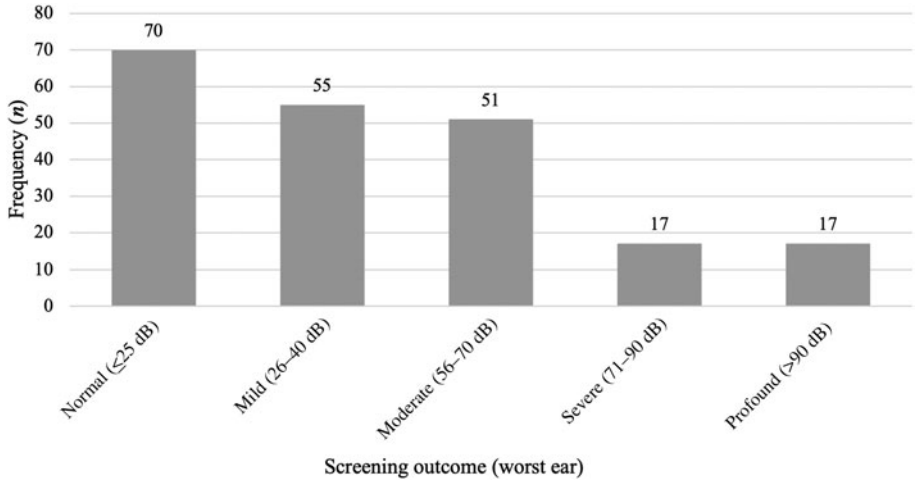

Figure 3. Frequency of hearing impairment severity as identified by SHOEBOX Audiometry in the virtual hearing loss and non-pulsatile tinnitus clinic.

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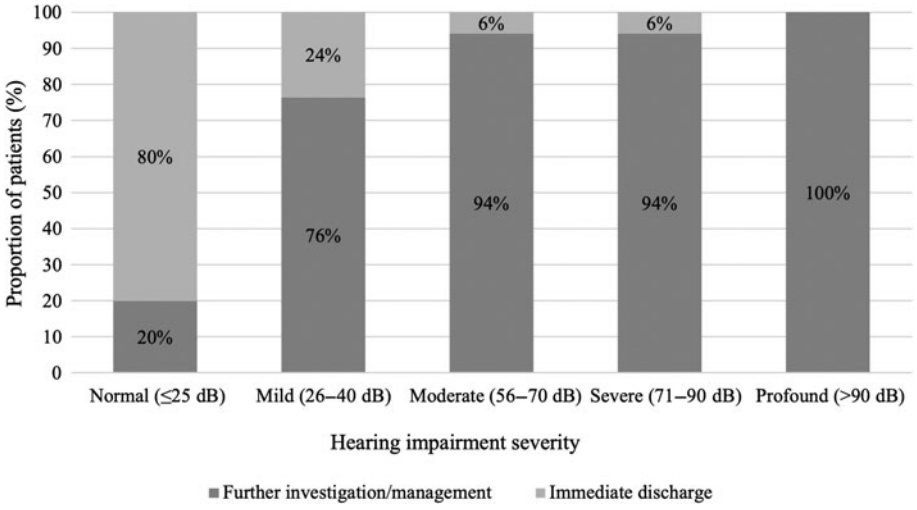

Figure 4. Proportion of patients immediately discharged, stratified by hearing impairment severity as identified by SHOEBOX Audiometry in the virtual hearing loss and non-pulsatile tinnitus clinic.

traditionally required an ENT face-to-face appointment with formal audiological assessment.

The first meta-analysis investigating the sensitivity and specificity characteristics of various pure-tone audiometric screening smart-phone applications was performed in early 2021 by Chen *et al.*[16] Their analysis rigorously screened 1157 individual papers; however, only 25 were deemed to be of acceptable standard and included. Principally, they found a sensitivity-specificity area under the curve performance of 0.96 compared against the 'gold standard' of formal audiometric assessment. This demonstrates exceptional diagnostic and rule-out performance ability for tablet-based audiometric screening. Pertinent secondary outcome results included the difference in performance yielded by using headphones versus earphones (area under the curve, 0.96 *vs* 0.92, respectively) and the use of soundproof *vs* non-silenced environments (area under the curve, 0.99 *vs* 0.94). This data supports our rationale for using a tablet audiometer and validates its performance against the existing 'gold standard'.

The SHOEBOX audiometer was chosen for our service because of its validated test performance characteristics, with confirmed sensitivities and specificities of 96 per cent and 100 per cent, respectively.[17] Comparable results have simultaneously been demonstrated by Saliba *et al.* (95.9 per cent, 100 per cent),[14] and Yeung *et al.* (93.3 per cent, 94.5 per cent).[12] Critically, Thompson *et al.* demonstrated that 95 per cent of thresholds identified by the SHOEBOX system were within 10 dB of 'gold standard' conventional audiometry.[18] SHOEBOX Audiometry is set apart from some competing tablet-based applications through use of calibrated headphones, as opposed to non-calibrated earphones with approximate equalisation thresholds. This yields greater audiometric accuracy compared with some competing solutions.[19]

Louw *et al.*[20] investigated the test accuracy differential between audiometric screening using tablet-based audiometry alongside a questionnaire versus isolated usage of the questionnaire only. They demonstrated that the combined assessment was superior with a hearing loss diagnostic test accuracy of 86.1 per cent *vs* 77.4 per cent when compared with the 'gold standard' of formal audiometric assessment, providing the rationale for adopting a combined screening approach.

