An Evaluation of the Readability and Suitability of Online Hearing-related Health Information in Traditional Chinese

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Abstract

Purpose: This study aimed to determine the readability and suitability of online hearing-related health information in traditional Chinese (TC) and to compare the readability and suitability between the TC and English materials available on the same websites.

Methods: The reading grade level of 17 selected websites, detailing the same hearing-related health information in TC and English, was assessed via the Chinese Readability Index Explorer (CRIE) for TC language, and Flesch-Kincaid Grade Level and Simple Measure of Gobbledygook (SMOG) for English. Then, the suitability of the webpages was rated using the Suitability Assessment of Materials (SAM).

Results: Online hearing-related health information in TC was significantly easier to read than the information written in English. More than 70% of the hearing-related health webpages provided information in TC that was written below the recommended 6th Reading Grade Level (RGL), whereas all the information in English was written above the 6th RGL. Overall, the suitability level of the online hearing-related health information in both languages was rated as 'adequate'.

Conclusion: A majority of the online hearing-related health information in TC language is readable and appropriate for the public. Yet, improvements still can be made to improve the quality of the current online hearing-related health information in TC. Future research may include utilizing the Cloze Test for testing TC readability, developing specific suitability assessments for evaluating online materials, and assessing the accuracy of online hearing-related health information in TC.

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List of Abbreviations

Artificial Neural Network (ANN)

Chinese Readability Index Explorer (CRIE)

Consumer Health Information (CHI)

Flesch Kincaid Grade Level (FKGL)

Health On the Net of Code of Conduct (HONcode)

Hong Kong (HK)

Intraclass Correlation Coefficient (ICC)

Medical Subject Headings (MeSH)

Non-Applicable (NA)

Online Consumer Health Information (OCHI)

Patient Education Materials Assessment Tool (PEMAT)

Reading Grade Level (RGL)

Simple Measure of Gobbledygook (SMOG)

Simplified Chinese (SC)

Suitability Assessment of Material (SAM)

Support Vector Machine (SVM)

Taiwan (TW)

Traditional Chinese (TC)

Uniform Resource Locator (URL)

United States Department of Health and Human Services (USDHHS)

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Chapter 1 Introduction

1.1 Study Overview

Consumer Health Information (CHI) is a Medical Subject Headings (MeSH) term first introduced in 2008. It is defined as "information intended for potential users of medical and healthcare services" (Medical Subject Headings [MeSH], 2008). CHI is important for patients, family members, caregivers, and people who are interested in health care and disease prevention. CHI plays a critical role in increasing consumers' health literacy level, promoting health knowledge and aiding psychosocial adjustment to illness (Lambert & Loiselle, 2007). Providing readable and suitable health information can be an effective teaching tool for adult health consumers (Foltz & Sullivan, 1999). CHI can be delivered through different formats, such as flyers, fact sheets, brochures, posters, booklets and on websites.

Nowadays, internet use around the world has continued to expand and has become one of the most common sources for public health education. Health information aims to enhance the knowledge of health care and disease prevention, and health promotion. The impact of the internet on public health education has transformed how the public accesses health information, understanding of own health conditions, improvement in health outcomes, and the interaction between the health professions and the patients. This has caused the rise of attention to the readability and suitability CHI on the internet for the last two decades (Stossel et al., 2012).

Standardized measurements such as readability formulas and suitability assessment tools have been developed to measure whether written information is accessible and suitable for the public. Readability formulas are language-specific as different languages have distinct linguistic

construction features. Currently, there are more than 12 different languages readability formulas available for text analysis (Doak et al., 1996), including Traditional Chinese (TC). Suitability Assessment of Materials (SAM) was first developed for evaluating printed materials in English (Doak et al., 1996), and later translated and validated for evaluating Chinese written materials (Chang et al., 2014).

Despite having accessible tools for analysing written information in TC, there is still a major gap in the readability and suitability of online consumer hearing-related health information in TC. Hsu et al. (2019) was the first study to investigate the readability of some hearing-related health webpages in TC and found a substantial part of the information exceeded the recommended 6th RGL. No previous study has evaluated the suitability of those webpages. Against this background, the present investigation aims to further assess the readability and suitability of online hearing-related health information in TC and compare with the readability and suitability of the same information in English from the same website.

1.2 Traditional Chinese Language

The Chinese language has the largest population of native speakers, while the English language is the most widely spoken language in the world (Ethnologue, 2020). There are approximately 1.12 billion Chinese speakers around the world (Ethnologue, 2020). The written forms of Chinese are divided into TC and Simplified Chinese (SC). They have the same writing systems but the written characters are completely different. The Chinese characters are formed by basic gestures which are known as strokes. TC has more strokes in each Chinese character than SC. For example, the term 'hearing sense' is written as '聽覺' in TC and '听觉' in SC. The

writing of TC characters looks more complicated than SC. Hong Kong and Taiwan are the only two Chinese-speaking regions using TC as their official language while SC is adopted by all the other Chinese-speaking regions.

1.3 Overview of Hearing Loss

Hearing loss is defined as "the complete or partial loss of the ability to hear from one (unilateral) or both (bilateral) ears" (MeSH, 2003). Hearing loss can occur in all ages. When an adult's hearing thresholds are better than or equal to 25 decibels in hearing level (dB HL), they are considered to have normal hearing (Katz et al., 2014). Disabling hearing loss refers to any hearing threshold across the tested frequency range of the better hearing ear being greater than 40 dB HL in adults and greater than 30 dB HL in children (World Health Organization [WHO], 2020). Some hearing loss can be temporary and reversible but most of the hearing loss incurred may be permanent. Hearing loss is classified into different types and severity levels – mild, moderate, moderately-severe, severe, or profound (Jerger & Jerger, 1980). The impacts of hearing loss can be varied and depends on an individual's daily communication needs and personal experiences.

The greatest impact of hearing loss is communication access. It directly affects an individual's ability to engage in conversation, obtain verbal information successfully, and establish social relationships with others as communication is disrupted. People with hearing loss are likely to rely on visual cues (e.g. lip-reading), linguistic context (e.g. the topic of the conversation and keywords), and situational cues when they cannot hear the conversation. This can make communication effortful for them, particularly when there is background noise and limited visual cues available (Fraser et al., 2010; Picou et al., 2013; Koeritzer et al., 2018).

Negative experiences in communication may lead to psychological stress, social isolation, and incompetence in learning, social situations, or at work (National Research Council, 2004). Individuals who are hearing impaired may also feel isolated, have low self-esteem, especially when they feel a lack of understanding from their spouse, family, friends, co-workers, or employers. Hence, hearing loss should be assessed and treated as early as possible to reduce the impact on an individual's communication access in daily life.

1.3.1 Prevalence of Hearing loss in Hong Kong and Taiwan

The World Health Organization (WHO, 2018) states that there are approximately 466 million people globally who have impaired hearing. The second highest prevalence of hearing loss was in East Asia (i.e. China, Hong Kong, Macau, and Korea), with approximately 21.6% of the population having hearing loss (WHO, 2018). Taiwan (TW) is also part of the East Asia region.

In 2014, the Census and Statistics Department (C&SD) of the Hong Kong Special Administrative Region of the People's Republic of China (HKSAR) reported 2.3% (n = 155,200) of the total Hong Kong (HK) population was diagnosed with hearing loss. 24.2% of the impaired hearing population were aged below 65 and 75.8% were aged 65 or above (C&SD, 2014). The Ministry of Health and Welfare (2016) of TW also reported 122,906 people, about 0.52% of the total TW population, had hearing loss in 2015, 97.52% of which were above the age of 18.

1.3.2 Management of Hearing Loss

Intervention options are varied for individuals due to numerous factors. These factors include the degree of hearing loss, nature of intervention, financial ability, ability to use digital

devices, hearing needs, other people's experiences, recommendations, and support available (Laplante-Lévesque et al., 2010). Aural rehabilitation consists of four components, including detecting and managing sensory deficits, providing instruction in hearing aid and accessory management, providing training on speech perceptual skills, and providing counselling on expectations and progress of rehabilitation (Boothroyd, 2007). A combination of the four components was proven to enhance an individual's function, activity, participation, and quality of life (Boothroyd, 2007). Furthermore, hearing aids are one of the most common treatment options for managing individuals with irreversible hearing loss. Besides, communication strategies are often applied to aural rehabilitation to maximise individual hearing outcomes. WHO has estimated that approximately 20% of the hearing loss population (72 million) required hearing aids (WHO, 2013); however, only 3% of this population considered hearing aid adoption.

1.4 Consumer Health Information on the Internet

1.4.1 Online Consumer Health Information

According to the Internet World Stats (2020b), it estimated that 4.5 billion internet users will exist worldwide by the end of December 2019. The top three regions included Asia (55.1%), Africa (17.2%), and Europe (10.7%). Asia had approximately 2.3 billion internet users in 2019 and has had a 1913% growth in the number of internet users since 2000 (Internet World Stats, 2020b).

The prevalence of people seeking online health information around the globe has been growing in this digital age, and the demand for online medical and health resources has significantly increased and expanded rapidly in the last two decades (Liu, 2020). The advantages

of seeking health information online include convenience, coverage of the information that people can find promptly (Chu, 2017), and the availability of different languages.

The positive outcomes of utilising Online Consumer Health Information (OCHI) include: 1) health consumers becoming more proactive in seeking consultation from health professions, 2) making decisions for their health care, 3) improving satisfaction with healthcare experiences and physician-patient interactions, 4) improving health status and 5) reducing worries (Granikov et al., 2016; Wald et al., 2007). Despite the advantages and positive outcomes of OCHI, seeking health information online can also lead to negative outcomes in various levels. These include internal level (such as increased worrying), interpersonal level (such as tension in the patient-clinician relationship and postponing a clinical encounter), and/ or service-related level (such as postponing a clinical encounter) (El Sherif et al., 2018, p.1). These possible disadvantages raise concerns over the content in the health information websites. El Sherif et al. (2018) has suggested some strategies to minimize the occurrence of the negative outcomes by providing reliable OCHI, educating the public to access the available online health resources, and encouraging health consumers to seek professional advice to clarify the OCHI they have found. As a result, the accuracy, reliability, suitability, and completeness of online health information continue to be a focus in every speciality of health care (Yan, 2010).

