The importance of early identification and prevention of hearing loss for people of all ages is well established. Within the adult population, research has shown an association between hearing loss and reduced quality of life (Dalton et al., 2003) as well as links between hearing loss and other health conditions such as dementia and depression (Kochkin & Rogin, 2000; Lin et al., 2011). Unfortunately, many adults are not aware of these associations. Similar to early detection for other medical conditions, adult hearing screening should be seen as one of many ways to provide preventative care and promote early access to treatment.

Essentials of a Hearing Screener

Three essential elements were defined to qualify an acceptable screening tool: reasonable cost, quick administration time and accuracy. Accuracy of a screening tool consists of sensitivity and specificity, which determine how well a clinical test or screening tool identifies those with and without a condition, respectively. An ideal test or screening tool would have 100 percent sensitivity and 100 percent specificity, meaning it refers all individuals with the disease and passes all of those without the disease (National Institutes of Health, 1993). Few clinical tests or screening tools meet these specifications; there is often a tradeoff between sensitivity and specificity. Considering the characteristics of an ideal screening tool and the lack of awareness of the consequences of untreated hearing loss, an innovative way to screen for hearing loss that is both accurate and accessible may result in greater awareness and in early access to treatment.

With the surge of smartphone popularity in recent years, many individuals have fast and convenient access to a wealth of information, which has transformed the way they educate themselves about their personal health, as well as the way medical professionals provide services. Leveraging this technology for use in hearing screenings may make it possible to reach people with hearing loss who might not otherwise be reached through other more traditional means such as health fairs and community events. Approximately 60 percent of people under the age of 45 and 30 percent of those...
over the age of 45 own a smartphone (The Nielsen Company, 2012). Additionally, with the number of mobile application downloads reaching 10.9 billion worldwide in 2010 and projected to reach 76.9 billion worldwide in 2014, use of this technology can be convenient, efficient, and effective for individuals wishing to both educate themselves about hearing loss as well as complete a basic hearing screening (International Data Corporation, 2010).

Implementing this type of technology for the purposes of hearing screening is not without disadvantages, however. Issues such as calibration, environmental noise levels and lack of patient instruction may contribute to inaccurate and inconsistent results. As the accuracy of mobile application hearing屏幕ers has yet to be formally established, the goal of this study was to compare several available hearing screening applications (Shargorodsky & Fligor, 2011). Of particular interest were the sensitivity and specificity of each application, time to complete the hearing screening and participant ratings regarding ease of use.

Comparing Mobile Screeners

Some hearing aid manufacturers, including Starkey Hearing Technologies, have leveraged the popularity and flexibility of mobile devices to create their own self-administered hearing screener applications. The unique screening applications included in this study were selected based on the availability of pure-tone testing functionality and popularity in the industry at the time of the study. Starkey Hearing Technologies’ hearing screening application, Sound Check, was included in the investigation along with three other applications, which will be referred to as Screeners A, B, and C (see Table 1 for more information on each application). Sound Check and Screeners A and B are mobile applications available for download from the Apple® App Store; Screener C, however, was an Internet-based screener that is no longer available online. Figure 1 displays Sound Check’s testing screen. The participant’s task is to press the blue button upon hearing a tone. After completing the screening, the participant has the option to view his or her results in various formats. Figure 2 displays the basic results screen, which contains an overview of the results for each ear. Figure 3 displays the advanced results screen, allowing the user to view frequency-specific results for each ear.

