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Abstract:

Accessibility awareness and development have improved in the past two decades, but many users still encounter accessibility barriers when using information technology (IT) artifacts (e.g., user interfaces and websites). Current research in information systems and human-computer interaction disciplines explores methods, techniques, and factors affecting the accessibility of IT artifacts for a particular population and provides solutions to address these barriers. However, design realized in one solution should be used to provide accessibility to the widest range of users, which requires an integration of solutions. To identify the factors that cause accessibility barriers and the solutions for users with different needs, a systematic literature review was conducted. This paper contributes to the existing body of knowledge by revealing (1) management- and development-level factors, and (2) user perspective factors affecting accessibility that address different accessibility barriers to different groups of population (based on the International Classification of Functioning by the World Health Organization). Based on these findings, we synthesize and illustrate the factors and solutions that need to be addressed when creating an accessible IT artifact.

Keywords: Accessibility, Web accessibility, Accessible IT Artifacts, Systematic Literature Review.

[Department statements, if appropriate, will be added by the editors. Teaching cases and panel reports will have a statement, which is also added by the editors.]

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1   Introduction

Designing IT artifacts[1] that are accessible to all people is a difficult task (Meiselwitz, Wentz, & Lazar, 2010). A well-known ISO standard (ISO 9241–11:2018) defines accessibility as the "extent to which products, systems, services, environments, and facilities can be used by people from a population with the widest range of user needs, characteristics, and capabilities to achieve identified goals in identified contexts of use" (International Organization for Standardization, 2018). Legislation and standards of accessibility globally enforce the need for public sector actors, in particular, to provide accessible web services. The importance of accessibility is no longer a question; rather, the question is now how to achieve and design IT artifacts that are accessible to users with different abilities and usable by the widest possible range of users (Persson, Åhman, Arvei Yngling, & Gulliksen, 2014).

Nearly two decades ago, Lazar et al. (2004) estimated that 70–98% of websites were not accessible. Since then, accessibility guidance has experienced remarkable enhancements. For instance, the Web Accessibility Initiative's Web Content Accessibility Guidelines (WCAG) have had two major updates: WCAG 2.0 (2008) and WCAG 2.1 (2018). The ISO standard of accessibility had its latest update in 2019 (ISO/IEC 30071-1:2019). In Europe, the European EN standard of accessibility, EN 301 549 V1.1.2 (2015–04), served as the basis for the EU directive on the accessibility of websites and mobile applications of public sector bodies (Directive 2016/2102., 2016). The EU directive has been localized to national legislation in EU countries. The accessibility guidance behind the regulations is based on the WCAG guidelines. It is notable that transforming WCAG-complied webpages to correspond with updated versions does not require a full revision of the webpages (S.-H. Li, Yen, Lu, & Lin, 2012).

As evidenced by this progress, awareness of accessibility at the government level and willingness to make improvements have grown over the past two decades. Unfortunately, most websites remain inaccessible (Brajnik, Yesilada, & Harper, 2011; Martins, Gonçalves, & Branco, 2017; Santana & Baranauskas, 2015; Vollenwyder, Iten, Brühlmann, Opwis, & Mekler, 2019). This may be due to insufficient accessibility knowledge, confusing guidelines, poor support by management, lack of time (Lazar et al., 2004; Vollenwyder et al., 2019), lack of consideration of human diversity in the web design process (Aizpurua, Harper, & Vigo, 2016), and lack of methods and tools to correct accessibility problems (Paiva, Freire, & de Mattos Fortes, 2021). Potential accessibility problems may occur at the individual, technological, or organizational level, or somewhere in between these. This places information systems (IS) research in an important role, as these are the core focuses of IS (Myers, 1997). Moreover, the IS discipline is constantly facing new technological artifacts, which prompt the need for new research (Rowe, 2012).

In addition, the Association of Information Systems (AIS) code of ethics states: "Technologies and practices should be as inclusive and accessible as possible and scholars and computing professionals should take action to avoid creating systems or technologies that disenfranchise or oppress people" (AIS, 2021-a; Hanson, 2017). This raises the importance of addressing accessibility in IS research. A multitude of accessibility-related studies have explored how to design IT artifacts (i.e., websites, user interfaces [UI], and applications) for use by users with disabilities in a specific target population (Mack et al., 2021). Moreover, the literature presents techniques and methods that can be applied to capture a specific user population's needs successfully (c.f., Link et al., 2006; Paiva et al., 2021). However, we argue that this knowledge is fragmented. There is a gap in our knowledge of the overall factors that affect the realization of accessibility in IT artifact development and the factors that cause accessibility barriers from the user perspective of different stakeholders (Lazar et al., 2004; Leuthold, Bargas-Avila, & Opwis, 2008; Vollenwyder et al., 2019). This constitutes a gap in our knowledge of how to develop IT artifacts that are accessible regardless of ability or disability. This gap motivated us to conduct a systematic literature review (SLR) of accessibility in the top and tier-2 IS outlets and top Human-computer interaction (HCI) outlets recommended by AIS. In this paper, we summarize prior knowledge in IS and HCI and synthesize factors affecting accessibility from different stakeholders.

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[1]An IT artifact is defined as an application (e.g., web application, web site, or user interface) of an IT that enables or supports a specified task embedded within the structure in a specified context (Alter, 2008).

In this study, we aim to advance accessibility by clarifying the existing evidence of factors that cause accessibility problems. We aim to extend the knowledge about the overall factors around accessibility that are related to development and human abilities and diversities and that cause accessibility barriers in IT use. Therefore, we ask:

> **What factors cause accessibility problems, and what does the literature suggest be done to address these?**

This study provides a summary of existing evidence of the factors and solutions related to accessibility issues at the individual and organizational levels. Individual accessibility needs are based on the classification of human abilities by the International Classification of Functioning, Disability, and Health (ICF). Finally, the results are synthesized, and the factors and solutions affecting accessibility are illustrated.

This paper is structured as follows. Chapter 2 presents the background of accessibility and related literature. Chapter 3 describes the SLR process. Our results are presented in Chapter 4. Chapter 5 describes the synthesized research findings. Chapters 6 and 7 present the discussion and concluding remarks.

2 Background and Related Literature Reviews

In accessibility research, the WCAG is considered one of the major accessibility guidelines in web development globally (Martins et al., 2017). There are three levels of WCAG requirements, ranging from A (lowest) to AAA (highest). The AA level is required in EU legislation. Guidelines are organized into four principles: perceivable, operable, understandable, and robust (W3C, 2018). These requirements outline how to make web content more accessible to people with disabilities. They address all web pages, documents, and embedded software that are rendered or intended to be rendered within the web pages. In addition, WCAG 2.0 is also standardized as the ISO/IEC 40500:2012 standard (International Organization for Standardization, 2012).

With respect to the difference and acceptance of persons with disabilities as part of human diversity and humanity, the United Nations' Convention on the Rights of Persons with Disabilities defines persons with disabilities as "those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others" (United Nations, 2006). Disability is a complex phenomenon that reflects a person's functional ability to interact with their environment, including their social context. Aspects of disability may vary from entirely internal to entirely external (Newman, Browne-Yung, Raghavendra, Wood, & Grace, 2017; World Health Organization [WHO], 2002). To classify a person's functional abilities in this study, we used the ICF, agreed upon by the World Health Assembly in 2001 (WHO, 2013). The ICF provides an ontological tool for understanding functioning in a society with a focus on health, functioning, and a person's abilities, rather than focusing on disabilities that may risk separating people into different categories (WHO, 2002). Thus, the ICF helps us to understand human diversities and to collect knowledge of the needs of individuals based on impairments or complex disorders. The ICF can support eligibility assessments, service planning, and system-based data generated by administrative processes (WHO, 2013) to assess whether the needs of the individual require changes in the design or provision of personal support for system use.

The ICF proposes two conceptual models of disability. First, the medical model defines disability as a feature of the person caused by disease, trauma, or other health condition requiring medical treatment to "heal" the individuals (WHO, 2002). Second, the social model sees disability as a socially created problem in which an unaccommodating environment is created by neglecting the rights of persons with disabilities (WHO, 2002). Finally, the ICF provides an intergraded model of disability that considers both the medical and social models, including biological, psychological, and social perspectives. This so-called bio-psychosocial model of disability is organized into two parts: (1) functioning and disability, which includes body functions and structures, and activities and participation; and (2) contextual factors, including environmental factors and personal factors (WHO, 2021; WHO, 2013). Notably, the UN's Convention of the Rights of Persons with Disability (United Nations, 2006) promotes the design and development of accessible information and communications to ensure equal access for all people. This includes ITs, assistive technologies (AT), and systems, meaning that the convention supports the provision of accessible IT artifacts.

Previous accessibility-related literature reviews have examined issues related to methods, techniques, and WCAG conformity. For example, Paiva et al. (2021) conducted an SLR (N = 94) on accessibility inclusion in software engineering, different phases of the software process life cycle, and methods used in studies published 2011–2019. The phases included requirements, design, implementation, testing, maintenance, process establishment, training, measurement, process improvement, and testing and design processes (Paiva et al., 2021). They found that, for the last decade, research on the inclusion of accessibility in software development had focused mainly on testing and design processes to conform to the needs of users with visual impairment rather than hearing impaired or cognitively disabled groups (Paiva et al., 2021). Similarly, a literature survey by Mack et al. (2021) revealed that 43% of the accessibility studies reviewed focused on accessibility for blind and low-vision people. They also confirmed that the most popularly used methods focused on design, evaluation, and user studies with a median sample size of 13 participants. They analyzed 836 papers that appeared in the proceedings of the Association for Computing Machinery (ACM) Conference on Human Factors in Computing Systems (ACM CHI) and the ACM Conference on Accessible Computing (ASSETS) from 1994 to 2019 and quantified the papers' target populations, goals, and methods.

An SLR (N = 58) by Ordoñez et al. (2020) investigated studies published between 2010 and 2018 related to the model-driven development of accessible software and found that many of the proposed recommendations included the use of the WCAG. WCAG conformity seems to be an area that has received significant attention in accessibility research. According to the SLRs conducted by Campoverde-Molina et al. (2020) (N = 25, 2009–2019) and Zhang et al. (2020) (N = 31, 2009–2019), educational websites and open educational resources often fail to meet WCAG requirements. However, accessibility can be improved by using automated and manual expert evaluations of WCAG principles (Campoverde-Molina, Luján-Mora, & Valverde, 2020). The SLRs carried out by Ordoñez et al. (2020), Campoverde-Molina et al. (2020), and Zhang et al. (2020) all found that the majority of studies suggested using the WCAG to improve accessibility.

In an SLR by Cinquin et al. (2019) (N = 29, 2011–2017), the authors aimed to develop a better understanding of online e-learning platform accessibility for people with cognitive impairments. Their results indicate a weak inclusion of accessibility standards and concern that studies often tend to provide design recommendations rather than evaluating the effectiveness of e-learning platforms (Cinquin et al., 2019). In addition, many scholars argue that even full compliance with existing accessibility standards or guidelines does not guarantee a full scope of accessibility or usability or a good user experience (UX) of a website (Aizpurua, Arrue, & Vigo, 2015; Babu, Singh, & Ganesh, 2010; Lazar et al., 2004; Leuthold et al., 2008; Martins et al., 2017; Petrie, Hamilton, & King, 2003). For example, only about 50% of the problems encountered by blind users have been found to be covered by and related to WCAG checkpoints (Petrie et al., 2003; Vigo & Harper, 2013). Furthermore, most of the approaches that have implemented these standards are based on economically unrealistic models and have therefore been ignored (Leuthold et al., 2008).

In conclusion, prior research has focused on testing, designing processes, methods, and WCAG conformity, investigating who is included, what methods and tools are used, and what issue is addressed. To our knowledge, no published study has looked at the combination of factors that affect accessibility at the development and management levels and factors that cause accessibility barriers for users. To address this gap, this paper presents an SLR that aims to clarify the factors behind accessibility problems and the suggestions presented in the literature for addressing these issues.

3　Systematic Literature Review Methodology

Inspired by suggestions by Kitchenham and Charters (2007) and Okoli (2015) on how to conduct an SLR, we set a four-phase research protocol for our purposes. In general, the phases recommended by the authors involve planning, search and selection, data extraction, synthesis, and reporting. Therefore, we set our study in the following phases: (1) planning the review phase, (2) conducting the review phase (including three steps), (3) data extraction phase, and (4) data synthesis phase (Table 1). In the following chapters, we describe our SLR protocol and phases in detail.

