Quality, readability and suitability of hearing health related materials: A descriptive review

Vinaya Manchaiah,[1,2] Rebecca J. Kelly-Campbell,[3] Monica L. Bellon-Harn,[1] & Eldré W. Beukes[1,4]

1. Department of Speech and Hearing Sciences, Lamar University, Beaumont, Texas, USA
2. Department of Speech and Hearing, School of Allied Health Sciences, Manipal University, Manipal, Karnataka, India
3. School of Psychology, Speech and Hearing, University of Canterbury, Christchurch, New Zealand
4. Department of Vision and Hearing Sciences, Anglia Ruskin University, Cambridge, United Kingdom

Corresponding author: Dr. Vinaya Manchaiah

Communication address: Department of Speech and Hearing Sciences, Lamar University, Beaumont, Texas 77710, USA

Email: vinaya.manchaiah@lamar.edu

Tel: +1 (409) 880 8927

Fax: +1 (409) 880 2265

Conflict of Interest

No relevant conflicts of interest

Funding

No funding as received for this study.

Abstract

Objectives: The objective of this descriptive review was to determine the quality, readability and suitability of ear and hearing health information and materials for patients and their significant others.

Method: A literature search was conducted between August 2018 and April 2019 in the databases CINAHL Complete, MEDLINE, and PsychInfo. Inclusion and exclusion criteria were used to shortlist studies. Data regarding quality, suitability and readability were extracted from the included studies. Data were assessed qualitatively.

Results: There were 34 studies included in this review. Of those, 8 examined quality, 33 assessed readability and 4 investigated the suitability of materials. The range of materials assessed included diagnostic reports, Patient Education Materials (PEMs), Patient Reported Outcome Measures (PROMs), and websites. Quality elements were examined in studies focusing on website information. Findings indicated that most websites were of poor quality. Suitability was examined in studies focusing on PEMs such as hearing aid user guides. Findings indicated that most of the existing materials were not suitable for the intended populations. The Reading Grade Level (RGL) of information across all four categories was found to be higher than the recommended 5^{th} or 6^{th} RGL for health-related materials. Revisions of some diagnostic reports and PEMs showed that improvements are possible.

Conclusions: This review suggests that ear and hearing related materials generally have lower quality and suitability with higher readability (more difficult to read). Development of materials which are suitable, of high quality, and at the appropriate readability levels, are required to improve accessibility of ear and hearing related materials.

Key Words

Health literacy, Health communication, Readability, Quality, Suitability, Patient education materials, Online information

Introduction

Health literacy refers to the ability of individuals to access, understand, and use information in ways that promote and maintain good health (Nutbeam, 2000). Traditionally, health information has been sought from health professionals, friends, family, or the news media (e.g., television, radio, or newspaper media). This information may be in the form of brochures, clinical forms, or questionnaires. More recently people are turning to electronic media such as the Internet websites and social media for information and management advice for health issues. When accessing online health information, eHealth literacy skills are required. These include the ability to seek, find, understand, assess and critically evaluate information from electronic sources (Norman & Skinner, 2006). The wealth of the information available can promote active engagement in self-management of health-related concerns and healthy living.

Literacy and health literacy are important components of health communication which have bearing towards how people relate to and understand health information. Generally, low overall literacy may negatively impact an individual's health literacy; however, the relationship between them is complex (Easton, Entwistle, & Williams, 2010). For instance, an individual may have high overall literacy and still have low health literacy. Nonetheless, adults with low levels of health literacy have a reduced understanding of health material, exhibit poorer health behaviors, and have worse

health outcomes compared with those with higher levels of health literacy (Berkman et al., 2011; Jensen et al., 2010; Kumar et al., 2010). When health information is adjusted to account for lower literacy skills patients are able to better understand the information presented. This has been linked to positive health outcomes as patients are able to take a more active role in their rehabilitation, resulting in higher levels of satisfaction about healthcare (Edwards, Davies, & Edwards, 2009). Hence, information that is easily understandable by patients may contribute to higher acceptance of their condition and aid self-management of their symptoms (Edwards, Wood, Davies, & Edwards, 2012; Sawesi et al., 2016).

Accessibility of health information can be conceptualized as the availability of information to patients and their significant others. However, considering health information accessability in terms of quality, readability, and suitability may provide more relevant information. This is critical in order to support patients' abilities to understand and use health information. However, a recent literature review suggests that poor readability is noted in online health information about hearing loss (Laplante-Lévesque & Thorén, 2015). It is important that both offline and online health information are of high quality and accessible to those with lower literacy skills (Beaunoyer et al. 2017; Kim & Xie, 2017).

Quality refers to the degree to which the online material is relevant and reliable. Tools are available to rate websites on various quality indicators and provide quantitative methods to assess Internet-based healthcare information. While there are various criteria for quality assessment (Hasan & Abuelrub, 2011), two frequently used methods for healthcare information include the Health On the Net (HON) certification

(Boyer et al., 1998) and results from the DISCERN instrument (Charnock et al., 1999). HON is a non-governmental organization that promotes and guides useful and reliable online health information. HON certification is an indication that the web developers adhere to recommended guidelines for quality information and formatting on a website (Boyer, Selby, Scherrer, & Appel, 1998). DISCERN is an instrument used assess content quality, specifically with regard to unbiased treatment decision-making (Charnock et al., 1999). The DISCERN instrument can be used to rate the websites or other health materials on various quality indicators and provided a quantitative method to assess healthcare information.

Readability refers to a measure of the difficulty experienced by people reading a text and a measure of the linguistic characteristics of a given text (McLaughlin, 1996). As such, reading levels at or below 6^{th} grade are recommended to ensure the information is understood by the general population (Weiss, 2003). Although many readability measures exist, there is no standard for choosing readability formulas (Breese & Burman, 2005). These formulas analyze characteristics of the words or sentences in a passage and quantify the reading difficulty of the materials (Gemoets, Rosemblat, Tse, & Logan, 2004). For most formulas, the estimate of readability is represented as a Reading Grade Level (RGL) which can be interpreted as the number of years of U.S. education required to understand what is written (Ley & Florio, 1996). Beaunoyer et al. (2017) suggests a battery of four readability tools that are highly reliable in a biomedical context and have been validated to analyze readability of online material. These include Flesch Reading Ease (FRE, Flesch, 1948), Flesch-Kincaid Grade Level (F-K GL), Simple Measure of Gobbledygook (SMOG; McLaughlin, 1996), Gunning Fog Index (GFI), and FORCAST. FRE, F-K RGL and

SMOG are suitable for examining readability of narrative text. The FORCAST formula is the most appropriate readability formula for use with a non-narrative text format, such as PROMs (Atcherson, Zraick, & Brasseux, 2011).

Suitability considers reading comprehension beyond reading levels that are obtained by readability formulas (Finnie, Felder, Linder, & Mullen, 2010). Tools to measure suitability consider the relative difficulty of understanding the meaning of the information (Doak, Doak, & Root, 1996). For example the Suitability Assessment of Materials (SAM; Doak et al., 1996) evaluates the (1) content, (2) literacy demand, (3) graphics, (4) layout and typography, (5) learning stimulation/motivation, and (6) cultural appropriateness of the material.

Within audiology contexts, hearing related information available to patients has been reported in the literature to be of poor quality and suitability and is written at higher than recommended reading levels. For example, hearing aid instruction guides are reported to have high readability levels and low suitability (Caposecco et al., 2014; Nair, & Cienkowski, 2010). The RGL required in hearing aid instruction guides may be high because the developers may not have written the text in simple language. Moreover, low suitability may be related to developers not considering aspects such as use of common vocabulary, use of subheadings, and presentation of problems and questions for reader engagement. Additionally, electronic hearing health information has also been found to have low quality and have high readability levels (Laplante-Lévesque, Brännström, Andersson, & Lunner, 2012; Manchaiah et al., 2019a). Brooke, Isherwood, Herbert, Raynor, and Knapp (2012) examined the usability of hearing aid booklets to determine how easy it is for its users to find and understand

the key facts. This study reported that hearing aid booklets contained information that may be difficult for many users to understand and follow, which may negatively impact hearing aid satisfaction and use. The authors of this study suggested that ensuring accessible written information in hearing aid booklect is essential in improving client satisfaction with hearing healthcare services. Moreover, it has been suggested that if the literacy burden is too substantial, patients may not complete or incorrectly respond to self-administered hearing questionnaires (Atcherson, Richburg, Zraick, & George, 2013a), although this needs to be confirmed through further research. Nevertheless, these studies highlight the need for evaluating hearing related information in terms of quality, readability, and suitability prior to dissemination.

