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Experiences of People with Visual Impairments in Accessing Online Information and Services: A Systematic Literature Review

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Abstract

The World Wide Web is the largest source of electronic information in the world. Over the years, rapid advances in the internet have made it less accessible thereby making it increasingly difficult for people with visual impairments to access online information and services. This paper systematically reviews previous research to identify challenges that people with visual impairments face, and the role of accessibility technologies and guidelines to support people with visual impairments in their access to online information and services. The findings discuss three categories emerged from the literature: inaccessible content for the visually impaired, improving website accessibility for the visually impaired, and accessibility technologies and their benefits and limitations for people with visual impairments. The findings further discuss the usability issues which are present in accessing online content, the different attempts that have been made to mitigate these problems, and the different guidelines and tools that can be adopted by web designers to make websites more accessible for the visually impaired. It also discusses the versatility and availability of various accessibility technologies. Although these technologies provide basic access to online information, they are greatly limited in their functionality. Therefore, it is up to the web designers to change their perceptions when designing websites. With the proper use of the guidelines, the capabilities of accessibility technologies can be accommodated in making information provided accessible to all users including those with visual impairments. The contributions of this research are that it offers a rigorous narrative review to summarise the state of knowledge on challenges that people with visual impairments face in accessing online information and services, the support and limitations of accessibility technologies in addressing some of these challenges. In addition, this study identifies gaps and areas that deserve more scrutiny in future research including digital exclusion issues among the visually impaired, explanation on the unwillingness of web designers to develop accessible websites, improvements to accessibility technologies to support increasingly visually complex websites, among others. Since the visually impaired are a diverse group with different degrees of impairments, needs and preferences, we encourage researchers to involve them in future studies.

Keywords: World Wide Web, accessibility, visual impairments, web designers, accessibility technology

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Introduction

In today's day and age, the internet is an important part of our daily lives. Compared to sighted individuals, there are still some challenges that the visually impaired face in their day to day lives due to web inaccessibility (Brady, Morris, Zhong, White, and Bigham, 2013). People with visual impairments can be classified as people with either full, partial or colour blindness. Approximately "285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 million have low vision. About 90% of the world's visually impaired live in low-income settings" (World Health Organisation, 2014, p.1).

Rapid advances in technology have given rise to various accessibility technologies that have helped individuals with visual impairments access the web independently (Scherer, 1996). Some of the accessibility software include screen readers such as Job Access With Speech (JAWS) that assist visually impaired people to read what is displayed on the computer screen with the help of a braille display or a speech synthesiser and screen magnification such as Magic that enlarges the text and graphics displayed on the screen (The American Foundation for the Blind, n.da , n.db, n.dc). There are still many obstacles to accessing information online that are faced by people who have visual impairments despite the advancement and support of technology (Soumi and Sachdeva, 2016).

Online information access among people with visual impairments and the role of accessibility technology have been investigated across diverse research strands such as digital divide, website accessibility for the visually impaired and the impact of accessibility technology on the quality of life for people with visual impairments, among others (Leuthold, Bargas-Avila, and Opwis, 2007), leading to a fragmented body of knowledge (Paré, Trudel, Jaana and Kitsiou, 2015). There are many commonly accepted benefits of accessibility technologies and internet use for people with visual impairments (Williamson, Wright, Schauder and Bow, 2001) as well as several independent studies that focus on individual areas such as the ones mentioned above, however, there does not seem to be much research that consolidates these different aspects of online information needs of visually impaired people, the problems encountered by them after integrating the digital means of accessing information into their lives, and what can be done to improve online information access for them (Dobransky & Hargittai, 2016). Therefore, there is a need to bring together these various strands of research to evaluate the current state of knowledge, identify areas that are under-researched and set directions for future research. Since knowledge accumulation is critical to evaluate progress in a research area, a rigorous synthesis of accumulated knowledge allows researchers to build on existing knowledge and identify gap in prior research (Templier & Paré, 2015). Therefore, the purpose of this research is to conduct a systematic literature review on challenges that people with visual impairments face in accessing online information and services, and the role of accessibility technologies in addressing some of these challenges. The research questions that guide this literature review are:

- What are some of the challenges that people with visual impairments face in accessing online information and services?
- What is the role of accessibility technologies and guidelines to support people with visual impairments in their access to online information and services?

The rest of the article is divided into four sections. Section 2 discusses the methodology used for this research, section 3 deliberates the findings, and section 4 presents the theoretical and practical contributions of this research, future research areas, and the limitations of this research.

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Methodology

For the methodology, we consulted Paré et al. (2015) and Ortiz de Guinea and Paré (2017) on a typology of review types to provide guidance to choose the most appropriate review type for our literature review study. Paré et al. (2015) classified literature review types by eight criteria: the overarching goal, theoretical review type, scope of questions, search strategy, nature of primary sources, explicit study selection, quality appraisal, and methods for synthesising/analysing findings. Whereas, Ortiz de Guinea and Paré (2017) provided six criteria that drew from previous work in this area. The six criteria are: the overarching goal, systematicity and transparency, focus, coverage, data source, and data analysis. Based on these criteria presented, we believe that our work should be classified as a rigorous narrative review because our goal is to summarise prior research to provide a broad background on challenges that people with visual impairments face in accessing online information and services, and the role of accessibility technology and guidelines to support them in their online access. Table A1 in the Appendix summarises the characteristics of our rigorous narrative review based on the criteria presented in Ortiz de Guinea and Paré (2017), Paré et al. (2015), and Templier and Paré (2015).

We followed Templier and Paré's (2015) systematic procedure to search and screen for relevant papers found in relevant scholarly databases, which should help improve the rigor, systematicity and transparency of our literature review (Paré, Tate, Johnstone and Kitsiou, 2016). We considered both conceptual and empirical papers. Following the guideline from Bandara, Furtmuller, Gorbacheva, Miskon and Beekhuyzen (2015), we coded the literature using an inductive approach in three steps: open coding, axial coding, and selective coding. The output of our review is a narrative summary of knowledge through the categories emerged from our analysis (Templier & Paré, 2015).

According to Templier and Paré (2015), the first step is to identify a problem, which is, to understand the challenges that the visually impaired people face in accessing online information and services, and the role of different accessibility technology to address some of these challenges. The second step is to do a literature search and identify what articles would be relevant to this research. The following scholarly databases were used: ACM digital library, JSTOR, ProQuest (computing), IEEE Explore Digital Library and Google Scholar to identify empirical studies on experiences of the visually impaired in accessing online information and services. For the preliminary search, the search terms utilised were 'accessibility technology', 'visually impaired', 'website accessibility', 'digital divide', 'blind', 'web accessibility guidelines' which resulted in a rundown of 76 to 574 journal articles and conference papers among these diverse databases after dispensing book chapters and press articles.

Next, we enhance the search terms based on the scanning of keywords in the articles in the preliminary search result. The full list of search terms are: 'internet accessibility and visually impaired', 'web accessibility and the visually impaired', 'internet accessibility and the blind', 'web accessibility and the blind', 'digital divide for people with visual disabilities', 'internet accessibility and the vision impaired', 'web accessibility and the vision impaired', 'user experiences of using accessibility technology for the blind', 'user experiences of using accessibility technology for the visually impaired', 'user experiences of using assistive technology for the visually impaired'. This resulted in a rundown of 104 to 2513 journal articles and conference papers among these diverse databases after dispensing book chapters and press articles.

The third step is to develop an inclusion criterion to select relevant papers to be included in the analysis. The inclusion criteria used in this study are papers that have collected primary data from visually impaired people, secondary data i.e. papers that have conducted literature reviews, papers that are in English, and journal and conference papers that have

been peer-reviewed. The irrelevant articles were removed after reading through abstracts and titles. These include those articles that do not address online accessibility for the visually impaired as the central theme, rather address assisting blind users in reading printed text, show replicate findings (that is, authors utilising similar data to report comparative outcomes in various journals), and articles that did not investigate the challenges faced by the visually impaired in accessing online information and the impact of accessibility technology. After eliminating these non-relevant articles, 25 peer-reviewed journal articles remained for further coding and classification. These articles span 19 years from 1998 to 2017. (Refer to Table A2 in the Appendices for a full list of articles).