Table 1. Procedure for Conducting the Systematic Literature Review

Phase	Phase Content	Phase Result
Planning the review	Identifying keywords, journal-selection from academic journal guide 2021, development of the review protocol.	Review protocol
Conducting the review (steps 1, 2, and 3)	Step 1: Conduct the search (First hits: 1476 articles), review title, abstract, and keywords. Exclusion criteria: keyword not found, literature review, editorial, opinion, commentary, short paper. Step 2: Review introduction and conclusions. Exclusion criteria: not focused on accessibility. Step 3: Review full article. Exclusion criteria: focus is not on accessibility in the sense of HCI.	Step 1: 398 articles Step 2: 131 articles Step 3: 82 articles
Data Extraction	Extract data with coding scheme (presented in Table 2).	Attributes collected from the primary studies.
Data Synthesis	Synthesize extracted data.	Domains, factors, roles and actions, solutions, and relationships identified.

3.1 Planning Phase

In the planning phase, we prepared a search protocol that consisted of a search strategy (keywords, database, and review protocol). We first conducted an initial search to identify relevant keywords and search strings that could be used to identify relevant studies for our purpose and objectives. We tried not to exclude potential papers in our use of keywords and string candidates; thus, instead of scoping the term to "web accessibility," we decided to use the broader term "accessibility."

We targeted research and empirical papers published in high-level journals in the IS and HCI disciplines. We selected journals recommended by the AIS Senior Scholars' Basket of Journals, as these are considered the top journals in the IS discipline (AIS, 2021-b). We selected the *European Journal of Information Systems*, *Information Systems Journal*, *Information Systems Research*, the *Journal of Association for Information Systems*, the *Journal of Information Technology*, the *Journal of Management Information Systems*, the *Journal of Strategic Information Systems*, and *Management Information Systems Quarterly*. We then selected the following tier-2 IS journals ranked by the Chartered Association of Business Schools (Academic Journal Guide 2021, 2021): *Decision Support Systems*, *Government Information Quarterly*, *Information and Management*, *Information and Organization*, *Information Society*, *Information Systems Frontiers*, *Information Technology and People*, *International Journal of Electronic Commerce*, *Internet Research*, *Journal of Computer-Mediated Communication*, and the *Journal of the Association for Information Science and Technology* (formerly the *Journal of the American Society for Information Science and Technology*). We also included top journals in the HCI discipline recommended by the AIS Special Interest Groups. These included *AIS Transactions on Human-Computer Interaction*, *ACM Transactions on Computer-Human Interaction*, the *International Journal of Human-Computer Studies*, *Human-Computer Interaction*, and *Computers in Human Behavior*. In addition, we included proceedings from the International Conference on Information Systems.

We then planned a review protocol. For our search, we used the AIS eLibrary and the journals' or conference's websites or portals. We collected articles published between 2000 and 2020. In our review protocol, we agreed to conduct the review in three steps. First, we collected articles featuring the search keyword "accessibility" in the title, abstract, or keywords. We excluded literature reviews, editorials, opinions, commentaries, and short papers. Second, we evaluated the studies by introduction and conclusion. Third, we evaluated the studies based on a review of the full paper. We decided that every article had to be evaluated by at least two authors.

3.2 Review Phase (Steps 1, 2, and 3)

In the first step of the review phase, two of the authors conducted the search for selected journals, resulting in 1476 articles, which were divided among two authors for exclusion criteria screening. We excluded 1078 articles. The foremost reason for the exclusion of articles was improper filtering by the

journal's search engine. In these cases, we screened the articles manually. At the end of step one, we had a list of 398 unique articles.

In the second step, we reviewed the selected articles' introductions and conclusions. Articles were excluded based on the focus of their content. Only studies that focused on accessibility were included. Two of the authors reviewed all the articles separately and independently from one another. The reviewers disagreed in their assessment of nine articles. To improve the quality of our review process, we reassessed articles with conflicting review results, and consensus was achieved in a meeting with all authors. Of the 398 articles reviewed, 131 were chosen for inclusion in the final step.

In the third and final step, we evaluated the articles based on their full text. Two authors conducted the evaluation, which concentrated on confirming the articles' focus on accessibility and relevance to considerations of human ability, disability, characteristics, or other diversities from the perspective of HCI. We selected 82 of the articles reviewed as primary studies. These articles were identified as relevant to our research questions and were included in the subsequent data extraction phase.

3.3   Data Extraction Phase

In the data extraction phase, we extracted information from each of the selected primary studies using an inductive approach in which we collected attributes to provide an overview of the selected studies and to collate knowledge relevant to the answer to the research question. First, we extracted descriptive attributes: journal/conference name, article title, keywords, research questions, publication year, methods, theoretical bases to have an overview of the primary studies. We then extracted attributes related to the main content of each study: main focus, main idea, contributions, future recommendations, stakeholders, and ICF coding for which we had predefined codes (Table 2).

Table 2. Coding Scheme for Data Extraction Attributes

Collected Attributes	Description of the Attribute Coded
Journal/conference name	The name of the publication venue
Article title	The title of the study
Keywords	Given keywords of the study
Research questions	Defined research questions of the study
Publication year	The year of publication
Methods	Methods applied in the study
Theoretical bases	Background theories of the study
Main focus	The focus area of the study. What is the application domain of the study? E.g., web content, game design, haptic, etc.
Main idea	The main idea of the study. What are the research aims?
Contributions	Contributions to theory and practice
Future recommendations	Provided recommendations for further research
Stakeholders	Parties related to specified group of people with disabilities
ICF coding	Specified group of people with disabilities corresponding to the ICF Browser coding scale: Body function and Structure (Mental functions; Sensory functions (seeing and related functions); Sensory functions (hearing and vestibular functions); Movement-related functions); Activities and Participation (Learning and Applying knowledge; Mobility); other

Two authors analyzed and interpreted the papers. To address our research question, we aimed to identify specific factors reported to create accessibility issues and proposed solutions. Two authors independently coded corresponding stakeholders (What human functioning or disability are concerned?), domains (Who and what factors affect accessibility?), and suggested solutions (How should the identified accessibility issue be tackled, or how should the IT artifact be designed?). We improved the accuracy of the data extraction by discussing divergent interpretations and confirming that all three authors agreed with the findings.

We focused on specific factors that cause accessibility barriers based on human functioning and disability, as these are fundamental to meeting general accessibility requirements in systems and UI designs. Thus, in order to align human functioning and disability, we modified the ICF framework to suit our research aims by including the main components of body functions (ICF code (b)) and activities and participation (ICF code (d)) (WHO, 2021). We then compared target groups from the primary studies to corresponding

ICF coding in the main categories (c.f., WHO 2021). We excluded body structures because the structure of the nervous system of an eye, for example, is irrelevant to our study purposes, and eventually, the variance in body structure reflects body functions and abilities. Furthermore, we excluded personal factors from the framework because variance in personal factors, such as age or level of stress, often appears as decreased cognitive capability. These factors were coded as Activities and Participation under the ICF Browser coding scale.

3.4 Data Synthesis Phase

In the data synthesis phase, we collated the causalities for the factors related to accessibility issues in IT artifact development and those with user perspectives. Then, we identified the corresponding stakeholders and the proposed solutions for these issues. We also categorized the elements of an IT artifact according to corresponding accessibility issues. Finally, we synthesized these findings and formulated an illustrative model to address the research question.

4 Results

In this section, we present the results of our SLR. The review phase described in Section 3.2 produced a total of 82 articles for analysis (see appendix for a list of included studies). After coding the selected papers, we identified factors at the management and development level that affect accessibility, as well as proposed solutions, which we present next in Section 4.1. In this study, we refer to developers as individuals who work at the development level, including web designers and coders. We next identified factors that cause accessibility problems in user perspective and solutions for these, which we present in Section 4.2 according to each specific body function and disability of a target group related to the ICF classifications.

4.1 Factors in Management and Development Level That Affect Accessibility and Proposed Solutions

According to Lazar et al. (2004), "accessibility is not just a high-level theoretical goal." In the IT artifact design process, several stakeholders contribute to the design of accessible interfaces, impacting perceived web accessibility (Lazar et al., 2004; Vollenwyder et al., 2019). Lazar et al. (2004) propose a "web accessibility integration model" to improve web accessibility, which identifies three categories that influence the promotion of web accessibility: (1) societal foundations, (2) stakeholders' perceptions, and (3) web development. Societal foundations include education and training, which influence web developers' perceptions of web accessibility. Policy, law, and present statistics on inaccessibility influence clients' perception of web accessibility. If neither of the two key stakeholders (web developers and clients) is aware of accessibility or willing to enhance it, the constructed website remains inaccessible (Lazar et al., 2004; Martins et al., 2017). Moreover, as the funding sources and goals of IT products in business and the public sector differ, the promotion of accessibility requires collaboration, including understanding and trust between researchers, developers, and disability advocacy organizations (Neufeldt, Watzke, Birch, & Buchner, 2007; Stienstra, Watzke, & Birch, 2007). Therefore, management and developers in the public and private sectors are in a key position to develop accessible IT artifacts. Table 3 presents a summary of domain-level factors that affect accessibility in IT artifact development. In the following subchapters, we describe each factor in detail.

Table 3. Summary of Factors in IT Artifact Development That Affect Accessibility and Solutions Proposed in the Literature

Domain	Factor(s)	Proposed Solutions	Effect	ID
Management	Support to web development	Provide education, training, manuals, and encouragement regarding accessibility that covers laws and practices of complying with guidelines and knowledge of how to apply techniques, testing methods, testing procedures, and techniques for AT compatibility (PS42, PS39, PS35, PS56, PS60, PS61, PS68) that fit local practices (PS53). Allocate time resources (PS42).	Web developers' perception of accessibility (PS42) and motivation to consider accessibility and quality of the product improved (PS35).	PS35, PS39, PS42, PS53, PS56, PS60, PS61, PS68

Management	The level of evaluators' expertise	Recruit experts to evaluate accessibility (PS82). For example, by using a barrier walkthrough method, one expert can detect 70% of the problems, two experts 94%, and three experts 100% (PS34, PS62).	Quality of measurements and validity, and reliability of the results improved (PS34).	PS34, PS62, PS82
Management	Engagement of a diverse range of stakeholders	Engage a diverse range of stakeholders, such as line managers, copywriters, and policymakers, to make accessibility a reality.	An attitude and commitment to promote accessibility.	PS59, PS64, PS65, PS72
Developers	Accessibility evaluation	Prioritize the evaluation of accessibility in general evaluation (PS75). Combine automated and manual evaluations. Automated tools can be used to identify accessibility errors violating principles (e.g., WCAG, Section 508) (PS34, PS39, PS54, PS55, PS77, PS80). These should be used regularly for new posts (PS55, PS62,). Evaluation should contain at least the homepage and first-level pages (PS78). Manual evaluation should involve a definition of the evaluation scope, techniques, and tools (e.g., user testing and result format) (PS39, PS62). Investigate client-side event logs to provide remote, informal, and asynchronous data (PS32).	Identification of accessibility errors (PS34, PS39, PS54, PS75), an understanding of characteristics and identification of barriers of event streams related to AT with real task performance (PS32). Service quality (PS69).	PS32, PS34, PS39, PS54, PS55, PS62, PS69, PS75, PS77, PS78, PS80
Developers	Use of guidelines	Use accessibility guidelines appropriate to content, like WCAG, Section 508, AbleGamers Charity, Game Accessibility Guidelines (PS21, PS35, PS39, PS62, PS63, PS66, PS75, PS76, PS77). Integrate other features, such as usability (PS13, PS11, PS40, PS39, PS38, PS35, PS57), user experience (PS47), and privacy (PS25) within accessibility.	Awareness of accessibility (PS21, PS66), web accessibility integration (PS42), and promotion of legal accessibility requirements (PS39, PS42, PS75).	PS11, PS13, PS21, PS25, PS35, PS38, PS39, PS40, PS42, PS47, PS57, PS62, PS63, PS66, PS75, PS76, PS77
Developers	Practices for users' participation and promotion of needs	Involve users with disabilities and non-disabled users using methods like participatory design, user-sensitive inclusive design (PS13, PS62), or user-centered design (PS35). Also, communicate with users after publication (PS62).	Creation of engaging experiences (PS13), exploration of new possibilities (PS13) and ideas of realistic input and output methods and actual challenges (PS4, PS13), motivation of web developers to promote accessibility (PS35), and levels of perceived privacy and satisfaction (PS25).	PS4, PS13, PS35, PS25, PS62

Developers	Design for AT compatibility	Provide easy-to-use AT extensions and natural interaction (PS22, PS29). Consider suitability for the context (PS14). Involve users with disabilities and their caregivers in designing AT (PS1, PS14).	Technology acceptance (PS18) and autonomy (PS1).	PS1, PS14, PS18, PS22, PS29

4.1.1   Support to Web Development

Managerial support for developers is crucial to achieving accessible websites. This support should involve training in accessibility importance and knowledge across the development process, including practices, as this motivates web practitioners to give greater consideration to web accessibility (Shi, 2007; Vollenwyder et al., 2019). In addition, because identified accessibility problems may not be known to managers and developers, these individuals should study how to respond to these problems (Navarro-Galera, Alcaraz-Quiles, & Ortiz-Rodríguez, 2016). Therefore, training should also engage educators, information professionals, and those who train developers and managers (Henninger, 2017). Project managers, as well as web developers, mostly face accessibility and usability compliance issues related to the complexity of guidelines and a lack of knowledge on how to incorporate accessibility techniques into different stages of the development process (Lazar et al., 2004; Martins et al., 2017; Vollenwyder et al., 2019). Therefore, providing manuals for government agencies, for example, can help them ensure that websites are compliant with regulations (Olalere and Lazar, 2011). From a sociocultural perspective, these practices should also allow for the involvement of local practices and promote synergy with local non-interactive design practices, techniques, and processes (Sharp et al., 2020). It is notable that accessibility issues are often less technical or functional. From a design science research perspective, Ilvari et al. (2020) suggest that accessibility is a criterion for artifact reusability, and should thus be reflected in the design principles of the artifact. These principles should be easy to understand, easy to comprehend, and intelligible (Iivari, Hansen, & Haj-Bolouri, 2020).

