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Smartphone-Based Applications to Detect Hearing Loss: A Review of Current Technology

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Abstract

BACKGROUND/OBJECTIVES: Age-related hearing loss (ARHL) is a widely prevalent yet manageable condition that has been linked to neurocognitive and psychiatric comorbidities. Multiple barriers hinder older individuals from being diagnosed with ARHL through pure-tone audiometry. This is especially true during the COVID-19 pandemic, which has resulted in the closure of many outpatient audiology and otolaryngology offices. Smartphone-based hearing assessment apps may overcome these challenges by enabling patients to remotely self-administer their own hearing examination. The objective of this review is to provide an up-to-date overview of current mobile health applications (apps) that claim to assess hearing.

DESIGN: Narrative review.

MEASUREMENTS: The Apple App Store and Google Play Store were queried for apps that claim to assess hearing. Relevant apps were downloaded and used to conduct a mock hearing assessment. Names of included apps were searched on four literature databases (PubMed/MEDLINE, EMBASE, Cochrane Library, and CINAHL) to determine which apps had been validated against gold standard methods.

RESULTS: App store searches identified 44 unique apps. Apps differed with respect to the type of test offered (e.g., hearing threshold test), cost, strategies to reduce ambient noise, test output (quantitative vs qualitative results), and options to export results. Validation studies were identified for seven apps.

CONCLUSION: Given their low cost and relative accessibility, smartphone-based hearing apps may facilitate screening for ARHL, particularly in the setting of limitations on in-person medical

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care due to COVID-19. However, app features vary widely, few apps have been validated, and user-centered designs for older adults are largely lacking. Further research and validation efforts are necessary to determine whether smartphone-based hearing assessments are a feasible and accurate screening tool for ARHL.

Keywords

age-related hearing loss; hearing test; telehealth

INTRODUCTION

Age-related hearing loss (ARHL) is an idiopathic degeneration of the auditory system associated with older age. Hearing loss is the third most common condition among older individuals, affecting nearly 50% of adults ages 60 to 69 and over 85% of those aged 85 years and older.[1–4] It is associated with decreased productivity,[5] financial autonomy, and social activity[6] and is a risk factor for dementia[7,8] and depression.[9–12] Hearing aids are the first-line treatment and may protect against these negative outcomes.[13] However, only one in seven adults aged 50 years and older with hearing loss wears a hearing aid,[14] and the average delay in adopting hearing aids is 8.9 years.[15] Timely diagnosis and treatment of ARHL is a national public health effort that may help older populations maintain their independence and vitality.

Generally, ARHL affects both ears and impairs perception of high-frequency sounds (or pitches, e.g., 6,000–8,000 hertz [Hz]) before eventually affecting middle (1,000–4,000 Hz) and lower (250–500 Hz) frequencies. In spoken language, consonants vibrate at high frequencies and are more softly spoken.[16] As a result, people with ARHL tend to first present with difficulty understanding speech, especially in noisy environments. Because hearing aids work by amplifying sound only at frequencies where hearing loss is present, it is important to obtain accurate hearing thresholds to ensure proper programming of hearing aids. Improper programming can result in poorer hearing by further distorting auditory signals.

Formal assessment of hearing thresholds is the first step in evaluation of ARHL. The gold standard diagnostic method is pure-tone audiometry conducted by an audiologist in a soundproof room. Pure-tone audiometry identifies the lowest threshold (sound level) that each ear can detect at several frequencies ranging from 250 to 8,000 Hz. Plotting this information creates an audiogram, which is a graph of hearing threshold versus frequency. Unfortunately, traditional audiometry requires trained personnel, costly equipment, time and space, and a physical visit to an audiology clinic.

Tele-audiology is a branch of telehealth that aims to broaden access to hearing health care. From video consultations to remote hearing aid fittings, tele-audiology helps providers reach patients who are otherwise unable to come into the office, such as older individuals with mobility and transportation challenges or those living in medically under- served areas.[17] Tele-audiology also has the potential to help patients navigate care among geriatricians, audiologists, and otologists by lessening the burden of multiple in-person medical visits.