The fourth step is quality assessment by including papers that are of similar quality and discuss similar issues regarding visually impaired people's use and benefits of accessibility technology, the challenges faced by them, web accessibility guidelines and techniques on improving web design to create more user-friendly websites. Data analysis is the next and last step in this process. All the relevant articles chosen is systematically evaluated, and the findings are presented in a meaningful way.

For the coding and analysis, an inductive approach was chosen as stated in Bandara et al. (2015), as it allows us to build a systematic state-of-the-art knowledge of the literature. Therefore, the initial step is to open-code and identify a set of key main concepts based on the overall data collected. Some examples of the open codes are World Wide Web, electronic information, accessibility technologies, audio format, visually appealing, obstacles regarding accessibility. After the end of this step, 50 low level open codes were attained. The next step in this process is to perform axial coding where 9 sub categories are identified. Some examples of sub-categories identified are 'impediments and digital exclusions of visually impaired users in accessing the web', 'web accessibility guidelines', and 'types and benefits of using accessibility technologies'. After identifying the sub-categories, the next step would be to perform selective coding to identify main categories based on the interrelationship between the sub-categories identified. The 3 main categories identified are 'inaccessible content for the visually impaired', 'improving website accessibility for the visually impaired', 'accessibility technologies and their benefits and limitations for people with visual impairments'. This process was done by repeatedly reading the 25 articles selected, and identifying common themes or topics covered across multiple articles. A full list of main categories, sub- categories, open codes and extracted text from selected journal articles associated with each category is presented in Table A3 in the Appendices.

Overall, the organised method that we used to search, screen, assess, analyse and interpret appropriate information ensures the systematicity in our literature review. In addition, we offered complete explanation of the methodological design and execution outlined above to establish the transparency of our review. Therefore, we believe that the trustworthiness of our literature review is achieved (Paré et al., 2016).

Findings

In this section, the findings will be presented based on main categories and sub-categories as shown in Figure 1 below. The three main categories are inaccessible content for the visually impaired, improving website accessibility for the visually impaired and accessibility technologies and their benefits and limitations for people with visual impairments. A summary of the findings can be found in Table 1 at the end of the findings section.

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Category 1 - Inaccessible content for the visually impaired	Category 2 - Improving website accessibility for the visually impaired	Category 3: Accessibility technologies and their benefits and limitations for people with visual impairments
Sub-Categories		
- Impediments and digital exclusions of visually impaired users in accessing the web - Complexity of visual features in web design - Unconstructive attitude of web designers	- Metrics for accessible web design - Web accessibility guidelines - Presentation-oriented solutions for web designers to improve website accessibility - Semantic-oriented solutions for web designers to improve website accessibility	- Types and benefits of accessibility technologies - Limitations of accessibility technologies

Figure 1 – Main Categories and Sub-Categories

Inaccessible content for the visually impaired

Under the main category 'inaccessible content for the visually impaired', the sub-categories that have been discovered and conceptually linked are, the impediments and digital exclusions of visually impaired users in accessing the web, the complexity of visual features in web design, and unconstructive attitude of web designers. These sub-categories delve into the different obstacles faced by visually impaired users in accessing online information. The discussion will look into the various problems for visually impaired users to access online content, the unconstructive attitude of web designers leading to various usability issues and how the complexity of a web page affects them as presented in the current literature.

Impediments and digital exclusions of visually impaired users in accessing the web

The World Wide Web is the largest source of electronic information in the world (Harper & Becchofer, 2007). Hypertext Markup Language (HTML) allows accessibility technologies to be designed in a way to render pages in an audio form for visually impaired users. Previous estimates have predicted that people who have visual impairments were increasingly less likely to use computers than those who were sighted. One of the reasons why people with visual impairments decide that they do not want to use the internet is due to the content being inaccessible for them (Cullen, 2001). Web designers are usually focusing on creating content that is more visually pleasing, but they are not paying enough attention to the usability and accessibility issues (Cullen, 2001). Although pages can be rendered in an audio form, adjustments in HTML and progresses in innovations have caused web pages to end up as simply being visually captivating. In the long run, this makes the web increasingly out of reach to debilitated individuals, specifically those who are visually impaired (Yesilada, Stevens, Harper and Goble, 2007). These impediments are exacerbated by the differences in the presentation and information requirements of a visually impaired person, while accessing online information, compared to that of a sighted user. Difficulties arise due to the web being visually centric with respect to the layout of information and presentation of data (Harper & Becchofer, 2007).

Recent research suggests that best practice on web accessibility is yet to be achieved. This is another cause for people with visual impairments having difficulties in accessing the web. For example, it was pointed out by Kelly (2002) that accessibility to websites for stores, banks, governmental websites, and universities in the United Kingdom were unsatisfactory. Furthermore, Takagi, Saito, Fukuda and Asakawa (2007) also came to the conclusion that only a small proportion of representative shopping websites are easy to navigate, and most of the sites have poor web accessibility. A similar finding was made through user evaluation by the Disability Rights Commission (DRC) in the United Kingdom. They found that 81% of websites do not even meet the basic requirements for accessibility (Harper & Becchofer, 2009). People who have visual impairments are forced to accept anything that is available with regards to information presented online. This is because there is a shortage of convenient, accessible information (Gerber, 2003).

There are a few studies which delve into the topic of the 'Digital Exclusion'. These papers categorise certain sets of people as being particularly deprived in their access of information and communication technologies (ICTs). These categories include: low income individuals, people who have lower education or who don't have high levels of literacy, people who are not employed, people in secluded or rural places, single parents, those who are elderly, girls and women, and the most significant one being people who have visual impairments (Harper & Becchofer, 2009). If success is to be found whilst attempting to address the topic of the digital exclusion, there are several potential obstacles that need to be taken into account. The fundamental concern which needs to be considered is the physical access to ICTs (Cullen, 2001).

It is important to allow the internet to be accessible by all members of the public. The fact is that the internet is full of information and provides the opportunity to have these means of communication open to people who have formerly been isolated from being able to take part in the economic and social life of the country they live in is seen as one of the many strengths the internet possesses. There is a continuous increase in the demand for visually impaired people to gain access to the internet, and it is presently seen as an issue of human rights. Therefore, there is a need for the education on both accessibility technologies and computer related skills (Cullen, 2001).

Complexity of visual features in web design

The design of a web page is determined by either the arrangement, or details of element. The definition of a web page is the "creative art of executing aesthetic or functional design" (Merriam-Webster, 2006). It is also apparent that the design of a website can either assist or obstruct a user through resources that are available. Ivory and Megraw (2005) conducted a study relating to web design patterns and found that web design tends to be progressively more graphical in its nature, dependent on browser scripts, and much less consistent over time. There have been significant changes which include "text and link formatting, graphics, tables, style sheets, scripts, and XHTML coding" (Harper, Michailidou and Stevens, 2009, p. 4). For example, websites are made increasingly difficult for visually impaired users when designers use larger font sizes and hyperlinks without the addition of lines underneath them (Ivory & Megraw, 2005). In addition, there was an increase in the use of organisational and ornamental graphics, such as bullets, form buttons, and icons (Ivory & Megraw, 2005). Although this made the web page visually appealing, the increased complexity makes web page navigation harder than usual. Studies demonstrate that the utilisation of visual feel, for example, sharp format, smart subtitles and intriguing pictures, can change a mass of dry content into something which users will approach energetically. However, these visual signals cannot be accessed by visually impaired individuals (Harper et al., 2009).