4.1.2   Evaluators' Level of Expertise

Whether or not the evaluator is a developer or an external evaluator, the management should consider the evaluator's level of accessibility expertise when recruiting to ensure the quality of measurements and to improve the validity and reliability of the results (Brajnik et al., 2011; Jaeger, 2006). Expertise can affect the quality of accessibility evaluation, especially in terms of validity and reliability (Brajnik et al., 2011). According to Lorca, Andrées, and Martínez (2012), big enterprises pay more attention to web accessibility, as they have high political costs and the resources to be more innovative and to hire experts. This finding suggests that accessibility requires resources. However, Yi (2015) suggests that there is no significant association between website accessibility and IT budget. This suggests that a lack of awareness of accessibility can present challenges.

4.1.3   Engagement of a Diverse Range of Stakeholders

In order to improve attitudes toward and commitment to promoting accessibility, managers should engage a diverse range of stakeholders, such as line managers, copywriters, policymakers, educators, and decision-makers, to make accessibility a reality (Henninger, 2017; Kennedy, Evans, & Thomas, 2011; Lazar et al., 2010; Wentz et al., 2014).

4.1.4   Accessibility Evaluation

To evaluate the level of accessibility, several studies suggest combining automated and manual evaluation procedures (Brajnik et al., 2011; Martins et al., 2017; Romano, 2002). Automated evaluation consists of automatic tools that can be used to screen websites effectively to identify accessibility errors violate design principles (e.g., WCAG and Section 508), recommendations, or other guidelines encoded in that tool (Brajnik et al., 2011; Martins et al., 2017). The evaluation should be conducted regularly to check ongoing accessibility compliance of new and updated posts on a website (Lazar et al., 2013). In order to assess the accessibility of the entire site accurately, the homepage and first-level pages should be evaluated for accessibility (Hackett & Parmanto, 2009).

As accessibility issues often require human intervention, manual assessment is still necessary (Brajnik et al., 2011). The manual evaluation procedure should involve a definition of the scope of evaluation, identification of evaluation tools, and a definition of the evaluation result format (Martins et al., 2017).

Manual evaluation may include several techniques, including inspection techniques, screening techniques, subjective assessments, and user testing (Brajnik et al., 2011). It is also necessary to evaluate perceived usability through a usability evaluation, such as a usability heuristics evaluation (Martins et al., 2017). Santana and Baranauskas (2015) propose a tool for investigating client-side event logs (usage data) of interactions that can be used to understand the characteristics of event streams related to AT and non-AT users. This technique may provide remote, informal, and asynchronous data due to the low effort required from participants and evaluators to identify barriers when AT users perform real tasks (Santana & Baranauskas, 2015). Matthew et al. (2020) propose a method for detecting arousal caused by frustration by measuring pupillary response and gaze behavior that can be used to complement other accessibility and usability testing methods. Frustration increases the level of arousal, and an increased level is a critical factor in performance and user experience (Matthews, Davies, Vigo, & Harper, 2020).

According to Brajnik et al. (2011), all these techniques differ in their generated results. Thus, the quality of the assessment method used can be considered in terms of the following: (1) effectiveness: how the method can help to identify all and only real problems; (2) usability: if the method is easy to understand, learn, and remember; (3) usefulness: the level of evaluation and how effectively the results reported by this method can be applied to practice; and (4) efficiency: the required resources for using this method. Overall, the evaluation of accessibility should be a higher priority in a general evaluation (Kamoun & Basel Almourad, 2014).

4.1.5   Use of Guidelines

The use of accessibility guidelines and practical design solutions to address the specific needs of people with disabilities is vital in the creation of an accessible website and to satisfy minimum legal requirements (Fagan & Fagan, 2004; Kamoun & Basel Almourad, 2014; Kuzma, 2010; Loiacono & McCoy, 2004; Parmanto & Zeng, 2005; Vollenwyder et al., 2019). However, if these guidelines are confusing, are hard to use, and do not cover the target group being addressed, they will likely be neglected, causing further accessibility problems (Brajnik et al., 2011; Kennedy et al., 2011; Lazar et al., 2004). Many scholars have criticized guidelines and argued that, despite the availability of existing accessibility guidelines, such as WCAG, most websites remain inaccessible (Brajnik et al., 2011; Giraud, Thérouanne, & Steiner, 2018; Lazar et al., 2004; Martins et al., 2017; Vollenwyder et al., 2019). Guidelines aim to improve accessibility from one perspective but do not necessarily consider other issues, such as privacy (Little, Briggs, & Coventry, 2005), usability (Giraud et al., 2018; King & Youngblood, 2016), or user experience (Aizpurua et al., 2015). For example, the UIs of systems used in public areas, such as ATMs, should be accessible. This might involve providing high-contrast and large text so that people may perceive the text on the screen easily while still considering strategies for preventing privacy violations (Little et al., 2005).

In some cases, web developers and web designers feel that implementing accessibility solutions will disturb their web design, as they treat their designed artifacts like pieces of art and make changes only if legislation forces them to do (Harper & Bechhofer, 2007; Lazar et al., 2004). However, some regulations only encourage designers to consider accessibility issues for people with disabilities, which means that the final decision regarding the implementation of accessibility features is made by designers (Kanayama, 2003). Nevertheless, the use of guidelines is crucial to making web content accessible and compliant with legal requirements, as well as to increasing awareness of web accessibility (Yi, 2015).

For example, Ruiz et al. (2011) implemented design for all principles in the context of a museum's multimedia guidance system to facilitate guide accessibility (Ruiz, Pajares, Utray, & Moreno, 2011). The authors provided an "accessibility mechanism" that allowed for the configuration and changing of resources to meet specific needs. For example, the guide soundtrack could be replaced with subtitling and signing windows, and images could be accompanied by an audio description, audio navigation, magnification, and a contrast modifier (Ruiz et al., 2011). Similarly, Santarosa et al. (2011) provided usability and accessibility design patterns for a full scope of implementation initiatives with the aim of reducing cognitive load and increasing autonomy for people with cognitional, sensorial, and physical needs, based on the following principles: (1) allow users to resize text, (2) label text alternatives for non-textual content, (3) allow keyboard access to all elements and functions with shortcut key orientation, (4) provide a consistent browsing mechanism, (5) place functionality in the same location and order, (6) help mechanisms provide situational sensitive content, (7) use sign language and audio in orientation, and (8) maximize compatibility with screen readers (Santarosa, Conforto, & Machado, 2014).

4.1.6 Practices for Users' Participation and Promotion of Needs

Many of the accessibility problems identified with automatic tools can be fixed relatively easily (N. E. Youngblood, 2014; S. A. Youngblood & Youngblood, 2018). However, while the use of accessibility guidelines in the design process is vital, the creation of an accessible website requires more than just compliance with existing guidelines or standards. In addition to confusing guidelines, developers also face problems such as lack of time and lack of support from the client (Lazar et al., 2004). If clients and users with a diverse range of abilities actively promote their needs and take part in the development process, accessibility (Jaeger, 2006; Vollenwyder et al., 2019) and levels of perceived privacy and satisfaction (Little et al., 2005) can become stronger. Vollenwyder et al. (2019) identify several beliefs that motivate developers to consider web accessibility: (1) involvement of users with a disability in the design process with a user-centered design method; (2) support of management through accessibility training across the development process, including practices that benefit web practitioners' "self-perceptions as a specialist," which motivates them to use their acquired knowledge in their professional capacity; and (3) acknowledgment of web accessibility by an organization as beneficial for improving the quality of the product (Vollenwyder et al., 2019).

Another major problem for developers is a lack of knowledge on how to incorporate accessibility techniques during the design process (Lazar et al., 2004). Often, developers either focus on users' limitations and compensate for these with viable solutions, or they concentrate on providing customization and alternatives in interaction patterns for existing content to prevent the impact of barriers (Martins et al., 2017). Scholars suggest involving users in the design process by using participatory design, user-sensitive inclusive design (Gerling et al., 2016), or user-centered design (Vollenwyder et al., 2019). Involving people with diverse needs and people with and without disabilities in the design process adds not only realistic perspectives regarding actual needs and challenges but also opportunities to identify new possibilities (Gerling et al., 2016; Jaeger, 2006; Seaborn et al., 2016). The involvement of users can be seen as crucial to creating engaging experiences or useful technology (Gerling et al., 2016). Moreover, communication channels should be kept open for continuous and iterative evaluation (Jaeger, 2006). Although user involvement in the design process is generally considered the most acceptable and respectful method for requirements elicitation, it also has challenges: participants' lack of experience participating in the design process, and there can be communication barriers (Gerling et al., 2016).

4.1.7 Design for AT Compatibility

AT is a means of equitable access for people with disabilities (Raisamo et al., 2019). The literature reviewed emphasizes the importance of understanding the functions and limits of AT and how users navigate IT artifacts with AT (Giraud et al., 2018; Pérez-Espinosa, Martínez-Miranda, Espinosa-Curiel, Rodríguez-Jacobo, & Avila-George, 2017). The studies reviewed primarily describe AT as an assistant that provides the inputs and outputs that a user may be lacking in an interaction (Loiacono, Djamasbi, & Kiryazov, 2013). The most widely adopted AT for digital information for individuals who are blind or visually impaired is the screen reader (Ferres, Lindgaard, Sumegi, & Tsuji, 2013). The use of read-aloud software also helps people with physical, cognitive, and literacy disabilities read an online text independently, while dictation software allows users to write text without unnecessary frustration with the keyboard, with both technologies improving user autonomy (Newman et al., 2017). Recent studies of screen readers have focused on issues with reading raw text from interface elements, such as text boxes, buttons, and menus, as well as on techniques that can interpret information from the different elements, such as graphs (Ferres et al., 2013) and simple shapes or images, through the use of haptics for people who cannot perceive visual information (Tekli, Issa, & Chbeir, 2018). Haptic assistance also improves interactions for people with motion impairments, for example, by reducing missed clicks during their interactions (Asque, Day, & Laycock, 2014). However, the use of an AT requires availability and the skills to use the technology, such as the ability to recall keyboard commands (Baldwin, Mankoff, Nardi, & Hayes, 2020).

Guerreiro et al. (2020) investigated smartphone-based virtual navigation apps that support independent navigation for blind people and could be used for learning routes and increasing prior knowledge of unfamiliar physical environments before a visit. They found that prior knowledge did not significantly improve users' performance; instead, users tended to rely on navigation systems in the moment (Guerreiro et al., 2020).

To ensure the acceptance of AT, we must make the interaction with AT as natural as possible (Pérez-Espinosa et al., 2017). For example, Pérez et al. (2019) propose a method that automatically recognizes

paralinguistic elements from voice input (e.g., shouting, hyper-articulation, and hesitation) and can be used to personalize assistive content for a user (Pérez-Espinosa et al., 2017). Furthermore, Raisamo et al. (2019) propose future research directions for wearable interactive technology that enables human augmentation, including augmented senses, augmented action, and augmented cognition (Raisamo et al., 2019). These easy-to-use wearable extensions could support the full inclusion of people with disabilities by, for example, supporting their sensorial lack with augmented senses, as well as supporting an active lifestyle for the elderly (Raisamo et al., 2019). However, the cost of these novel technologies presents a problem for full adoption, as does suitability for individual users' needs, such as hearing impairment (Raisamo et al., 2019).