1.4.2 The Health on the Net Code of Contact – the validation of OCHI

The Health On the Net of Code of Conduct (HONcode) certification is a code to help the public recognising OCHI that is reliable and trustworthy (Boyer et al., 2007). The HONcode is only given to websites that have been assessed under eight principles, including authoritative, complementarity, privacy, attribution, justifiability, transparency, financial disclosure, and

sponsorship (Boyer et al., 2007). Besides that, it is easy and convenient for internet users to simply install the HONcode toolbar as an extension on the Chrome browser to identify the HONcode proven health information websites. However, not all online health websites have applied for this validation process.

1.4.3 Prevalence of Seeking OCHI and Online Health Information Seeking Behaviour

In HK and TW, statistics showed that 92.6% (22 million) people in TW and 89.3% (6.6 million) people in HK were Internet users (Internet World Stats, 2020a). TW placed fourth and HK placed fifth in internet penetration within the Asia region in January 2020. In HK and TW, Google is the most commonly utilised search engine, used by 89.45% and 92.45% of internet users respectively in May 2020 (Statcounter, 2020a; 2020b).

Several studies indicated that a significant proportion of people in HK and TW had experience seeking health information on the Internet. A study by Chang et al. (2015b), involving 1365 parents and 1869 adolescents in TW, showed 73% of parents and 60% of adolescents using the Internet to access health information. In Wong and Cheung's (2019) cross-sectional study of online health information-seeking behaviour in HK, 87.4% of 1162 primary care patients have searched for health information online. Wei (2014) identified that individuals who tend to seek health information online were more likely to have adequate health literacy and higher educational background than those with inadequate/ marginal health literacy and poorer educational levels overall. These findings are consistent with other studies (Jacobs et al., 2017; Wong & Cheung, 2019; Yan 2010).

Wong and Cheung's (2019) study stated the main reason for seeking health information online was due to "noticing new symptoms or change in health", and the search keywords were generally symptoms experienced. Similar findings were noted in previous studies (Chang et al., 2015b; Jacobs et al., 2017; Pang et al., 2014; Wei, 2014). In Chu (2017), most participants reported "limited time" and "lack of time to discuss or elaborate on certain issues" with the doctor during consultations; therefore, OCHI was perceived as a valuable resource and a second option for enhancing their health knowledge. Some participants also reported that it was due to their desire to increase knowledge in health-promoting behaviour, the symptoms of a specific disease, and the treatment for a medical condition (Wei, 2014). Other reasons included preparing for medical consultation, seeking clarification on information given by the medical professional, and the need for additional information on professional opinions (Wei, 2014).

Studies in HK identified the main criteria of choosing online health resources included "convenience" and "easy to understand", then "top results from search engines" (Wong & Cheung, 2019; Chu, 2017) which are also consistent with other studies (Andreassen et al., 2007; Maon et al., 2017). Furthermore, the types of websites that people would generally visit were professional health websites that are impartial and reputable, such as hospital, government, disease-focused organisations, or university websites (Chu, 2017; Maon et al., 2017; Yan, 2010).

1.5 Health literacy

1.5.1 Definition and Importance of health literacy

The term 'health literacy' has appeared in health literatures for more than 30 years (Ad Hoc Committee on Health Literacy, 1999). It is the relationship between the literacy level of an individual and his/her ability to obtain, process and implement the prescribed therapeutic

regimens (Ad Hoc Committee on Health Literacy, 1999; Kindig et al., 2004; Nutbeam, 1998b), while "eHealth literacy" involves the use of electronic sources. This infers that an individual's health literacy skills help to seek, comprehend, appraise information, make appropriate decisions, take prompt actions about his/her health state and take part in executing and evaluating intervention (Nielsen-Bohlman, Panzer, & Kindig, 2004; Levin-Zamir, Leung, Dodson, & Rowlands, 2017; Nutbeam, 1998a; Nutbeam 2000). It is a key determinant of health outcomes (HLS-EU Consortium, 2012; Nutbeam, 2009). Several studies have identified factors that can affect the health literacy level of an individual, including gender, age, education levels, household poverty, employment status, marital status, academic performance rates and urban or rural residence (Berkman et al., 2011; Chang et al., 2015b; Doak, Doak, & Root, 1985; Jayasinghe et al., 2016; Nutbeam 2000; Wei, 2014; Wilson, 2009; Wong & Cheung 2019).

1.5.2 Impact of health literacy on health outcomes

In the early 90s, Weiss et al. (1992) started assessing the relationship between literacy and health status. The physical health status of their subjects with low literacy levels were poorer than the subjects with higher literacy levels (Weiss et al., 1992). Individuals with lower health literacy were also more passive in seeking health information and had relatively poor abilities in obtaining, appraising, and utilizing information relevant to health (Nutbeam, 2009; Sørensen et al., 2012; Wei, 2014). Low health literacy increases difficulties communicating one's own health conditions and issues, having lower awareness and less understanding of own health conditions, health prevention and health information, which may lead to delay of treatment and affect health outcomes (Berkman et al., 2011; Williams et al., 2002). Patients with limited health literacy also reported worse overall health status, higher rates of hospitalisation, and less understanding of

treatment options (Williams et al., 2002). Hence, the lower the health literacy, the poorer the health outcomes.

1.5.3 Literacy Level and Recommended RGL for CHI

The accessibility of CHI is closely related to the level of the reading materials. By ensuring the appropriateness and provision of comprehensible online information on hearing-related health websites, public hearing-health literacy capacities should improve. If health information is too difficult for the public to comprehend, the information will remain inaccessible to people with low reading ability and low health literacy levels. In 1996, Doak et al. highlighted the mismatch between literacy of health consumers and readability of the health-related materials. In the U.S., the average literacy level of adults is approximately at an 8th to 9th reading grade level (RGL) (Paasche-Orlow et al., 2005; Kutner et al., 2006). According to Boyd (1987), health education materials should be 2 to 4 reading grades below the average RGL of adult health consumers. Thus, the recommendation for CHI in the English language was suggested to be at the 6th RGL or below (Doak et al., 1996; Leonard, 2017). However, many studies have revealed the readability of a substantial portion of OCHI in English exceeds the recommended 6th RGL, and the mean RGL produced by different formulas ranged from 10th to 15th (Cheng & Dunn, 2015; Daraz et al, 2018; Hutchinson et al., 2016; Walsh & Volsko, 2008).

There is no data suggesting the average literacy level of adults who can read TC in HK and TW. Hence, no recommended RGL of CHI or OCHI in TC has been suggested by researchers. The Ministry of Education in HK and TW implemented a 9-year compulsory education scheme from 1977 and 1968 respectively (Education Bureau, 1997; Ministry of Education Republic of China, 2018). Recently, they have changed to a 12-year compulsory

education scheme (Education Bureau, 2020; Ministry of Education Republic of China, 2018). The average reading level of the TC adult population in HK and TW should reach at least the 9th RGL of TC. Hence, the recommended "6th RGL or below" can also be implemented on OCHI written in TC. However, an individual's literacy level may not be consistent with his or her education level (Wilson & McLemore, 1997) and the average literacy level can only be an estimation. There is a still major gap in assessing the readability of OCHI written in TC language.

1.6 Measures

1.6.1 Readability

1.6.1.1 English Readability

Readability is defined as the legibility, ease of reading, and ease of understanding of a text (Klare, 1984; Ley & Florio, 1996). English readability formulas have been developed, validated, and applied widely in evaluating the comprehensibility of CHI written in English (Ley & Florio, 1996). There are more than 40 different readability formulas available for the English language (Redman, 2007) to generate a readability score and convert to a reading grade level for publishing health or non-health education materials. Ley and Florio (1996) stated a readability equation generally includes one or more of the following components into a numerical equation. These include average word length in syllables, average sentence length in words, the proportion of common words used, proportion of words with 3 or more syllables in them, and proportion of monosyllabic words (Ley & Florio, 1996).

The two most widely used readability formulae for evaluating English written health education materials include the Flesch Kincaid Grade Level (FKGL) (Kincaid et al., 1975) and

the Simple Measure of Gobbledygook (SMOG) (McLaughlin, 1969). They are computer-based formulas. The FKGL measures the average word length in syllables and average sentence length in words (Kincaid et al., 1975), whereas SMOG only measures the average word length in syllables (McLaughlin, 1969). The two formulas can generate different ranges of reading grade levels. The FKGL generates reading scores ranging from "4th grade or below" to "16th grade and above" (Dale & Chall, 1948), whereas SMOG scores range from grade level 4 to 18 (McLaughlin, 1969). Some research findings have reported the FKGL tends to generate a lower RGL rating than other readability formulas (Friedman & Hoffman-Goetz, 2006; Friedman & Kao, 2008). Some studies have also recommended using SMOG for analysing health education materials (Brangan, 2015; Contreras, Garcia-alonso, Echenique, & Daye-contreras, 1999; Doak, Doak, & Root, 1996; Shieh & Hosei, 2008). The inter-correlations between these two formulas are high (Meade & Smith, 1991). Ley and Florio (1996) suggested two options to solve the differences in estimated RGLs of more than one readability formula; to take the highest estimated RGL or to take the average RGL.

Additionally, the United States Department of Health and Human Services (USDHHS) suggested categorising RGLs into different ranges of difficulty and to report the level of difficulty instead of a specific RGL. The three readability categories include below or 6th RGL as "easy to read", 7th and 9th RGL as "average difficulty", and above 9th RGL as "difficult" (United States Centers for Medicare & Medicaid Services [UCFM&MS], 2012, p.23).