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Studies have shown that it takes a visually impaired person up to two minutes to extract a web page, whereas the same task would take a sighted person less than five seconds. Therefore, a visually impaired individual will not even attempt to interact with the website if the web pages are too visually complex. Visually complex websites are those that have a very large quantity of images, too much colour, and font styles that are challenging to decipher. Harper et al. (2009) argue that "the commonly used slang phrase "surfing the web" implies rapid and free access. It has also been long established that this potentially complex and difficult access is further complicated, and becomes neither rapid nor free, if the user is visually impaired" (Harper et al., 2009, p. 1).

Unconstructive attitude of web designers

Empirical research shows that there are issues that people with visual impairments face when it comes to accessing online content. According to Harper & Becchofer (2007), authors and designers of websites think that it is unnecessary to create a separate semantic mark-up to fit with the standard extensible hypertext mark-up language, which is the type of language designers can use to code websites to make them more accessible for the visually impaired. Most designers' primary focus is to produce "beautiful and effective" websites and are not willing to compromise. In one such conversation with website designers the message received was that "if there is any kind of overhead above the normal concept creation then they are less likely to implement it. They believe in creating beautiful and effective sites, they are not information architects" (Harper & Becchofer, 2007, p. 2).

Web documents are required to be designed according to users' needs and this sometimes can be difficult to convey (Harper & Becchofer, 2007). However, it is important for web designers to understand the information needs and behaviour of visually impaired persons, as technical accessibility does not guarantee usability (Tomlinson, 2016). Web design should involve actual end-users who are sighted as well as visually impaired for it to effectively assist a variety of users in accomplishing their information goals. Although involving actual end-users is critical to user-centred designs, there is an inadequate amount of qualitative research examining the perceptions and experiences of visually impaired persons regarding access to online content (Tomlinson, 2016). Although there has been a great deal of discussion around people with visual impairments, there is minimal direct involvement with visually impaired people in research, thus leading to a minimal attempt to evaluate accessibility (Hill, 2013). True user-centred design requires designers to learn as much about the users as possible, "including their culture, capabilities, and common tasks" (Schulze, 2001, p. 117). In a pilot study evaluating perceptions of accessibility and usability by blind or visually impaired persons by Tomlinson (2016), the concept of web design for accessibility originated from three of the five participants. They were aware of the possibility of being able to fix some of the inaccessible features on websites, and that issues surrounding usability could be improved with increased awareness by web designers regarding the impact of the web design on visually impaired persons. A few of the accessibility issues mentioned included images without alt text, text on images, inaccessible PDFs, information in tables, auto play videos, pop-up windows, CAPTCHA without an accessible closed audio, alternative captioning, difficulties with form fields, and video control buttons. Usability was closely tied to accessibility for these participants. If there was an inaccessible element in a web resource, it was also generally not usable. The issue with usability was seen to be linked with the individual websites rather than the screen reader technology, or the specific individual trying to use the particular web resource. It is important to emphasise that perceptions of accessibility and usability were created through experience, practice, and familiarity; a familiar web resource gave an impression of being more usable. This needs to be understood by web designers as they need to change their perceptions of accessibility

and usability when designing websites. (Tomlinson, 2016).

Improving website accessibility for the visually impaired

Under the main category 'Improving website accessibility for the visually impaired', the sub-categories that have been covered are, metrics for accessible web design, web accessibility guidelines, presentation-oriented solutions for web designers to improve website accessibility, and semantic-oriented solutions for web designers to improve website accessibility. These sub-categories delve into the different attempts that have been made to mitigate problems relating to the access of online information by visually impaired users, metrics for web page design that could predict whether a website is rated highly with respect to its complexity and the different guidelines, tools and solutions that can be adopted by web designers to make websites more accessible for the visually impaired.

Metrics for accessible web design

Further studies have attempted to identify metrics for web page design that could predict whether a website is rated highly with respect to its complexity (Ivory, Sinha and Hearst, 2000, 2001; Germonprez & Zigurs, 2003). These metrics include ranking of web pages based on several attributes. Germonprez & Zigurs (2003) introduced a proposition of three dimensions of factors that would impact the complexity of a website. These dimensions are cognition, content, and form. Human cognition affects the way in which a user retrieves and applies the information received. The content presented on a website, as well as the amount of information available, all affect complexity, as it can cause an overload of information on the page. Finally, the form of the websites can also affect the complexity of the page with regards to user interface, navigation, and structure. Ivory et al. (2000, 2001) outline quantitative evaluations of web page attributes, for example, number of fonts, images, and words, using a large collection of websites that were judged based on content, structure and navigation, visual design, functionality, interactivity, and overall experience. These authors reported many differences between web pages and websites on various dimensions. These include "layout quality, screen coverage and information quality" (Ivory et al., 2000, p. 11).

Metrics relating to page composition help predict, with 63% accuracy, whether a web page is able to be assigned a high or low rating in relation to its complexity from human judges. The metrics include word and link count, page formatting (e.g. emphasised text and text positioning), as well as overall page characteristics, such as page size (Harper et al., 2009). Based on overall ratings, profiles of web pages were designed to distinguish between good and bad pages in terms of its design. The characteristics that differentiated between good and bad elements were drawn from Ivory et al. (2001). Yet again, they still did not try to define or investigate visual complexity and user perception. The requirement for the organisation and control of information overload, and attraction of user's attention to visual elements, can result in visually complex web pages that hinder sighted users from completing their tasks due to cognitive overload, or visually impaired users due to accessibility issues (Ivory et al., 2000).

Web accessibility guidelines

There are a number of guidelines, regulations, and laws in place which are intended to encourage web designers to create websites that are accessible. However, it has been observed that even in the presence of these regulations, some designers only paid attention to the letter of the guidelines and regulations without understanding why it is important to follow them (Asakawa, 2005). For example, Ivory and Megraw (2005) found that the number of tables used to control page layouts had increased from the years 2000 to 2003. Keeping in mind the World Wide Web Consortium guidelines, increase in the number of tables used will impede visually impaired users from accessing the web page contents due to the limitations of

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accessibility technologies. Many web designers are currently still ignorant of the guidelines or fail to understand the difficulties facing visually impaired users in accessing the web (Harper et al., 2009).

Multiple web accessibility guidelines and standards have been developed for the web on both desktops, as well as for handheld mobile devices. The definition of accessibility for interactive systems is represented as ‘‘the usability of a product, service, environment or facility by people with the widest range of capabilities’’ (Rømen & Svanæs, 2011, p. 4). As an example, the BBC standards and guidelines for mobile accessibility are a set of practices which are unbiased towards the use of various technological tools to help solve a diverse range of problems for mobile web (Zhang, Zhou, Uchidiuno and Kilic, 2017).

The W3C WAI (Web Accessibility Initiative)-ARIA (Accessible Rich Internet Applications) suite propose that web developers should use landmarks plus region roles to distribute web content into several sections, creating a logical subdivision of user interface areas. The ARIA metadata which is embedded in websites ought to be used in describing live areas, roles, and states of dynamic content, that are able to be accessed by screen readers. This allows them to improve the accessibility of web applications (Zhang et al., 2017). Regrettably, in practice, web designers frequently fail to follow these standards and guidelines of web accessibility whilst designing websites. A number of websites which claim that they are fully compliant with the W3C guidelines are in fact inaccessible to visually impaired users (Power, Friere, Petrie and Swallow, 2012).