Notably, the recent COVID-19 pandemic has altered the way patients interact with the healthcare system. Social distancing requirements and necessary-care only regulations have greatly limited the ability of patients to see providers in their offices, thereby expanding the need for tele-audiology tools. Moreover, there may be reluctance to enter healthcare settings to avoid contracting COVID-19, especially among vulnerable older adults who make up the ARHL population.[18] To combat this issue, the Centers for Medicare & Medicaid Services increased coverage of telemedicine services, including audiology and hearing health care, during the COVID-19 public health emergency.[19,20]

Remote hearing evaluations may help solve the multifactorial and persistent access problem hindering formal audiometry in older adults. For example, the National Hearing Test used in the Netherlands has successfully offered remote hearing testing through the telephone and internet.[21,22] Smartphone-based mobile health applications (apps) offer another potential solution. In the last 5 years, older individuals have increasingly adopted smartphones and the mobile health app market has expanded dramatically. The percentage of U.S. adults aged 65 and older who own a smartphone increased from 42% in 2016 to a 53% majority in 2019.[23,24] Between 2016 and 2017 alone, the number of mobile health apps grew over 30% to include 325,000 apps.[25] Given their growth and availability, apps offer a potential platform to perform hearing tests outside of the clinic setting.

There are two broad categories of apps that support hearing testing: clinical apps and consumer apps.[26] Clinical apps essentially function as mobile audiometers that are administered by hearing professionals using specific, calibrated equipment.[27] These apps are often not publicly available through app stores, which limits their accessibility.[26] Consumer apps, on the other hand, are widely available on app stores and enable users to self-administer a hearing test without professional involvement or specific equipment. Despite existing for several years, relatively few consumer apps had been validated as of 2016.[28]

The objective of this review is to provide an up-to-date summary of validated and unvalidated consumer apps that enable users to self-administer a hearing test on a smartphone. The advantages and limitations of these apps will be examined while paying specific attention to the needs of older individuals. This topic is particularly relevant to geriatricians, given both the near-universal prevalence of ARHL and the role of primary care providers as a common gatekeeper for referral to hearing specialists.

METHODS

Search Strategy

In May 2020, two authors (Alexandria L. Irace and Rahul K. Sharma) queried apps related to hearing loss testing using the Apple App Store to identify iOS apps and Google Play Store to identify Android apps. These two app stores represented the near-total majority of the mobile app market at the time of this review.[29] Search terms included *audiogram*, *audiometry*, *hearing check*, *hearing exam*, *hearing loss*, *hearing problem*, *hearing test*, and *pure-tone audiometry*. Apps were included if they were available to download on a smartphone device. We did not exclude apps that were also available to download on other

devices, such as a tablet computer. We focused on smartphone apps rather than tablet apps, because recent reports show that smartphone ownership is more prevalent than tablet ownership among older adults.[24,30]

Mobile App Screening and Selection

The titles of apps were first screened for relevance to hearing. Apps with irrelevant titles were excluded (e.g., titles that do not mention hearing or sound, titles describing games or entertainment). Apps with relevant or ambiguous titles were then manually screened by reviewing the app description in the app store. Apps were included if their description mentioned hearing testing. Apps were excluded if they did not claim to assess hearing, were not in English, were designed for children or animal usage, were not available to the general public (e.g., required private institutional login information to access the app), were intended for hearing aid programming (as this would require the user to already own a hearing aid), required a specific brand of headphones to access the app (other than Apple EarPods for iOS apps because they are included with some recent iPhone models), or did not provide an assessment of hearing.