Another major factor that impacts the adoption of AT is its contextual suitability (Mäkelä & Vellonen, 2018). For example, in the context of special education, educators often have the best understanding of what is appropriate to match their pupils' needs and strengths, as well as what features AT should contain to promote active participation and thus match learning goals (Mäkelä & Vellonen, 2018). Therefore, designers need to consider the specific requirements of each context (Mäkelä & Vellonen, 2018) and involve both people with disabilities and their caregivers in the design process. Mentors with disabilities can identify difficulties experienced by others with disabilities and support growth in different areas of their lives, such as career, education, lifestyle, and social activity, to help them achieve higher levels of autonomy and develop their identity (Shpigelman, Weiss, & Reiter, 2009). According to Newman et al. (2017), the key barrier that arises in online social networking and digital inclusion of young people with disabilities, such as individuals with cerebral palsy, is their parents' lack of IT confidence. If parents are not aware of the available AT and social benefits that come from being online, they may not encourage their child to use IT without outside support (Newman et al., 2017).

4.2 Factors That Cause Accessibility Problems in Specific Population Groups and Proposed Solutions

To investigate the factors that cause accessibility problems for specific groups of people with disabilities, we used the ICF as a frame to categorize these groups. We used the ICF to compare which body functions and disabilities associated with specific groups were considered by the primary studies. From the primary studies, we identified factors relating to body functions and structures (ICF code (b)), including sensory functions and pain (b2) with sub-categories; seeing and related functions (ICF code b210-b229); hearing and vestibular functions (ICF code b230-b249); and neuromusculoskeletal and movement-related functions (b7). We then looked at activities and participation (d), including learning and applying knowledge (d1) and mobility (d4) (see appendix). In some cases, we were not able to identify the level and the type of disability to correspond to the ICF sub-codes, which we then addressed to the main domain. Table 4 presents the factors identified as causing accessibility barriers for specific groups of people with disabilities in IT artifact use. In the following subchapters, we describe the general characteristics of these groups and explain the identified factors in detail.

Table 4. Summary of the User Perspective Factors Causing Accessibility Problems in IT Artifact Use and Suggested Solutions by the Literature

ICF	Factors Causing Problems	Solutions Suggested by the Literature	ID
Seeing and related functions	Relevant content is far away.	Provision of extension that restructures relevant information first (PS6). Provision of summaries of the relevant content (PS12).	PS6, PS12
Seeing and related functions	The difference between primary and secondary menus expressed visually cannot be recognized.	Provision of a dual Interface (text-only) for blind users.	PS11
Seeing and related functions	Exploration of all repeated menu options on different pages takes too much time. Menu items can be learned after one recitation of all items.	Provision of a dual interface (text-only) for blind users (PS11). Provision of a link to skip navigation (PS19).	PS11, PS19
Seeing and related functions	Unnecessary visual content and application features.	Provision of extension that allows visual content to be removed (PS6). Provision of a system that automatically removes unnecessary features (PS50).	PS6, PS50

Seeing and related functions	Toggle menu not found.	Provision of extension that allows toggle menu to be set on and off.	PS6, PS12
Seeing and related functions	Visually presented information in graphs and figures are not perceivable. Text alternatives are missing.	Use of natural language to facilitate auditory processing (PS5, PS77). Provision of alternative texts, captions, mentions text labels, and metadata when information is presented in figures, graphs, and other image-related texts.	PS5, PS56, PS58, PS61, PS67, PS77, PS79, PS81
Seeing and related functions	Links without clear indication of their goal.	Provision of consistent link with the description of its purpose (Gist summaries) and described accessibility level of the link target.	PS12
Seeing and related functions	Input field in forms is missing.	Placement of input field right after question text.	PS3
Seeing and related functions	Design is unfamiliar.	Promotion of familiar design. Ensuring that the location of functionalities and their goal are recognized.	PS12
Seeing and related functions	Focus area and status in the forms and in the application are missing.	Provision of clear feedback regarding current status (PS3, PS50). Add voice awareness (PS74).	PS3, PS50, PS74
Seeing and related functions	Looping, dead-ending, or complex navigation.	Provision of directed linear paths (allowing for exploration) (PS12). Provision of simple navigation (PS72).	PS12, PS72
Hearing and vestibular functions	Difficulty comprehending or drafting accurate grammatical sentences.	The use of a bilingual approach.	PS43
Movement-related functions (PS30) Learning and applying knowledge (PS29, PS26)	Cannot hit the target in pointing interaction.	Provision of virtual cursors (PS30, PS29). No suggestion for an alternative, but it should not be replaced with special assistance (PS26). Provision of possibilities for horizontal screen mirroring and changing cursor behavior (Up-Down) (Left-Right) (PS74).	PS26, PS29, PS30, PS74
Learning and applying knowledge	Information retrieval difficult (accurate queries, word recognition).	Use of icons and words in a list structure with an array-like format.	PS23
Learning and applying knowledge	Remembering task-related steps.	Provision of wizards for the main functions or a level-structured design.	PS26
Learning and applying knowledge	Difficult terminology or jargon and long sentences.	Use of consistent terminology grounded in everyday life and short sentences.	PS26, PS72
Seeing and related functions (PS46) Learning and applying knowledge (PS23, PS7)	The format of the content does not support individual learning styles.	Provision of a combination of multiple outputs, such as audio, text, and images.	PS7, PS23, PS38, PS46, PS72

4.2.1 Seeing and Related Functions

Twenty of the primary studies focused on user groups that had visual disabilities or visual impairments. A "blind user" refers to an individual who cannot see any light (Loiacono et al., 2013) or visually presented information on a screen (Babu et al., 2010). Despite the existence of text-to-braille technology, many blind users and users with visual impairments prefer to use text-to-speech AT to interact with computers and voice commands with smartphones, which makes the interaction a listening and speaking activity (Babu et al., 2010; Dim, Kim, & Ren, 2018; Tesoriero, Gallud, Lozano, & Penichet, 2014). Compared to sighted users, blind users have a strong ability to encode verbal auditory sounds and identify individual sounds

(Baldwin et al., 2020). However, for sighted people, visual elements and non-audible content, such as text size, colors, and formatting, may convey meaning and provide cues about web page structure and intended navigation space, while blind users must form their mental model of the structure from linearly presented audible information of navigation items and other audible cues from the visual context (Leuthold et al., 2008). Text-to-speech AT, often called screen readers, reads a web page aloud from the top left to the bottom right (Babu et al., 2010). Thus, the navigation behavior of blind users is completely different from that of sighted users, which makes surfing the web extremely difficult for blind people (Harper & Bechhofer, 2007; Leuthold et al., 2008).

Baldwin et al. (2020) investigated nonvisual computing for blind and limited-vision users through an activity theory lens. They indicated challenges that users have with organizing their activities into specific tasks, realizing current operation status, and tracking web-surfing history, for example, when operating file management windows (Baldwin et al., 2020). The problem is that screen translation tools do not filter contextually irrelevant information from the processing stream. At the activity level, the system should not translate all open applications into audio space but only the application the user is focused on. At the application level, the system should recognize the current task and automatically remove unnecessary features (Baldwin et al., 2020). Distinctions between levels of activity should be made clear and systematic in the design, and the burden of file and application management should be transferred from the user to the system (Baldwin et al., 2020). Leuthold et al. (2008) present examples of problems that blind persons face when navigating graphical UIs. First, the difference between primary and secondary menus expressed visually cannot be recognized. Second, recurring menu options on different pages can be learned only after listening to all page menus. Third, the exploration of all menu options takes time. Strategies that sighted people may use when interpreting content, such as trial and error, do not work for blind people because they require too much effort (Leuthold et al., 2008). Poor web design forces the user to spend extra time and physical or mental effort addressing problems (Babu et al., 2010).

To address this issue, Leuthold et al. (2008) propose providing a dual UI with a text-only interface for blind people. Thus, blind people can advance without having to listen to the auditive substitute for the visual content elements (Leuthold et al., 2008). However, in practice, providing an alternative interface for people with disabilities does not conform to the terms of inclusion, as it separates people into different groups. Furthermore, developers are not eager to create separate semantic mark-ups or make any compromises to their design (Harper & Bechhofer, 2007). Therefore, it is important to deal with the gap between visually pleasing sites and visually impaired users who interact with these sites (Harper & Bechhofer, 2007). Giraud et al. (2018) propose filtering all redundant and irrelevant information that is not necessary for task completion from the layout to reduce cognitive overload. For example, if web pages containing redundant elements, such as logos, menus, and advertisements, are filtered after the first page, the user will not have to listen to all these elements again while navigating pages. This will reduce cognitive load and improve performance in three usability criteria: effectiveness, efficiency, and satisfaction (Giraud et al., 2018). In addition, Aizpurua et al. (2016) emphasize the importance of providing features for skipping navigation links, as well as careful consideration of information architecture, navigation menus, and text quality to provide better UX for blind users. To support inclusion in the learning context, Morrison et al. (2019) present a tool (physical programming) that enables an inclusive learning experience for children with mixed visual abilities together with sighted children, which provides the additional benefits of supporting friendship between these children.

Technologies embedded in smartphones, such as motion sensors, have enabled the development of 3D-space motion- and gesture-based marking menus (physical movement of the device in a certain direction to assign a selection) as an alternative navigation system to voice command, which can be insufficient in noisy environments or inappropriate in quiet public environments (Dim et al., 2018). Dim et al. (2018) propose an optimal number of menu items that could be adaptable for users with visual impairments. To reduce frustration with voice guiding and increase efficiency and comfort, Dim et al. (2018) recommend that users be able to customize their menu layout. They recommend that designers use four, six, or eight items in breadth and a maximum of two-level-deep menus (Dim et al., 2018). Harper and Bechhofer (2007) propose technical solutions that allow for the emergence of implicit structural-semantic information, as this can help users find and access information. The proposed provision of an extension gives particular characteristics (upper-level ontology) to specific cascading stylesheet elements. Users can (1) remove unnecessary visual information, such as banners and advertisements, to increase reading speed and cognition; (2) turn toggle menus on and off, as these menus are inaccessible to people with visual impairments; and (3) reorder the content by bringing important items to the top by using a "document level" feature in the XHTML structure (Harper & Bechhofer, 2007).

Other visual content, such as graphs, figures, and other image-related texts, are likely to remain inaccessible to blind people unless a tool is developed that compensates vision with another sensory modality, such as sound, touch, or a combination of these (Ferres et al., 2013; Shi, 2007). According to Ferres et al. (2013), previous research related to blind users' interpretation of visual information in graphs has proposed technical solutions using haptic interfaces, sonification, natural language interfaces, and hybrid interfaces to convey visual information using touch, sound, or both. By using a vibrating touchscreen, blind users can identify, recognize, manipulate, and map simple line shapes, geometric objects, graphics, and images; however, people with visual impairments are still keen to use natural language technology when interacting with these technologies (Ferres et al., 2013). Language modality has, therefore, been more successful than haptic or sonification solutions (Ferres et al., 2013), yet the more common strategy is still to use text alternatives, captions, mentions, text labels, and metadata to ensure that people with visual disabilities are able to perceive the same information presented visually (Hackett & Parmanto, 2005; Splendiani & Ribera, 2016; Youngblood & Youngblood, 2018; Yu & Parmanto, 2011). In addition, adding additional auditory feedback to icons and nearby elements can assist users with visual impairments by providing navigational information that enables users to create strategies for task completion (Barreto, Jacko, & Hugh, 2007). For these reasons, Ferres et al. (2013) propose using a natural language interface to facilitate auditory processing of visual elements, such as graphs.

Babu et al. (2010) reported four main issues that blind users face when interacting with online assessments, questionnaires, and interactive forms. First, blind users are prone to missing questions if the system does not provide clear feedback in the focus area and status. Second, the user's answer selection for a multiple-choice question does not indicate the action of the enter key in the checkbox area. This raises difficulties in comprehending the selection process for multiple-choice questions. Third, with essay-type questions, users may have difficulty finding the input field if it is not placed directly after the question text in the layout. Fourth, users may be expelled by the system if they use the backspace key to delete text from a text input field (Babu et al., 2010).