The Web Accessibility Initiative (WAI) consists of the Web Content Accessibility Guidelines (WCAG) which have become the generally accepted standards for accessibility on the web. Version 1.0 of the WCAG is currently the foundation of web accessibility guidelines and evaluations in a large number of countries (Rømen & Svanæs, 2011). Since 2000, there have been dramatic changes to the web as there has been a shift from being an HTML-only world, to advancements into an exciting, captivating medium which provides innovative services for both stationary and handheld mobile devices. One of the major goals of WCAG 2.0 was to describe what the requirements are for web content accessibility in a technology neutral language. The purpose of this goal was so that the web content could be applied to any W3C or non W3C technology (Power et al., 2012). Another major goal of WCAG 2.0 was to ensure that the requirements can all be tested objectively, allowing policy makers to be able to adopt the requirements exactly as they are (Rømen & Svanæs, 2011). These requirements are structured around four general accessibility principles, 12 guidelines and 61 success criteria. The four general accessibility principles set out the foundation required for a person to access and use web content. WCAG 2.0 mentions that if anyone wants to use the web, they must have content that is “perceivable, operable, understandable and robust” (Rømen & Svanæs, 2011, p.2). If websites do not follow these four criteria, then users with visual impairments are not going to be able to use the web (Rømen & Svanæs, 2011). However, WCAG 2.0 includes guidelines that only address problems specifically relating to people with disabilities. This comprises of difficulties around the blockage of access or interface regarding access to the web, more severely for disabled people (Power et al., 2012).

The international standard ISO 9241-171:2008, Ergonomics on human–system interaction—Part 171: Guidance on software accessibility, offers some guidance regarding the design of the interactive system’s software, allowing those interactive systems to achieve the highest level of accessibility as possible. The standard is built upon the current understanding surrounding the characteristics of those individuals with particular physical, sensory, and/or cognitive impairments (Power et al., 2012). The standard is comprised of 21 guidelines and 143 requirements. Within these requirements, 62 of these must be met to claim conformance. The process of

designing a human-system interaction, for increasing accessibility, promotes an increase in effectiveness, efficiency and satisfaction for people who have a wide variety of preferences and capabilities. We can therefore find a strong connection between the concepts of accessibility and usability (Rømen & Svanæs, 2011). In this standard, there is guidance for integrating accessibility goals and features into web design as early as possible, and to address the increasing necessity of considering social and legislative demands. This is to ensure accessibility through the removal of barriers that prevent people from participating in society.

Another technique that can be used to support web document design is the 'disabled-enabled' criteria of Bobby. Bobby is the "web-based validation service maintained by the Centre for Applied Special Technology (CAST)" (Cullen, 2001, p. 6), and it is now acknowledged as the world standard. What Bobby does is that it offers a guideline to evaluate the accessibility features of a website to ensure that they meet the W3C's Web Content Accessibility Guidelines which were mentioned previously. Bobby is a requirement in the United States, United Kingdom, New Zealand, and by other governments for the use of their individual websites (Cullen, 2001).

In addition to the guidelines mentioned above, an alternative strategy available for web designers to use is called universal design. Universal design is an approach that can be implemented in the design of websites to allow them to be used by everyone. This includes the design of products and environments to permit them to be usable by all people, to the utmost degree possible, without requiring the use of adaptation or specialised design (Rømen & Svanæs, 2011). There are seven fundamental principles that universal design is centred around, which are necessary in ensuring accessibility. These are: "(1) Equitable use, (2) Flexibility in use, (3) Simple and intuitive, (4) Perceptible information, (5) Tolerance for error, (6) Low physical effort and (7) Size and space for approach and use" (Rømen & Svanæs, 2011, p. 3). To some degree, all principles are relevant when web design is concerned, especially principles three, four, five, and six. Principle six displays close relevance to the concept of usability, stating that the design can be used efficiently and comfortably (Rømen & Svanæs, 2011).

Despite the availability of various guidelines mentioned above, designers need to be willing to adopt them in their practices otherwise problems will still be encountered by visually impaired people. To illustrate, text and links that start with the same letter and can be read almost exactly the same, are an example of some problems that are mostly experienced by users who are visually impaired. There is a simple guideline which could offer a solution, such as ''stating the most important information or word first'', which is a common tip for usability. This could further lead to improvements in accessibility as well. For example, there are links with identical spelling that point to different link targets (e.g., ''Click here to go to A and here to go to B''), a high number of links, and links which are redundant. For these types of links, extra effort is required by users who use screen readers. Often it was found that the surface area of a screen element, menu, or button seemed to be larger than the actual clickable surface (Rømen & Svanæs, 2011).

Presentation-oriented solutions for web designers to improve website accessibility

Accessibility technologies do not give seamless access to every information, but they do improve information access and provide access to basic online information. Therefore, technical communicators and web designers need to act as accessibility advocates to take steps to meet the needs of the completely and partially visually impaired. Presentation-oriented solutions are solutions for improving the presentation and visual appearance of websites to make them more user friendly (Gerber, 2003).

The only way accessibility technologies are able to make graphics and significant colours accessible is by keeping layouts

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and designs as simple as possible through the use of the descriptive text which is given with them. These can include captions, descriptions in paragraphs, alternative text, or additional explanations (Ray & Ray, 1998). The focus of text descriptions should be on the content of a graphic rather than on appearance. Similarly, the design of an email program's interface should be stressed. Instead of focusing on the visual appearance i.e. a list of mail folders on the left-hand side of the window, while presenting a list of mail messages on the right-hand side, it should be presented in a way that it can be easily accessible by accessibility technologies. An example of a better designed email program interface would be, a list of mail folders is presented on the screen, and the content of the email is shown on a new or separate screen (Ray & Ray, 1998). Website designers should also use fonts that are readable. High quality fonts which are able to scale well should be used for online presentations, such as TrueType fonts, rather than lower resolution fonts which are built into the system. High contrast colours should also be used. Colours should be chosen that contrast well (for example, it would not be good to use black on a dark blue background). In an ideal situation, system default colours should be used as it makes it easier for the reader to adjust the specific needs of the display and enhancements should be used sparingly (Gerber, 2003).

It is not possible for accessibility technologies to interpret bold, italic, underlined, or special fonts at all. In some cases, the readers will need to keep track of how it has been interpreted. Due to these difficulties, there are a number of things website designers can do to aid those with visual impairment. For example, they could label links clearly as well as separate them. They could also use descriptive names such as "Glossary", "Table of Contents" or "Related Article" instead of having options such as "click here for the Glossary, click here for the Table of Contents, and click here for a Related Article" or "choose Glossary, Table of Contents, Related article" (Gerber, 2003).

If technical communicators and website developers were to be accessibility advocates on top of using accessible communication techniques, they would also have a say while being involved in any process during product development. Particularly, it would promote techniques about providing accessible information. No matter what product the documentation is being developed for, there is a high chance that the developers are creating documentation that is likely to, on some level, be used by those who are visually impaired- either as operators, technicians, or administrators (Ray & Ray, 1998). Using plain ASCII text or no-frills HTML is a better, and more positive, option than not having anything at all. This would be by using consistent, widely accepted menus, keys, and shortcuts. If these techniques were implemented, it would make it possible for visually impaired users to rapidly become familiar with what information is available and be able to navigate the software much faster.

Allowing for complete keyboard navigation is a further step that should be taken, by making sure that everything from within the program is able to be accessed by using the keyboard, and that the orders of tabs are logical and usable (Ray & Ray, 1998). It is helpful if descriptive names were provided for buttons, icons, and graphics. Web designers would need to make sure that text descriptions are able to stand on their own, without any accompanying graphic elements (Gerber, 2003). Additionally, they should make sure that placeholder descriptions, such as "image" or "Put Alternative Text Here", are not left in the final product. They should let users be able to control the onscreen appearance. Finally, designers should also make use of system-standard codes for standard interface features, and also let users change the onscreen colours, fonts, resize dialogue box text and buttons, and resize toolbars. Following these strategies would make websites more accessible and usable for people with visual impairments through accessibility technologies (Gerber, 2003).