A recent literature review that examined the quality and readability of hearing health Internet information reported that high readability levels (i.e., mean RGLs ranged from 9 to over 14) were required to understand hearing health information (Laplante-Lévesque & Thorén, 2015). The scope of the review by Laplante-Lévesque and Thorén (2015) was limited to examining readability of Internet-based health information. As noted, other elements such as quality and suitability are also important in evaluating accessibility of health information which were not included in this review. Addtionally, only online health information was examined in Laplante-Lévesque & Thorén (2015), resulting in a review of 8 studies. However, patients and their significant others obtain information from both online and offline sources. Hence, examination of quality, readability, and suitability of offline and online hearing health information in needed. An updated literature review is needed to reassess the accessibility hearing health information with a broader scope by (a) including all types of information and/or materials; and (b) examining the quality,

readability, and suitability of information. The objective of this descriptive review was to determine the accessibility of ear and hearing health information and materials for patients and their significant others in terms of quality, readability and suitability.

Method

A literature search was conducted between August 2018 to April 2019 using CINAHL Complete, MEDLINE, and PsychInfo. The literature review adhered to the principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA) 2015 statement (Moher et al., 2015). PRISMA prescribes a flow diagram describing the process in four phases, including: searching, identification, screening, and inclusion (see Figure 1).

<Figure 1 near here>

Search Strategy

The search string "(hearing OR audiology OR tinnitus OR vestibular OR ear OR otolaryng* OR otitis*) AND (Internet OR online OR website OR questionnaires OR education materials) AND (quality OR readab* OR suitab* OR literacy)" were used. In addition, manual searches were implemented to increase the coverage of the available literature. This included: (1) hand-searching key journals and the reference lists from the included studies, (2) searching Google Scholar, and (3) contacting researchers and experts in the field to inquire if any records were missing or if they had any manuscripts that had been accepted for publication.

Inclusion/Exclusion Criteria and Screening of Records

A broad definition of health related materials was used to include a wide range of materials for patients and their significant others. These were broadly classified as: (a) diagnostic reports; (b) Patient Education Materials (PEMs) such as brochures, user guides or documents from websites; (c) Patient Reported Outcome Measures (PROMs) such as standardized and validated questionnaires completed by patients to measure their perception of their functional well-being and health status (e.g., Hearing Handicap Inventory for Adults; HHIA; Newman, Weinstein, Jacobson, & Hug, 1990); and (d) websites.

Table 1 lists the study eligibility criteria with reference to participants, intervention, control, outcomes and study design (PICOS; Schardt et al., 2017) as well as criteria for the publication language and publication type. Figure 1 shows the search process. Two researchers independently conducted the search. Notes were compared and inclusion and exclusion criteria were applied.

<Table 1 near here>

Data Extraction and Synthesis

The data from included studies were extracted and synthesized. Standardized and commonly used quality, readability and suitability elements were examined. Table 2 provides details of these measures including the studies' scope, scoring and interpretation. Understanding these measures is necessary to be able to interpret the findings of the studies. HON certification (Boyer et al., 1998) and DISCERN instrument (Charnock et al., 1999) were the main measures used in evaluating the quality of information. The Suitability Assessment of Materials (SAM; Doak et al.,

1996) was the main scale used to assess the suitability of information. Various readability formulas were used to determine readability levels (see Table 3).

The study quality analysis was not conducted as almost all of the studies were descriptive in nature. All the studies included in the review used appropriate methods, although some limitations were noted in reporting the results.

<Table 2 near here>

<Table 3 near here>

Results

Scope of the Included Studies

In total, 34 studies met the pre-agreed inclusion/exclusion criteria (see Table 4). Of these, 33 examined the readability levels, 8 examined the quality and only 4 examined the suitability of materials. These studies focused on a range of issues including hearing impairment, tinnitus, auditory processing disorders, hearing aids, and ear disorders (e.g., glue ear, acoustic neuroma). Moreover, the studies included four types of materials: a diagnostic report (1 study), PEMs (15 studies), PROMs (6 studies), and websites (12 studies). English language materials were examined in 30 studies, two studies examined Spanish language materials and one study examined Hindi language materials.

Some studies had wider scope and examined other elements of accessibility including the content, design instructions, comprehension (using Cloze test), self-efficacy, opinions, understandability and actionability (using the Patient Education Materials

Assessment Tool; PEMAT), shared-decision making, and clinical practice guidelines compatibility. The studies focusing on websites and PROMs mainly reported the quality, readability and suitability of existing materials. However, some studies focusing on diagnostic reports (Donald & Kelly-Campbell, 2016) and PEMs (McMullan et al., 2017) made an effort to revise the existing materials to improve the readability. Also, some studies focusing on PEMs (mainly hearing aid user guides) developed new more accessible materials and evaluated the readability levels of these materials rather than examining the existing materials (Caposecco et al., 2011, 2016).

There was great variability noted in terms of reporting of quality, readability and suitability scores. For instance, some authors reported mean, standard deviation and range, whereas other reported just the mean or median. Some earlier studies reported only the percentage of materials exceeding certain grade level or grade level relating to certain age group (e.g., Kelly, 1996; Pothier, 2005). Moreover, limited effort was noted in examining the accuracy or evidence-base associated with the information. Harris et al. (2017) examined the compatibility of information with clinical practice guidelines in websites related to tympanoplasty tubes. Also, McKearney and McKearney (2013) assessed the variability and accuracy in websites which were also related to tympanoplasty tubes.

<Table 4 near here>

Quality

The eight studies that examined quality focused on websites (see Table 5). Three of those studies reported HON certification, whereas all eight studies reported

DISCERN scores. Of the websites including ear and hearing information, between 13% to 45% had HON certification. More specifically, only 13% of the hearing loss and tinnitus websites had HON certification (Laplante-Lévesque et al., 2012; Manchaiah et al., 2019a), whereas 45% of the otitis media websites had HON certification (Joury et al., 2012). These results indicate that the websites providing hearing health information generally lack HON certification raising concerns towards their quality.

The DISCERN instrument scores can range from 16 to 80 with higher scores indicating better quality. The mean DISCERN instrument scores of websites offering ear and hearing information ranged from 35 to 57 (see Table 5). However, two of the studies only reported the mean of item 16 which provided overall quality of websites. The mean scores ranged from 2.05 to 2.39 out of 5. These results indicated low to medium quality websites related to ear and hearing health. Nonetheless, most of the websites were found to have lower quality. As such, it is worth examining if the website origin has any bearing towards its quality. For instance, websites developed and managed by non-profit or government organizations may be of better quality when compared to commercial organization and vice versa. Mixed results were found in studies examining the association between quality and website origin (e.g., commercial, non-profit, or government). Laplante-Lévesque et al. (2012) reported a positive association between origin of hearing-related websites and quality. Websites from a government origin were significantly more likely to have HON certification when compared to websites from a commercial and from a non-profit origin. Websites from a non-profit origin had higher DISCERN scores than those from a

commercial or government origin. However, Manchaiah et al. (2019a) reported no association between website origin and quality in tinnitus websites.

<Table 5 near here>

Readability

Almost all the studies (33 out of 34) reported on readability levels, although variability was seen in the choice of readability formula, in particular in formulas used for reporting of RGL. In total, 11 different readability formulas were used across English language studies, 4 formulas across Spanish language studies and 2 readability formulas in the Hindi language study. However, the four most commonly used formulas were FRE, F-K RGL, SMOG and FORCST. Table 6 provides readability data across the studies. For simplicity, F-K RGL was used to summarize results of studies focusing on diagnostic reports, PEMs and websites. FORCST is most appropriate for non-narrative text; hence, it was used in summarizing results of studies focusing on PROMs.

Only one study examined a diagnostic report, which reported a F-K RGL of 14.1 (Donald & Kelly-Campbell, 2016). However, researchers re-wrote the diagnostic report to reduce the RGL to be within the recommended RGL (i.e., F-K RGL of 5.8).

Fifteen studies examined readability levels of PEMs. The PEMs included: user guides (7 studies), decision aid (1 study), brochures (1 study), and articles or documents from websites (6 studies). The Mean F-K RGL for PEMs reported across studies varied from 5.05 to 11.4, with most studies reporting RGL exceeding recommended levels.