It is necessary to understand the behavior of blind users to identify problems in their interaction with web pages. Vigo and Harper (2013) identify and categorize several coping tactics that blind users employ when facing certain situations, such as situations of uncertainty, reduced mobility, confusion, and overload. People may experience uncertainty due to unfamiliar design grounds. To avoid this, it is essential to design for familiarity, or at least learnability, by promoting the user's understanding of the task flow and making sure that all functionalities of the interface, their location, and their goal are recognized. Navigation problems that allow users to get stuck in dead-end or looping navigation paths can be avoided by providing directed linear paths together, allowing users to explore off-shoots as well (Vigo & Harper, 2013). Situations of confusion were the most common type of challenging situation encountered by blind users. Confusion can arise when exploring the links that lacked a clear indication of the goal, such as a situation in which a user becomes confused by clicking a link and landing on an unexpected page (Vigo & Harper, 2013). This problem could be solved by avoiding ambiguity and providing consistent link text that describes the purpose and goal of the link, or by providing augmented techniques, such as Gist summaries of the link target page and its level of accessibility (Vigo & Harper, 2013). Factors like high information density and the presentational order of information may cause overload (Vigo & Harper, 2013). Providing relevant summaries of the content or applying techniques that enable users to highlight important information, remove irrelevant content, or clear cluttered content can help mitigate overload (Vigo & Harper, 2013).

4.2.2 Hearing and Vestibular Functions

According to Hammami et al. (2019), 5% of the global population has disabling hearing loss, which is about 466 million people worldwide, 34 million of whom are school-aged (WHO Newsroom, 2020). Despite this large number, our SLR revealed only one study that focused fully on the accessibility issues of people with disabling hearing loss. The World Federation of the Deaf (WFD) reports that 80% of deaf people lack education and are illiterate or semi-illiterate (Hammami et al., 2019). Learners with hearing impairments face difficulties in reading and writing, comprehending or drafting accurate grammatical sentences, and internalizing the core concepts of their educational coursework (Hammami et al., 2019). According to Hammami et al. (2019), the use of technology to provide adaptable learning environments to meet the educational requirements of deaf students is vital to achieving better learning outcomes. They propose an adaptable e-learning system in which students' learning achievements are monitored by identifying and specifying any weaknesses and then determining alternative activities with specific

additions, such as conducting reading and questions in sign language and the students' official language to develop students' reading and writing skills (Hammami et al., 2019).

The majority of deaf individuals primarily use sign language to communicate. Their second language is usually the official language of their region. Deaf people usually communicate with manualism and oralism. Manualism is the communication of words and concepts through the use of the fingers. Oralism involves hearing training, high voice, and lip-reading for pedagogical purposes. New teaching methods, such as bilingual and bicultural methods, are being adopted to teach deaf students. To achieve lesson objectives in the learning context, Hammami et al. (2019) recommend concentrating on general objectives by indicating the core idea rather than the words themselves.

4.2.3   Neuromusculoskeletal and Movement-Related Functions

Four of the selected studies examined movement-related disabilities in people with motor impairments (MI). People with MI may have difficulties using standard pointing and input devices, such as mice and keyboards, to interact with computers (Almanji, Claire Davies, & Susan Stott, 2014; Pérez, Valencia, Arrue, & Abascal, 2019), and communicating and accessing education tools due to the limited dexterity of their upper limbs (Pérez et al., 2019). Individuals with MI may also have difficulty using a computer due to poor coordination, slow movements, low strength, tremors, spams, rapid fatigue, or difficulty controlling direction or distance (Pérez et al., 2019). Various AT have been developed to facilitate these needs (Almanji et al., 2014; Pérez et al., 2019). Parallel symptoms are also caused by some diseases, such as cerebral palsy, spinal cord injury, multiple sclerosis, muscular dystrophy, Parkinson's disease, arthritis, or missing limbs and digits (Pérez et al., 2019).

Further studies need to be conducted to develop a deeper understanding of how to design accessible IT artifacts to assist people with movement-related disabilities (Almanji et al., 2014). A few studies have recognized the pointing and clicking interaction (e.g., targeting and clicking a dropdown menu or other small element on a web page) as difficult for people with MI. To strengthen IT artifact interaction for people with MI, Pérez et al. (2019) recommend providing virtual cursors, like cross cursors, that highlight the mouse cursor area with a light-colored full-page cross to assist perception when pointing and clicking. An accurate understanding of the user's physical ability to use a pointing device (i.e., a mouse) is needed. The ability to use pointing devices could be measured, for example, by movement time, acceleration, average speed, or distance traveled (Almanji et al., 2014; Lin, Breugelmans, Iversen, & Schmidt, 2017; Pérez et al., 2019). Movement time is the greatest predictor of ability (Almanji et al., 2014). Furthermore, mobile device applications should be designed so that they can be used by both hands, as people do not always have the same skills or abilities in both hands (Tesoriero et al., 2014). An accurate understanding of a user's ability to move their limbs, including their finger movements, enables designers to build systems with adaptive interfaces where the system can recognize what physical control the user is using and automatically calibrate different adaptions to different individuals (Lin et al., 2017).

4.2.4   Learning and Applying Knowledge

We identified nine studies that addressed issues relating to learning and applying knowledge. Cognitive disabilities that affect the application of knowledge, learning, thinking, problem solving, and decision making (WHO, 2013) are often considered together, but individuals have different patterns of cognitive deficits. It is, therefore, necessary to consider each specific cognitive deficit when analyzing its role in interaction (Sevilla, Herrera, Martínez, & Alcantud, 2007). For example, dyslexia is a common learning disability that occurs in 3–10% of the population (Berget, Mulvey, & Sandnes, 2016). Dyslexia is treated as a permanent disability that affects word recognition, decoding, and spelling in various forms and degrees (Berget et al., 2016). Between 18% and 20% of the dyslexic population have dual diagnoses of other specific learning disabilities, such as attention deficit hyperactivity disorder (ADHD) or attention deficit disorder (ADD) (Berget et al., 2016). Dyslexia is usually discussed in learning contexts (Alghabban, Salama, & Altalhi, 2017; Berget et al., 2016). Alghabban et al. (2016) and Kennedy, Evans, and Thomas (2011) recommend providing a combination of multiple outputs, such as audio, text, and images, in learning materials to allow students to interact with the content according to their learning style. It has been argued that content with multimodal interactions, such as the use of voice to narrate pages, can remove barriers for people with cognitive disabilities (Alghabban et al., 2017; Berget et al., 2016; Kennedy et al., 2011; Sevilla et al., 2007). For example, providing icons and words in a list structure benefits both dyslexic and non-dyslexic users (Berget et al., 2016). However, other studies contradict these findings. Some scholars claim that visual content can accommodate users with reading impairments, while others

argue that pictures may distract users from the text, negatively affecting reading comprehension (Berget et al., 2016). According to Dyson and Haselgrove (2001), many accessibility studies concentrate on identifying factors that can improve reading performance and support effective reading, such as the use of sans-serif font types, large font sizes, increased letter spacing, and reduced line length (medium 55 characters per line). Beyond this, research should focus more on the barriers that dyslexic individuals and people with intellectual disabilities self-report, such as website navigation or information retrieval, that require accurate queries and word recognition skills (Berget et al., 2016; Kennedy et al., 2011).

Aging and its relationship to the development of cognitive disabilities, such as changes in sensory, motor, and cognitive abilities (Pérez-Espinosa et al., 2017), is a relevant topic, since the populations of many countries are reportedly aging. Sayago and Blat (2010) argue that factors that cause cognitive difficulties, such as cognitive load, remembering task-related steps, understanding terminology, or using a mouse, are more relevant to older people than difficulties like reading from the screen or perceiving other visual information, like icons. Aging is also a cognitive factor that influences cognitive mapping, which is a crucial component of wayfinding ability that people use to recall and understand the environment and navigate through it (Sharlin et al., 2009). To reduce cognitive load, designers should avoid using long sentences, difficult terminology or jargon in the text content of an IT artifact, as this may significantly increase older people's motivation to use information and communication technology (Kennedy et al., 2011; Sayago & Blat, 2010). Autonomy and inclusion are key factors that improve older people's motivation to use information and communication (Sayago & Blat, 2010). Autonomy means that individuals with disabilities do not need to rely on others when using the system, and inclusion means that they do not feel different or like they need special assistance (Sayago & Blat, 2010).

4.2.5 Mobility

We identified four studies on accessibility issues related to mobility. One study discussed the information-use behavior of people with physical disabilities (Liang, Xue, & Zhang, 2017), two discussed game design (Gerling et al., 2016; Seaborn et al., 2016), and one discussed AT acceptance (Barbosa, Tavares, Cardoso, Alves, & Martini, 2018). The ICF defines mobility as moving by changing body position or location or by transferring from one place to another; by carrying, moving, or manipulating objects; by walking, running, or climbing; and by using various forms of transportation (WHO, 2013).

According to Liang et al. (2017), level of disability affects how a user perceives information quality and system quality. Information quality and system quality are predictors of perceived benefits and perceived risk of using information, such as online health information. Liang et al. (2017) argue that people with a higher level of disability perceive risk as having no significant difference if the information quality is low or high; however, if the system quality is high, it has a strong positive effect on the perceived risk, which can be dangerous because fake websites, for example, can give the impression of having high system quality, which users rely on to assess risk.

Seaborn et al. (2016) identify user generated themes that should be considered in a mixed-reality game designed for people with mobile impairments. These themes contain factors, such as the inclusion of people with various skills and abilities, players on foot, opportunity to socialize with new people, opportunities to select a role that balances skill and ability fairly, challenges, accessibility, and easy-to-use equipment and UI (Seaborn et al., 2016). According to Gerling et al. (2016), the involvement of people in wheelchairs and non-disabled people in the design of games with participatory designs is crucial to designing an engaging experience that is realistic regarding disability, has the concept of play, and is technically feasible. Barbosa et al. (2018) investigated how wheelchair users might be assisted by providing context-aware assistance based on location information produced by ubiquitous technology integrated into a wheelchair and how this technology is accepted. This type of inclusively designed AT can provide positive social opportunities and autonomy for people with disabilities (Barbosa et al., 2018).

5 Synthesizing Research Findings

We identified management- and development-level factors that affect accessibility and possible solutions suggested in the literature (Table 3). We also identified factors that cause accessibility barriers for users and solutions for these (Table 4). To develop an understanding of the key factors and actions between domains, we interpreted the results and synthesized what needs to be addressed to achieve accessible IT artifacts. As shown in Figure 1, we identified four domains, the factors within them, and their roles and actions that influence the realization of accessibility. The domains are (1) user, (2) management (3)