Attempts have been made to mitigate problems relating to the access of

complicated visual information by visually impaired users (Harper & Becchofer, 2007). This was done through recent shifts towards separating presentation, metadata, and information such as a cascading style sheet (CSS). There are currently options available which attempt to transform inaccessible web documents into accessible ones. As discussed earlier, these involve the use of guidelines, automated validation, and best practice. Complications still exist regarding old and badly built documents; therefore, solutions have been developed which aim to change poor content to more favourable content. Collectively, the solutions are called transcoding. Transcoding is the conversion of information from one form to another. In the case of the visually impaired, transcoding would be applied to convert online information from text to audio format. (Harper & Becchofer, 2007).

Semantic-oriented solutions for web designers to improve website accessibility

Sematic-oriented solutions are another attempt to overcome limitations of accessibility technologies. These solutions include changes in the programming language itself. One of the commonly-used accessibility technologies by visually impaired people are screen readers. These allow for access to the web in an audio format. As long as the web pages have been designed in accordance with the Web Standards and Accessibility guidelines, the screen readers work adequately (Nielsen Norman Group, 2001). Unfortunately, this is not the case seen often. This is partly because the design of web pages is mainly for visual interaction through the use of complex visual elements.

Unfortunately, audio rendering of these web pages has a tendency to create an increasingly complex environment compared to default visual rendering. As an example, the Manchester University (MU) home page is very well structured in its visual element. That is, the main content of the pages is separated from the navigation links through the use of sidebars, and the title of the page is highlighted in the header (Nielsen Norman Group, 2001). Despite the fact that the main purpose of using the visual elements is for the improvement of aesthetic values, what they actually provide for is visual guidance to simplify the access to the environment. Nonetheless, audio rendering of the same page is being excluded from all these visual cues. It is not explicitly defined in the source code what the role of these visually objects are, therefore screen readers are only able to render the pages as a long list of items (Plessers, Casteleyn, Yesilada, Troyer, Stevens, Harper and Goble, 2005; Yesilada et al., 2007).

In an attempt to overcome these limitations, there has been a proposal of using the Dante approach. Dante is one of the many approaches that along with the other guidelines and techniques mentioned above that assesses web pages and separates the visual elements which instigate easier movement throughout the web page (mobility) with the use of the travel analysis framework presented by Yesilada, Harper, Goble and Stevens (2003; 2004a; 2004b). These objects form a crucial element to the confident, simple, and accurate movement of an environment, which is known as travel. These identified travel objects are explained by Dante through the use of semantic annotation techniques from the Web Authoring for Accessibility (WAfA) ontology. WAfA is a set of concepts that describe the illustration of concepts and the relationships which are necessary to model the properties of structure and navigation for web pages. The main purpose behind the WAfA ontology is to advance the annotation pipeline encrypted in Dante (Plessers et al., 2005).

Another semantic-oriented solution is structural semantics for accessibility. It is seemingly contradictory that the designers are the ones who could help solve the problem as they determine the order of how the information on screen is scanned when it is accessed through an accessibility technology. As mentioned earlier, Hypertext Markup Language (HTML) has played a noteworthy part in the fast development of the web as it allows

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accessibility technologies to be designed in a way to render pages in an audio form for visually impaired users. Extensible Hypertext Markup Language (XHTML) is the modern version of HTML. XHTML content is accessed through accessibility technologies from top-left to bottom-right, as opposed to visual rendering after CSS is applied. The content accessed is not scanned, and the progress through information is slow. Additionally, the information is carried out in the order that the designer has determined, rather than what is required by the user. Generally, the labels get encoded into the class or ID attributes of XHTML elements, forming the connection between the cascading stylesheet and the XHTML document structure. By forming a link between the class and ID labels together with selected XHTML elements, an independent visual rendering of the XHTML document is generated. This rendering of the XHTML document does not alter the document structure. These labels can be used as semantic annotation (Harper and Bechhofer, 2005). Additionally, the labels can also be related to structural semantics such as footer, menu, content, heading etc. These can be interpreted as being implicit and accurate annotations and used to deliver better content to users with visual impairments.

Accessibility technologies and their benefits and limitations for people with visual impairments

Under the main category 'accessibility technologies and their benefits and limitations for people with visual impairments', the sub-categories that have been covered are types and benefits of accessibility technologies, and limitations of accessibility technologies. These sub-categories delve into the versatility and availability of various accessibility technologies, the restrictions of using various accessibility technologies and how with the use of the guidelines, the capabilities of accessibility technologies can be accommodated in making information provided accessible to all users.

Types and benefits of accessibility technologies

Visually impaired people have increased ease of access to online information resources. This is because of the versatility and the availability of accessibility technologies such as screen readers, screen magnifiers and braille display (Gerber, 2003). However, web content will only be useful to the visually impaired only if it is both usable and accessible. Braille displays are a means of communication in the arrangement of perceptible writing and reading. Braille is when each character is formed of six to eight dots that are raised in a rectangular display of two columns. It produces a specific sensation on the fingertip of the visually impaired depending on the combination of the dots to represent letters of the print alphabet (Zhang et al., 2017). For visually impaired people with low vision, with a difficulty of reading small text, screen magnifiers have also been developed to assist people with these difficulties. The function of the screen magnifier is to zoom into an area of a screen in detail, expanding both images and text on screen (Zhang et al., 2017).

It is often assumed by technical communicators that the population will interact with information presented online in a similar way as they do. They see fonts, colours, links, and the layout of the page, and read or interpret them according to what they think is appropriate. The fact is though, a large proportion of the population are people with visual impairments and many of them cannot interact with web online and do require the assistance of accessibility technologies (Ray & Ray, 1998). The interaction that visually impaired people have with online content depends on the specific accessibility technology as well as the limitations of an individual. Accessibility technologies do help provide access to online information, but it is not the ultimate solution for the visually impaired as accessibility technologies are still limited in their functionality and cannot audio render all information presented on screen (Tomlinson, 2016). Accessibility technologies cannot represent most visual cues sufficiently such as using colour to

support meaning, fonts to differentiate between information, table and column formats to illuminate information, and images to recapitulate information. This often results in the exclusion of visually impaired people as they still do not have full access and use to online information. "Essentially, screen readers can provide access to information, but only if it is presented through simple text formats and descriptions" (Ray & Ray, 1998, p. 6).

Visually impaired users are still able to browse mobile websites and skim web content the same as sighted users, although they rely on screen readers to do so. However, this is done in a dissimilar way, and is partially dependent on specific types of screen readers (Zhang et al., 2017). Screen readers assist visually impaired users by rendering the audio version or braille translations of the visual cues on a web page, such as reading text within a document, text descriptions of images, and text built into software programs (such as a name associated with a toolbar icon). They help with moving through menus, buttons, icons, and other interface elements (Ray & Ray, 1998).

Many professionals in the field of visual impairments recognise that the use of computers, accessibility technology, as well as being able to access the internet can provide for an enormous difference for people who have visual impairments (Gerber, 2003). There have been some relevant studies that attempted to report what impact technology, in particular computer related accessibility technology, has on the performance in the classroom, overall literacy, the placement of jobs and being able to maintain them, and overall the satisfaction one feels in their entire life (Zhang et al., 2017). What these technologies provide for is to improve opportunities of education and employment, improving social platforms (through emails and online groups), as well as enabling the ability to do things independently (for example, being able to access personal information) (Gerber, 2003).

Limitations of accessibility technologies

During more recent times, there has been a decrease in the effectiveness of screen readers and magnifiers for visually impaired people. This is due to the screen readers and magnifiers not providing full access to progressively complex graphical interfaces and the designs and layouts of online documents (Gerber, 2003). In essence, there has been a step backward taken in the trends of visual communication relating to accessibility and usability for the community. Although these visual communication trends significantly benefit sighted people in terms of communication, they obstruct the ability of accessibility technologies in making information accessible and usable (Harper et al., 2009).