However, studies reporting revised PEMs (i.e., hearing aid user guides) reported F-K RGL of 2.6 to 5 (Caposecco et al., 2011; McMullan et al., 2017) suggesting that PEMs can be revised successfully to stay within the recommended RGL.

Eleven studies examined the readability levels of websites related to ear and hearing health. The mean F-K RGL reported in these studies ranged from 10.1 to 11.8, suggesting a much higher RGL than recommended. No studies reported revision of text in websites.

Six studies examined the readability levels of PROMs. The mean readability as measured by FORCST formula were around the 9^{th} to 10^{th} RGL, suggesting that it may be difficult for many people in the general population to understand the questions in these PROMs. No studies reported revision of text in PROMs.

Schyve (2007) described a "triple threat" in which limited English proficiency, cultural differences and low health literacy converge to create a barrier to effective communication for health seekers. As a result, there has been increased interest in providing health information in people's preferred language. However, this review suggest that there is limited research to assess the non-English hearing-related materials. Only three studies in this review assessed non-English material. Similar to the findings of the English-language material, the studies found that the readability levels of the material exceeded the recommended reading level. One barrier to performing this research is the limited availability validated non-English readability formulas, as noted by Diwan and Kelly-Campbell (2018). None of the studies assessed quality or suitability of the material.

Some studies also examined the association between different readability measures, or readability and other elements such as the origin of information or materials or the quality. Such associations have mainly been reported in studies focusing on websites. Strong correlations have been found between different readability measures such as FRE, F-KGL, SMOG and FORCAST (Laplante-Lévesque et al., 2012; Manchaiah et al., 2019a). There was no consensuses about the association between website origin and readability levels with some studies reporting an association (e.g., Cherla et al., 2013), whereas other studies reported no association (e.g., Laplante-Lévesque et al., 2012; Manchaiah et al., 2019a). Relation between readability and quality also had mixed results with some studies reported small but statistically significant associations (e.g., Manchaiah et al., 2019a), whereas other studies reported no associations (e.g., Laplante-Lévesque et al., 2012; Spiers et al., 2017).

<Table 6 near here>

Suitability

The four studies that examined the suitability of hearing related materials focused on PEMs, specifically hearing aid user guides all of which used the SAM instrument (see Table 7). Higher scores on the SAM indicate higher suitability with overall scores of 70% to 100% considered as superior, 40% to 69% considered as adequate, and 0% to 39% considered as not suitable. Caposecco et al. (2014) reported suitability of 36 existing hearing aid user guides. Studies by Caposecco et al. (2016) and McMullan et al. (2017) examined the suitability of an existing hearing aid user guides and of revised user guides. Another study by Caposecco et al. (2011) focused on developing a new hearing aid user guide and evaluated its suitability. The average SAM score for

existing hearing aid user guides ranged between 29 to 52 suggesting "not suitable" to "adequate suitability." It is noteworthy that two of these studies (Caposecco et al., 2011; McMullan et al., 2017) examined only 1 hearing aid user guide, whereas the Caposecco et al. (2014) examined 36 user guides. According to Caposecco et al. (2014), only around 30% of user guides were rated 'adequate' regarding their suitability. Poor scores were noted on various elements including: scope, vocabulary, aspects of layout and typography, and learning stimulation and motivation. However, the three studies reporting SAM scores for revised or newly developed hearing aid user guides were over 80 suggesting 'superior' for their suitability (Caposecco et al., 2011, 2016; McMullan et al., 2017).

<Table 7 near here>

Discussion

This manuscript reviewed the studies that examined the quality, readability and suitability of ear and hearing health information and materials for patients and their significant others. Readability was the primary evaluation included in the studies. As noted, readability is a measure of the linguistic characteristics of a given text and provides a metric to determine the level of difficulty a user may experience. While there are many tools to evaluate readability constructs, the studies reviewed in this study used formulas for RGLs. Regardless of the type of material or language in which the material was presented, readability levels were found to be higher than recommended 5th or 6th RGL for health-related materials. Only studies examining PEMs indicated that the text was subsequently revised after readability was determined to be too high. This review is consistent with Laplante-Lévesque and

406 Thorén (2015), who reported that a large portion of Internet-based ear and hearing
407 health information is at reading levels that are too high for the majority of the
408 population.
409
410 While readability measures are an excellent starting point in providing appropriate
411 accessible health information, it is important to note that they do not provide direct
412 information about comprehension. Readability formulas are based on inferences and
413 correlations with measures of comprehension and do not take individual reader factors
414 into account or measure typographic features (Redish, 1981). It is important that
415 researchers and developers of health information keep this in mind and extend
416 assessment of material beyond readability measures alone. However, only 4 studies
417 evaluated suitability of hearing related materials and only 8 studies examined quality.
418
419 With regard to quality, results indicated that the tool used for all studies was the
420 DISCERN instrument. The DISCERN instrument rated websites on various quality
421 indicators. Also, DISCERN was used to evaluate the quality of written information
422 about treatment choices publication reliability and quality of treatment information.
423 Overall, quality of hearing health information was rated at low or moderate levels.
424 Only three of the studies reported HON certification. It may be that those who
425 manage the hearing healthcare websites (e.g., audiology business owners) are
426 unaware of this type of website certification to ensure a standard level of quality.
427 Alternatively, it may not be used on websites due to cost to maintain the certificate
428 (Bizzi, Ghezzi, & Paudyal, 2017). It is notable that only quality of websites was
429 evaluated. Quality of other forms of written ear and hearing information was not

examined. Clearly a gap exists across various types of written materials in the rigor with which high quality materials are developed and disseminated.

With regard to suitability, only hearing aid user guides were examined using the SAM (Doak et al., 1996). As with evaluations of quality, a gap in measures of suitability exists across various types of written materials. In particular, suitability includes measures of cultural appropriateness. As noted by Schyve (2007) cultural differences and low health literacy converge to create a barrier to effective communication for health seekers. As such, it is critical that cultural and linguistic diversity be evaluated, and tools related to suitability may serve this purpose. Overall, there was variability reported in the four studies in that some of the guides were reported to be superior and others were reported to not have adequate suitability. It is noteworthy that revised guides were reported to be superior suggesting that developers are working to increase the ability of users to understand the material by including common vocabulary, engaging questions, and chunking information with clear headings. Overall, it is difficult to interpret suitability of materials since only four studies included suitability assessment. Of those, two studies examined only 1 hearing aid guide.

Some assessment tools discussed in this review (e.g., SAM, DISCERN) were primarily developed for printed materials, although they have been used to evaluate the online information and/or materials. However, there are some tools such as the Patient Education Materials Assessment Tool for Audiovisual Materials (PEMAT-A/V; Shoemaker, Wolf, & Brach, 2014) can be used when assessing more interactive material that includes audiovisual information. This is particularly important given

455 that around 80% of American adults use the Internet to search for information about
456 health-related conditions (Fox, 2006). All age groups appear to search the Internet for
457 health-related information including older adults and or their significant others
458 (Washington, Meadows, Elliott, & Koopman, 2011) as well as children and
459 adolescents (Park & Kwon, 2018). In addition, some patients access information
460 online through video or audio, rather than text, meaning that online health information
461 analysis can be incomplete if this interactive element is not assessed (Finnie et al.,
462 2010).
463
464 Only a few studies included in this review examined the accuracy of the material's
465 content (e.g., Harris et al., 2017; McKearney & McKearney, 2013). This can be done
466 by using trained health professionals to examine the content or to map the content to
467 clinical practice guidelines (e.g., Bompastore, Cisu, & Holoch, 2018; Storino et al.,
468 2006). Generally, the research in other fields indicates there is a concerning lack of
469 accuracy of online health information. This trend needs to be investigated for online
470 ear and hearing health material. For example, Fackrell et al. (2012) examined quality
471 and content of tinnitus websites preferred by general practitioners (GPs). It would be
472 useful to examine materials aimed at professionals as they tend to use range of
473 sources in gaining knowledge in areas they are less knowledgeable (Azzam et al.,
474 2017).
475
476 **Clinical Implications**
477 Accessibility of health information has many practice implications. The type and
478 quality of information may influence the knowledge and behavior of patients and their
479 family members. Hence, hearing healthcare professionals should be aware of

accessibility issues surrounding health information accessed by patients and their significant others. Various stakeholders including clinicians, researchers and patient organizations who are involved in health materials (e.g., PEMs or PROMs) should consider accessibility as the central component. Health professionals should take proactive measures to improve accessibility of health information especially in open sources such as websites (Azzam et al., 2017; Benigeri & Pluye, 2003). Moreover, although hearing healthcare professionals are aware that limited health literacy can be an obstacle for patients, they have limited understanding of ways in which they can improve health literacy and accessibility of the information provided (Atcherson, Zraick, & Hadden, 2013b). These findings highlight the need for training in this area.