Data Extraction and Quality Assessment

Two of the authors (Alexandria L. Irace and Rahul K. Sharma) tested each app by conducting a mock hearing assessment and producing a test result (e.g., hearing thresholds, scores). Mock hearing assessments were performed using uncalibrated headphones in a quiet room to replicate expected testing conditions. Android apps were tested on Samsung Galaxy S10 (Android version 10.0 with One UI 2.1; Google, Mountain View, CA) and iOS apps were tested on an iPhone XR (iOS 13.4.1; Apple, Cupertino, CA). Variables collected included the cost of the app, additional equipment required (i.e., test will not begin without equipment) or recommended (i.e., user instructed to use equipment) besides a smartphone, the type of test conducted (e.g., hearing threshold test), strategies to reduce ambient noise during testing, volume specifications, test output (including whether qualitative or quantitative), and options for exporting results (email, text, or messaging app).

A literature review was conducted of all included apps to identify validation studies in peer-reviewed literature. The name of each app was searched using PubMed/ MEDLINE, EMBASE, Cochrane Library, and CINAHL. Studies that compared an app to gold standard methods (i.e., pure-tone audiometry) were included. Studies were excluded if they were not in the English language.

RESULTS

Overall, 44 unique apps were included in this review. Sixteen apps were available only on the Apple App Store, 11 were available only on the Google Play Store, and 17 additional apps were available on both platforms. Tables 1, 2, and 3 provide a summary of all included apps available on iOS only, Android only, and both platforms, respectively.

Thirty-six apps (82%) were free to download and use, whereas eight had associated download costs that ranged from 0.99 USD to 38.99 USD. No apps had required subscription costs. Most apps (37/44, 84%) incorporated a hearing threshold test, either

alone or in conjunction with other types of hearing tests or a questionnaire. Twenty-eight apps (64%) employed an ambient noise reduction strategy. These strategies included detecting ambient noise levels using the smartphone's microphone and instructing the user to enter a quiet space if necessary, or instructing the user to enter a quiet space without detection of noise levels. Twenty-seven apps (61%) instructed users to set their phone volume to a specified percentage level or a subjective range (e.g., "comfortable" level) before testing.

The most common quantitative output was an audiogram (29/44, 66%), followed by a score grading the user's hearing (8/44, 18%). Qualitative output was produced by 25 apps (57%) and consisted of either binary classification, such as "normal hearing" versus "abnormal hearing" (3/44, 7%), or graded categories of hearing loss, such as "mild loss," "moderate loss," and so on (22/44, 50%). Of the apps that produced audiograms, a majority (18/29, 62%) also provided qualitative descriptors of hearing. Less than half of all included apps (20/44, 45%) had integrated data sharing features enabling users to export results directly through email, text message, or a messaging app (e.g., WhatsApp).

Validation studies published in peer-reviewed journals were identified for seven (16%) of all included apps. Validated apps included uHear (iOS), Audcal (iOS), Audiogram Mobile (iOS), Hearing Test e-audiologia.pl (Android), Hearing Test Pro e-audiologia.pl (Android), hearScreen USA (iOS, Android), and hearZA (iOS, Android). The most widely studied app was uHear, with 12 validation studies published to date.

DISCUSSION

Smartphone-based hearing assessments may offer an opportunity to screen for ARHL in a low-cost and easily accessible manner. Various audiometric tests have been shown to produce similar results between in-person and remote testing modalities.[31] Patients may even prefer mobile-based self-administered audiometry to conventional audiometry.[32] This review provides an overview of commercially available smartphone apps that claim to assess hearing.

Numerous apps available on the Apple App Store and Google Play Store met inclusion criteria, despite substantial variability in design and function. Most apps measured hearing thresholds (i.e., the minimal loudness needed to detect a sound), similar to conventional audiometry. Some of these apps yielded audiograms, while others yielded arbitrary scores or qualitative results such as "normal hearing" or "mild loss." In addition to hearing threshold testing, some apps included a questionnaire that requested information such as the user's age, gender, and past or present hearing concerns. Though questionnaire responses should not influence objective, quantitative results, it is unclear whether responses factored into qualitative results due to a lack of methodologic description.