Using a combined screening approach such as this acts as a stepping stone between referral from primary care and full formal audiological evaluation. Such high-specificity protocols have been demonstrated to significantly reduce assessments by filtering out non-candidate patients.[21]

Limitations of the virtual clinic for hearing loss and non-pulsatile tinnitus include the inability of a small number of patients to engage with the SHOEBOX system due to cognitive, motor, or visual impairment which may not have been evident at the time of the referral being vetted. Chen *et al.* demonstrated that elderly patients using tablet-based

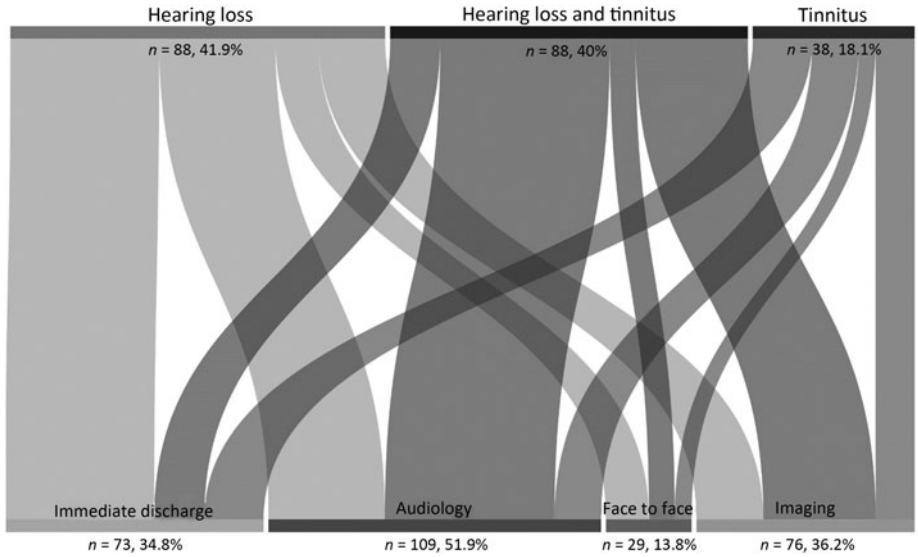

Figure 5. Modified Sankey chart depicting patient flow through the virtual hearing loss and non-pulsatile tinnitus clinic. Note that outputs sum to greater than inputs due to instances of patients having multiple outcomes.

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audiometers have lower test performance characteristics than the adult range.[16] They suggested this may be due to reduced technological literacy within these groups.

The standard SHOEBOX Audiometry system, for patients to self-administer, only allows for air conduction screening. Our virtual clinic for hearing loss and non-pulsatile tinnitus has since evolved to include Rinne's and Weber's tuning fork tests performed by the healthcare assistant administering the SHOEBOX test. This provides additional information at the time of virtual review, which will help to identify which patients should be seen by ENT and audiology jointly.

- Hearing-loss and tinnitus cases generate substantial capacity pressures in ENT out-patient clinics
- The virtual hearing loss and non-pulsatile tinnitus clinic utilises Shoebox Audiometry, a patient questionnaire and a primary care referral letter
- An ENT specialist virtually assesses cases using this data
- This approach facilitated immediate discharge, with advice, for 80 per cent of patients with normal hearing, and over one third of all patients
- The need for formal audiological assessment was halved
- This increased the availability of ENT clinics for cases requiring face-to-face assessment

Future directions of the virtual clinic for hearing loss and non-pulsatile tinnitus might include delivery of SHOEBOX Audiometry in community settings, such as general practice surgeries, to establish if onward referral is necessary. Decentralisation of hearing assessment has already been trialled in remote and developing regions and is actively recommended by the WHO as it has implications for earlier treatment and detection of impairment. Similar benefits may be obtained in the developed world setting.[22,23]

Conclusion

This study demonstrates that 34.8 per cent of patients referred to ENT with hearing loss and/or non-pulsatile tinnitus were discharged upon virtual review without requiring a traditional face-to-face ENT out-patient appointment or formal audiologist assessment. Face-to-face ENT appointments were deemed necessary for only 13.8 per cent of patients.

The virtual clinic approach can help reduce waiting times for patients with these typically benign presentations who might otherwise face a prolonged wait for a traditional face-to-face clinic appointment. An initial virtual clinic approach can improve appropriate utilisation of limited face-to-face ENT clinic capacity and enable earlier identification of patients with brain tumours causing their symptoms.