Future Directions

The current review provide some good directions for future research in this area. First, future researchers should be more consistent in reporting results. This is in regard to types of tools used (e.g., readability formulas) and also types of data (e.g., mean, SD). Second, researchers should evaluate multiple elements of accessibility including quality, suitability, understandability and actionability, and accuracy of information in addition to evaluating the readability. Third, the current review shows that most studies in this area are focusing are evaluating hearing health information in English language and more efforts are needed to examine and improve accessibility of hearing health materials in other languages.

Conclusions

This manuscript reviewed the studies that examined the readability, quality and suitability of ear and hearing related materials aimed at patients and their significant

505 others. Moreover, this review included published studies that examined various
506 sources of materials including websites, reports and PEMs. The findings suggest that
507 ear and hearing related materials are not always suitable for the intended populations.
508 Their quality was low, where assessed and they are generally difficult to read (above
509 the recommended 5th or 6th RGL). Quality assessments were done for some website
510 information, but further quality assessments were lacking. Further work is required to
511 ensure the quality of materials. Suitability was mostly assessed by evaluating PEMs
512 (i.e., hearing aid user guides) and found that existing materials were not suitable for
513 intended populations. Some efforts in revising the diagnostic reports and PEMs
514 showed that improvements are possible. Further efforts are needed to improve
515 accessibility of ear and hearing related materials by developing materials which are of
516 high quality, appropriate readability and superior suitability.
517

518 ## References

519 Atcherson, S.R., Zraick, R.I., & Brasseux, R.E. (2011) Readability of patient-reported
520 outcome questionnaires for use with persons with tinnitus. *Ear and Hearing 32*(5),
521 671-673. https://doi.org/10.1097/AUD.0b013e3182134654
522
523
524 Atcherson, S. R., Richburg, C. M., Zraick, R. I., & George, C. M. (2013a).
525 Readability of questionnaires assessing listening difficulties associated with (central)
526 auditory processing disorders. *Language, Speech, and Hearing Services in Schools,*
527 *44*(1), 48. https://doi.org/10.1044/0161-1461(2012/11-0055)
528

529 Atcherson, S.R., Zraick, R.I., & Hadden, K. (2013b). A need for health literacy
530 curriculum: knowledge of health literacy among U.S. audiologists and speech-
531 language pathologists in Arkansas. *Education for Health*, 26(2), 85-
532 88. https://doi.org/10.4103/1357-6283.120699.
533
534 Atcherson, S.R., DeLaune, A.E., Hadden, K., Zraick, R.I., Kelly-Campbell, R.J., &
535 Minaya, C.P. (2014) A computer-based readability analysis of consumer materials on
536 the American Speech-Language-Hearing association website. *Contemperory Issues in*
537 *Communication Science and Disorders*, 41, 12-23.
538 https://doi.org/10.1044/cicsd_41_S_12
539
540 Azzam, A., Bresler, D., Leon, A., Maggio, L., Heilman, J., Orlowitz, J., …… McCye,
541 J.D. (2017). Why Medical Schools Should Embrace Wikipedia: Final-Year Medical
542 Student Contributions to Wikipedia Articles for Academic Credit at One
543 School. *Academic Medicine*, 92(2), 194–
544 200. https://doi.org/10.1097/ACM.0000000000001381
545
546 Beaunoyer, E., Arsenault, M., Lomanowska, A. M., & Guitton, M. J. (2017).
547 Understanding online health information: Evaluation, tools, and strategies. *Patient*
548 *Education and Counseling*, *100*(2), 183-189.
549 https://doi.org/10.1016/j.pec.2016.08.028
550
551 Benigeri, M., & Pluye, P. (2003). Shortcomings of health information on the Internet.
552 *Health Promotion International*, 18(4), 381–386.
553

554 Berkman, N.D., Seridan, S.L., Donahue, D.E., Halpern, D.J., Viera, A., Cortty, K.,
555 …Viswanathan, M. (2011). Health literacy interventions and outcomes: An updated
556 systematic review. *Evidence Report/Technology Assessment, 199*, 1-941.
557
558 Bizzi, I., Ghezzi, P., & Paudyal, P. (2017). Health information quality of websites on
559 periodontology. *Journal of clinical periodontology*, *44*(3), 308-314.
560
561 Bompastore, N. J., Cisu, T., & Holoch, P. (2018). Separating the wheat from the
562 chaff: An evaluation of readability, quality, and accuracy of online health information
563 for treatment of peyronie disease. *Urology, 118*, 59-64.
564 https://doi.org/10.1016/j.urology.2018.02.054
565
566 Boyer, C., Selby, M., Scherrer, J.R., & Appel, R.D. (1998). The Health on the Net
567 code of conduct for medical and health websites. *Computers in Biology and Medicine*,
568 28, 603–610.
569
570 Breese, P., & W. Burman. (2005). Readability of Notice of Privacy Forms Used by
571 Major Health Care Institutions. *Journal of the American Medical Association*,
572 293(13): 1588–1594. https://doi.org/10.1001/jama.293.13.1593.
573
574 Brooke, R.E., Isherwood, S., Herbert, N.C., Raynor, D.K., & Knapp, P. (2012).
575 Hearing aid instruction booklets: Employing usability testing to determine
576 effectiveness. *American Journal of Audiology*, 21(2):206-14.
577 https://doi.org/10.1044/1059-0889(2012/12-0008).
578

579 Caposecco, A., Hickson, L., & Meyer, C. (2011). Assembly and insertion of a self-
580 fitting hearing aid: Design of effective instruction materials. *Trends in Amplification*,
581 15, 184–195. https://doi.org/10.1177/1084713811430837.
582
583 Caposecco, A., Hickson, L., & Meyer, C. (2014). Hearing aid user guides: Suitability
584 for older adults. *International Journal of Audiology*, 53(Suppl 1), S43–S51.
585 https://doi.org/10.3109/14992027.2013.832417
586
587 Caposecco, A., Hickson, L., Meyer, C., & Khan, A. (2016) Evaluation of a modified
588 user guide for hearing aid management. *Ear and Hearing*, 37(1), 27–
589 37. https://doi.org/10.1097/AUD.0000000000000221.
590
591 Charnock, D., Shepperd, S., Needham, G., & Gann, R. (1999). DISCERN: an
592 instrument for judging the quality of written consumer health information on
593 treatment choices. *Journal of Epidemiology and Community Health*, 53(2),105-111.
594 https://doi.org/10.1136/jech.53.2.105
595
596 Cherla, D. V., Sanghvi, S., Choudhry, O. J., Jyung, R. W., Eloy, J. A., & Liu, J. K.
597 (2013). Readability assessment of Internet- based patient education materials related
598 to acoustic neuromas. *Otology & Neurotology*, 34(7), 1349-54.
599 https://doi.org/10.1097/MAO.0b013e31829530e5
600
601 Coco, L., Colina, S., Atcherson, S.A., & Marrone, N. (2017). Readability level of
602 Spanish-language patient-reported outcome measures in audiology and

603 otolaryngology. *American Journal of Audiology*, 26(3), 309-317.
604 https://doi.org/10.1044/2017_AJA-17-0018
605
606 Davison, A. (1984). Readability—Appraising text difficulty. In: R. C. Anderson, J.
607 Osborn, & R. J. Tierney (Eds.), Learning to read in American school: Basal
608 readers and content texts (pp. 121–139).
609
610 Diwan, S., & Kelly-Campbell, R.J. (2018). Readability ease of online hearing related
611 information in Hindi. *Journal of Indian Speech, Language and Hearing Association*,
612 32(2), 62-66.
613
614 Doak, C.C., Doak, L.G., & Root, J.H. (1996). *Teaching Patients with Low Literacy*
615 *Skills (2nd Ed).* Philadelphia, PA: J.B. Lippincott Company.
616
617 Donald, A. J., & Kelly-Campbell, R. J. (2016). Pediatric audiology report:
618 Assessment and revision of an audiology report written to parents of children with
619 hearing impairment. *Journal of Speech, Language, and Hearing Research*, 59(2),
620 359–372. https://doi.org/10.1044/2015_JSLHR-H-15-0120
621
622 Douglas, A., & Kelly-Campbell RJ. (2018). Readability of Patient-Reported Outcome
623 Measures in Adult Audiologic Rehabilitation. *American Journal of Audiology*, 27(2),
624 208-218. https://doi.org/10.1044/2018_AJA-17-0095
625