Most apps that did not measure pure-tone hearing thresholds implemented speech-in-noise or digits-in-noise testing. These tests, conducted at conversational levels, involve identification of words or digits in background noise to estimate the signal-to-noise ratio that enables the user to correctly identify 50% of words or digits (no apps tested the ability to

correctly identify words in quiet, often called speech-in-quiet testing or speech audiometry). These tests provide valuable information about hearing in real-world environments (e.g., a crowded restaurant). However, these tests do not yield an audiogram and may be confounded by cognitive impairments or lack of fluency in the testing language.[33,34] A battery of tests is typically required to disentangle the audiometric and cognitive components that may underlie an abnormal score, which these apps do not provide. Thus, these apps may be a useful screening tool for audiology referral, but diagnostic decisions should not be based off these apps in isolation.

Usability of mobile health apps by older populations is an important consideration in telehealth. While the majority of U.S. adults aged 65 and older own a smartphone,[23] ownership does not guarantee adoption of the technology.[35] Smartphone usage is higher among those who are younger, more educated, have a higher income, and live in urban/suburban areas.[23] Older adults may be apprehensive about their ability to effectively use apps due to poor user-friendliness and a steep learning curve.[36] For example, older users are hindered when they must navigate through multiple screens, make sense of unclear explanations, or retrieve data through an app.[37] In our review, instructions for many apps were extremely limited, with some even neglecting to instruct users to wear headphones during testing. Data export options enabling users to send results to their provider were also lacking. These apps did not incorporate user-centered designs for older adults, which should accommodate for possible cognitive impairment, physical and dexterity limitations hindering use of a touch-screen interface, and impaired vision.[38] Previous research has shed light on how human factors affect adoption of telehealth systems by older individuals and the importance of universal design features to improve ease of use.[35,39–42] Some of these features include increasing touch button size and font size, using high contrast color schemes, employing automation, adding step-by-step instructions, avoiding medical jargon, incorporating visual and vibratory tactile cues, and providing secure in-app data export options.

Output from self-administered hearing testing apps should be useful to both geriatricians and hearing specialists. Geriatricians are often responsible for making referrals to audiologists and otolaryngologists for ARHL. An easy-to-use screening tool, such as a smartphone app, can improve identification of patients needing referral. Moreover, the recently passed Over-The-Counter Hearing Aid Act, which will enable adults with mild to moderate hearing loss to access hearing aids without being seen by a hearing professional, may increase interest in self-administered apps to detect hearing loss.[43] As hearing aids become more widely accessible, geriatricians' knowledge of these apps will become even more important.

Audiograms were the most common output from apps in this review (29/44, 66%). Although a comprehensive audiogram provides detailed information, it is difficult to interpret by non-specialists and thus less useful for screening purposes. Our review shows that over 60% of apps that produced audiograms also provided qualitative descriptors of hearing, such as "abnormal hearing" or "profound hearing loss", which can enable interpretation by primary care providers. Ideally, quantitative output should include descriptive qualitative results to facilitate navigation of care.

In addition to issues with interpretation, app-produced audiograms may not be reliable due to calibration issues. Calibration of hardware (i.e., the smartphone speaker or headphones) ensures that the sound level presented to the user is consistent with the sound level intended to be tested. Calibration is approached differently depending on whether the app is designed as a clinical tool or for consumer use. Clinical apps intended for field use as mobile audiometers must adhere to calibration standards in order to produce accurate results. Clinicians administering these apps will typically provide any necessary equipment and ensure it is calibrated before conducting the test. Consumer hearing apps, however, may be self-administered using any uncalibrated equipment that the user has in their home. Some consumer apps attempt to loosely adhere to calibration standards by instructing users to utilize a specific model of headphones (e.g., Apple EarPods) or requiring users to manually set the smartphone volume to a quantitative level (e.g., 50% of full volume). These specifications theoretically enable the audio output to be more consistent across tests. However, this falls short of true calibration as it does not account for headphones malfunctioning over time, variation in volume scales on different devices, incompatibility between different smartphone models and headphones (with variation in types [wired vs wireless] and styles [in-ear, over-ear, etc.]), or human error. Thus, determining exact hearing thresholds without calibration is not currently possible. Of note, speech-in-noise tests do not require adherence to strict calibration standards,[22,44] but other confounders such as cognitive or language barriers may undermine these results. Due to these various issues, we believe that consumer apps should be considered a potential screening tool only and should not be used to diagnose hearing loss.