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Competing interest. None declared

References

1 Tinnitus UK. Tinnitus guidance for GPs. In: https://tinnitus.org.uk/what-we-do/our-vision/ [19 August 2023]
2 Action on Hearing Loss. Hearing matters report. In: https://rnid.org.uk/wp-content/uploads/2020/05/Hearing-Matters-Report.pdf [7 December 2022]
3 Park HM, Jung J, Kim JK, Lee YJ. Tinnitus and its association with mental health and health-related quality of life in an older population: a nationwide cross-sectional study. *J Appl Gerontol* 2020;**41**:181–6
4 Dixon PR, Feeny D, Tomlinson G, Cushing S, Chen JM, Krahn MD. Health-related quality of life changes associated with hearing loss. *JAMA Otolaryngol Head Neck Surg* 2020;**146**:630–8
5 UK Government. Research and analysis, Saleem: profoundly deaf user. In: https://www.gov.uk/government/publications/understanding-disabilities-and-impairments-user-profiles/saleem-profoundly-deaf-user#statistics-about-hearing-loss [7 December 2022]
6 Slade K, Plack CJ, Nuttall HE. The effects of age-related hearing loss on the brain and cognitive function. *Trends Neurosci* 2020;**43**:810–21
7 Moore DR, Zobay O, Ferguson MA. Minimal and mild hearing loss in children: association with auditory perception, cognition, and communication problems. *Ear Hear* 2020;**41**:720–32
8 Shukla A, Harper M, Pedersen E, Goman A, Suen JJ, Price C, *et al.* Hearing loss, loneliness, and social isolation: a systematic review. *Otolaryngol Head Neck Surg* 2020;**162**:622–33
9 Saunders GH, Roughley A. Audiology in the time of COVID-19: practices and opinions of audiologists in the UK. *Int J Audiol* 2021;**60**:255–62
10 Popelka MM, Cruickshanks KJ, Wiley TL, Tweed TS, Klein BE, Klein R. Low prevalence of hearing aid use among older adults with hearing loss: the Epidemiology of Hearing Loss Study. *J Am Geriatr Soc* 1998;**46**:1075–8
11 SHOEBOX Audiometry Pro. In: https://www.shoebox.md/products/clinical-audiometer/ [7 December 2022]
12 Yeung J, Javidnia H, Heley S, Beauregard Y, Champagne S, Bromwich M. The new age of play audiometry: prospective validation testing of an iPad-based play audiometer. *J Otolaryngol Head Neck Surg* 2013;**42**:21
13 Yeung JC, Heley S, Beauregard Y, Champagne S, Bromwich MA. Self-administered hearing loss screening using an interactive, tablet play audiometer with ear bud headphones. *Int J Pediatr Otorhinolaryngol* 2015;**79**:1248–52
14 Saliba J, Al-Reefi M, Carriere JS, Verma N, Provencal C, Rappaport JM. Accuracy of mobile-based audiometry in the evaluation of hearing loss in quiet and noisy environments. *Otolaryngol Head Neck Surgery* 2017;**156**:706–11
15 Rourke R, Kong DC, Bromwich M. Tablet Audiometry in Canada's North: a portable and efficient method for hearing screening. *Otolaryngol Head Neck Surg* 2016;**155**:473–8
16 Chen CH, Lin HH, Wang MC, Chu YC, Chang CY, Huang CY *et al.* Diagnostic accuracy of smartphone-based audiometry for hearing loss detection: meta-analysis. *JMIR Mhealth Uhealth* 2021;**9**:e28378
17 Bastianelli M, Mark AE, McAfee A, Schramm D, Lefrancois R, Bromwich M. Adult validation of a self-administered tablet audiometer. *J Otolaryngol Head Neck Surg* 2019;**48**:59
18 Thompson GP, Sladen DP, Borst BJ, Still OL. Accuracy of a tablet audiometer for measuring behavioral hearing thresholds in a clinical population. *Otolaryngol Head Neck Surg* 2015;**153**:838–42
19 Bright T, Pallawela D. Validated smartphone-based apps for ear and hearing assessments: a review. *JMIR Rehabil Assist Technol* 2016;**3**:e13
20 Louw C, Swanepoel W, Eikelboom RH. Self-reported hearing loss and pure tone audiometry for screening in primary health care clinics. *J Prim Care Community Health* 2018;**9**:1–8
21 Akbari A, Mayhew A, Al-Alawi MA, Grimshaw J, Winkens R, Glidewell E *et al.* Interventions to improve outpatient referrals from primary care to secondary care. *Cochrane Database Syst Rev* 2008:CD005471
22 Tanser F, Gijsbertsen B, Herbst K. Modelling and understanding primary health care accessibility and utilization in rural South Africa: an exploration using a geographical information system. *Soc Sci Med* 2006;**63**:691–705
23 WHO. Global estimates on prevalence of hearing loss. In: https://www.who.int/pbd/deafness/WHO_GE_HL.pdf [7 December 2022]
24 Sankey Diagram. In: https://developers.google.com/chart/interactive/docs/gallery/sankey [7 December 2022]

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