626 Easton, P., Entwistle, V.A., & Williams, B. (2010). Health in the 'hidden population'
627 of people with low literacy. A systematic review of the literature. BMC Public Health,
628 10, 459. doi: 10.1186/1471-2458-10-459.
629
630 Edwards, M., Davies, M., & Edwards, A. (2009). What are the external influences on
631 information exchange and shared decision-making in healthcare consultations: a
632 meta-synthesis of the literature. *Patient Education and Counseling*, *75*(1), 37-52.
633 https://doi.org/10.1016/j.pec.2008.09.025.
634
635 Edwards, M., Wood, F., Davies, M., & Edwards, A. (2012). The development of
636 health literacy in patients with a long-term health condition: the health literacy
637 pathway model. *BMC Public Health*, *12*(1), 130. https://doi.org/10.1186/1471-
638 2458-12-130.
639
640 Eloy, J.A., Li, S., Kasabwala, K., Agarwal, N., Hansberry, D.R., Baredes, S., &
641 Setzen, M. (2012) Readability assessment of patient education materials on major
642 otolaryngology association websites. *Otolaryngology - Head and Neck Surgery,*
643 147(5), 848–854. https://doi.org/10.1177/0194599812456152.
644
645 Fackrell, K., Hoare, D.J., Smith, S., McCormack, A., & Hall, D.A. (2012) An
646 evaluation of the content and quality of tinnitus information on websites preferred by
647 General Practitioner. *BMC Medical Informatics and Discision Making,* 12, 70.
648 https://doi.org/10.1186/1472-6947-12-70
649

650 Finnie, R.K., Felder, T.M., Linder, S.K., & Mullen, P.D. (2010). Beyond reading
651 level: a systematic review of the suitability of cancer education print and Web-based
652 materials. *Journal of Cancer Education*, 25(4), 497–505.
653 https://doi.org/10.1007/s13187-010-0075-0.
654
655 Flesch, R.F. (1948). A new readability yardstick. *Journal of Applied Psychology*, 32,
656 221–33
657
658 Fox, S. (2006). *Part 1. 113 Million Internet Users Seek Health Information Online*.
659 Available from: https://www.pewinternet.org/2006/10/29/part-1-113-million-internet-
660 users-seek-health-information-online/#fn-793-5 (accessed on December 05, 2019).
661
662 Gemoets, D., Rosemblat, G., Tse, T., & Logan, R. (2004). Assessing readability of
663 consumer health information: An explaratory study. *Studies in Health Technology and*
664 *Informatics*, 107(Pt. 2), 869-873.
665
666 Greywoode, J., Bluman, E., Spiegel, J., & Boon, M. (2009). Readability analysis of
667 patient information on the American Academy of Otolaryngology–Head and Neck
668 Surgery website. *Otolaryngology–Head and Neck Surgery*, 141(5), 555–558.
669 https://doi.org/1010.1016/j.otohns.2009.08.004.
670
671 Harris, V.C., Links, A.R., Hong, P., Walsh, J., Schoo, D.P., Tunkel D.E., Stewart,
672 C.M., & Boss, E.F. (2018). Consulting DrGoogle: quality of online resources about
673 tympanostomy tube placement. *The Laryngoscope*, 128(2), 496–501.
674 https://doi.org/10.1002/lary.26824.

Hasan, L., & Abuelrub, E. (2011). Assessing the Quality of Web Sites. *Applied Computing and Informatics*, 9, 11-29. https://doi.org/10.1016/j.aci.2009.03.001

Jensen, J. D., King, A. J., Davis, L. A., & Guntzviller, L. M. (2010). Utilization of internet technology by low-income adults: the role of health literacy, health numeracy, and computer assistance. *Journal of Aging and Health*, *22*(6), 804-826. https://doi.org/10.1177/0898264310366161.

Joseph, J., Svider, P.F., Shaigany, K., Eloy, J.A., McDonald, P.G., Folbe, A.J., & Hong, R.S. (2016). Hearing aid patient education materials: Is there room for improvement? *Journal of the American Academy of Audiology,* 27(4), 354-359. https://doi.org/10.3766/jaaa.15066.

Joury, A., Joraid, A., Alqahtani, F., Alghamdi, A., Batwa, A., & Pines, J.M. (2018). The variation in quality and content of patient-focused health information on the Internet for otitis media. *Child: Care Health and Development*, 44(2), 221–226. https://doi.org/1010.1111/cch.12524.

Kasabwala, K., Agarwal, N., Hansberry, D. R., Baredes, S., & Eloy, J. A. (2012). Readability assessment of patient education materials from the American Academy of Otolaryngology– Head and Neck Surgery Foundation. *Otolaryngology–Head and Neck Surgery*, 147(3), 466–471. https://doi.org/10.1177/0194599812442783

699 Kelly, R.J. (1996). The readability of hearing aid brochures. *Journal of the American*
700 *Rehabilitative Audiology*, 39, 41-47.
701
702 Kelly-Campbell, R.J., Atcherson, S.R., Zimmerman, K.R., & Zraick, R.I. (2012)
703 Readability of audiologic self-report assessment tools. *Journal of the Academy of*
704 *Rehabitative Audiology,* 45, 63-73.
705
706 Kim, H., & Xie, B. (2017). Health literacy in the eHealth era: a systematic review of
707 the literature. *Patient Education and Counseling*, *100*(6), 1073-1082.
708 https://doi.org/1010.1016/j.pec.2017.01.015.
709
710 Kumar, D., Sanders, L., Perrin, E.M., Lokker, N., Patterson, B., Funn, V.,
711 …Rothman, R.L. (2010). Parental understanding of infant health information: Health
712 literacy, numeracy, and the Parental Health Literacy Activities Test (PHLAT).
713 *Academic Pediatrics, 10*, 309-316. https://doi.org/101010.1016/j.acap.2010.06.007.
714
715 Laplante-Lévesque, A., Brännström, K.J., Andersson, G., & Lunner, T. (2012)
716 Quality and readability of English-language internet information for adults with
717 hearing impairment and their significant others. *International Journal of Audiology,*
718 51(8), 618-26. https://doi.org/10.3109/14992027.2012.684406.
719
720 Laplante-Lévesque, A., & Thorén, E. S. (2015). Readability of Internet Information
721 on Hearing: Systematic Literature Review. *American Journal of Audiology*, 24(3),
722 284-288. https://doi.org/10.1044/2015_aja-14-0091
723

Ley, P., & T. Florio. (1996). The Use of Readability Formulas in Healthcare. *Psychology, Health, & Medicine*, 1(1), 7–28. https://doi.org/10.1080/1354 8509608400003.

Manchaiah, V., Dockens, A.L., Flagge, A., Bellon-Harn, M., Hartwell Azios, J., Kelly-Campbell, R. & Andersson, G. (2019a). Quality and readability of English-language Internet information for tinnitus. *Journal of the American Academy of Audiology*, 30(1), 31-40. https://doi.org/10.3766/jaaa.17070

Manchaiah, V., Granberg, S., Grover, V., Saunders, G.H. & Hall, D.H. (2019b). Content validity and feasibility of patient-reported questionnaire instruments of hearing disability. *International Journal of Audiology*, 58(9), 565-575. https://doi.org/10.1080/14992027.2019.1602738.

McLaughlin, G.H. (1969). SMOG grading - a new readability formula. *Journal of Reading*, 12, 639–46.

McKearney, T. C., & McKearney, R. M. (2013). The quality and accuracy of Internet information on the subject of ear tubes. *International Journal of Pediatric Otorhinolaryngology*, 77(6), 894–897. https://doi.org/10.1016/j.ijporl.2013.03.021.