Methods

Thirty-two adults, 13 females and 19 males, were selected for participation in this study. All participants were aged 40 years or older, with an average age of 57.9 years. A pure-tone air conduction audiogram was conducted by an audiologist in a sound-treated booth prior to beginning the screening evaluations. Sixteen participants were classified as normal hearing based on a high-frequency pure-tone average (PTA) (average of thresholds at 1000, 2000, and 4000 Hz) of less than 25dB hearing loss in both ears, and 16 participants were classified as hearing impaired based on a PTA of greater than or equal to 25dB hearing loss in both ears. In order to mimic a typical environment when using a home-based, self-administered screener, the hearing screenings were conducted in random order in a quiet room using an iPad® and personal computer (PC) with standard Apple earbuds. Steps were taken to ensure that participants were blinded to the developer of each screening application. During each screening, each participant was timed by the audiologist in order to obtain information on how long each screener took to complete. Immediately

<table>
<thead>
<tr>
<th>Screening Application</th>
<th>Mobile or Internet</th>
<th>Number of Frequencies Tested</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Check</td>
<td>Mobile</td>
<td>4</td>
<td>Free</td>
</tr>
<tr>
<td>Screener A</td>
<td>Mobile</td>
<td>6</td>
<td>Free</td>
</tr>
<tr>
<td>Screener B</td>
<td>Mobile</td>
<td>Up to 7</td>
<td>$3.99</td>
</tr>
<tr>
<td>Screener C</td>
<td>Internet</td>
<td>2</td>
<td>Free</td>
</tr>
</tbody>
</table>

Table 1: Characteristics of screening tools included in this study.
following each screening, participants completed a questionnaire regarding ease of use of the screening tool.

Results

Participant responses regarding ease of use revealed no significant findings. All of the screeners were rated as relatively easy to use (see Figure 4). Timing results indicated that participants were able to complete all screenings in less than 10 minutes. However, as shown in Figure 5, Sound Check was significantly faster than all other screening tools.

The results provided by each screening tool were used to determine pass and referral rates. A patient passed if the results provided by the screener indicated normal hearing in both ears. A patient was referred if the results provided by the screener indicated hearing loss, of any degree, in one or both ears.

Overall referral rate was calculated for each screening tool. Assuming a screener correctly referred all hearing impaired participants, an ideal referral rate for this group of participants would be 50 percent. Sound Check referred approximately

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Figure 1: Sound Check’s testing screen. The patient presses the blue button in the middle of the screen and can monitor his or her progress with the colored bars at the bottom of the screen.

Figure 2: Sound Check’s basic results screen. Ear specific hearing status is indicated, and a referral to a professional is made if hearing loss is detected.

Figure 3: Sound Check’s advanced results screen. Screening results are displayed as a function of frequency.
56 percent of all participants while Screeners A, B and C referred over 90 percent of the participants.

As shown in Figure 6, Sound Check had a sensitivity and specificity of 94 percent and 81 percent, respectively. In comparison, Screener A correctly identified 100 percent of all hearing impaired individuals; however, 81 percent of normal hearing participants were incorrectly referred for hearing loss. Screener B and C had similar results with a sensitivity of 100 percent and a specificity of six percent.

Conclusion

Mobile application screening tools are cost effective, as most are available for download free of charge, and they are relatively quick to complete. All of the investigated screeners were able to identify most of the hearing impaired participants. However, Screeners A, B, and C were unsuccessful at identifying most individuals with normal hearing, making them ineffective as screening tools. Sound Check was most effective at appropriately identifying those with and without hearing impairment.

Based on these results, considerations must be made before deciding to use or recommend a mobile application screening tool. Thresholds measured at low frequencies may be influenced by environmental noise. In addition, different screening tools may use different pass/refer criteria, and a more conservative criterion for determining a pass or referral may result in an increased referral rate.

Obtaining information regarding how individuals are using the information that is provided to them by a screening tool may assist in the development of future mobile hearing screening applications. It is of utmost importance that a professional evaluate an application before recommending it due to the clear variance in accuracy across applications. Other factors such as accessibility, ease of use, and time to complete may also help in determining value. However, use of such tools for our industry to educate the public about hearing health, while promoting opportunities to strengthen the relationship between the patient and professional, may become invaluable. When put to the test, Sound Check proved to be an accurate screening tool, establishing itself as one of multiple successful mobile applications developed by Starkey Hearing Technologies.
References