Because online content is extracted as text, the screen reader does technically provide access to online information, nevertheless, the extracted content is impractical and incomprehensible. Without the assistance of associated descriptive text, the information provided through images cannot be communicated to the visually impaired by the screen reader. For example, if the screen has a graph that summarises data, the screen reader would depend on a text description to tell the chart's contents to visually impaired users (Harper et al., 2009). Additionally, screen readers also require associated descriptive text to construe colours. For example, online tutorials use different colours for different tasks. They could use the colour red for completed tasks and green for tasks that are yet to be completed (Gerber, 2003). These tasks cannot be differentiated unless a descriptive text is added such as "you have completed task 1" for the end of each red text, and "you are about to start task 2" for the beginning of each green text. It is also not possible for screen readers to ease the navigation of intricate page layouts. For example, multicolumn formats, headers, footers, and other page features are not easy to read as they increase the difficulty of the document flow, in turn making it hard to follow (Harper et al., 2009).

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Like screen readers, screen magnifiers also pose a number of problems for people who are visually impaired. For instance, content that is enlarged can become extremely difficult to use. When enlarged to a certain extent, there is a possibility for text to only be read one letter at a time. This would create a situation where the user is required to mentally reconstruct and remember where on-screen elements are located (Harper et al., 2009). This further adds to the already burdensome process of using the internet. Moreover, a number of fonts also become hard to decipher, almost impossible to be read, when enlarged to this level (Gerber, 2003). An obstruction is usually caused by the magnified area in terms of content, toolbars, or menu bars, which make it difficult to navigate pages (Harper et al., 2009).

Lastly, it is not always possible for screen magnifiers to make graphics usable. In particular, large graphics are often not able to be used because there is not much of the image visible when it is magnified. This requires people to scroll around the graphic to gain full access to the image (Harper et al., 2009). Also, depending on the quality of the graphics, it might not be possible for smaller graphics to be usable because of jagged lines or any other problems caused by magnification.

To overcome these limitations, aside from attending to the guidelines and regulations for increasingly accessible websites as mentioned previously, designers and developers need to understand and take into consideration the way visually impaired people use the web (Ray & Ray, 1998). This will help them determine which elements of the page are more usable, and less accessible, and endeavour to find a way to decrease the problems surrounding accessibility. One approach to this problem is through understanding the processes involved in sighted users perceiving the visual presentation and complexity of a web page. Furthermore, insights can be gained by examining how their perception is shaped to help them in completing a task (Harper et al., 2009).

Table 1 – Summary of Findings

Main categories	Sub-categories	Selected evidence
Inaccessible content for the visually impaired	Impediments and digital exclusions of visually impaired users in accessing the web	• Previous estimates have predicted that people who have visual impairments were increasingly less likely to use computers than those who were sighted due to the content being inaccessible for them (Cullen, 2001). • Web designers are focusing very closely on creating content that is more visually pleasing, but they are not paying enough attention to the usability and accessibility issues present (Cullen, 2001).
	Complexity of visual features in web design	• The complex design of a web page can obstruct a users' navigation of a website (Ivory & Megraw, 2005). • With data on the web continually expanding, web pages turn out to be all the more visually intricate, which puts a lot more pressure on visually impaired users (Harper et al., 2009).
	Unconstructive attitude of web designers	• Authors and designers of websites believe that it is unnecessary to create a separate semantic mark-up to fit with the standard extensible hypertext mark-up language, to make web pages accessible for the visually impaired (Harper & Becchofer, 2007).

		• Most designers wish to produce "beautiful and effective" websites and are not willing to compromise (Harper & Becchofer, 2007).
Improving website accessibility for the visually impaired	Metrics for accessible web design	• Studies have attempted to identify metrics for web page design that could predict whether a website is rated highly with respect to its complexity (Ivory et al., 2000, 2001; Germonprez & Zigurs, 2003). • Some of the metrics include word and link count, page formatting, as well as overall page characteristics, such as page size (Harper et al., 2009).
	Web accessibility guidelines	• There are a number of guidelines, regulations, and laws in place which are intended to support web designers to create websites that are accessible (Asakawa, 2005). • Despite the availability of various accessibility guidelines, web designers need to be willing to adopt them in their practices otherwise problems will still be encountered by visually impaired people (Rømen & Svanæs, 2011).
	Presentation-oriented solutions for web designers to improve website accessibility	• The only way accessibility technologies are able to make graphics and significant colours accessible is by keeping layouts and designs as simple as possible through the use of the descriptive text and by using fonts that are readable (Ray & Ray, 1998). • Designers should make use of system-standard codes for standard interface features, and let users change the onscreen colours, fonts, resize dialogue box text and buttons, and resize toolbars. (Gerber, 2003).
	Semantic-oriented solutions for web designers to improve website accessibility	• To overcome limitations of the web, there has also been a proposal of using the Dante approach and structural semantics for accessibility that assesses web pages and separates the visual elements for easier mobility on a web page (Yesilada et al., 2003; 2004a; 2004b).
Accessibility technologies and their benefits and limitations on the quality of life for people with visual impairments'	Types and benefits of accessibility technologies	• Visually impaired people have increased ease of access to the web because of the versatility and the availability of accessibility technologies such as screen readers, screen magnifiers and braille display (Gerber, 2003). • Accessibility technologies improve opportunities of education and employment, improving social interactions, as well as enabling the ability for people with visual impairments to do things independently (Gerber, 2003).
	Limitations of accessibility technologies	• There has been a decrease in the effectiveness of screen readers and magnifiers for visually impaired people due to these technologies not providing full access to progressively complex graphical interfaces, and the designs and layouts of online documents (Gerber, 2003). • Due to problems imposed by accessibility technologies, users are forced to mentally reconstruct and remember

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		where on-screen elements are located (Harper et al., 2009). • A number of fonts have become hard to decipher, it is also not possible for screen readers to ease the navigation of intricate page layouts and it is not always possible for screen magnifiers to make graphics usable (Gerber, 2003).

Discussion and Conclusion

The presented findings, based on the narrative review of the literature, offer an understanding of the various challenges faced by visually impaired people in accessing online information and services. It further looks into how the complexity of a web page affects people with visual impairments. It also delves into the usability issues which are present due to the unconstructive attitude of web designers. It has been estimated previously that people who have visual impairments are less likely to use computers than sighted individuals. Over the years the web has been fast developing and HTML has played a substantial part in this development (Harper & Becchofer, 2007). It assists accessibility technologies to be extracted in an audio form for visually impaired individuals. Unfortunately, though, adjustments in HTML and progresses in innovations have changed the presentation of websites. Web pages now end up as only being visually captivating. These changes are due to the inherent focus of designers in creating web pages which are visually appealing, rather than making the content accessible by truly understanding users' behaviour (Zheng and Yen, 2016). Web designs tend to be increasingly graphical in nature with the use of organisational and attractive graphics. They are dependent on browser scripts, which make them much less consistent over time, thereby making websites visually complex and difficult to use (Karmokar, Singh and Tan, 2016). In the long run, this makes the web increasingly out of reach to those who are visually impaired (Suomi & Sachdeva, 2016). It is therefore important for web designers to understand the information needs and behaviour of visually impaired persons, as technical accessibility does not guarantee usability. Users need to feel comfortable and satisfied when working with a website (Issa & Isaias, 2014).

Despite these challenges associated with the visual nature of web design and the unwillingness of web designers to create accessible web pages, different attempts have been made to mitigate some of these problems. There are metrics for web page design that could predict whether a website is rated highly with respect to its complexity. Furthermore, there are also different guidelines and tools, including presentation-oriented solutions such as Bobby, W3C's User Agent Accessibility Guidelines and Web Content Guidelines, and transcoding that can be adopted by web designers to make websites more accessible. Sematic-oriented solutions are another attempt to overcome limitations of accessibility technologies. These solutions include changes in the programming language itself to make websites more accessible through the use of accessibility technologies. Lastly, the findings discuss the versatility and availability of various accessibility technologies, and the restrictions of using them.