McKearney, R. M., MacKinnon, R. C., Smith, M., y Baker, R. (2018). Tinnitus information online - Does it ring true? *Journal of Laryngology & Otology*, 132(11), 984–989. https://doi.org/10.1017/S0022215118001792

McMullan, A., Kelly-Campbell, R., & Wise, K. (2017). Improving hearing aid self-efficacy and utility through revising a hearing aid user guide: A pilot study. *American Journal of Audiology*, 27(1), 45–56. https://doi.org/10.1044/2017_AJA-17-0035.

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew M, ….. PRISMA-P Group. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic Reviews, 4, 1. https://doi.org/10.1186/2046-4053-4-1.

Nair, E. L., & Cienkowski, K. M. (2010). The impact of health literacy on patient understanding of counseling and education materials. *International Journal of Audiology*, 49(2), 71-75. https://doi.org/10.3109/14992020903280161.

Nassif, S.J., Wong, K., & Levi, J.R. (2018). The Índice Flesch-Szigriszt and Spanish Lexile Analyzer to evaluate Spanish patient education materials in otolaryngology. *Laryngoscope*, 128, E21-E26. http://doi.wiley.com/10.1002/lary.26910

Nicholson, N., Atcherson, S.R., Martin, P., Spragins, M.G., Schlagenhauf, L., & Zraick, Z.I. (2016). Readability, user-friendliness, and key content analysis of newborn hearing screening brochures. *The Journal of the Early Hearing Detection and Intervention*. 1(1), 66-77.

Norman, C.D., & Skinner, H.A. (2006). eHealth literacy: essential skills for consumer health in a networked world. *Journal of Medical Internet Research*, 8(2), e9. https://doi.org/10.2196/jmir.8.2.e9

Nutbeam, D. (2000). Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. *Health Promotion International*, *15*(3), 259-267. https://doi.org/10.1093/heapro/15.3.259

Park, E., & Kwon, M. (2018). Health-related internet use by children and adolescents: Systematic review. *Journal of Medical Internet Research*, 20(4), e120. https://doi.org/10.2196/jmir.7731.

Pothier, D. D. (2005). Patients and the Internet: Are websites on glue ear readable? *Clinical Otolaryngology*, 30(6), 566. https://doi.org/10.1111/j.1749-4486.2005.01115.x

Pryce, H., Durand, M.A., Hall, A., Shaw, R., Culhane, B.A., Swift, S., ….. Chilvers, K. (2018). The development of a decision aid for tinnitus. *International Journal of Audiology*, 57(9), 714–719. https://doi.org/10.1080/14992027.2018.1468093.

Redish, J. (1981). Understanding the limitations of readability formulas. *IEEE Transactions on Professional Communication, PC-24*(1), 46-48. https://doi.org/10.1109/TPC.1981.6447824

Ritchie, L., Tornari, C., Patel, P.M., & Lakhani, R. (2016). Glue ear: how good is the information om the World Wide Web? *Journal of Laryngology & Otology*, 130(2), 157-161. https://doi.org/10.1017/S0022215115003230.

Sawesi, S., Rashrash, M., Phalakornkule, K., Carpenter, J. S., & Jones, J. F. (2016). The Impact of information technology on patient engagement and health behavior change: a systematic review of the literature. *JMIR Medical Informatics*, 4(1), e1. https://doi.org/10.2196/medinform.4514.

Schyve, P. M. (2007). Language differences as a barrier to quality and safety in health care: the Joint Commission perspective. *Journal of General Internal Medicine*, *22*(2), 360-361.

Shoemaker, S. J., Wolf, M. S., & Brach, C. (2014). Development of the Patient Education Materials Assessment Tool (PEMAT): A new measure of understandability and actionability for print and audiovisual patient information. *Patient Education and Counseling, 96*(3), 395-403. https://doi.org/10.1016/j.pec.2014.05.027.

Simpson, A., & Baldwin, E. (2017). Googling NDIS: Evaluating the quality of online information about the National Disability Insurance Scheme for caregivers of deaf children. *Deafness & Education International*, 19(1), 22-28. http://doi.org/10.1080/14643154.2017.1285979

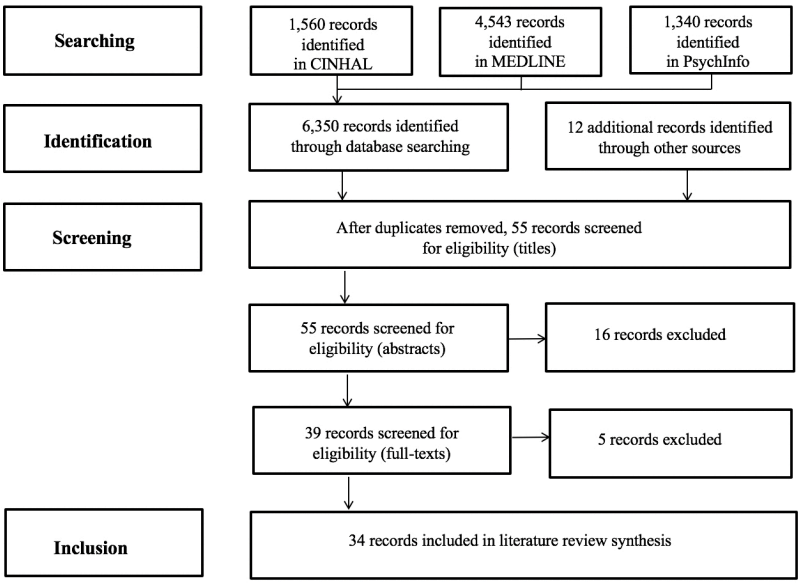
Spiers, H., Amin, N., Lakhani, R., Martin, A.J., & Patel, P.M. (2017). Assessing Readability and Reliability of Online Patient Information Regarding Vestibular Schwannoma. *Otology & Neurotology, 38(1)*, e470–e475. http://doi.org/10.1097/MAO.0000000000001565.

824 Storino, A., Castillo-Angeles, M., Watkins, A. A., Vargas, C., Mancias, J. D.,
825 Bullock, A., . . . Kent, T. S. (2016). Assessing the accuracy and readability of online
826 health information for patients with pancreatic cancer. *JAMA Surgery, 151*(9), 831-7.
827 http://doi.org/10.1001/jamasurg.2016.0730.
828
829 Newman, C.W., Weinstein, B.E., Jacobson, G.P., & Hug, G.A. (1990). The Hearing
830 Handicap Inventory for Adults: psychometric adequacy and audiometric
831 correlates. *Ear and Hearing*, 11(6), 430–433.
832
833 Washington, K.T., Meadows, S.E., Elliott, S.G., & Koopman, R.J. (2011).
834 Information needs of informal caregivers of older adults with chronic health
835 conditions. *Patient Educcation and Counseling*, 83(1), 37-44.
836 http://doi.org/10.1016/j.pec.2010.04.017.
837
838 Weiss, B.D., & Coyne, C. (1997) Communicating with patients who cannot read. *The*
839 *New England Journal of Medicine*, 337(4), 272–274.
840
841 Wong, K., & Levi, J. R. (2016). Readability of pediatric otolaryngology information
842 by children's hospitals and academic institutions: Pediatric otolaryngology
843 readability. *The Laryngoscope*, 127, E138–E144. https://doi.org/10.1002/lary.26359
844

845 # Figures

846 **Figure 1: Flow diagram showing the searching, identification, screening, and**
847 **inclusion process**
848

849



850

851

852 **Table 1: Inclusion and exclusion criteria**

853

Criteria	Inclusion	Exclusion
P (Population)	Individuals with ear and hearing-related health conditions and their communication partners (including parents, teachers, general public).	Studies evaluating health information aimed at healthcare providers or healthcare educators.
I (Intervention)	Hearing-related health information (including disease-specific information) in any medium (internet, print, verbal) in any language. This includes hearing-related information on conditions such as tinnitus, balance, and Auditory Processing Disorders.	Medical information not exclusively relating to hearing.
C (Comparison)	Any comparison	None
O (Outcome)	Validated readability score, validated quality (i.e., Health On the Net, DISCERN) and suitability measurement (i.e., Suitability Assessment of Materials).	Use of unvalidated measurements
S (Study Design)	Any empirical study design	Opinion and theoretical publications with no empirical data.
Additional Criteria		
Language	Published in English language journal	Research published in a language other than

		English.
Publication Type	Published in peer reviewed journal	Unpublished research
Publication Date	Unrestricted	
Setting	Studies in all geographic locations were included	