Ambient noise can interfere with testing, leading to worse-than-true performance on hearing assessments. Instructing users to perform the test in a quiet space without verifying ambient noise levels provide the lowest level safeguard. A better option is to use the smartphone's microphone to detect ambient noise and prevent commencement of the test until the environment is sufficiently quiet. One app (Jacoti Hearing Center) not only detected ambient noise before testing, but also continuously monitored noise levels throughout testing and instructed users to find a quieter space whenever necessary. Continuous monitoring of ambient noise is a critical feature as many users, particularly those with true hearing loss, may not be aware of noise levels in their environment. Aside from active monitoring, another strategy to reduce ambient noise involves using passive sound-attenuating headphones (tight-fitting over-the-ear headphones or in-ear models) or active noise-cancellation headphones. As noise-canceling headphones become more popular and less expensive, future apps may require this equipment. However, equipment restrictions may limit broad accessibility, and more research is needed to determine which noise reduction methods are most appropriate for remote hearing testing.

It is challenging to determine which apps offer clinical value due to the high quantity and wide variation among apps. Currently, few mobile health apps have undergone rigorous testing and there is no comprehensive resource to identify validated apps aside from searching the literature.[45] In our review, 44 apps were examined, but only 7 had been described in published validation studies. Of note, despite being available for public use, some of the referenced validation studies for AudCal,[46] uHear,[47,48] Hearing Test e-audiologia.pl,[49] and hearScreen USA[50–53] were performed in a controlled clinical setting

with assistance from hearing professionals and calibrated equipment. Due to differences in testing conditions, these validation studies may not be applicable when the hearing tests are self-administered in a home environment. The paucity of validation for consumer apps may result in unreliable app quality, misleading claims, unnecessary referral and testing (if a false positive), or delayed diagnosis (if a false negative). One proposed validation framework recommends that apps undergo technical validation (Is the app functional, accurate, and reliable compared to gold standards?), clinical validation (How does the app impact clinical outcomes?), a usability assessment (Is the app easy to use for its intended purpose? Does the interface reflect the preferences of the target user audience?), and cost-effectiveness analysis.[45] Such regulation and oversight could be implemented by a large government agency, such as the FDA or Federal Trade Commission, or an unbiased third party organization. Until this is achieved, apps that are used for remote hearing testing should be validated against pure-tone audiometry and have known sensitivity, specificity, and positive/negative predictive values. Overall, more oversight of the mobile health app market-place is needed to implement regulations to ensure validation and accuracy.

Data security is another important concern.[54,55] Over 80% of reviewed apps were free, which leads to the question of where their revenue is derived. Apps that sell data to third parties risk undermining patients' privacy and should be avoided. Unfortunately, this phenomenon is often not transparent. In addition, many apps allowed users to export their results through email or text, which are potentially insecure methods of communication. Ideally, results would be exported directly from the app to an encrypted patient portal or encrypted data storage platform that can be accessed by both the patient and provider using private login information. However, based on our review, no apps enabled users to share results through these methods.

There are several limitations to this review. First, we included only smartphone apps because of the near ubiquity of smartphones and the recent surge in app development. This included apps that were available on smartphones in addition to other platforms, such as tablets. However, we did not study apps available only on tablets or desktop computers, nor did we study website-based hearing assessments. Nevertheless, smartphones continue to dominate computing in the modern era. Nearly 20% of American adults, and 12% of adults aged 65 years and older, are "smartphone-only" internet users, meaning they do not have access to non-smartphone broadband internet at home.[23] Another limitation is that we were unable to ensure compatibility of apps with all smartphone models, which was outside the scope of this review.