developers, and (4) features of IT artifact. We identified relationships between these domains, which include interaction loops. These interaction loops are illustrated as an arrow (Arrow a-g) in Figure 1. The relationships include (1) the interaction between user and IT artifact features, (2) the interaction between user and developers, (3) the interaction between developers and management, and (4) the interaction between developers and IT artifact. In the following sub-sections, we discuss the key factors by domain, how they should be addressed, and what are the essential interactions between them.
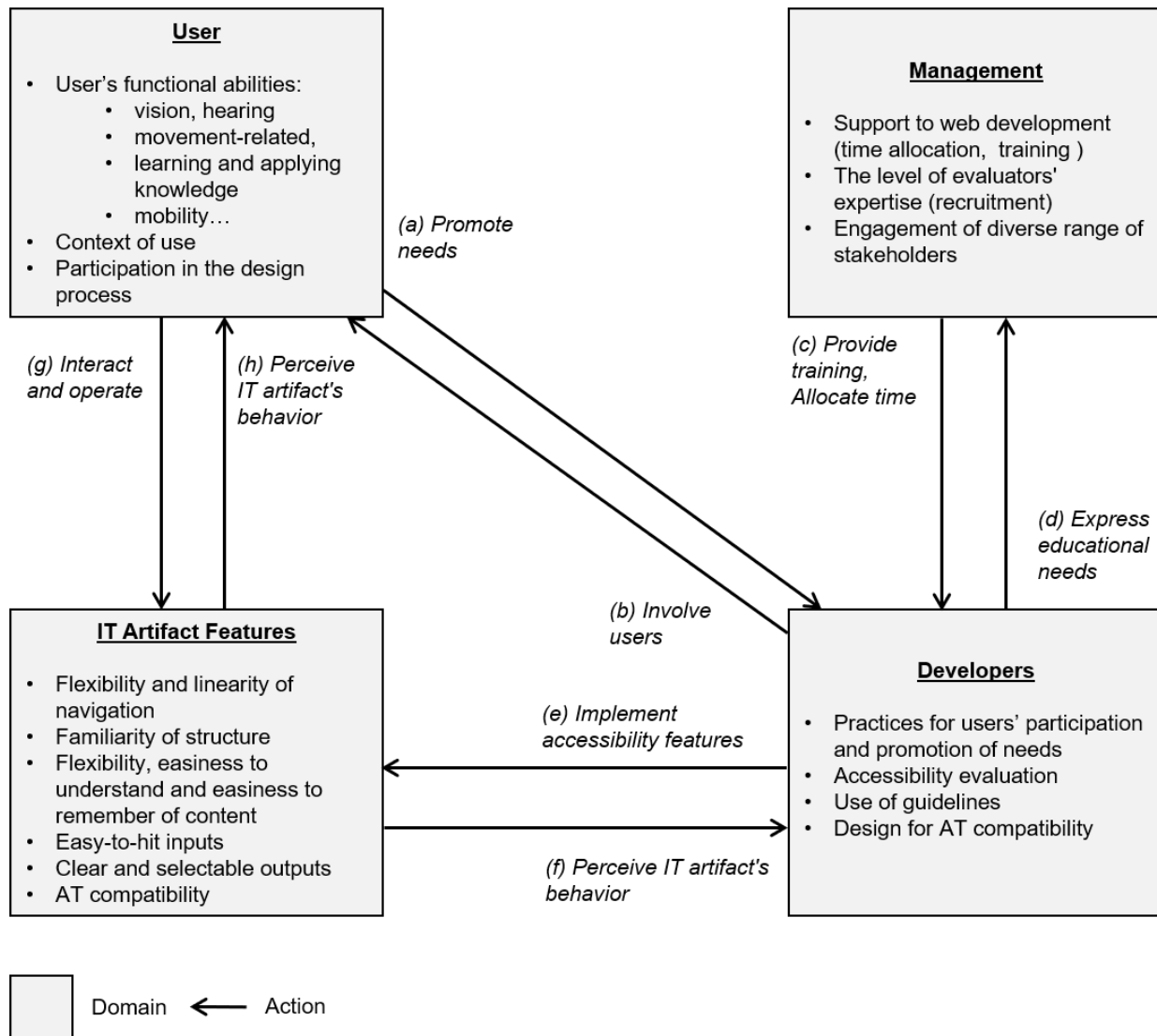

Figure 1. Key Factors and Solutions Affecting Accessibility

5.1 User

In the user domain, four factors related to the *user's functional abilities* affect a user's interaction with an IT artifact, including their sensory ability (e.g., seeing and hearing), movement-related ability, ability to learn and apply knowledge (cognitive), and ability for mobility. Information about the *context of use* and *participation in the design process* are two additional factors that influence developers' knowledge. Therefore, research-based knowledge of users' abilities (see Section 4.2) and *users' promotion of their actual needs* (Arrow a) through participation in design and evaluation processes are crucial to expanding developers' knowledge of accessibility issues and motivation to promote accessibility and to explore new opportunities of experience. During participation, *users interact and operate* (Arrow g) with an IT artifact in development and *perceive the IT artifact's behavior* (Arrow h), thereby increasing their awareness of their own needs for IT artifact features. These needs should involve the factors that the interaction with an AT raises and information about the users' context (Mäkelä & Vellonen, 2018; Santana & Baranauskas, 2015). These need should be communicated to developers. Depending on the participant's level of

disability, their caregivers should also be invited to participate to ensure thorough information gathering (Mäkelä & Vellonen, 2018; Newman et al., 2017). Detailed descriptions of the factors related to accessibility barriers for each group and proposed solutions suggested by the primary studies have been described previously in Section 4.2.

5.2 IT Artifact Features

We reviewed studies that explored accessibility barriers for particular groups of people and made suggestions as to how to design and implement accessibility in IT artifact features to break down these barriers. Our synthesis identified six key factors related to IT artifact features. As these factors describe IT artifact features, they can be considered suitable solutions to improve accessibility. These factors include *flexibility and linearity of navigation*; *familiarity of structure*; *flexibility, ease of understanding*, *and ease of remembering content*; *ease-to-hit inputs*; *clear and selectable outputs*; and *AT compatibility*.

Accessibility issues relating to navigation often present barriers for users with seeing and related disabilities. Our results reveal that accessible navigation should be flexible and straightforward. The navigation should provide one mechanism (Leuthold et al., 2008) that is as linear as possible, allowing for exploration (Vigo & Harper, 2013); should allow the user to skip navigation (Aizpurua et al., 2016); should be modifiable (Harper & Bechhofer, 2007; Vigo & Harper, 2013); and should provide information about links with informative names (Aizpurua et al., 2016).

An accessible structure should also be familiar (Vigo & Harper, 2013). Its elements should be in consistent locations, and the goal of its functionalities clearly indicated (Babu et al., 2010; Vigo & Harper, 2013).

Poor accessibility of content affects the interaction of users with visual, auditory, and cognitive disabilities. To improve accessibility, the content should be flexible, easy to understand, and easy to remember. Flexibility means that IT artifacts should contain functions or extensions that allow users to remove visual content and reorganize relevant content to appear first (Baldwin et al., 2020; Harper & Bechhofer, 2007), or the relevant content should be designed so as to appear first (Vigo & Harper, 2013). All visually presented information (e.g., graphs) should also be presented as natural language so that screen readers can read these (Ferres et al., 2013; Hackett & Parmanto, 2005; Splendiani & Ribera, 2016). Easy to understand means that the text content should be presented with consistent and everyday terminology and with a bilingual approach (Hammami et al., 2019; Sayago & Blat, 2010). List structures should be presented with icons to improve word recognition (Berget et al., 2016). Easy to remember means that the exploration of the content should be guided with task-related steps, or tasks should be designed on a level structure (Sayago & Blat, 2010).

Interaction with pointing devices may present a barrier for users with movement-related or cognitive disabilities. An IT artifact should help users to hit the target with a pointing device (e.g., mouse) by providing virtual cursor assistance to indicate the cursor area (Almanji et al., 2014; Pérez-Espinosa et al., 2017). This technique should be implemented not as special assistance but as a regular feature so that individuals do not feel that their need for special assistance weakens their feeling of inclusion (Sayago & Blat, 2010).

If IT artifact outputs are based on only one format, this may cause barriers for people with visual or cognitive disabilities. Thus, IT artifacts should contain multiple modalities in output formats, such as text, audio, and images, so as to share information that is selectable by the user (Alghabban et al., 2017; Berget et al., 2016; Ruiz et al., 2011; Sevilla et al., 2007). The focus area should be indicated with clear feedback (Babu et al., 2010; Baldwin et al., 2020).

5.3 Management

Management-related key factors and solutions in IT development projects relate to the *support of web development*, including *training and time allocation* (Arrow c) for the project (Lazar et al., 2004; Martins et al., 2017; Sharp et al., 2020; Vollenwyder et al., 2019) and *recruitment of end-users*, and the utilization of designers' knowledge and expertise of accessibility issues, motivating them to conform to users' needs (Gerling et al., 2016; Little et al., 2005; Seaborn et al., 2016; Vollenwyder et al., 2019). Also, *the level of evaluators' expertise* should be considered when recruiting expert evaluators (Brajnik et al., 2011). To ensure a continuum of product accessibility, management should *engage a diverse range of stakeholders* to promote accessibility.

5.4   Developers

Developer-related key factors and solutions relate to *practices for users' participation and promotion of needs.* User requirement elicitation is the one step of IT artifact design process in which designers extract information from the users and other resources to provide design implications that comply with users' needs. *Involving users* (Arrow b) in promoting their needs is a key factor in understanding users' actual needs. User–developer collaboration should involve requirement elicitation, design evaluation, user tests, and so forth, using methods like participatory design, user-sensitive inclusive design, and user-centered design (Gerling et al., 2016; Little et al., 2005; Seaborn et al., 2016; Vollenwyder et al., 2019). The studies reviewed did not specify how many users and from which group of population should be involved in the development process.

An *accessibility evaluation* should be conducted using automated evaluation against principles and manual evaluation (Brajnik et al., 2011; Martins et al., 2017; Santana & Baranauskas, 2015). To confirm a certain level of accessibility, *the use of accessibility guidelines* (e.g., WCAG) and standards are vital but often insufficient alone (Cairns, Power, Barlet, & Haynes, 2019; Martins et al., 2017; Vollenwyder et al., 2019). The integration of other features, like usability, user experience, and privacy, is needed for the final design solution (Aizpurua et al., 2015; Gerling et al., 2016; Leuthold et al., 2008; Link, Armsby, Hubal, & Guinn, 2006; Little et al., 2005; Martins et al., 2017; Ruiz et al., 2011; Vollenwyder et al., 2019). When *designing for AT compatibility*, natural interaction, integration of easy-to-use AT extensions, and appropriateness given the context should be designed and validated with users (Mäkelä & Vellonen, 2018; Newman et al., 2017; Pérez et al., 2019; Pérez-Espinosa et al., 2017; Raisamo et al., 2019). If knowledge of these methods and techniques is lacking, it should be *expressed to the management* (Arrow d). During the design process and testing, developers must *implement accessibility features* into the IT artifact (Arrow e) and *perceive the IT artifact's behavior* (Arrow f).

6   Discussion

This SLR aimed to explore the factors related to accessibility barriers that should be considered when designing an accessible IT artifact as well as the solutions to accessibility barriers posed by the extant literature. These factors are presented as micro-level factors that have an impact on individual perceptions of accessibility, and management and development-level factors related to the IT artifact design project management and development processes.

This review adds to the body of knowledge by identifying the factors that present barriers to the accessible use of IT artifacts and by categorizing IT artifact features where these barriers occur. This review also identifies factors that affect accessibility and should be considered in IT artifact development. The AIS "basket of eight," tier-2 IS journals, and AIS-recommended top HCI journals reviewed did not produce any SLR studies on the same topic within the study timeframe. We found that literature reviews on accessibility factors and solutions are infrequent, especially in the IS discipline.

Other accessibility-related SLRs, such as the studies by Paiva et al. (2021) and Mack et al. (2021), present methods and tools that researchers have suggested could be used to incorporate accessibility into different phases of software development. Their findings also indicate that studies lack user group representation, including hearing impaired and cognitively disabled groups. The SLRs carried out by Ordoñez et al. (2020); Campoverde-Molina et al. (2020); and Zhang et al. (2020) found that most articles on the topic suggest using the WCAG to improve accessibility. However, the findings of the present study reveal that using only the WCAG is not enough to create accessible IT artifacts. This claim is supported also by Petrie et al. (2003) and Vigo and Harper (2013), who suggest that only about half of the accessibility issues encountered by blind people are covered in the WCAG.

Compared to previous studies, this study presents accessibility barriers that users with different abilities may face during their interaction with IT artifacts. This study has described design solutions that address these critical barriers and give users the opportunity to better use IT artifacts. After this critical point (when the user is able to use the IT artifact), we must question how the user perceives other features, such as usability, privacy, and good user experience. Many definitions of accessibility in the literature emphasize the importance of including usability in accessibility (Petrie, Savva, & Power, 2015); however, only a few studies have investigated this integration. Martins et al. (2017) provide a full scope of evaluation, which inspects accessibility and usability separately. Aizpurua et al. (2016) suggest a significant connection between how perceived web accessibility correlates with user experience features. Santarosa et al. (2011) provide a combination of accessibility and usability design patterns, which improve the perception of both

of these features for deaf users, blind and low-vision users, users with reduced mobility, and users with attention deficit disorders and intellectual disabilities. Therefore, we agree that accessibility, usability, user experience, and privacy are all important considerations, but in light of our findings, we feel that accessibility and usability should be discussed in the research as unique features, as defined by the ISO standard and WCAG (International Organization for Standardization, 2018). In practice, this will improve the performance of both features because, if we were to combine these two features, it might confuse the evaluation, focus of the design, and focus of the development process, including training of the practices, which may result in overlap and some factors being missed. For example, instead of efficiency, accessibility describes the extent of autonomy (Ferres et al., 2013). More research is needed to clarify the methods and techniques for integrating these two features into one solution.

As a contribution to practice, we identified three qualities that together create a goal for accessibility. These qualities include users' perceived autonomy, perceived system quality, and perceived information quality. The goal describes the user's state of use and should be the goal of developing more accessible features. Accessibility is the extent to which users can interact and operate (using their perception, cognition, and action) (Babu et al., 2010; Gerlach & Kuo, 1991) a system successfully without external assistance. Therefore, one quality of accessibility is autonomy (Barbosa et al., 2018; Ferres et al., 2013; Newman et al., 2017; Santarosa et al., 2014; Sayago & Blat, 2010; Shpigelman et al., 2009). According to Ferres et al. (2013), autonomy is even more important than efficiency for certain people, such as those with seeing and related disabilities. Autonomy also influences motivation to use IT artifact in the future (Sayago & Blat, 2010).