854 **Table 2: Information about commonly used quality, readability and suitability measures**
855

Dimension	Measure	Scope	Scoring	Interpretation
Quality	Health on the Net (HON; Boyer et al., 1998)	Certification provides examination of 8 principles (authoritative, complementary, privacy, attribution, justifiability, transparency, financial disclosure, and advertising policy) of the HON code of conduct.	HON certification of websites can be checked in the website https://www.hon.ch/HONcode/	Having HON certification suggests better quality website.
	DISCERN (Charnock et al., 1999)	Quality is subjectively rated based on a scale which examines 16 quality criteria.	16-item rating tool scored on a scale (1=No, 2 to 4=Partly, 5=Yes). Overall scores can range from 16 to 80.	Higher score indicated better quality.
Readability	Flesch Reading Ease (FRE; Flesch, 1948)	Analyzes the average words per sentence and the average syllables per word to determine a readability score.	Scores range from 0 (very difficult to read) to 100 (very easy to read).	Higher score indicates easier reading. Scores of 90–100 can be understood by someone with a 5th grade education. People with an 8th -9th grade education can understand documents with a score of 60–70; and college graduates can understand documents with a score of 0–30.
	Flesch-Kincaid Grade Level (F-K GL)	Most applicable for use with manuals and forms. This formula calculation is based upon an assumption of 75% comprehension and uses the total number of words, sentences, and syllables present within the text to derive a Reading Grade Level (RGL).	Results are presented as RGL with the US school grade level as reference.	Lower RGL indicates easier reading.
	Simple Measure of Gobbledygook (SMOG; McLaughlin, 1996)	Based on an assumption of 100% comprehension and, thus, is recommended for use with health information.	Results are presented as RGL with the US school grade level as reference.	Lower RGL indicates easier reading.
	FORCAST	Focuses on functional literacy and does not use a sentence-length measurement. Most appropriate for non-narrative text.	Results are presented as RGL with the US school grade level as reference.	Lower RGL indicates easier reading.
Suitability	Suitability	Suitability is rated based on the following	22-item rating tool scored on 3-point	Higher score indicated more suitability.

	Assessment of Materials (SAM; Doak et al., 1996)	factors: (1) content, (2) literacy demand, (3) graphics, (4) layout and typography, (5) learning stimulation and motivation, and (6) cultural appropriateness.	scale (0=Not suitable, 1=Adequate, 2=Superior, NA=Not Applicable). Scores can range from 0 to 44. However, this can be converted into percentage. The score is calculated by adding the total points and dividing by the total possible score to derive a percentage score [i.e., converted percent=total score/total possible score (44=22 items×2 maximum score per item)×100].	Material with overall scores of 70% to 100% is considered as superior, 40% to 69% is considered as adequate, and 0% to 39% is considered as not suitable in terms of suitability.

856
857 **Table 3: Readability formulas (measures) in different languages**
858

Language	Readability Formulas
English	▪ Automated Readability Index (ARI) ▪ Coleman-Liau Index (CLI) ▪ Fry Graph ▪ Flesch Reading Ease (FRE) ▪ Flesch-Kincaid Grade Level (F-K GL) ▪ FORCAST ▪ Gunning-FOG Index (GFI) ▪ New Dale-Chall (NDC) ▪ New Fog Count (NFC) ▪ Raygor Readability Estimate (RRE) ▪ Simple Measure of Gobbledygook (SMOG)
Hindi	▪ Readability Hindi 1 (RH1) ▪ Readability Hindi 2 (RH2)
Spanish	▪ Fernandez-Huerta ▪ Índice Flesch-Szigriszt (INFLESZ) ▪ Spanish Lexile

	▪ Spaulding

Table 4: Summary of studies (Note: PEMs=Patient Education Materials; PEMAT=Patient Education Materials Assessment Tool; PROMs=Patient Reported Outcome Measures**)**

Author (Year)	Language	Scope	Source	Quality	Readability	Suitability	Other Elements
Atcherson et al. (2011)	English	Tinnitus	PROMs (n=15)		✓		
Atcherson et al. (2013)	English	Auditory processing disorders	PROMs (n=8)		✓		
Atcherson et al. (2014)	English	Audiology consumer info	PEMs: Articles in ASHA website after 2011 (n=74)		✓		
Caposecco et al. (2011)	English	Hearing aids	PEMs: Newly developed user guide (n=1)		✓	✓	Design instructions for written materials
Caposecco et al. (2014)	English	Hearing aids	PEMs: User guides (n=36)		✓	✓	Content
Caposecco et al. (2016)	English	Hearing aids	PEMs: User guide (n=1), Original and revised		✓	✓	Hearing aid management tasks
Cherla et al. (2013)	English	Acoustic neuroma	Websites (n=67)		✓		
Coco et al. (2017)	Spanish	Audiology and otolaryngology	PROMs (n=5), Original and revised		✓		Functionalist translation
Diwan & Kelly-Campbell (2018)	Hindi	Hearing related information	Websites (n=25)		✓		Comprehension (Cloze test)
Donald & Kelly-Campbell (2016)	English	Pediatric audiology	Diagnostic report (n=1), Original and Revised		✓		Comprehension (Cloze test), Self-efficacy, Opinions
Douglas & Kelly-Campbell (2018)	English	Audiological rehabilitation	PROMs (n=10)		✓		
Eloy et al. (2012)	English	Otolaryngology association	PEMs: Documents from websites (n=262)		✓		
Greywoode et al. (2009)	English	Head and neck surgery	PEMs: Articles in AAO-HNS website (n=104)		✓		
Harris et al. (2017)	English	Tympanoplasty	Websites (n=10)		✓		Understandability and actionability

		(ear) tubes					(PEMAT), Shared-decision making, Clinical practice guidelines compatibility
Joseph et al. (2016)	English	Hearing aids	PEMs: User guides (n=6) and websites (n=20)		✓		
Joury et al. (2012)	English	Otitis media	Website (n=35)	✓	✓		Content, JAMA Benchmark criteria, Minervation validation instrument (LIDA tool)
Kasabwala et al. (2012)	English	Head and neck surgery	PEMs: Articles on AAO-HNS website (n=152)		✓		
Kelly (1996)	English	Hearing aids	PEMs: User guides (n=109)		✓		
Kelly-Campbell et al. (2012)	English	Audiology	PROMs (n=4)		✓		
Laplante-Lévesque et al. (2012)	English	Hearing impairment	Websites (n=66)	✓	✓		
Manchaiah et al. (2019a)	English	Tinnitus	Websites (n=134)	✓	✓		
Manchaiah et al. (2019b)	English	Hearing disability	PROMs (n=14)		✓		Content
McKearney & McKearney (2013)	English	Tympanoplasty (ear) tubes	Websites (n=84)	✓	✓		Accuracy, variability
McKearney et al. (2018)	English	Tinnitus	Websites (n=27)	✓	✓		
McMullan et al. (2017)	English	Hearing aids	PEMs: User guide (n=1), Original and revised		✓	✓	Hearing aid self-efficacy, Utility performance
Nair & Cienkowski (2010)	English	Hearing aids	PEMs: User guides (n=Not reported)		✓		Readability of verbal and written information
Nassif et al. (2017)	Spanish	Otolaryngology	PEMs: Articles from websites (n=497)		✓		
Nicholson et al. (2016)	English	Newborn hearing screening	PEMs: Brochures (n=48)		✓		Content, User-friendliness
Pothier (2005)	English	Glue ear	Websites (n=20)		✓		
Pryce et al. (2018)	English	Tinnitus	PEMs: Newley developed decision aid (n=1)		✓		Frequently asked questions, Usability (focus groups)

Ritchie et al. (2016)	English	Glue ear	Websites (n=27)	✓	✓		
Simpson & Baldwin (2017)	English	Disability insurance	Websites (n=20)	✓			
Spiers et al. (2017)	English	Vestibular schwannoma	Websites (n=58)	✓	✓		
Wong & Levi (2017)	English	Pediatric otolaryngology	PEMs: Articles from hospitals and institutes (n=508)		✓		

Table 5: Quality of hearing related materials (Note: Mean, SD and range of DISCERN scores are provided when reported in the publication. *=studies reporting DISCERN scores of item 16 which provides overall quality rather than reporting overall scores)