The COVID-19 pandemic has resulted in many obstacles hindering care for older patients at higher risk of contracting the disease.[18] These hurdles have encouraged geriatricians to harness telehealth's potential to improve and expand patient care. Tele-audiology screening for ARHL is an important application of telehealth that may become more crucial in the months and years to come. Therefore, geriatricians will benefit by knowing which apps are available, understanding their limitations, recognizing important features, and familiarizing themselves with the types of tests and outputs.

Numerous commercially available tele-audiology apps claim to assess hearing, but few have been validated in peer-reviewed literature. Given their low cost and relative accessibility, these apps may facilitate screening for ARHL, particularly in the setting of limited in-person medical care due to COVID-19. Apps that produce both quantitative and qualitative output, such as an audiogram with hearing thresholds and complementary descriptive qualifiers, are most useful to provider teams. Further research should establish the accuracy, reliability, and usability of consumer apps, and more regulatory oversight is needed to support validation studies.

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Key Points

- Age-related hearing loss is a prevalent yet undertreated condition among older adults.

Why Does this Paper Matter?

Smartphone-based hearing test apps may facilitate remote screening for hearing loss, but limitations surrounding app validation, usability, equipment calibration, and data security should be addressed.

Table 1.

iOS-only Supported Apps

App Name (Developer)	Cost (USD)[a]	Equipment	Test	Ambient Noise Reduction	Volume Setting	Qualitative Output	Quantitative Output	Data Export	Valid[b]
Audcal	0	Recommends Apple EarPods	Hearing threshold	None	50%	"Normal" – "profound" HL	Audiogram, Average threshold in each ear, Percentage hearing handicap	Email, text	Yes[46]
Audicus Hearing Test	0	Requires headphones	Hearing threshold	None	100%	"Normal" – "severe/profound" HL	Percentage of hearing in each ear for low/mid/high freq.	Email	No
Audiogram Mobile	38.99	Recommends headphones	Hearing threshold	None	None	NA	Audiogram	Email	Yes[56,57]
EasyHear	0	Recommends headphones	Hearing threshold	Detects noise level before test	50%	"Normal" – "severe" HL	Audiogram (lacks numerical dB thresholds)	No	No
Easy Hearing Test	0	Recommends headphones	Hearing threshold	None	"Near middle"	NA	Audiogram	No	No
Fennex by Smart Hear	0	Requires Apple EarPods or AirPods	Hearing threshold	Instructs user to enter quiet space	100%	NA	Score (0–100) for low/mid/high freq.[c]	No	No
Hearing Analyzer Lite	0	Recommends headphones	Hearing threshold	None	50%	NA	Audiogram	No	No
Hearing Analyzer Portrait	3.99	Recommends headphones	Hearing threshold	None	None	NA	Audiogram	No	No
Hearing Check In	0	Recommends headphones	Hearing threshold	Instructs user to enter quiet space	"Quiet"	NA	Score (unknown range)[c]	No	No
Hearing Test 4 All	0.99	Recommends in-ear headphones	Hearing threshold	Instructs user to enter quiet space	50%	"Normal," "slight loss," "impaired hearing"	Audiogram (lacks numerical dB thresholds)	No	No
Hearing Test App iOS (Zipdev LLC)	0	Recommends headphones	Hearing threshold	Instructs user to enter quiet space	Until user cannot hear tone	NA	Audiogram	Email, text	No
Hearing Test & Ear Age Test	0	Recommends headphones	Hearing threshold	Instructs user to enter quiet space	50%	"Normal" – "severe" HL	Audiogram	Email, text	No
HearMate	0	Requires headphones	Hearing threshold	None	None	NA	Audiogram	Email, text	No
Jacoti Hearing Center	0	Requires Apple EarPods	Hearing threshold	Detects noise level throughout test	100%	"Normal" – "profound" HL	Audiogram	Email, text	No
uHear	0	Recommends headphones	1. Hearing threshold 2. Speech-innoise 3. Questionnaire	Detects noise level before test	None	"Normal" – "profound" HL	1. Audiogram (lacks numerical dB thresholds) 2. Signal-to-noise ratio (in dB)	No	Yes[47,48,58–67]