Perceived system quality is a multidimensional quality, but from an accessibility perspective, accessibility itself is the strongest predictor of system quality (Liang et al., 2017). Other factors of system quality, such as fastness, navigability, and readability of the content (Liang et al., 2017), can be improved through accessibility features. For example, fastness can be improved by reducing cognitive load and improving remembering. Navigability can be improved through several accessibility factors related to navigation. The readability of content can be improved using a bilingual approach and by addressing the factors related to information architecture. Similarly, information quality can be improved by implementing accessibility features. Accessibility features themselves improve information perception. For example, intrinsic, contextual, accuracy, and completeness (Alkhattabi, Neagu, & Cullen, 2011), can be improved by context-sensitive design and by addressing the factors related to information architecture.

Information quality and system quality are both beneficial for value creation (Li & Shang, 2020). Information quality increases people with physical disabilities' perception of benefits, while system quality decreases their perceived risk (Liang et al., 2017). These two qualities have a positive effect on use behavior (Liang et al., 2017).

In sum, in order to achieve accessible IT artifacts (considering perceived autonomy, perceived system quality, and perceived information quality), management and developers need to follow the suggestions presented in Table 3. The user perspective factors identified as causing accessibility problems and the proposed solutions to these issues (presented in Table 4) should be addressed when designing IT artifact features. Lastly, the key factors and solutions, including actions between domains, presented in Figure 1 should be addressed.

Our study identified accessibility research themes related to the following issues that we recommend for further research in the IS and HCI disciplines:

(1) **Text content accessibility:** Our results reveal several suggestions for designing accessible content (e.g., locating relevant content first, using a bilingual approach, using everyday terminology). What guidelines can support content creators in producing accessible text that is beneficial for people with various disabilities, not just people with learning difficulties? It is noteworthy that text is still the primary form of information sharing on the web (Kalender et al., 2018), which makes reading the primary form of content interaction (Rello, Pielot, & Marcos, 2016).

(2) **Users with communication disabilities:** As interaction with IT artifacts often requires communication using language, signs, and symbols, including receiving and producing messages and carrying on a conversation (WHO, n.d.), IT developers need to consider possible barriers. What factors influence accessibility for users with communication disabilities?

(3) **Human augmentation and social acceptance of AT:** AT is often discussed in accessibility studies as it can augment users' abilities (Raisamo et al., 2019). Screen readers are a mainstream

AT that are crucial for some and benefit many users, including blind and visually impaired users and users with learning difficulties. Yet few studies have investigated the use of AT to assist users' thinking (e.g., cognitive matters) or communication. Furthermore, the use and acceptance of AT depend on how users perceive social acceptance, which influences their decision to apply these technologies. How does social acceptance influence AT acceptance?

(4) **Universal accessibility:** As stated before, the universality of accessibility solutions is rarely discussed in the literature. We see that the causalities between different features, such as accessibility and usability, are still underrepresented. Therefore, we suggest that IS and HCI research continue to examine how these two features and their design patterns affect one another. Further research should also look at how users with different levels of ability perceive these features. In addition, research should investigate how these design patterns can be integrated into one design solution.

This study, however, has its limitations. First, we based our SLR on the selected list of journals recommended by AIS and ranked by the Chartered Association of Business Schools. This scope may create some biases because the database is restricted to certain journals. We, however, identified 82 primary studies relevant to our research question which enabled us to achieve our research goals. Therefore, we believe we had a good sample that represented top and tier-2 IS research and top HCI research. Then, we used the search term "accessibility" solely. This may exclude some papers that used other similar terms. We expected that studies focused on accessibility do use this term in the paper. Third, the authors may have misinterpreted the results of primary studies in the data extraction phase. To avoid this, every step of exclusion was conducted by at least two authors to ensure the reduction of biases.

7   Conclusion

This paper presented a SLR of articles published in the top IS and HCI journals recommended by the AIS, and tier-2 IS journals ranked by the Chartered Association of Business Schools. Our findings produced a set of factors that affect accessibility in the development of IT artifacts and solutions to tackle these. We then listed the factors that led to accessibility barriers from the perspective of the user, and solutions to tackle these. We based user abilities on the ICF. Finally, we synthesized and illustrated factors and solutions related to accessibility.

Based on the results presented in this paper, a user's functional abilities—including sensory abilities, such as seeing and hearing; movement-related abilities; cognitive abilities, including the ability to learn and apply knowledge; communication abilities; and mobility—set certain design requirements for the features of an IT artifact. Some of these requirements address more than one ability. The elements of an IT artifact that feature these requirements relate to navigation, structure, content, input method, and output method. Specifically, navigation must be flexible and straightforward, the structure must be familiar, the content must be flexible and easy to understand and remember, the inputs must be easy to hit, and the outputs must be selectable and provide clear feedback.

Regarding the development of an IT artifact, managers, developers, and users play an important role in promoting accessibility. In the management domain, project managers influence accessibility knowledge by providing education and training for developers, recruiting experts to evaluate accessibility, and allocating time resources to the project. In the development domain, we identified factors that affect accessibility conformance. We found that users with disabilities, their caregivers, and non-disabled users should be involved in the design, testing, and evaluation processes to promote their actual needs. The compatibility of accessibility guidelines is vital to gaining a certain level of accessibility and complying with legal requirements but should not be used as the only method. Techniques for applying these guidelines should be considered in training. Evaluation should combine automated tools to identify accessibility errors that violate accessibility guidelines and manual evaluation procedures, including user testing and event logs. Other features, such as usability, user experience, and privacy, should be considered and integrated into the design so that they do not violate each other. The compatibility of AT should be considered in the design or integrated into the IT artifact as an extension. The AT should be designed with collaboration from users with disabilities and their caregivers to ensure suitability to the context. The IT artifact's suitability to the context should be considered in a context-sensitive design. Finally, we identified three qualities that that together create a goal for accessibility: perceived autonomy, perceived system quality, and perceived information quality.

These results provide future research directions for developing knowledge on accessibility. First, people with communication disabilities could be a target group for future studies, as they are a less studied group. Second, few studies have focused on how to produce accessible text not just for dyslexic individuals but also for those with other disabilities. We identified several design patterns to create accessible content, but future studies could extend this line of research. Third, studies on AT have have focused on the provision of augmented access, including input and output methods, but assistance for cognitive matters and the perceived social acceptance of these technologies have received less attention. We believe that gaining an understanding of needs in these proposed areas and integrating these needs into IT artifact design will be a step toward universal accessibility.

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Appendix: List of Primary Studies by ICF Category

ICF Domain Codes: Body functions and structures (b); Activities and participation (d)

ICF Sub-Domain Codes: Seeing and related functions (b210-b229); Hearing and vestibular functions (b230-b249); Neuromusculoskeletal and movement-related functions (b7); Learning and applying knowledge (d1); Mobility (d4).

ID	Paper	Specific Research Focus and Study Participants	Summary of Findings
ICF Domain Code: Body functions and structures (b) **ICF Sub-Domain Code:** Seeing and related functions (b210-b229)		
PS3	(Babu et al., 2010)	Blind users' web accessibility and usability problems, 6 participants with blindness	Blind users encounter the following problems with forms and questionnaires: susceptibility of skipping a question; inability to comprehend the process of answering multiple-option questions; ambiguity about responding to short-answer questions; threat of losing the assessment.
PS5	(Ferres et al., 2013)	Evaluation of a tool that improve access to charts and graphs, 10 participants with blindness and 10 sighted	"People with visual impairments can interact with natural language interfaces accurately to answer relatively complex questions about simple line graphs."
PS6	(Harper & Bechhofer, 2007)	Semantic web, persons with visual impairment	Semantic information encoded in documents can help users to understand visually presented information.
PS11	(Leuthold et al., 2008)	Design of text UIs, 39 participants with blindness	With text user interface, users can perform tasks faster with fewer mistakes.
PS12	(Vigo & Harper, 2013)	Coping tactics on the web, 19 participants with visual impairment or blindness	Coping in the web occurs in situations of uncertainty, reduced mobility, confusion, and overload.
PS15	(Dim et al., 2018)	Motion marking menu UI in smartphones, 12 participants with visual impairment or blindness	Participants can perform menu selections using marking menus faster than when using a touch-based menu.
PS16	(Lahib, Tekli, & Issa, 2018)	Vibrating touchscreens, 29 participants (6 blind since birth, 7 blind after birth, 16 sighted persons)	Fitts' Law can be applied to evaluate blind candidates using the vibration modality on a touchscreen and varying target sizes and distances on the touchscreen.
PS17	(Tekli et al., 2018)	Vibrating touchscreens for shapes and graphs, 29 participants with blindness or blindfolded	Participants are capable of accessing simple shapes and graphics presented on a vibrating touchscreen. However, issues, such as prolonged time, remain.
PS19	(Aizpurua et al., 2016)	Web accessibility correlation to UX, 11 participants with blindness	Web accessibility is correlated with UX.
PS20	(E. T. Loiacono et al., 2013)	Factors affecting user acceptance in a website, 59 participants with visual impairment	Reliability and convenience of access to information in websites should be considered in acceptance models.
PS24	(Bicakci & Kiziloz, 2016)	Human interaction proofs, 372 participants (203 normal vision, 162 "corrected to normal," 3 partially sighted, 2 with blindness)	Pure text-based human interaction proofs are more enjoyable than visual human interaction proofs.
PS31	(Giraud et al., 2018)	The effect of redundant and irrelevant information on a website, 76 participants with blindness	Filtering redundant and irrelevant information on a website reduces cognitive load.
PS33	(Morrison et al., 2019)	Computational learning with physical programming, 30 teachers and 75 children with vision impairment, blindness, or learning and physical disability	Children can learn computation successfully using physical programming.
* PS37	(Santarosa et al., 2014)	Universal design, Persons with visual or hearing impairment, or users with reduced mobility	UIs and tools with universal design address the user's cognitive, sensorial, and physical specificity intending to minimize cognitive load and develop more autonomy for people.

PS44	(Barreto et al., 2007)	Spatial auditory feedback in computer use, 10 volunteer with visual impairment	"Spatialization of icon sounds provides additional remote navigational information to users, enabling new strategies for task completion."
PS47	(Aizpurua et al., 2015)	The influence of prior experience to accessibility, 11 participants with blindness	Past experience affects the way in which users perceive and experience accessibility and UX.
PS50	(Baldwin et al., 2020)	Computing, 11 students with vision impairment or blindness	Changes between active windows and the status of operations at the application level should be designed with systematic distinctions between activity levels to reduce struggling in computing.
PS51	(Guerreiro et al., 2020)	Virtual navigation, 14 participants with blindness	Participants rely on their navigation system rather than virtually learned navigation routes before navigating in the real world, even if the system advances their prior knowledge of the environment.
PS62	(Jaeger, 2006)	U.S. governmental webpages, multi-methodological evaluation included 10 participants with visual or mobility impairments	Lacks the compliance with Section 508. Suggestions: design for accessibility, involve users with disability in testing, have accessibility experts in development team, use automated testing tools, have open communication channels, test accessibility on iterative basis, focus on accessibility for all users.
PS74	(Tesoriero et al., 2014)	Perception of the selection and environment on the screen	Voice awareness; operations should be usable with both hands; possibilities to adjust the font size.
ICF Domain Code: Body functions and structures (b) **ICF Sub-Domain Code:** Hearing and vestibular functions (b230-b249)			
* PS37	(Santarosa et al., 2014)	Multiple foci. See previous description.	
PS43	(Hammami et al., 2019)	Adaptive learning systems, Students with hearing impairment	An adaptive learning system improves students' reading and writing skills.
ICF Domain Code: Body functions and structures (b) **ICF Sub-Domain Code:** Neuromusculoskeletal and movement-related functions (b7)			
PS9	(Lin et al., 2017)	Adaptive interface design, Physical disabilities, particularly arthritis (in the hand)	Comprising eye-tracking and data glove technologies, user's physical ability can be translated to computer controls that utilize the user's abilities rather than focusing on disability.
PS10	(Asque et al., 2014)	Haptic assistance, 6 participants with different degrees of motion-impairment	Deformable haptic cones and deformable virtual switches reduce missed clicks and targeting time.
PS18	(Pérez et al., 2019)	Virtual cursors, 15 participants (9 with motor impairments and 6 without disability)	Virtual cursors improved the effectiveness and efficiency of most participants in link selection.
PS30	(Almanji et al., 2014)	Effects of impairment severity on cursor control, 29 participants with bilateral cerebral palsy	Movement time, acceleration–deceleration cycles, and average speed are used to assess different MACS (Manual Ability Classification System) levels.
* PS74	(Tesoriero et al., 2014)	Multiple foci. See previous description.	
ICF Domain Code: Activities and participation (d) **ICF Sub-Domain Code:** Learning and applying knowledge (d1)			
PS7	(Sevilla et al., 2007)	Web accessibility, 20 participants with a cognitive disability	"Equivalent but alternative content is a good model for people with cognitive disabilities."
PS8	(Sharlin et al., 2009)	A tangible user interface for assessing cognitive mapping ability, 20 participants	The use of tangible UIs for assessing cognitive mapping ability can improve flexibility, accessibility, sensitivity, and control.
* PS13	(Gerling et al., 2016)	Participatory design, 9 young wheelchair users with cognitive disabilities and 22 undergraduate students	The involvement of both groups is crucial for creating engagement, technical feasibility, and understanding realistic perspectives of disability.
PS23	(Berget et al., 2016)	Advances of visual content in text search, 21 participants with dyslexia and 21	Presenting icons and words in a list structure will benefit both groups in terms of search performance.