1.6.1.2 Traditional Chinese Readability

Traditional Chinese language has many differences in linguistic features, including lexical, syntactic, semantic, contextual, and grammatical functions compared with English

language (Wang & Chen, 2013). Several TC readability formulas have been developed in recent years to accommodate the needs of analysing written materials in TC, including Yang's readability formula (Yang, 1970), Jing's readability formula (Jing, 1992; 1995), Jeng's readability formula (Jeng, 2001) and the Chinese Readability Index Explorer (CRIE) (Sung et al., 2016).

The first developed TC Chinese readability formula was Yang's formula which analyses six components: character, bi-character word, sentence, multi-character word, complex stroke, and word list (Yang, 1970). It also analyses another three factors including the number of character that has more than 10 strokes, the average number of words per sentence and proportion of difficult words and simple words used (Yang, 1970). However, Yang (1970) only discussed the key factors that can affect readability. It lacks the empirical verification of the readability formula and is considered to have poor validity (Lau, 2006).

Jing's readability formula generates reading grade level by the average length of sentence, the length of the passage, and the proportion of frequent characters (Jing, 1992; 1995). It also involves two other elements, poetry and ancient Chinese which involves a different linguistic system. They are presented as binary decision value which means their value is either 1 (Yes, it is poetry/ ancient Chinese.) or 0 (No, it is not.). The database of the frequent character list was developed by words selected from the corpora of the TC language education materials for 1st to 6th grade in TW. There are 496 characters in the final character list. This list is limited and it does not refer to other external corpora. Other readability formula studies established common word lists through multiple corpus data, and then compared the ratio of the words used in the word inventory as the reference for the reading grade level (Dale & Chall, 1948;

McLaughlin, 1969; Yang, 1970). The process of character selection for Jing's formula database also lacks verification. Therefore, there is a limitation in analysing and applying the Jing's readability formula in analysis study. Previously, Jing's readability formula was developed into a web-based analysis system which means the RGL of any TC text can be generated through computer-based automatic calculation. However, the hyperlink for the computer-based Jing readability formula recently broke and can no longer be accessed by the public.

Jeng's (2001) study used an Artificial Neural Network (ANN) approach to develop a readability formula for analysis. The ANN approach is an overly complex computational process involving the combination of human judgements and mathematical models (Jeng, 2001). The factors in Jeng's formula are overly complicated for researchers to calculate the RGL of the written materials. The concepts of some elements in the formula are vague and overall makes it difficult to utilise this formula in this study.

The CRIE is the most recently developed, computer-based Chinese readability formula. It employs stepwise regression model and support vector machine (SVM) as its readability prediction modal (Sung et al., 2016). It involves three processes, the segmentation of sentences, part-of-speech tagging, and grammar parsing (Sung et al., 2015; Sung et al., 2016). Sung et al. (2015) showed an accuracy of 72.92% when using CRIE to predict the RGL of Grade 1-6 art textbooks used in TW. The computer-based system analyzes and presents the statistical data of each element in the Chinese passage. Elements analysed include the proportion of difficult words, simple sentence ratio, content word frequency in logarithmic and personal pronouns (Sung et al., 2015; Sung et al., 2016). Although the accuracy rate of the CRIE version 1.0 was only 55% (Sung et al., 2013) and the validity of applying CRIE to health education materials is

still questionable, it was utilised in Hsu et al. (2019) because it was easier to compute RGL and analyse a wider range of elements from the text compared to other TC readability formulas. Additionally, the CRIE formula has recently been updated to a 3.0 version on its web-based system (www.chinesereadability.net/CRIE/?LANG=CNT) (Chinese Readability Index Explorer [CRIE], 2019). There is no published article discussing its update and the specification of the latest version of this formula.

1.6.1.3 Previous studies

Many studies have applied the FKGL and SMOG readability formulas to evaluate the RGL of the English OCHI, including cancer, stroke, infertility, insomnia, mastectomy and lumpectomy resources (Lee et al., 2018; Ma et al., 2017; Robins et al., 2016; Tian et al., 2014; Tran et al., 2017; Walsh & Volsko, 2008). Research findings highlighted that the OCHI in the English language is generally written at a level above the 6th grade. Consistent findings were also found in English hearing-related health information on the internet (Felipe et al., 2020; Laplante-Lévesque et al., 2012; Laplante-Levesque et al., 2011; Laplante-Lévesque & Thorén, 2015; Manchaiah et al., 2019; Potter, 2015) using FKGL and SMOG formulas.

Hsu et al. (2019) study utilised Jing and CRIE readability formulas to evaluate the RGL of 32 hearing-related health webpages in TC. None of the selected hearing-related health webpages from Hsu et al. (2019) has obtained HONcode. The study discovered that the two TC formulas generated different RGL but have a high inter-correlation (Hsu et al., 2019). The research findings also reported that Jing tends to generate scores at 2 RGL higher than CRIE. CRIE formula identified 25% of the websites exceeded the recommended RGL of 6, with the highest RGL being 10. Jing's formula identified 81% of the websites exceeded 6th RGL with the

highest RGL being 12. The results indicated that online information on hearing-related websites in both TC and English language is generally difficult for the public to read. This reduces the chances of delivering hearing health information successfully due comprehension difficulties (Friedman & Hoffman-Goetz, 2006).

Hsu et al. (2019) suggested further evaluating the suitability of TC hearing-related health websites. Readability formulas only evaluate limited features, such as word length, sentence length and proportion of difficult words. Formulas have ignored the content, suitability, cohesion, writing style, and completeness of the information presented, such as visual attractiveness, layout, graphics, use of vocabulary, and cultural factors (Caposecco et al., 2011; Meade & Smith, 1991; Redish, 2000). Furthermore, the difference and variability in scoring generated by different formulas support the limitations of solely using readability formula to access 'how readable' the information is (Finnie et al., 2010). Hence, suitability analysis should be conducted to compensate for the limitation of readability formulas and evaluate aspects that have been ignored (Doak et al., 1996; Meade & Smith 1991).

1.6.2 Suitability Analysis of English and TC written materials

Suitability is defined as the appropriateness of the information for a target population. Suitability Assessment of Materials (SAM) is a widely used and is a valid tool for evaluating the suitability of printed health education materials in English (Kelly-Campbell & Manchaiah, 2020; Lampert et al., 2016; Shieh & Hosei, 2008). It is a simple and quick tool with good reliability and validity for evaluating the elements of the written education materials that are ignored by readability analysis (Hoffmann & Ladner, 2012). It identifies specific factors that require modification to improve the quality of the written materials. SAM consists of 22 items under 6

different factors, including graphics, layout and typography, learning stimulation and motivation, and cultural appropriateness of the websites (Doak et al., 1996). It also includes readability as one of the evaluation components. Based on the specific criteria of the 22 items, each can be rated as 0 (not suitable), 1 (adequate), 2 (superior), or missing/ not applicable (NA). 'Missing or NA' means the material does not consist the corresponding component. Hence, it gives a maximum score of 44 if no item is missing. The score can then be converted into a percentage score and classified into three different levels of suitability – 'not suitable', 'adequate' or 'superior' (Doak et al., 1996). The following table summarizes the interpretation of the SAM percent score.

Table 1.1

The interpretation of SAM score in percentage.

SAM Score in percentage	**Level of suitability**
0% - 39%	Not suitable
40% - 69%	Adequate
70% - 100%	Superior

SAM has also been translated into a Chinese version. SAM-Chinese version is shown to have an excellent content validity index for the total scale (Scale-Level-CVI = 0.99) (Chang et al., 2014). Chang et al. (2014) suggested that it is important to consider the language discrepancies while analysing Chinese-language text using SAM. The differences between the TC and the English version include the criteria for 'suitable line length and text type' and should be adjusted accordingly, and as the Chinese language has no 'capital characters', the original evaluation criterion "NO ALL CAPS for long headers or running text" can be ignored.

1.6.2.1 Previous studies

Researches have utilized SAM and SAM-Chinese version in evaluating different consumer health information in English and Traditional Chinese, such as prenatal health (Shieh & Hosei, 2008), asthma (Tzeng & Gau, 2018; Chang, 2012), cancer (Helitzer et al., 2009), hearing-related health information (Caposecco, Hickson, & Meyer, 2014; Convery et al., 2011; Elmadani, 2019; McMullan et al., 2018; Ming & Kelly-Campbell, 2018; Potter, 2015).

Suitability Assessment of Materials not only provides the level of suitability of the materials but it also identifies areas that require improvement. In Caposecco et al. (2014) study, results showed the mean of suitability of hearing aid user guides was 52.42 (adequate level). Specific factors included the scope of information, vocabulary, layout and typography, and readability required improvement (Caposecco et al., 2014). Elmadani (2019) used SAM to assess the suitability of online noise-induced hearing loss (ONIHL) information and provided specific comments for how the materials can be improved. The authors or website host organization can then receive specific comments on how to improve factors that are rated as not suitable. Several studies have also proven the benefits of utilizing SAM to improve the readability and suitability of hearing-related health materials by following the results from SAM and the best-practice guidelines written by Doak et al. (1996) (Convery et al., 2011; McMullan et al., 2018; Ming & Kelly-Campbell; 2018). These findings highlight the efficacy of assessing the suitability of hearing-related health information using SAM.

1.6.3 Correlation between readability and suitability

Doak et al. (1996), who developed the SAM, suggested an association between

readability and suitability; an increase in RGL can usually lead to a decrease in SAM score. That is to say, the higher the reading grade level of the materials, the harder it is for the health consumers to understand. Some studies have shown a significant correlation between the two variables (Elmadani, 2019; Robins et al., 2016). Robins et al. (2016) looked at the readability and suitability of infertility web-based information in English and showed a weak negative association between RGL and SAM (Pearson's $r(28) = -.39$, $p = <.001$). Whereas Elmadani (2019) showed a weak positive association (Pearson's $r(30) = .45$, $p = .01$) between the readability and suitability of online NIHL information in English. Abou-Diab et al. (2019) found no significant correlation between the readability and suitability scores, and by changing the readability formula it changes the correlation between RGL and SAM scores. Hence, this suggests it is important to separate analysis between the two variables.