This study contributes to research by offering a rigorous narrative review to summarise the state of knowledge on challenges that people with visual impairments face in accessing online information and services, and the role of accessibility technologies in addressing some of these challenges. In particular, studies suggest that people with visual impairments face challenges from the complexity of website as well as the unaccommodating attitudes of website designers whose primary focus is towards creating visually appealing websites rather than creating more accessible websites.

On the positive side, various attempts including accessibility guidelines and presentation-oriented and semantic-oriented solutions have been made to encourage website designers to create accessible websites. From a technology support's perspective, accessibility technologies offer support people with visual impairments to access online information and services. However, it is important to recognise that accessibility technologies do not offer a complete solution to address the inaccessible online information and services for people with visual impairments because they cannot overcome the increasingly complex graphical designs and layouts of online documents.

In addition, this research identifies gaps and areas that deserve attention in future studies (see table 2 below). Current research tends to focus more on physical access to computers of the disability community as a whole rather than digital exclusions of just the visually impaired community. There should be more research done in the field that solely focuses on the digital divide faced by visually impaired people; the findings from these studies can help develop a precise set of digital exclusion challenges faced by the visually impaired. Future research on website accessibility for people with visual impairments should investigate underlying reasons to answer why web designers are not willing to develop accessible websites. Research may want to investigate policies, enforcements and their efficacy on accessible websites.

Due to rapid advances of technologies, the effects of emerging and innovative technologies on content accessibility should also be considered in future research. Since accessibility technologies are currently imbued with some limitations, it could prompt researchers to further improve these technologies to better support people with visual impairments as well as help generate more progressive tools for web developers to assess web accessibility.

Future research should emphasise and distinguish the dual importance of accessibility' among Web developers. In particular, studies should involve visually impaired users to offer their views on what usability means to them. One way of doing this would be to get real users of different caliber to perform different tasks online which in turn helps in developing nuanced understanding based on user types such as a beginner user, an advanced user and so on based on their performance. Lastly, we need to recognise that the visually impaired are an intricate and diverse group that need additional research to continue to expand the comprehension of procedures for improving accessibility and usability. This could be achieved by altering web resources and understanding, as well as addressing their information needs.

The practical contributions of this research are that it can help organisations and web designers change their perceptions when it comes to designing their future websites. It can also assist with increasing awareness of the challenges of accessing online information and services for people with visual impairments. It furthermore offers a better understanding of the benefits of accessibility technologies as well as their limitations and provides evidence for governments or international agencies to consider developing policies and initiatives to promote accessibility and usability, thus enhancing inclusiveness in a digital society.

The following limitations of this study are also recognised. The articles used in this study are all journal or conference papers, therefore the findings do not reveal any information from other important resources such as book chapters. The study is also based on past work by other researchers as it does not collect primary data, consequently, the weaknesses from their studies may have been reflected in this research. Furthermore, it cannot be assured that all journal and conference papers that discuss the issues of people with visual impairments and their access to online information and services have been covered.

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Table 2: Research Gaps and Suggestions for future research

What is known from the literature	Gaps	Future research suggestions
There are still digital exclusion challenges for the visually impaired to access ICT (Yesilada et al., 2007)	Current research tends to focus more on physical access to computers rather than digital exclusion challenges. Additionally, there is not much research that focuses on the problems faced by the visually impaired community, rather it focuses on the challenges faced by the entire disability community.	More research that solely focuses on the digital divide and challenges faced by the visually impaired community in accessing online content is needed. The findings of these studies can help develop a precise set of digital exclusion challenges faced by the visually impaired.
Despite several useful accessibility guidelines, the compliance is relatively low (Asakawa, 2005)	Current research heavily focuses on the different accessibility guidelines that are to be followed by web designers, however, research does not put much emphasis on why it is important for designers to follow them and why creating graphically intriguing websites should not be a priority.	Future research on website accessibility for people with visual impairments should investigate underlying reasons to answer why web designers are not willing to develop accessible websites. In addition, research may want to look into policies, enforcements and their efficacy on accessible websites.
Accessibility technologies are helpful to improve access to basic online information, but they cannot support access to visually complex websites (Gerber, 2003)	Besides attending to the guidelines and regulations for accessible websites for easier access to the web through accessibility technologies, there isn't much technical research that aims to make better accessibility technologies or update the existing ones that can support access to slightly complex elements on websites.	Further technical research should be done in this area on how to improve the current accessibility technologies or make better ones to support images on websites, drop down menus, etc.
Web content will only be useful to the visually impaired only if it is both usable and accessible (Zhang et al., 2017)	Current research focuses on how to make websites accessible for visually impaired but not usable. Technical accessibility does not guarantee usability and it is important to understand the needs of people with visual impairments when designing online content.	Future research should put more emphasis on the usability aspect as well by conducting empirical research with visually impaired people around usability testing of new websites. This would help in developing various usability models based on different real-life circumstances of visual impaired users.

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Appendices

Table A1- Summary of the characteristics of rigorous narrative review	
Characteristic	Description
Overarching goal	Our goal is to summaries prior research on challenges that people with visual impairments face in accessing online information and services and the role of accessibility technologies and guidelines to support them in their online access. This fits into what Ortiz de Guinea and Paré (2017) identified as the goal of describing.
Scope of questions	A broad background to understand the current state of knowledge in relation to challenges that people with visual impairments face in accessing online information and services and the role of accessibility technologies and guidelines to support them in their online access.
Systematicity	We followed a six-step procedure proposed by Templier and Paré (2015) to search, screen and evaluate the relevant literature. Note that the six-step procedure goes beyond identifying relevant studies. This procedure includes the following steps: (1) formulating the problem, (2) searching the literature, (3) screening for inclusion, (4) assessing quality, (5) extracting data, and (6) analyzing and synthesizing data.
Search strategy	We followed the representative coverage and employed "structured search methods to form a representative sample of a larger group of published works that are related to [an] area of investigation" (Paré et al., 2015, p. 186) by surveying and including the materials published in relevant scholarly databases.
Primary sources	We included both conceptual and empirical papers.
Analysis method	Inductive coding approach

Table A2- List of articles used in the data analysis			
Article	Author	Research approach	Sub-category
1. SADIe: Structural semantics for accessibility and device independence	Harper, S. and Bechhofer, S. (2007).	Experiments	• Impediments and digital exclusions of visually impaired users in accessing the web • Unconstructive attitude of web designers • Presentation-oriented solutions for web designers to improve website accessibility
2. Evaluating DANTE: Semantic transcoding for visually disabled users	Yesilada, Y., Stevens, R., Harper, S. and Goble, C. (2007).	Experiments	• Impediments and digital exclusions of visually impaired users in accessing the web • Semantic-oriented solutions for web designers to improve website accessibility
3. Toward a definition of visual complexity as an implicit measure of cognitive load	Harper, S., Michailidou, E. and Stevens, R. (2009).	Experiments	• Impediments and digital exclusions of visually impaired users in accessing the web • Complexity of visual features in web design • Metrics for accessible web design • Web accessibility guidelines • Limitations of accessibility technologies