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App Name (Developer)	Cost (USD)[a]	Equipment	Test	Ambient Noise Reduction	Volume Setting	Qualitative Output	Quantitative Output	Data Export	Valid[b]
							3. Questionnaire score (normal if >20)		
uSound	0	Requires headphones	Hearing threshold	None	None	“Normal” – “severe” HL	NA	No	No

Abbreviations: freq., frequencies; HL, hearing loss; NA, not applicable.

[a]Initial download cost. No apps had a required subscription fee.

[b]Validation study conducted against pure-tone audiometry.

[c]Unknown unit and unclear how the score was calculated.

Table 2.

Android-only Supported Apps

App Name (developer)	Cost (USD)[a]	Equipment	Test	Ambient Noise Reduction	Volume Setting	Qualitative Output	Quantitative Output	Data Export	Valid[b]
Audiogram Pro	1.49	Recommends headphones	Hearing threshold	Instructs user to enter quiet space	100%	“Normal” – “severe” HL	Audiogram	No	No
Eartone Hearing Test	0	Recommends headphones	Questionnaire, hearing threshold	Instructs user to enter quiet space	100%	“Normal” – “profound” HL	Audiogram	Text	No
Hearing Test (Android Crazy Studio)	0	Recommends headphones	Hearing threshold	None	None	NA	Audiogram	WhatsApp	No
Hearing Test (leo4google)	0	Requires headphones	Hearing threshold	Instructs user to enter quiet space	None	“Normal” vs “abnormal”	Audiogram	No	No
Hearing Test (Nick ZT)	0	None	Hearing threshold	None	None	NA	Audiogram	Email	No
Hearing Test (eaudiologia.pl)	0	Requires headphones	Hearing threshold	Instructs user to enter quiet space	None	“Normal” – “deafness”	Audiogram	Email, text	Yes[49,68]
Hearing Test Pro (e-audiologia.pl)	4.59	Requires headphones	Hearing threshold	Detects noise level before test		“Normal” – “deafness”	Audiogram	Email, text	Yes[69]
Hearing Test EN	5.99	Recommends headphones	Freiburg monosyllabic speech test	Instructs user to enter quiet space	“Pleasant”	“Not good” – “perfect”	NA	No	No
Indian Hearing Screening Testing	0	Recommends headphones	Questionnaire, hearing threshold	Instructs user to enter quiet space	100%	“Normal” – “profound” HL	Audiogram	No	No
Test My Hearing	0	None	Hearing threshold	None	None	“Normal” – “profound” HL	Audiogram	No	No
uSound for Samsung	0	Requires headphones	Questionnaire, hearing threshold	Detects noise level before test	100%	“No risk” – “high risk”	Audiogram	No	No

Abbreviations: HL, hearing loss; NA, not applicable.

[a] Initial download cost. No apps had a required subscription fee.

[b] Validation study conducted against pure-tone audiometry.

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Table 3.