Author (Year)	Scope	Source	Quality	
			HON Certification (%)	DISCERN [Mean±SD (Min to Max)]
Joury et al. (2012)	Otitis media	Website (n=35)	45.7	47 (20 to 69)
Laplante-Lévesque et al. (2012*)	Hearing impairment	Websites (n=66)	13.64	2.05±0.64 (1.13 to 3.93)
Manchaiah et al. (2019a*)	Tinnitus	Websites (n=134)	13.4	2.39±1.2 (1 to 5)
McKearney & McKearney (2013*)	Tympanoplasty (ear) tubes	Websites (n=84)		38.5 (18 to 64)
McKearney et al. (2018)	Tinnitus	Websites (n=27)		34.5±11.2 (15 to 57)
Ritchie et al. (2016)	Glue ear	Websites (n=27)		57 (26 to 75)
Simpson & Baldwin (2017)	Disability insurance	Websites (n=20)		(23 to 88)
Spiers et al. (2017)	Vestibular schwannoma	Websites (n=58)		52.96

870
871
872 **Table 6: Readability of hearing related materials** (Note: Mean, SD and range of readability scores are provided when reported in the
873 publication. Readability scores of revised materials are provided where reported. Abbreviations: ARI= Automated Readability Index, CLI=
874 Coleman-Liau Index, F-K GL= Flesch-Kincaid Grade Level, FRE= Flesch Reading Ease, GFI=Gunning Fox Index, INFLESZ= Índice Flesch-
875 Szigriszt, NDC= New Dale-Chall, NFC=New FOG Count; RRE= Raygor Readability Estimate, SMOG= Simple Measure of Gobbledygook,
876 RGL=Reading Grade Level)
877

Author (Year)	Scope	Reading Grade Level [Mean±SD (Min to Max)]				
		FRE	F-K GL	SMOG	FORCAST	Other
Diagnostic Report						
Donald & Kelly-Campbell (2016)	Pediatric audiology	Original=34 Revised=74	Original-=14.1 Revised =5.8	Original-15.5 Revised =8.1		
Patient Education Materials (PEMs)						
Atcherson et al. (2014)	Audiology consumer info	54.2±13.1 (3.0-83.0)	9.0± 2.1 (4.5 to15.1)		10.8 ±0.9 (9.2 to 13.4)	GFI: 11.2±2.5 (5.7 to 19.5)
Caposecco et al. (2011)	Hearing aids	91.1	2.6			Fry Graph: 3; NFC: 4.9
Caposecco et al. (2014)	Hearing aids		8.08± 1.01 (5.8 to 10)			Fry Graph: 9.67±1.96 (6 to 15); GFI: 11.23± 1.27 (8.1 to 13.2)
Caposecco et al. (2016)	Hearing aids					Combined Fry Graph, F-K GL, GFI: 10.5 (Revised 4.2)
Eloy et al. (2012)	Otolaryngology association		9.7 to 17.1		10.4 to 12.1	Fry Graph: (10 to 17); NFC: (8.5 to 11.8); RRE: (10.5 to 17); CLI: (10.7 to 15.9); NDC: (8.6 to 16)
Greywoode et al. (2009)	Head and neck surgery	10.8 (6.3 to 16.7)				
Joseph et al. (2016)	Hearing aids	(51.8 to 54.7)		(11.9 to 12.6)		GFI: (11 to 12); NFC: (7.6 to 9); RRE: (10.5 to 11.4)

Kasabwala et al. (2012)	Head and neck surgery	46.5± 0.76 (44 to 49)	11.4± 0.08 (11.2 to 1.6)	13.4± 0.07 (13.2 to 13.6)		Fry Graph: 13.3±0.21 (13 to 14); GFI: 12.5±0.12 (12.2 to 12.9); RRE: 12.5±0.22 (12 to 13); CLI: 12.4±0.18 (11.9 to 12.9)
Kelly (1996)	Hearing aids		58% materials at college RGL, 20% at high school RGL, 16% at junior high school RGL, 6% at grade school RGL			
McMullan et al. (2017)	Hearing aids	Original=42.2 Revised =75.8	Original =11.4 Revised= 5	Original =13 Revised= 6		
Nair & Cienkowski (2010)	Hearing aids		7.96±1.0			
Nassif et al. (2017)	Otolaryngology	18.27 (Spanish)	15.18 (Spanish)	15.54 (Spanish)		Spanish – INFLESZ: 57.75; Spanish Lexile: 1062L
Nicholson et al. (2016)	Newborn hearing screening	72.98±7.75	5.05±1.45	7.78±1.02	10.09±0.66	GFI: 7.52±1.4
Pryce et al. (2018)	Tinnitus		Original=8.7 Revised=7.8			
Wong & Levi (2017)	Pediatric audiology	51				
Patient Reported Outcome Measures (PROMs)						
Atcherson et al. (2011)	Tinnitus	74.3±8.4 (58 to 91)			9.1±0.9 (7.0 to 10.9)	GFI: 9.0±1.5 (6.3 to 11.8)
Atcherson et al. (2013)	Auditory processing disorders	73.4± 10.1 (60 to 89)			10.1±1.1 (8.4 to 11.4)	GFI: 8.1±1.5 (4.8 to 9.6)
Coco et al. (2017)	Audiology and otolaryngology					Spanish - Fry Graph: 4th to 9th grade; Fernandez- Huerta: 2.1 to 83.7; Spaulding: 56.6 to

						81.9
Douglas & Kelly-Campbell (2018)	Audiological rehabilitation		Median 6.3 to 9.5			Original: Combined Median F-K RGL, FOG, SMOG & FORCAST: Median 6.3 to 15.4 Revised Scores: 3.2-6.4
Kelly-Campbell et al. (2012)	Audiology	79.0±4.7 (73 to 82)	6.2±1.1 (5.4 to 8.7)	9.5±1.4 (7.8 to 11.2)		
Manchaiah et al. (2019b)	Hearing disability	(51 to 84)	(4.5 to 10.2)	(8.6 to 13.5)	(8.5 to 11.3)	
Websites						
Cherla et al. (2013)	Acoustic neuroma	39.2±9.4 (12.0 to 62.1)	11.8±1.6 (8.6 to15.8)	14.0± 1.2 (11.9 to 17.2)		GFI: 14.8± 1.9 (11.8 to 19.9)
Diwan & Kelly-Campbell (2018)	Hearing related information					Hindi: Readability Hindi 1: 3.03 to 11.40; Readability Hindi 2: 3.12 to 5.74
Harris et al. (2017)	Tympanoplasty (ear) tubes	50.4±11.6 (28.8 to 70.6)	(6 to 15)			
Joury et al. (2017)	Otitis media	52.2	9.9			ARI: 9
Laplante-Lévesque et al. (2012)	Hearing impairment	48.26±10.42 (21.42 to 66.88)	11.10±2.16 (7.31 to 17.16)	12.36±1.82 (8.48 to 17.75)		
Manchaiah et al. (2019)	Tinnitus	47.82±13.4 (6 to 81)	10.27±2.5 (5.8 to 18.6)	11.85±2.2 (7.7 to 19)		
McKearney & McKearney (2013)	Tympanoplasty (ear) tubes	49.4±12.9 (5.7 to 71.6)	10.1±1.7 (6.6 to 12)			
McKearney et al. (2018)	Tinnitus	52.6±7.7 (35.7 to 64.2)				
Pothier (2005)	Glue ear					FRE and F-K RGL Combined: 11.1 to 16.5 years
Ritchie et al. (2016)	Glue ear	49.7 (25.8 to 65.7)				
Spiers et al. (2017)	Vestibular schwannoma	48.75	10.27			GFI: 13.4

878

Table 7: Suitability of ear and hearing related materials (Note: Mean, SD and range of SAM scores are provided when reported in the publication. SAM scores of revised materials are provided where reported.)

Author (Year)	Scope	Source	Suitability (SAM) [Mean±SD (Min to Max)]
Caposecco et al. (2011)	Hearing aids	PEMs: Newly developed user guide (n=1)	88
Caposecco et al. (2014)	Hearing aids	PEMs: User guides (n=36)	52.42±7.69 (40 to 68)
Caposecco et al. (2016)	Hearing aids	PEMs: User guide (n=1), Original and revised	50 (Revised 90)
McMullan et al. (2017)	Hearing aids	PEMs: User guide (n=1), Original and revised	28.95 (Revised 78.95)