4. An accessibility analysis of UK university entry points	Kelly, B. (2002).	Survey	• Impediments and digital exclusions of visually impaired users in accessing the web
5. Analysis of navigability of Web applications for improving blind usability	Takagi, H., Saito, S., Fukuda, K. and Asakawa, C. (2007).	Interview, Experiments	• Impediments and digital exclusions of visually impaired users in accessing the web
6. Perceptions of accessibility and usability by blind or visually impaired persons: a pilot study	Tomlinson, S. (2016).	Semi-structured interviews	• Unconstructive attitude of web designers • Types and benefits of accessibility technologies
7. Disability and accessibility in the library and information science literature: a content analysis.	Hill, H. (2013).	Content analysis	• Unconstructive attitude of web designers
8. User-centered design for information professionals	Schulze, A.N. (2001).	Observations	• Unconstructive attitude of web designers
9. Semantic triage for increased accessibility	Harper, S. and Bechhofer, S. K. (2005).	Experiments	• Semantic-oriented solutions for web designers to improve website accessibility
10. Evolution of websites design patterns	Ivory, M.Y. and Megraw, R. (2005).	Experiments	• Complexity of visual features in web design • Metrics for accessible web design • Web accessibility guidelines
11. Causal factors for websites complexity.	Germonprez, M. & Zigurs, I. (2003).	Conceptual	• Metrics for accessible web design
12. Preliminary findings on quantitative measures for distinguishing highly rated information-centric web pages.	Ivory, M. Y., Sinha, R. R. and Hearst, M.A. (2000).	Survey	• Metrics for accessible web design
13. Empirically validated web page design metrics	Ivory, M. Y., Sinha, R. R. and Hearst, M.A. (2001).	Experiments	• Metrics for accessible web design
14. Guidelines are only half of the story: Accessibility problems encountered by blind users on the web.	Power, C., Friere, A., Petrie, H. and Swallow, D. (2012).	Experiments	• Web accessibility guidelines
15. Personalized Assistive Web for Improving Mobile Web Browsing and Accessibility for Visually Impaired Users	Zhang, D., Zhou, L., Uchidiuno, J. O. and Kilic, I. Y. (2017).	Experiments	• Web accessibility guidelines • Types and benefits of accessibility technologies
16. What's the web like if you can't see it?	Asakawa, C. (2005).	Description of the historical progress of blind user experience	• Web accessibility guidelines

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		vs. the historical progress of web accessibility	
17. Validating WCAG versions 1.0 and 2.0 through usability testing with disabled users	Rømen, D. and Svanæs, D. (2011).	Controlled experiment	• Web accessibility guidelines
18. Beyond ALT text: Making the Web easy to use for users with disabilities	Nielson Norman Group. (2001).	Behavioural research (usability testing)	• Semantic-oriented solutions for web designers to improve website accessibility
19. Dante: Annotation and transformation of Web pages for visually impaired users	Yesilada, Y., Harper, S., Goble, C. and Stevens, R. (2004a).	Design science	• Semantic-oriented solutions for web designers to improve website accessibility
20. Screen readers cannot see: Ontology based semantic annotation for visually impaired Web travellers	Yesilada, Y., Harper, S., Goble, C. and Stevens, R. (2004b).	Design science	• Semantic-oriented solutions for web designers to improve website accessibility
21. A foundation for tool-based mobility support for visually impaired Web users	Yesilada, Y., Harper, S., Goble, C. and Stevens, R. (2003).	Experiments	• Semantic-oriented solutions for web designers to improve website accessibility
22. Accessibility: A Web engineering approach	Plessers, P., Casteleyn, S., Yesilada, Y., Troyer, O. D., Stevens, R., Harper, S. and Goble, C. (2005).	Design science	• Semantic-oriented solutions for web designers to improve website accessibility
23. Adaptive Technologies for the Visually Impaired: The Role of Technical Communicators	Ray, S. D. and Ray, E. J. (1998).	Description of adaptive technologies	• Presentation-oriented solutions for web designers to improve website accessibility • Types and benefits of accessibility technologies • Limitations of accessibility technologies
24. The Benefits of and Barriers to Computer Use for Individuals Who Are Visually Impaired.	Gerber, E. (2003).	Focus groups	• Impediments and digital exclusions of visually impaired users in accessing the web • Presentation-oriented solutions for web designers to improve website accessibility • Types and benefits of accessibility technologies • Limitations of accessibility technologies
25. Addressing the digital divide	Cullen, R. (2001).	Description and evidence of digital divide in three countries, contributing	• Impediments and digital exclusions of visually impaired users in accessing the web

		factors and strategies to reduce digital divide	

Table A3 - Categories, sub-categories, open codes and associated text for the findings

Main categories	Sub-categories	Open codes	Associated text
Inaccessible content for the visually impaired	Impediments and digital exclusions of visually impaired users in accessing the web	World wide web, largest source, electronic information, accessibility technologies, audio format, visually appealing, obstacles regarding accessibility, digital divide, deprived in understanding ICTs, physical access, human rights, obstacles, open communication.	The inherent focus of designers in creating web pages which are visually appealing, rather than focussing on creating an audio platform. In the long run, this makes the web increasingly out of reach to debilitated individuals, specifically those who are visually impaired. Therefore, visually impaired users can therefore be impeded in their endeavours to access this biggest archive of electronic data (Yesilada, Stevens, Harper and Goble, 2007). There is a continuous increase in the demand for visually impaired people to gain access to the internet, and it is presently seen as an issue of human rights (Cullen, 2001).
	Complexity of visual features in web design	Arrangement, details of element, text and link formatting, graphics, style sheets, XHTML coding, visually complex, usability	One of the major and important issues in the website design and usability field is the access to, and navigation around complicated multimedia surroundings such as the web (Harper et al., 2009).
	Unconstructive attitude of web designers	Website authors, website designers, beautiful and effective sites, information architects, immovable designed artefacts, information needs and behaviour, accomplishing information goals, user centred design, technical accessibility, usability, inaccessible features, increased awareness	"If their design is compromised in any way they will not implement. They believe in creating beautiful and effective sites, they are not information architects" (Harper & Becchofer, 2007, p.2).
Improving website accessibility for	Metrics for accessible web design	Metrics for web design, content, structure, visual design, layout quality,	Further studies have attempted to identify metrics for Web page design that

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the visually impaired		screen coverage, information quality, text positioning, information overload, visual elements, mitigate problems, complicated visual information, audio format, visual manner, limited access, visual presentation, transform inaccessible web documents, transcoding, convert online information.	could predict whether a Websites is rated highly with respect to its complexity (Germonprez & Zigurs, 2003; Ivory et al., 2000, 2001).
	Web accessibility guidelines	Guidelines, regulations, laws, BBC standards and guidelines, W3C, UAAG, WAI, ARIA, Bobby, WCAG, conformance, sufficient and advisory techniques, human system interaction, success criteria	There are guidelines, regulations, and laws in place which are intended to force Web designers to create Websites which are accessible. However, it has been observed that, even in the presence of these regulations, some designers only paid attention to the letter of the guidelines and regulations without understanding why it is important to follow them (Asakawa, 2005).
	Presentation-oriented solutions for web designers to improve website accessibility	Seamless access, ASCII text formats, simple layout and design, alternative text format, descriptive text, standard colour codes, accessibility advocates	Technical communicators and web designers need to act as accessibility advocates to take steps to meet the needs of the completely and partially visually impaired since accessibility technologies are not fully ripe yet (Gerber, 2003).
	Semantic-oriented solutions for web designers to improve website accessibility	Extensible hypertext mark-up language, CSS, limited visual presentation, programmatic document object model, class attributes, ID attributes, ontologies, semantic infrastructure, semantic annotation	This solution does use ontologies, semantic infrastructure, and programmatic document object model (DOM) parsing to accomplish DOM transcoding by identifying elements within the web page (Harper & Becchofer, 2007).
Accessibility technologies and their benefits and limitations on the quality of life for people with visual impairments'	Types and benefits of accessibility technologies	Ease of access, online information resources, usable and accessible, accessibility technologies, user experience, user centred design, screen readers, braille displays, screen magnifiers, usability, translation, overall satisfaction	There is an extensive range of tools and accessibility technologies that have been developed to help visually impaired people with easier access to online information. Some of these tools include braille displays, screen magnifiers and screen readers (Ray & Ray, 1998).

	Limitations of accessibility technologies	Impractical, incomprehensible, mentally reconstruct, descriptive text, burdensome process, smaller graphics, jagged lines, exceptional effort	Because online content is extracted as text, the screen reader does technically provide access to online information, nevertheless, the extracted content is impractical and incomprehensible (Harper et al., 2009).

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