Apps Supported by Both iOS and Android Platforms

App Name (Developer)	Cost (USD)[a]	Equipment	Test	Ambient Noise Reduction	Volume Setting	Qualitative Output	Quantitative Output	Data Export	Valid[b]
Absolute Ear: Diagnostics	0	Recommends headphones	1. High freq. hearing threshold 2. Speech-in-noise	None	None	NA	1. Percentage of freq. heard (11–20 kHz) 2. Percentage correct	No	No
AudioCardio Hearing Training	0	Recommends headphones	Hearing threshold	Instructs user to enter quiet space	60%	NA	Score (0–10)[c], Hearing threshold for each ear at freq. 1–12 kHz	No	No
Check Your Hearing	0	Recommends headphones	Hearing threshold	None	100%	"Normal" – "profound" HL	Audiogram	*iOS*: Email, text *Android*: No	No
Hearing Test, Audiogram (IT ForYou)	0	Requires headphones	Hearing threshold	Instructs user to enter quiet space	100%	NA	Audiogram (lacks numerical dB thresholds)	No	No
Hearing Test – Best (Appxone)	0	Recommends headphones	Hearing threshold, speech-in-noise	Instructs user to enter quiet space	None	NA	Hearing "age", Percentage of hearing	No	No
hearScreen USA	0	Requires headphones	Questionnaire, Digits-in-noise	Instructs user to enter quiet space	*iOS*: 20% to 55% *Android*: "Comfortable"	"Needs help," "hearing difficulties," "OK," "good," "awesome"	Score (0–100)[c]	No	Yes[50–53]
hearWHO	0	Requires headphones	Digits-in-noise	*iOS*: Detects noise level before test *Android*: Instructs user to enter quietspace	Until user can hear digits	"Some degree of hearing loss" (score < 50), "check your hearing regularly" (score 50–75), "Good hearing" (score > 75)	Score (0–100)[c]	Email, WhatsApp	No
hearWHO Pro	0	Requires headphones	Digits-in-noise	Detects noise level before test	Until user can hear digits	Same as hearWHO	Score (0–100)[c]	Email, WhatsApp	No
HearZA	0	Requires headphones	Questionnaire, digits-in-noise	Instructs user to enter quiet space	"Comfortable"	NA	Score (0–100)[c]	No	Yes[70]
Human Benchmark	0.99	None	High freq. hearing threshold	None	None	NA	Highest freq. heard	No	No
MDHearing	0	Requires headphones	Hearing threshold	None	100%	NA	Audiogram	Email	No
MFA Hearing Test	0	None	Hearing threshold	Detects noise level before test	*iOS*: Test not functional *Android*: Until user can hear sound	*iOS*: Test not functional *Android*: "Normal" – "profound" HL	*iOS*: Test not functional *Android*: Audiogram	*iOS*: Test Not functional *Android*: Email	No

App Name (Developer)	Cost (USD)[a]	Equipment	Test	Ambient Noise Reduction	Volume Setting	Qualitative Output	Quantitative Output	Data Export	Valid[b]
Mimi Hearing Test	0	Requires headphones	Questionnaire, hearing threshold	iOS: Detects noise level before test Android: Instructs user to enter quiet space	*iOS*: 50% *Android*: "Comfortable"	"None" – "severe" HL, identifies better ear, compares hearing to age-matched average	Audiogram, Percentage of hearing in each ear	Email	No
Signia Hearing Test	0	Recommends headphones	Speech-in-noise	Detects noise level before test	None	"Normal hearing" vs "bad hearing"	Score (0–9) of correct results	No	No
SoundCheck	0	Recommends headphones	Hearing threshold	Detects noise level before test	50%	"Normal" vs "hearing loss" for low/mid/high freq.	Audiogram (lacks numerical dB thresholds)	Email	No
Temporary Hearing Loss Test	2.99	Recommends headphones	Temporary threshold shift test	None	None	NA	Change in hearing threshold (dB) after noise exposure	Email	No
TuneFork (Listening Applications LTD)	0	Recommends headphones	Hearing threshold	Instructs user to enter quiet space	None	NA	Audiogram	No	No

Abbreviations: freq., frequency; HL, hearing loss; NA, not applicable.

[a] Initial download cost. No apps had a required subscription fee.

[b] Validation study conducted against pure-tone audiometry.

[c] Unknown unit and unclear how the score was calculated.

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