1.7 The Aims of Study

In recent study, Hsu et al. (2019) assessed the readability of some hearing-related health webpages in TC and showed a substantial portion of the webpages exceeded 6th RGL. To date, it was the first and the only study to access the readability of hearing-related online materials presented in TC language. In addition, there is still a major gap in identifying the content suitability and design of online hearing-related health information in TC which has never been accessed before. Hence, suitability analysis should be conducted to provide more insight on the quality of hearing-related health websites in TC. The purpose of this current study was to determine the readability and suitability of the online hearing-related health information in TC. For comparison purposes, this study also compared and discussed the readability and suitability between the TC and English materials provided by the same website host organization.

1.7.1 Research Questions

1. What is the readability of online hearing-related health information in TC and English?
2. What is the suitability of online hearing-related health information in TC and English?
3. Is there any difference in the readability and suitability of the selected online materials between the two languages?

1.7.2 Research Hypotheses

1.7.2.1 RGL of hearing-related webpages based on language

1a) The median RGL of the webpages in TC is not significantly greater than 6th RGL.

1b) The median RGL of the webpages in English is not significantly greater than 6th RGL.

1.7.2.2 Suitability level of hearing-related webpages based on language

2a) The average suitability rating of the online information in TC is not significantly greater than 40%, indicating the online hearing health materials are reaching the adequate suitability level.

2b) The average suitability rating of the online information in English is not significantly greater than 40%, indicating the online hearing health materials are reaching the adequate suitability level.

1.7.2.3 Correlation between RGL and SAM score based on language

3a) It is hypothesized there is no significant correlation between the RGL and the suitability for the webpages in TC.

3b) It is hypothesized there is no significant correlation between the RGL and the suitability for the webpages in English.

1.7.2.4 Between-group comparison of RGL and Suitability level

No previous studies have compared the results of readability and suitability in Traditional Chinese and English from the same website. Therefore, a secondary aim of this study is to compare the RGL and the suitability rating obtained for each webpage in both languages.

4a) The median RGL of webpages in TC is not significantly different from the median RGL in English.

4b) The median suitability rating of webpages in TC is not significantly different form the median suitability of webpages in English.

Chapter 2 Methods

2.1 Overview

This current study is an extension of Hsu et al. (2019) and aims to investigate the readability and suitability of hearing-related health webpages which provide information in TC, and to compare the ratings of the TC material with the English version of the material retrieved from the same websites. This study has obtained University of Canterbury ethics approval (see Appendix). This following chapter will outline the evaluation methods of readability and suitability. First, TC readability will be assessed using CRIE, and English readability will be assessed using FKGL and SMOG. Second, the suitability of webpages in both languages will be evaluated using SAM and SAM-Chinese evaluation forms.

2.2 Search Terms and Internet Search

This study applied the same search terms that were identified in Hsu et al. (2019) study. The 13 keywords include 耳朵 (Ear), 聽力 (Hearing ability), 耳聾 (Deaf), 耳朵聽不清楚 (Can't hear properly), 聽不清楚 (Can't hear properly), 重聽 (Hard of hearing), 聽力障礙 (Hearing impairment), 聽力退化 (Hearing deterioration), 助聽器 (Hearing aids), 聽力治療 (Hearing intervention), 聽覺受損 (Hearing damage), 重聽治療法 (Treatment for hard-of-hearing), and 耳鳴 (Tinnitus) (Hsu, 2017).

A MacBook Air with macOS Catalina (version 10.15.5) operating system was used to conduct the online webpage search. An online search of all 13 keywords from Hsu et al. (2019) was completed on google.com using the Chrome browser (Version 84.0.4147.89) with HONcode

toolbar (Version 3.1.3) installed. The search setting was set up with 20 results per page and the search region as HK and TW. In the advanced search setting, the language of search results was also narrowed to TC only. The function of automatic translating SC to TC was switched off to ensure all the webpages were originally written in TC language. The first 20 results of each keyword from the internet search were recorded, resulting in a total of 520 webpages.

2.3 Inclusion and Exclusion Criteria

This research applied similar inclusion and exclusion criteria as Hsu et al. (2019). Yet, there are two additional inclusion criteria in this study for comparing the readability and suitability of the hearing-related health information in TC and English. To minimise the difference in factors like the origin, types of organization and types of content, only TC webpages that provide an English version of the same content were included in this study.

The inclusion criteria of this current study are stated as follow: the webpage must (1) provide hearing-related health information in TC, (2) a direct link to an English version of the same information from the same webpage organization, (3) contain information relating to hearing loss, hearing assessments or hearing treatments (Hsu et al., 2019), (4) be available for public access (Hsu et al., 2019), (5) allow text to be copied and pasted (Hsu et al., 2019), (6) contain the information of the hosting organization (Hsu et al., 2019).

The exclusion criteria from Hsu et al. (2019) study included “the webpage must not: (1) be a Google identified advertisement, (2) be a video or a video hosting website, (3) be an animation, (4) be an image, (5) be a directory listing, (6) contain less than 100 words in length, (7) only contain information relevant to paediatric or congenital hearing loss, (8) only contain

information about tinnitus, and (9) only contain information about vision, the vestibular system, and tumors or other brain lesions". Duplicate webpages were identified. A result of 17 webpages in TC met all the criteria to be included in this study.

2.4 Collection of webpage information and content

The plain text on each selected webpage was copied and pasted in Microsoft word documents. Each word document was saved as text files (.txt). A Microsoft Excel file was also created to record the uniform resource locator (URL) of each webpage, the name, location, and type of the host organization, the language used for presenting information, types of hearing information presented and whether the webpage has granted the HON certification. The types of host organizations were classified into non-profit and profit, and the content of hearing information were categorized. To identify whether the webpage was granted the HON certification, the HONcode toolbar on Chrome was utilized.

2.5 Computer-based Readability Formulas

2.5.1 Traditional Chinese Readability Analysis

The readability of TC materials was assessed using the computer-based CRIE system (http://www.chinesereadability.net/CRIE/?LANG=CHT) Chinese Readability Index Explorer [CRIE], 2019). The CRIE 3.0 is the latest version that was used in this study. CRIE provides a readability formula to generate the reading grade level of the text, as the system does not directly assign a RGL for the users. The formula generates the RGL based on the following four textual features: 'proportion of difficulty words' (難詞數), 'simple sentence ratio' (單句數比率),

‘content word frequency in logarithmic’ (實數頻對數平均) and ‘personal pronouns’ (人稱代名詞數) (Sung et al., 2016).

First, textural features were chosen from the list on the CRIE system. All TC text files were then compressed into one zip file. The zip file was uploaded onto the CRIE system, and the analysis results were outputted and saved as a Microsoft Excel file. The raw numerical data of the textural features for each webpage were input into the CRIE readability formula (Sung et al., 2016) to generate the RGL and saved manually in a Microsoft Excel file for data analysis.

2.5.2 English Readability Analysis

English readability analysis was also assessed using WebFX online analysis system (http://webfx.com/tools/read-able) (WebFX, 2020). This online system generates RGLs based on all the most frequently used English readability formulas. These include Flesch Kincaid Reading Ease, FKGL, Gunning Fog Score, Coleman Liau Index, Automated Readability Index, and SMOG index. This study used the FKGL and the SMOG index to generate an average RGL for statistical analysis.

Plain texts from each English webpage were copied and pasted into a Microsoft word document. This was strictly for data recording purposes. The selected English texts were then directly pasted on the textbox of the readability system. The length of the text should be at least 30 sentences or more for the SMOG index. There is a minimum 100-word requirement for the FKGL (Kincaid et al., 1975). The results were generated by the readability system and were inputted manually into a Microsoft Excel file for data analysis.

2.6 SAM analysis

After obtaining the average RGL for each webpage, the study proceeded to assess the suitability of the materials on the hearing-related health webpage. Both the original SAM (English) version and the SAM-Chinese version were utilized in this study. The Chinese version was validated and translated from the original SAM (Doak et al., 1996) that was designed for printed materials. Hence, researchers selected a version of SAM based on the language of the materials that they rated on. The ratings for all factors were recorded on a Microsoft Excel file, including the total suitability score and the percentage score. The percentage ratings were then interpreted as three different levels of suitability (superior, adequate, and not suitable). However, the level of suitability was used strictly for discussion purposes and was not included in the statistics. Instead, the numerical percentage score was used to make more precise analyses of variance.

To test the reliability of the SAM rating results, two other researchers were assigned to rate one trial on half of the selected TC and English materials. In this research, Intraclass correlation coefficient (ICC) was conducted to test inter-rater reliability. The SAM ratings between researchers were compared, and the level of agreement between two evaluators was presented in the value of ICC which is the mean of *k* evaluators. The value of ICC is range from 0 to 1 (Koo & Li, 2015). '0' indicates the level of agreement is random or no agreement, and as the value closer to '1' which indicates excellent agreement. The general guideline of interpreting the value of ICC is as follow: values less than 0.5 are indicative of poor reliability, 0.5 to 0.75 indicate moderate reliability, 0.75 to 0.9 indicate good reliability, and greater than 0.90 indicate excellent reliability (Koo & Li, 2015; Portney & Watkins, 2009).

2.7 Statistics

SPSS Statistics version 25 (IBM Corp, 2017) was utilized for statistical analysis. Descriptive statistics was conducted to find the median, minimum, maximum, range and outliers of RGL and SAM scores. One-sample Wilcoxon Signed Ranks Test was utilized to address hypothesis 1a, 1b, 2a and 2b. ICC was calculated to estimate the interrater reliability of the SAM ratings between two evaluators. The Mann-Whitney Test was utilized to address hypothesis 4a and 4b. To address hypotheses 3a and 3b, correlation between readability and SAM scores were analysed by Spearman's rho correlation, which is a non-parametric tool that measures the dependence of the two factors to one another on a scale of 0 to 1. Correlations present as a R-value; weak correlation is below 0.39, moderate correlation is between 0.40 to 0.59, and strong correlation is above 0.60.