		controls	
PS26	(Sayago & Blat, 2010)	E-mailing (ethnographical study), 388 older people	Barriers, such as cognitive load, difficulties using input devices, and perception of visual information are recognized. Cognitive difficulties are much more relevant than difficulties in reading from the screen.
PS29	(Pérez-Espinosa et al., 2017)	Speech-based systems, 62 participants (31 elderly and 31 younger)	A method of recognizing paralinguistic phenomena in a speech, such as shouting, or hesitation could be used to estimate the quality of an interaction.
* PS36	(Shpigelman et al., 2009)	E-mentoring, 13 pupils with physical, emotional, behavioral, or intellectual impairment	E-mentoring with peers can improve personal development and empowerment.
PS46	(Alghabban et al., 2017)	Multimodal interface for learning	The use of multimodalities (images, audio, and text) for content supports learning.
PS72	(Kennedy et al., 2011)	Best practices for building websites for people with intellectual disabilities, 31 web designers and developers with 29 people with intellectual disabilities	Images to communicate core content; simple navigation; simple text; short sentences; voicing to narrate pages; and incorporate video, animation, and sound; the attitudes of decision-makers; engagement with stakeholders.
ICF Domain Code: Activities and participation (d) **ICF Sub-Domain Code:** Mobility (d4)			
PS2	(Liang et al., 2017)	243 participants with physical disabilities (difficulties walking, climbing stairs, lifting heavy groceries, or getting in and out of bed)	"Physical disability weakens the effect of information quality on perceived risk, strengthens the effect of system quality on perceived risk, and strengthens the effect of perceived benefits on information use."
PS4	(Seaborn et al., 2016)	Mixed-reality gaming for powered chair users, 13 adult participants who use a powered wheelchair	Mixed-reality game design should consider device and UI accessibility; inclusion of player skills allowing them to improve these; socialization with others; and game challenge.
* PS13	(Gerling et al., 2016)	Multiple foci. See previous description.	
PS28	(Barbosa et al., 2018)	Context-aware systems to assists wheelchair users, 10 wheelchair users	The use of ubiquitous technologies to support accessibility for wheelchair users are useful and acceptable.
* PS62	(Jaeger, 2006)	Multiple foci. See previous description.	
Accessibility itself (not in ICF)			
PS1	(Newman et al., 2017)	18 young people (10-18) with a physical disability (CP) acquired brain injury, 17 parents	Intensive, personalized and long-term support from within and beyond (peers and tutors) the family to get online is required. Parents' limited IT confidence, IT knowledge and access to appropriate AT influences the amount of support required.
PS14	(Mäkelä & Vellonen, 2018)	Education tools for special education, 57 participants special education teachers and school assistants	Do-it-yourself tools can give special educators a more active and creative role in technology adoption and benefit special education by increasing accessibility, motivation, and interaction possibilities.
PS21	(Cairns et al., 2019)	Accessibility in games, Persons with disabilities	Accessibility in games should not only consider whether people can operate the games but also their perceived experience.
PS22	(Raisamo et al., 2019)	Human augmentation, Persons with different disabilities (conceptual)	Integrated and intelligent wearable systems are the next progression in augmenting human abilities, but they have also potential ethnical and societal issues.
PS25	(Little et al., 2005)	Public space systems privacy and accessibility design, 60 participants	Screen sizes in public space systems, such as ATMs, affect users' perception of privacy.
PS27	(Dyson & Haselgrove, 2001)	Reading speed and line length, 36 participants	"A medium line length (55 characters per line) appears to support effective reading at normal and fast speeds."
PS32	(Santana & Baranauska	A remote evaluation tool for usage patterns,	By considering data of real usage patterns, potential usability and accessibility problems can be identified.

		s, 2015)	180 participants	
PS34	(Brajnik et al., 2011)	The effect of expertise on web accessibility evaluation, 19 expert and 57 non-expert judges	Expertise matters in the quality of accessibility evaluation, especially in validity and reliability.
PS35	(Vollenwyder et al., 2019)	Web practitioners' intention to consider web accessibility, 342 practitioners, Web questionnaire	Web practitioners' intention to consider accessibility is influenced by users' promotion of their needs, the role of professionalism, and desire for a high-quality product.
* PS36	(Shpigelman et al., 2009)	Multiple foci. See previous description.	
* PS37	(Santarosa et al., 2014)	Multiple foci. See previous description.	
PS38	(Ruiz et al., 2011)	Design for all, persons with hearing impairment	Multimodality in input and output modalities can be used to design inclusive technologies.
PS39	(Martins et al., 2017)	Accessibility evaluation procedure, Conceptual	Automatic web accessibility evaluation, manual web accessibility evaluation, and web usability heuristics evaluation should be conducted to identify accessibility and usability issues.
PS40	(Link et al., 2006)	Accessibility and acceptance of virtual human technology, 50 telephone interviewees	Responsive virtual human technologies with improved speech recognition have a potential for training and educational purpose.
PS41	(S.-H. Li et al., 2012)	WCAG study, Conceptual	Transforming WCAG-compliant webpages to correspond with updated versions does not require a full revision of the webpages.
PS42	(Lazar et al., 2004)	Web practitioners' intention to consider web accessibility, 175 webmasters, A survey	Societal foundations, stakeholders' perception, and web development influence web accessibility.
PS45	(Alkhattabi et al., 2011)	Information quality, 27 students	Availability, relevancy, accessibility, and response time indicate accessibility quality factors.
PS48	(Owei & Maumbe, 2006)	E-services in developing country, Conceptual	Strategies for e-service modeling, design, development, implementation, marketing, and access are needed for integration.
PS49	(Iivari et al., 2020)	Accessibility as a criteria of reusability in design science research, Conceptual	Design principles for IT artifacts should be accessible to be reusable.
PS52	(Matthews et al., 2020)	Pupillary response during interaction, 40 participants	Pupillary response indicating arousal (as frustration) during interaction is a potential setting in usability and accessibility lab testing.
PS53	(Sharp et al., 2020)	Sociocultural factors and capacity building in interaction design, 10 participants	Synergy between local design practices and interaction design practices is recommended.
PS54	(Kuzma, 2010)	UK governmental websites, 130 websites evaluated	Sites are not meeting legal mandates and industry accessibility guidelines. Tools should encourage web designers to comply with requirements when creating new sites.
PS55	(Lazar et al., 2013)	Governmental websites, 25 websites inspected by a total of 150 human inspections	Website development and redesign should apply fully accessible templates.
PS56	(N. E. Youngblood, 2014)	Assessment of the development of accessibility in governmental websites, 60 websites tested	Accessibility compliance has not improved substantially in 10 years.
PS57	(King & Youngblood, 2016)	U.S. governmental websites, analysis of 34 websites for voting	Governmental e-voting has accessibility issues. Development should use guidelines and usability heuristics.
PS58	(Yu & Parmanto, 2011)	U.S. governmental websites, 50 websites evaluated	U.S. state government websites perform better in terms of accessibility compared to the federal government and commercial websites
PS59	(Wentz et al., 2014)	Sign-up system to receive governmental emergency-related	Sign-up system is not accessible even when messages are. Government procurement processes

		messages, 26 counties evaluated	need to be used more effectively to enforce accessibility.
PS60	(Olalere & Lazar, 2011)	U.S. governmental websites, 100 federal websites evaluated	90% of the web pages had accessibility violations. Web pages should apply Section 508.
PS61	(Shi, 2007)	Chinese governmental websites, 399 websites evaluated with evaluation tools	Web pages had WCAG problems. Specific group managed by government should ensure the law is followed.
PS63	(Fagan & Fagan, 2004)	U.S. governmental webpages, automatic evaluation for 50 websites	Users with AT, US states websites are not accessible. Adoption of guidelines is crucial.
PS64	(Henninger, 2017)	U.S. governmental information in websites, Case study concerns 500 undergraduate students	Accessibility of information is far more multidimensional and multiperspective than simple discoverability and usability.
PS65	(Lazar et al., 2010)	Accessibility policy	The implementation of regulations lags. Education about legal requirements and regulations as well as appropriate and effective ways to interact with persons with disabilities.
PS66	(Yi, 2015)	Web accessibility compliance with Section 508 and public libraries' IT budgets, 20 public library systems evaluated	There is no significant association between the public library websites' accessibility and their IT budgets, which suggests that awareness of web accessibility is the major challenge.
PS67	(S. A. Youngblood & Youngblood, 2018)	Accessibility evaluation of Local Emergency Management Agencies' website, 42 websites evaluated	The most compelling example of failure is the use of appropriate alternative text attributes.
PS68	(Navarro-Galera et al., 2016)	Online dissemination of information in 17 Spanish regional governments	Developers and managers must study how to respond to the unmet needs of users.
PS69	(Y. Li & Shang, 2020)	E-government service quality dimensions: accessibility, Survey with 1650 respondents	Technical features, such as system quality, accessibility, and reliability, only have weak effects on citizens' perceived service value.
PS70	(Kanayama, 2003)	Accessibility policy making	Regulations only encourage businesses to consider accessibility issues for people with disabilities. Policy should enforce the promotion of accessibility.
PS71	(Stienstra et al., 2007)	Collaboration between governments, industry, and disability advocacy organizations	Differences in motivating forces between disability advocacy organizations and the IT industry should be considered.
PS73	(Neufeldt et al., 2007)	Difference of promoting accessibility in public and business	Research and business interests, goals, differences in funding require communication and trust between research and the private sector.
PS75	(Kamoun & Basel Almourad, 2014)	Dubai governmental webpages evaluation, 21 websites evaluated	Accessibility should be given a higher priority in general evaluation.
PS76	(E. Loiacono & McCoy, 2004)	The Americans with Disability Act (ADA), Companies' website accessibility evaluation, 45 websites evaluated	Only 9% of the websites included in the study have accessible home pages. Companies need to act proactively in creating accessible websites.
PS77	(Nicholas C. Romano Jr, 2002)	Fortune 250 Companies' website accessibility evaluation, 248 websites evaluated	75% of websites have accessibility errors. Solutions: use of guidelines; automatic and human reviews; text-only versions; alternative methods for obtaining information (phone number, e-mail, or postal).
PS78	(Hackett & Parmanto, 2009)	Accessibility evaluation of a website, 50 websites evaluated	Evaluating only the homepage is not sufficient to determine the accessibility. First-level pages should be included for more accurate results.
PS79	(Hackett & Parmanto, 2005)	Higher education websites, 45 education websites evaluated	Forgetting to supplement alternative text for images is an issue that causes accessibility barriers for persons with disabilities.
PS80	(Parmanto & Zeng,	Web accessibility evaluation, 1518 websites evaluated	Metric for quantitatively measuring the content accessibility (based on WCAG) is proposed.

	2005)		
PS81	(Splendiani & Ribera, 2016)	Accessibility of visual content in academic articles, 30 articles in PDF format evaluated	The information presented in figures, graphs, and other image-related texts should be designed to ensure that people with visual disabilities can receive the same information. This can be done with text alternatives, the use of captions, mentions, text labels, and metadata.
PS82	(Lorca et al., 2012)	The effect of firm size and national culture/legislation on level of web accessibility	Both size and culture have a significant effect on web accessibility.
Note: *Indicates studies with multiple foci.			

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