Chapter 3 Results

3.1 Overview

The aims of this current study were 1) to determine the readability and suitability of the hearing-related health webpages in TC, and 2) to compare the readability and suitability between the online TC and English materials provided by the same host organization. Of the 520 webpages obtained during the internet search (13 search terms × first 20 results × 2 browser – Google.com.hk and Google.com.tw), 17 webpages were included in the analyses after the removal of duplicates and application of the inclusion and exclusion criteria. All final 17 webpages have the same hearing-related health information in TC and English version. Sixteen of them were profit, only one webpage was non-profit. All the host organizations of the webpages were located in Hong Kong. None of the selected webpages had obtained HON certification.

The content from the webpages in both languages were copied and sorted into two groups based on language. Table 3.1 shows the language and URL of the selected webpages including the webpage ID. Table 3.2 includes webpage ID, information about the organization name, type of webpage content and type of host organization.

This following chapter will outline the descriptive statistical analysis and the results of the hypothesis testing.

Table 3.1

The URL of hearing-related webpages selected after matching against inclusion and exclusion criteria.

Traditional Chinese		English	
ID	URL	ID	URL
1	https://www.medel.com/hk/hearing-loss/	18	https://www.medel.com/about-hearing/types-of-hearing-loss
2	https://www.otichearing.com/adult-hearing-test/	19	https://www.otichearing.com/en/adult-hearing-test/
3	https://www.optical88.com.hk/hearing/zh/hearing-info/	20	https://www.optical88.com.hk/hearing/hearing-info/
4	http://www.ear.com.hk/zh-TW/audiology/audiology-services	21	http://www.ear.com.hk/en/audiology/audiology-services
5	https://www.phonak.com.hk/tc/hearing-problem.php	22	https://www.phonak.com.hk/en/hearing-problem.php
6	http://odcb.org.hk/b5_content.php?sid=4&cid=11&sub=1	23	http://odcb.org.hk/en_content.php?sid=4&cid=11&sub=1
7	https://gleneagles.hk/tc/medical-conditions/hearing-loss	24	https://gleneagles.hk/medical-conditions/hearing-loss
8	http://www.union.org/audiology/tc/adult.php	25	http://www.union.org/audiology/en/adult.php
9	https://www.kamhearing.com.hk/index.php?route=information/information&information_id=77	26*	
10	https://www.kamhearing.com.hk/index.php?route=information/information&information_id=79	27*	
11	https://www.kamhearing.com.hk/index.php?route=information/information&information_id=82	28*	
12	https://www.phonak.com.hk/tc/hearing-product.php	29	https://www.phonak.com.hk/en/hearing-product.php
13	https://www.optical88.com.hk/hearing/zh/services/hearing-assessment/	30	https://www.optical88.com.hk/hearing/services/hearing-assessment/
14	https://www.optical88.com.hk/hearing/zh/product/products-hearing-aids/	31	https://www.optical88.com.hk/hearing/product/products-hearing-aids/
15	https://www.otichearing.com/hearing-aids-and-types-of-hearing-aids/	32	https://www.otichearing.com/en/hearing-aids-and-types-of-hearing-aids/
16	https://www.widexhongkong.com.hk/zh-hk/about-hearing-loss	33	https://www.widexhongkong.com.hk/en-HK/about-hearing-loss
17	https://www.medel.com/hk/audiogram/	34	https://www.medel.com/about-hearing/audiogram

*The hearing-related health information in TC and English from KAM Hearing Health Hong Kong Limited shared the same URL.

Table 3.2

The information of hearing-related webpages selected after matching against inclusion and exclusion criteria.

Language		Organization Name	Type of content	Type of organization
TC ID	EN ID			
1	18	Medel	Hearing loss	Profit
2	19	Otic	Hearing assessments	Profit
3	20	Optical 88	Hearing care	Profit
4	21	ENT Laser	Hearing aids	Profit
5	22	Phonak	Hearing information	Profit
6	23	ODCB	Hearing aids	Non profit
7	24	Gleneagles	Hearing loss and treatments	Profit
8	25	Union	Hearing assessments	Profit
9	26	KAM hearing	Hearing loss	Profit
10	27	KAM hearing	Hearing aids	Profit
11	28	KAM hearing	Hearing aids	Profit
12	29	Phonak	Hearing aids	Profit
13	30	Optical 88	Hearing assessments	Profit
14	31	Optical 88	Hearing aids	Profit
15	32	Otic	Hearing aids	Profit
16	33	Widex	Hearing loss	Profit
17	34	Medel	Audiogram	Profit

3.2 Descriptive Statistics

3.2.1 Readability

Chinese Readability Index Explorer generated a RGL for each webpage in TC and were displayed in Figure 3.1. FKGL and the SMOG index generated a RGL for each webpage in English. An average English RGL was calculated for each webpage and the average RGLs were displayed in Figure 3.2.

Statistical analysis indicated that there was significant bias and outliers as shown in Figure 3.3. These violated the assumption of normality. Therefore, non-parametric testing was used. Median readability level for all the webpages in TC was 4.54 and 11.05 for the webpages in English. The box plot in Figure 3.3 shows the spread of webpages' RGL for each language group. The webpage in TC language with the minimum RGL was Optical88 Hearing aids (Webpage ID: 14) with a RGL of 3.21 while the maximum RGL was Phonak Hearing info (Webpage ID: 5) with a RGL of 10.78. The webpage in English language with the lowest CRIE RGL was Otic Hearing aids (Webpage ID: 32) with a RGL of 6.40 while the highest was ODCB Hearing aids (Webpage ID: 23) with a RGL of 17.75.

3.2.2 Suitability

There were initially 22 items established in SAM; however, only 21 items were rated in this study. This was because webpages are not like books, they do not have a cover page or cover graphic. Hence, the researchers decided to exclude item 3a '*Cover graphic*'. According to the criteria of SAM, the 21 items were rated as either 'Not suitable' (0 point), 'Adequate' (1 point), 'Superior' (2 points) or 'Missing' (NA). One 'missing' item will minus 2 points from the total

possible score. A percent score was generated by adding the given points and dividing by the total possible score [i.e. percent score = total points/total possible score $\times$ 100 (42 = 21 items $\times$ 2 maximum points per item $\times$ 100)]. The total SAM score were then translated into three levels of suitability: 0% to 39% as 'not suitable', 40% to 69% as 'adequate', and 70% to 100% as 'superior'.

Additionally, a converted suitability percent score was also generated for each of the SAM items which is a mean score per item. The overall converted suitability percent scores of all 17 webpages were 55.88% and 52.94% in TC and English respectively, which represents adequate suitability when all the webpages were taken together. Table 3.3 and Table 3.4 presents the frequencies and the converted suitability percent score per rating item for each language group.

Statistical analysis indicated there were bias and significant outliers as shown in Figure 3.4, hence, non-parametric testing was used. Median total SAM percent score for all the webpages in TC was 60% (adequate), and for the webpages in English was 57.50% (adequate). The webpage in TC language with the minimum suitability level was Optical 88 Hearing assessment (Webpage ID: 13) with a rating of 37.4% (not suitable) while the maximum was Optical 88 Hearing care (Webpage ID: 3) with a rating of 80% (superior). The webpage in English language with the lowest suitability level was again Optical 88 Hearing assessment (Webpage ID: 30) with a rating of 30% (not suitable) while the highest was MED-EL Hearing assessment (Webpage ID: 34) with a rating of 76.2% (superior).

The ICC for inter-rater reliability was between good and excellent at 0.84 to 0.98 ($p < .001$) for TC webpages, and 0.78 to 0.94 ($p < .001$) for English webpages.

Table 3.3

Summary of frequency of Suitability Assessment of Material (SAM) scores by webpages in TC. Converted percent = $([number\ of\ websites\ \times\ 0\ point] + [number\ of\ websites\ \times\ 1\ point] + [number\ of\ websites\ \times\ 2\ points]) \div total\ possible\ best\ scores\ (34 = 17\ websites\ \times\ 2\ maximum\ points\ per\ item) \times 100.$

Webpages in TC (n=17)	Frequency								
	Not suitable (0)		Adequate (1)		Superior (2)		Missing (NA)		Converted %
SAM factor and items	n	%	n	%	n	%	n	%	
1 Content									
1a. Purpose	1	5.88%	2	11.76%	14	82.35%			88.24%
1b. Content topics	11	64.71%	3	17.65%	3	17.65%			26.47%
1c. Scope	2	11.76%	2	11.76%	13	76.47%			82.35%
1d. Summary and review	17	100.00%	0		0				0.00%
2 Literacy demand									
2a. Reading Grade Level (RGL)	3	17.65%	1	5.88%	13	76.47%			79.41%
2b. Writing Style	1	5.88%	6	35.29%	10	58.82%			76.47%
2c. Common vocabulary	2	11.76%	9	52.94%	6	35.29%			61.76%
2d. Context given first	2	11.76%	2	11.76%	13	76.47%			82.35%
2e. Learning enhancement by advance organizers (use of 'road signs')	3	17.65%	3	17.65%	11	64.71%			73.53%
3 Graphics									
3a. Cover graphic shows purpose	0		0		0		17	100.00%	NA
3b. Type of illustration	1	5.88%	7	41.18%	7	41.18%	2	11.76%	61.76%
3c. Relevance of illustrations	3	17.65%	6	35.29%	6	35.29%	2	11.76%	52.94%
3d. Graphics: lists, tables, graphs, charts, geometric forms	0	0.00%	3	17.65%	4	23.53%	10	58.82%	NA
3e. Captions used to explain graphics	6	35.29%	1	5.88%	8	47.06%	2	11.76%	50.00%
4 Layout and typography									
4a. Layout factors	0		7	41.18%	10	58.82%			79.41%
4b. Typography	1	5.88%	10	58.82%	6	35.29%			64.71%
4c. Subheadings or 'chucking' used	1	5.88%	5	29.41%	9	52.94%	2	11.76%	67.65%
5 Learning stimulation and motivation									
5a. Interaction included in text/ graphic	13	76.47%	4	23.53%	0				11.76%
5b. Desired behaviour modelled, shown in specific	12	70.59%	3	17.65%	2	11.76%			20.59%
5c. Motivation	3	17.65%	2	11.76%	12	70.59%			76.47%
6 Cultural appropriateness									
6a. Match in logic, language and experience (LLE)	1	5.88%	5	29.41%	11	64.71%			79.41%
6b. Cultural image and examples	0		17	100.00%	0				50.00%
Overall average	1	5.88%	13	76.47%	3	17.65%			55.88%

Table 3.4

Summary of frequency of Suitability Assessment of Material (SAM) scores by webpages in English. Converted percent = $([number\ of\ websites \times 0\ point] + [number\ of\ websites \times 1\ point] + [number\ of\ websites \times 2\ points]) \div total\ possible\ best\ scores\ (34 = 17\ websites \times 2\ maximum\ points\ per\ item) \times 100.$

Webpages in EN (n=17)	Frequency								
	Not suitable (0)		Adequate (1)		Superior (2)		Missing (NA)		Converted %
SAM factor and items	n	%	n	%	n	%	n	%	
1 Content									
1a. Purpose	0		0		17	100.00%			100.00%
1b. Content topics	11	64.71%	5	29.41%	1	5.88%			20.59%
1c. Scope	1	5.88%	4	23.53%	12	70.59%			82.35%
1d. Summary and review	17	100.00%	0		0				0.00%
2 Literacy demand									
2a. Reading Grade Level (RGL)	13	76.47%	4	23.53%	0				11.76%
2b. Writing Style	2	11.76%	10	58.82%	5	29.41%			58.82%
2c. Common vocabulary	5	29.41%	7	41.18%	5	29.41%			50.00%
2d. Context given first	0		5	29.41%	12	70.59%			85.29%
2e. Learning enhancement by advance organizers (use of 'road signs')	1	5.88%	0		16	94.12%			94.12%
3 Graphics									
3a. Cover graphic shows purpose	0		0		0		17	100.00%	NA
3b. Type of illustration	3	17.65%	6	35.29%	7	41.18%	1	5.88%	58.82%
3c. Relevance of illustrations	4	23.53%	5	29.41%	7	41.18%	1	5.88%	55.88%
3d. Graphics: lists, tables, graphs, charts, geometric forms	0		3	17.65%	4	23.53%	10	58.82%	NA
3e. Captions used to explain graphics	9	52.94%	2	11.76%	5	29.41%	1	5.88%	35.29%
4 Layout and typography									
4a. Layout factors	0		5	29.41%	12	70.59%			85.29%
4b. Typography	0		8	47.06%	9	52.94%			76.47%
4c. Subheadings or 'chucking' used	1	5.88%	5	29.41%	10	58.82%	1	5.88%	73.53%
5 Learning stimulation and motivation									
5a. Interaction included in text/ graphic	14	82.35%	3	17.65%	0				8.82%
5b. Desired behaviour modelled, shown in specific	12	70.59%	2	11.76%	3	17.65%			23.53%
5c. Motivation	3	17.65%	3	17.65%	11	64.71%			73.53%
6 Cultural appropriateness									
6a. Match in logic, language and experience (LLE)	1	5.88%	6	35.29%	10	58.82%			76.47%
6b. Cultural image and examples	0		17	100.00%	0				50.00%
Overall average	2	11.76%	12	70.59%	3	17.65%			52.94%

3.3 Hypotheses

3.3.1 Reading grade level (RGL) of hearing-related webpages based on language

Hypothesis 1(a): The median RGL of the webpages in TC is not significantly greater than 6. A one-sample Wilcoxon Signed Ranks Test revealed that the data supported this hypothesis: $Z(17) = 49.0$, $p(asym) = .193$.

Hypothesis 1(b): The median RGL of the webpages in English is not significantly greater than 6. A one-sample Wilcoxon Signed Ranks Test revealed that the data did not support this hypothesis: $Z(17) = 153.0$, $p(\text{asym}) < .001$.

3.3.2 Suitability level of hearing-related webpages based on language

Hypothesis 2(a): The median Suitability of the webpages in TC is not significantly greater than 40. A one-sample Wilcoxon Signed Ranks Test revealed that the data did not support this hypothesis: $Z(17) = 152.0$, $p(asym) < .001$.

Hypothesis 2(b): The median Suitability of the webpages in English is not significantly greater than 40. A one-sample Wilcoxon Signed Ranks Test revealed that the data did not support this hypothesis: $Z(17) = 146.5$, $p(asym) = .001$.

3.2.3 Correlation between RGL and Suitability based on language

Hypothesis 3(a): There is no significant correlation between RGL and suitability for the webpages in TC. A Spearman's rho correlation revealed that the data supported this hypothesis: $rs(17) = .017$, $p = .950$.

Hypothesis 3(b): There is no significant correlation between RGL and suitability for the webpages in English. A Spearman's rho correlation revealed that the data supported this hypothesis: $rs(17) = -.596$, $p = .012$.

3.2.4 Between-group comparison of reading grade level and suitability level

Hypothesis 4(a): The median RGL of webpages in TC is not significantly different from the median RGL of webpages in English. A Mann-Whitney Test revealed that the data did not support this hypothesis: $U(34) = 17.00$, $p < .001$.

Hypothesis 4(b): The median suitability of webpages in TC is not significantly different from the median suitability of webpages in English. A Mann-Whitney Test revealed that the data supported this hypothesis: $U(34) = 119.0$, $p = .389$.

Figure 3.1

Bar graph of the RGLs of hearing-related webpages presented in TC. A red horizontal line marked is the recommended 6th RGL.

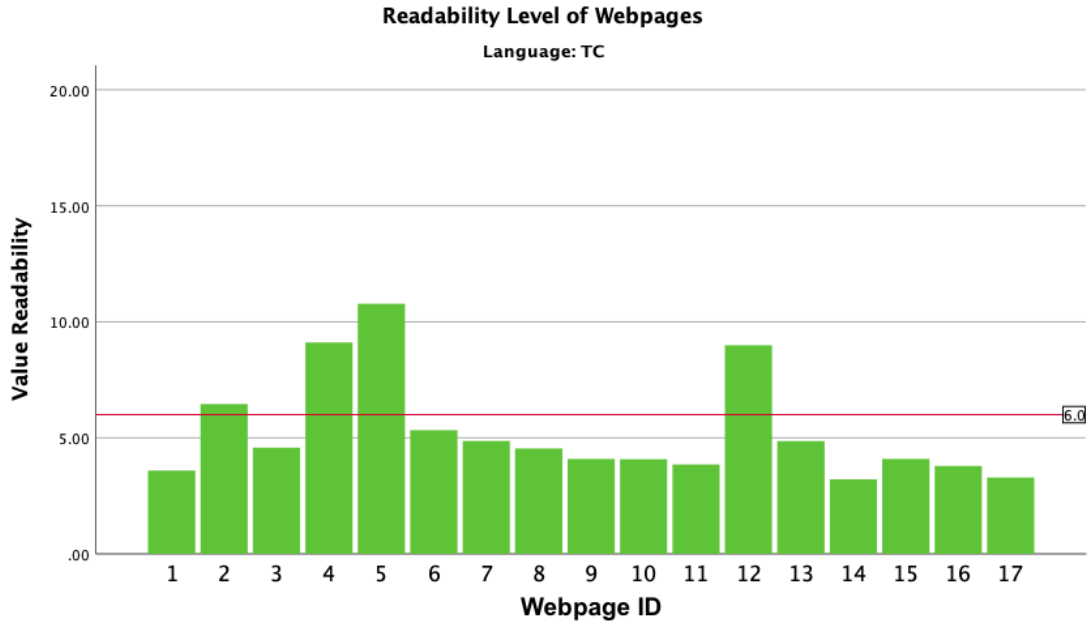


Figure 3.2

Bar graph of the RGLs of hearing-related webpages presented in English. A red horizontal line marked is the recommended 6th RGL.

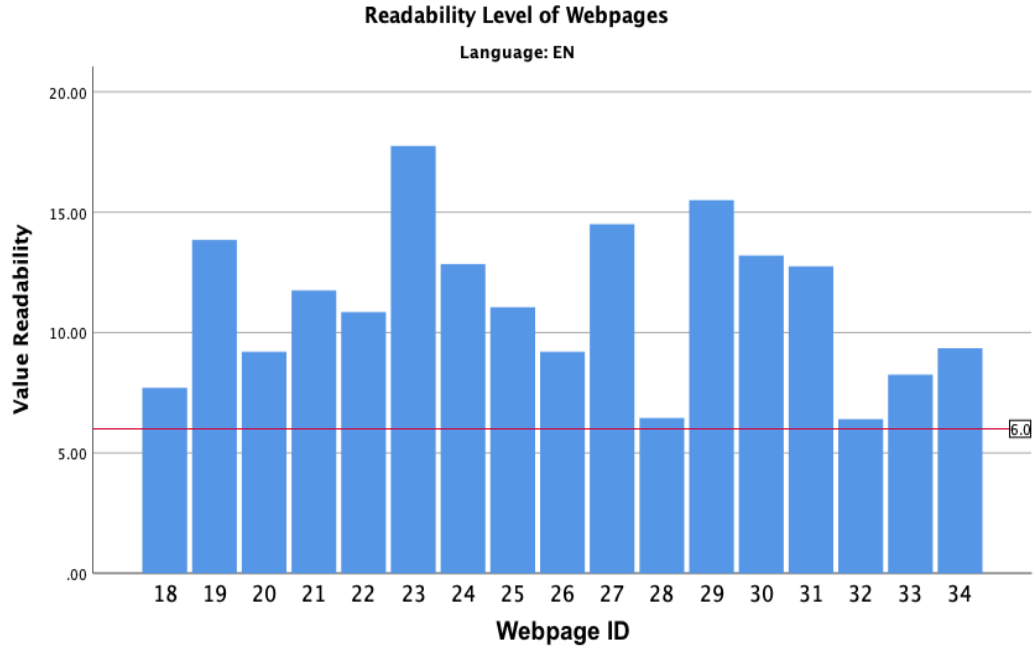


Figure 3.3

Boxplot of the readability levels of webpages in each language group; TC = Traditional Chinese, EN = English. The boxes represent the middle 50% of the readability of the webpages, the horizontal line inside the boxes represents the median. The vertical line on top of the boxes represents the upper 25% of webpages, the bottom vertical line represents the lower 25% of webpages. Three extreme values in the TC data set were plotted as separate points (potential outliers) on the boxplot (i.e. webpage 4,5, and 12). A red horizontal line marked is the recommended 6th RGL.

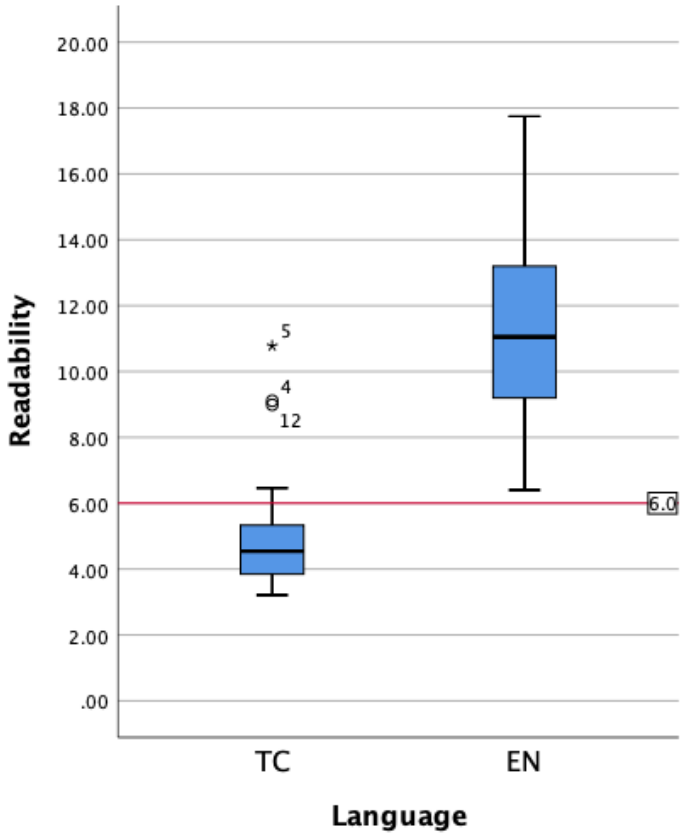
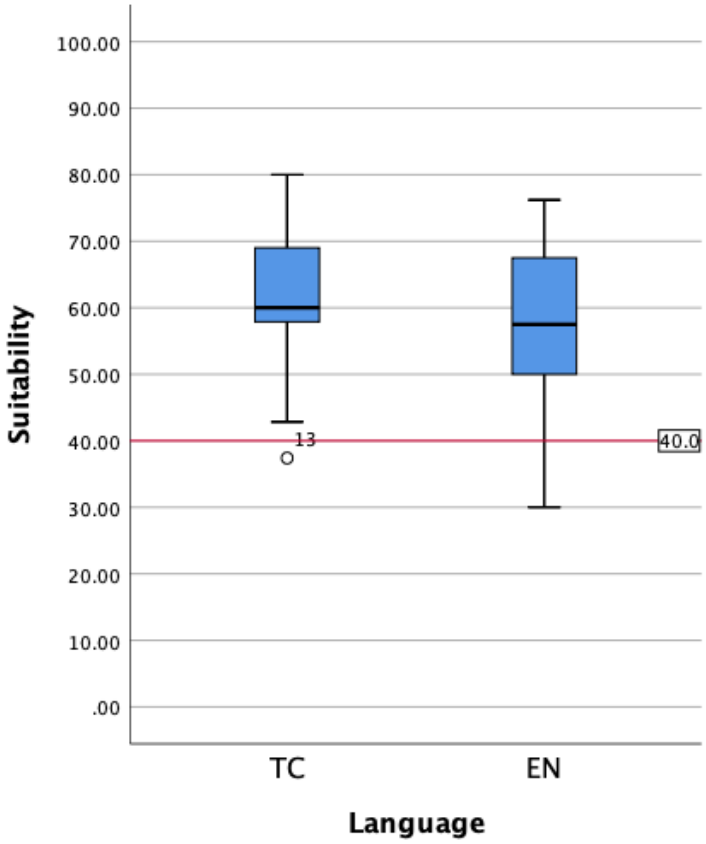


Figure 3.3

Boxplot of the suitability levels of webpages in each language group. TC = Traditional Chinese; EN = English. The boxes represent the middle 50% of the readability of the webpages, the horizontal line inside the boxes represents the median. The vertical line on top of the boxes represents the upper 25% of webpages, the bottom vertical line represents the lower 25% of webpages. An extreme value in the TC data set was plotted as separate point (potential outlier) on the boxplot (i.e. webpage 13). A red horizontal line marked is the adequate level of SAM.



Chapter 4 Discussion

4.1 Overview

The current study evaluated the reading level and suitability level of online TC hearing-related health information and compared this the English version of the materials provided by the same webpage host organization.

The findings of this study indicated that a majority of TC online hearing-related health information was written at an accessible RGL for the TC-reading population. Whereas, the readability level of English materials was identified as difficult to read for the English-reading population. The results showed that online hearing-related health information in TC was significantly easier to read than the information written in English on the websites. This study also sought to appraise the suitability of the materials in TC and compare them with the English version. The Content and Learning stimulation and Motivation categories were rated with least suitable on SAM scores for the TC materials, suggesting the needs for improvement in those areas when developing online hearing-related health materials for the TC-reading population. For the English materials, apart from Content and Learning stimulation and Motivation, items in Literacy demand and Graphic categories were also rated least suitable on SAM scores. There was no significant difference between the suitability ratings of TC and the English version of the webpages.

The following sections will discuss these results regarding the literature and clinical implications for hearing health literacy, patient-centered care, and future research.

4.2 Readability and Suitability

4.2.1 Readability

The first hypothesis (1a) stated that the median readability of the webpages in TC is not significantly greater than the 6th RGL (Hsu et al., 2019). The results of this study were in accordance with the findings reported in Hsu et al. (2019), in which the median readability generated by CRIE was lower than the recommended 6th RGL and over 80% of the TC hearing-related health webpages were written below the 6th RGL. This also reflected that TC hearing-related health webpages are likely to be written below the 6th RGL. Yet the size of the analysis was small in both studies and the validity of the CRIE formula was debatable (Hsu et al., 2019; Sung et al., 2013).

Additionally, in this current study, three of 17 webpages that were rated above the 6th RGL were identified with a higher proportion of difficult words used compared to the other 14 webpages. Those 3 webpages contain more than 600 difficult words, and yet the other 14 webpages contain less than 400 difficult words. The use of technical terms or difficult words certainly increases the literacy demand for the target readers. This may hinder the outcome of enhancing the public health literacy level by providing CHI, especially for the low TC literacy populations (Doak et al. 1996).

Hypothesis 1b stated the median RGL of the webpages in English is not significantly greater than 6th RGL. The results of this study showed the median RGL of the English materials was significantly greater than the 6th RGL, and thus this result did not support hypothesis 1b. Yet these findings were unsurprising and were consistent with the high RGLs reported in other studies of online English hearing health information (Felipe et al., 2020; Laplante-Lévesque et

al., 2012; Laplante-Levesque et al., 2011; Laplante-Lévesque & Thorén, 2015; Manchaiah et al., 2019; Potter, 2015).

The readability scores from the English materials were significantly higher than the RGLs from the TC materials, indicating that the English version was harder to read than the TC version. Revising webpages that have exceeded 6th RGL is recommended. For example, rewriting the materials and limiting the use of medical jargon, difficult words, or vocabulary can reduce the literacy demand for the readers.

4.2.2 Suitability

4.2.2.1 Suitability of Webpages written in TC language

The current study hypothesised that the median suitability rating of online information in TC is not significantly greater than 40%. The median suitability of online TC hearing-related health information was found to be 'adequate' and thus did not support hypothesis 2a. This means the online information in TC is appropriate for online health seekers to read. The findings of this study were in accordance with similar studies conducted in English materials (Caposecco et al., 2014; Convery et al., 2011; Elmadani, 2019; McMullan et al., 2018; Ming & Kelly-Campbell, 2018; Potter, 2015), which also found a majority of the online hearing-health information is generally at ‘adequate’ level.

The findings of this study showed two of 17 webpages in TC were rated as not suitable (<40%). The overall ratings for all TC webpages showed four SAM items were rated 'not suitable', including Content Topics, Summary and Review, Interaction included in texted or graphic, and Desired behaviour modelled. The suitability rating of the TC materials can be

improved by following the guidelines provided by the SAM instrument (Caposecco et al., 2011; Doak et al., 1996; Ming & Kelly-Campbell, 2018).

Within the Content category, purpose and scope were rated 'superior', content topics, and summary or review were rated 'not suitable'. 64.71% of the webpages were written with less than 40% of content topics focusing on desirable behaviours. For example, it should focus on ways of hearing protection and the importance of seeking hearing health professionals, rather than the pathophysiology of hearing loss. None of the webpages included a summary or review. This aspect can be easily improved by providing some key objectives on the webpage to promote retention of the presented information (Doak et al., 1996).

Within the Learning Stimulation and Motivation category, interaction and modelling of desired behaviour was rated 'not suitable', and motivation was rated 'superior'. Similar findings were also found in Elmadani (2019) on Noise Induced Hearing Loss online information. To enhance interaction, webpage developers can present information in a question-and-answer format to promote understanding. For example, giving multiple-choice questions with the answer provided, or providing a self-assessing questionnaire on hearing health knowledge. To improve modelling of the desired behaviour, a webpage can provide a checklist or step-to-step directions of the patient journey for the patients or readers to follow with.

Additionally, within the Graphics category, most of the websites did not include graphics. Considering the substantial percentage of non-applicable (NA) ratings, no converted percentage was calculated for this item (3d). Yet, webpages that included graphics were all rated 'adequate' or 'superior', as the illustrations were supported with clear captions and relevant to the content.

4.2.2.2 Suitability of webpages written in English language

The median SAM score of the English materials in this study was significantly greater than 40%, and 70% of the English materials were rated ‘adequate’; thus, did not support hypothesis 2b. These findings were consistent with the ‘adequate’ ratings of online hearing health information reported in previous studies (Caposecco et al., 2014; Convery et al., 2011; Elmadani, 2019; McMullan et al., 2018; Ming & Kelly-Campbell, 2018; Potter, 2015).

There were six SAM items rated ‘not suitable’ among the webpages in English, including content topics, summary and review, RGL, captions used, interaction, and desired behaviour modelled. Four of these six items were also rated 'not suitable' in the TC materials which were discussed in previous section (4.2.2.1). The recommendation for reducing the RGL rating has also been discussed in the readability section (4.2.1). Lastly, within the Graphic category, 35.29% of webpages were rated 'not suitable' based on text captions used. This can be resolved by adding simple and explanatory captions alongside all illustrations and graphics (Doak et al., 1996).

There was no significant difference in SAM scores between the two language groups. Both language groups have the greatest proportion of webpages falling into the 'adequate' level - 13 TC webpages and 12 English webpages. The materials in each language group contain different strengths and weaknesses. Those strengths and weaknesses add together to produce a similar overall effect on the suitability level. If webpage developers continue to improve the least suitable items on the webpages, less difference should be found between the two language groups. In short, the ultimate goals of evaluating the suitability of online hearing health information were to identify and improve the factors analyzed by SAM, create and improve the online resources to a ‘superior’ suitability level and promote hearing health knowledge and prevention to the general public.

4.2.3 Correlation between Readability and Suitability levels

Based on the materials identified in this study, there was no significant correlation between RGL and SAM ratings in both TC materials and English materials. These findings were consistent with the results reported in Abou-Diab et al. (2019). However, some studies have reported a weak negative and positive correlation (Elmadani, 2019; Robins et al., 2016). Considering there are 22 items in SAM, RGL is only one of five items under the Literacy Demand category, hence, the strength of correlation between RGL and SAM ratings also depends on the ratings of other items. Only if all items are rated consistently 'not suitable' or 'superior', including RGL, a significant negative or positive correlation is likely to occur, as was suggested by Doak et al. (1996). This suggests that the suitability of online hearing-related health information can be heightened by enhancing the suitability of all items, not only readability.

4.3 Clinical Implications

4.3.1 Improving Hearing Health Literacy

The internet is considered to be one of the major platforms for patients of all ages to seek information related to health conditions they have experienced (Chu, 2017; Wallhagen, 2009). Webpage developers and audiologists have the responsibility to create and ensure that online hearing-related health information is accessible and can be understood by the target population. Readable health information is particularly important to the low-literacy population (Doak et al., 1985). Improving the readability and suitability of online TC hearing-related health information can enhance the consumers' health literacy, promote health knowledge, empower patients and strengthen their sense of control over their health condition (Broom, 2005; Lambert & Loiselle, 2007). Improving health literacy leads to better communication, awareness, and understanding

of own hearing conditions, hearing prevention, and hearing treatment options and outcomes. The findings of this study show online hearing-related health information in TC language is readable and the appropriateness of the information is considered at 'adequate' suitability. Yet, some areas still require improvement to achieve an 'adequate' level; other items that were rated 'adequate' can be further improved to a 'superior' level. Webpages developers and audiologists should use established instruments, the SAM best-practice guidelines, or web design guidelines to revise the online resources.

4.3.2 Clinician-patient relationship and patient-centered communication skills

Numerous studies have reported that OCHI has significant positive effects on the delivery of health care service and the clinician-patient relationship (Iverson et al., 2008; Tan & Goonawardene, 2017; Wald et al., 2007). However, there are also potential disadvantages of patients seeking OCHI. The quality of OCHI can be highly variable and does not necessarily bring advantages to the health consumers and clinicians. Misleading or misinterpreting of OCHI can lead to reverse outcomes including increasing patient anxiety and stress,and lowering their trust in clinicians (El Sherif et al., 2018; Wald et al., 2007). Consequently, these can lead to a greater burden for clinicians in re-educating the patients, causing delayed treatment and poor health outcomes for the patients. Hence, it is important to ensure not only readability and suitability but also the reliability of online health resources.

In addition, patient-centered communication skills are important in the process of health care (Berkhof et al., 2010; Ha et al., 2010). King & Hoppe (2013, p.390) summarized some effective communication skills including attentive listening skills, use of open-ended questions, being clear and concise minimising the use of jargon, using repetition, using simple language,

clarifying, emphasising, and summarising key information. Clinicians can also take the initiative in asking their patients if they have searched health information online prior to the consultation and finding out the origins of the resources (King & Hoppe, 2013). This can enhance communication, understanding of the patient's health literacy, sharing of trustworthy resources, and ensuring the OCHI accessed by the patients is reliable (Ha et al., 2010; King & Hoppe, 2013).

4.4 Limitations

Limitations of this study included the statistical methods that were applied, the validity of the CRIE readability formulae, and the lack of specific and valid tools for evaluating the suitability of online written health resources. Firstly, non-parametric methods were used for statistical analysis because of a small sample size and the presence of outliers, even though this may lessen the power of the results compared with standard parametric tests. Secondly, the validity of CRIE readability formulae is still questionable and is not clearly stated by the developers. Only the accuracy rate of the CRIE 1.0 and 2.0 version has been stated in Sung et al. (2013) and Sung et al. (2015). The validity of all TC readability formulae will likely to be extremely important for future studies.

Thirdly, SAM was originally developed to evaluate the suitability of printed material, such as textbooks, booklets, or brochures, hence, it is not specifically designed for online written materials. The designs for presenting written materials for paper-based and web-based are different (Gregory, 2004). For example, online materials do not have a book cover or cover graphic (SAM item 3a), and online materials can include visuals to support the delivery of information to the audience, such as videos and animated illustrations. These examples

demonstrated limitations of the criterion of the SAM items when examining the suitability of web-based written resources compared to evaluating paper-based written materials. It will be advantageous to modify the SAM tools or create a new suitability assessment that is specifically designed for evaluating web-based written materials which will be useful for future studies.

4.5 Future research

4.5.1 Cloze test for readability testing

Cloze test is a tool that measures the comprehensive of written materials (Bormuth, 1968) by deleting words from a passage following certain rules. It is a different style of readability testing which requires participants or readers to fill in the blank spaces with the words they think have been deleted. The comprehensiveness of written material is then rated by the percentage of the correct matching words and correct pronunciation of the words filled in the blank spaces (Bormuth, 1968). This test can be applied in research of readability of online TC hearing-related health information to provide a cross-checking for the RGL generated by computer-based readability formulae.

4.5.2 Suitability Assessment for online materials

None of the current suitability assessments, including SAM and Patient Education Materials Assessment Tool (PEMAT), is specifically designed for online health education materials. Therefore, it would be worth the effort for future studies to work towards developing a standardized suitability evaluation tool for online materials that can be applicable for TC language.

4.5.3 The accuracy of online TC hearing-related health information

This study also looked beyond the readability of the online TC hearing-related health information and extended to evaluating its suitability, yet the accuracy of the health information should still be the top priority. We would like to deliver health information that is accurate and reliable, so readers can learn and improve their health literacy without any deviation from the scientific evidence. Ideally, the accuracy of online health information should be evaluated by a valid tool, however, there is still a lack of research in developing such an evaluation tool. Meanwhile, audiologists need to help monitor and distinguish online hearing-related health materials that are considered to be trustworthy for the general public.

4.6 Conclusions

In conclusion, this study was conducted to raise awareness of the readability and suitability of online hearing-related health information written in TC language and to compare it with the English version from the same website host organization. This study used both objective and subjective measurements to analyze the quality of various components and factors of online information related to hearing health care. The findings from this study show that the online hearing-related health information in TC language is readable and appropriate to the target population. Furthermore, these findings help to provide recommendations on specific elements in which the available online TC hearing-related health materials are less adequate and how these online resources could be revised and improved. We hope that these findings can motivate improvements and provide recommendations for webpage developers and audiologists, including monitoring and enhancing the accessibility and appropriateness of the online TC hearing resources to educate TC-reading populations about the importance of hearing health care.

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Appendix

HUMAN ETHICS COMMITTEE

Secretary, Rebecca Robinson
Telephone: +64 03 369 4588, Extn 94588
Email: human-ethics@canterbury.ac.nz

Ref: HEC 2019/07/LR Amendment 2

14 February 2020

Rebecca Kelly
Psychology, Speech and Hearing
UNIVERSITY OF CANTERBURY

Dear Rebecca

Thank you for your request for an amendment to your research proposal "Quality of Hearing-Related Internet Information" as outlined in your email dated 10th February 2020.

I am pleased to advise that this request has been considered and approved by the Human Ethics Committee.

Yours sincerely

Dr Dean Sutherland
Chair, Human Ethics Committee

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