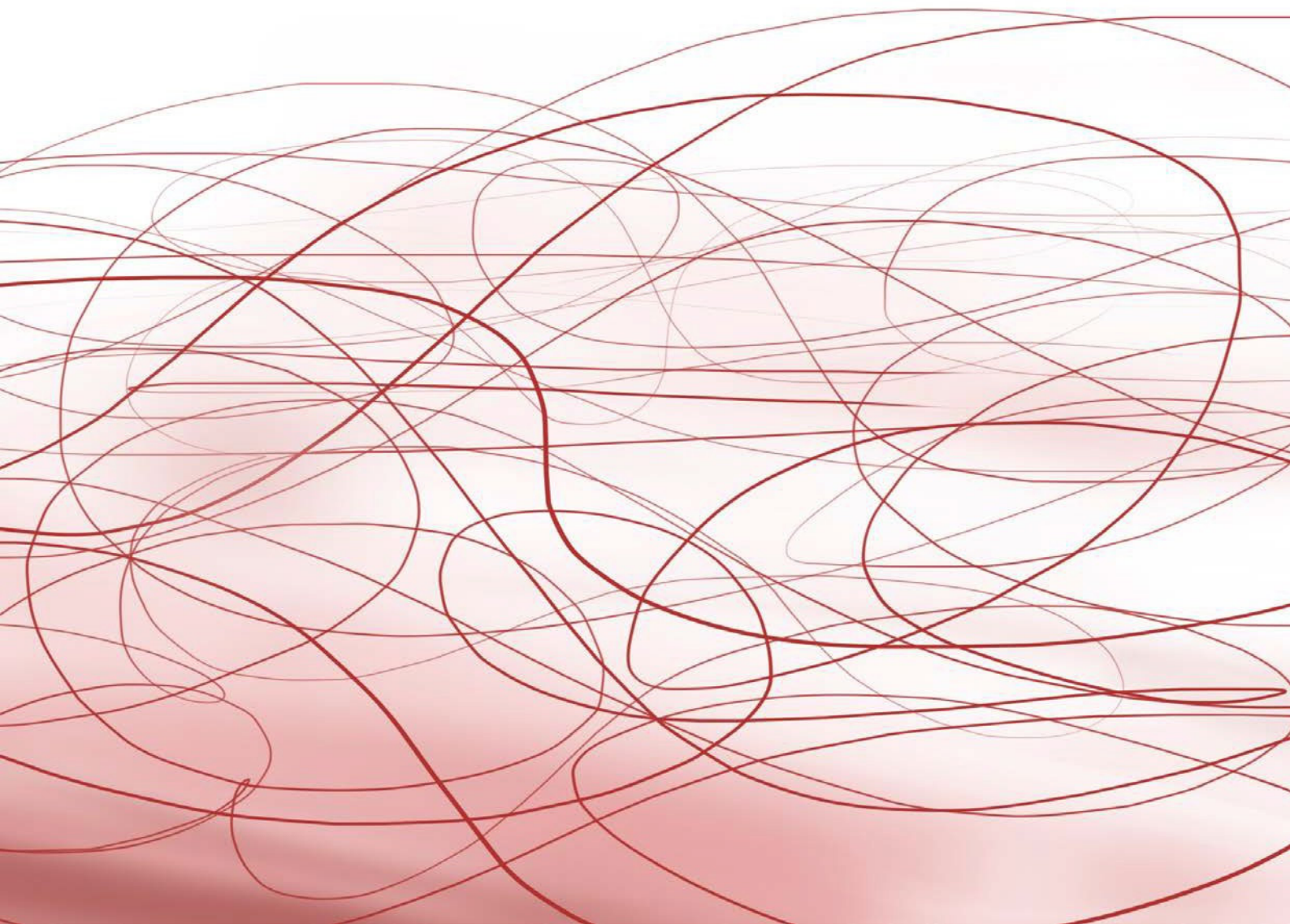


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Low-code solution development and accessibility

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Abstract: In recent years, digital communicators and web developers have recognised the importance of producing web applications and content that is accessible to disabled users. Digital accessibility is measured by how closely an app or page adheres to Web Content Accessibility Guidelines (WCAG). Numerous browser-based accessibility checkers exist that can help identify accessibility issues and WCAG violations. However, their effectiveness with solutions produced by low-to-no code (L2NC) platforms is mainly unknown. This paper is a research project that investigates L2NC solution development and accessibility, focusing on a custom low-code application built within Power Apps. It investigates the challenges disabled users face in accessing digital content and evaluates the effectiveness of accessibility checkers within low-code solutions. To test the low-code application, two accessibility tools (WAVE and Lighthouse) and the product's internal accessibility checker were used to test two versions of a specific solution: a staff directory. One version of the staff directory was created to be accessible, whilst the other incorporated several of the most common WCAG violations identified in the literature. User testing was also carried out on both staff directory applications to gauge user perceptions of them. Descriptive statistics were produced to explain the paper's findings. Both WAVE and Google's Lighthouse were found to be ineffective at detecting WCAG violations within low-code solutions but the internal accessibility checker, whilst not able to identify all common WCAG violations within the staff directories, was the most successful utility. However, the inbuilt accessibility checker's rules do not align well with WCAG violations and have issues detecting colour contrasts. The findings indicate that significant accessibility barriers exist within low-code platforms. The 'ease of use' capabilities and other advantages offered by L2NC utilities are achieved by abstracting out complex paradigms, such as accessible design.

Keywords: accessibility, low-code, no-code, Wave, WCAG, Lighthouse

1. Introduction

Department Y is public body that works in the field of trade and industry. As a public body, Department Y is compelled by law to deliver accessible digital products by complying with Web Content Accessibility Guidelines (WCAG) as set out in The Public Sector Bodies (Websites and Mobile Applications) (No.2) Accessibility Regulations 2018 (Alim, 2021; Ginley, 2020).

Unfortunately, Department Y has not yet achieved full WCAG compliance across all its digital commodities. The public Department Y website is supported by a large, experienced team of content designers and developers, who collectively guarantee that WCAG compliance is achieved. Internal utilities, such as the corporate intranet, have a different ownership model in which a team of solution designers (known as the collaboration team) function as both product owners and platform developers. The collaboration team accept that the intranet is not WCAG compliant

when compared to the external website, which can make the product hard to use for impaired users.

Department Y intranet content is primarily static material written by volunteer editors that possess little training in accessible content design. Initially, the collaboration team perceived accessibility as a measure of how consumable digital content is for disabled users via internet browsers (Taylor & Burnett, 2019). Additionally, the Department Y intranet includes low-to-no code (L2NC) solutions designed to address specific business needs that were not constructed with accessibility in mind (Martinez & Pfister, 2023). Because Department Y employs several experienced content designers, the collaboration team opted to research accessibility within L2NC solution development specifically.

1.1. Software engineering and L2NC solutions

Software engineering applies engineering design processes to design, develop, test, maintain, and evaluate computer software. Historically, software engineering has been the domain of mainframes, servers, and desktop computing (Morse, 1986), but more recently encompasses web and mobile applications (Frezza, 2016). Conventional software engineering skills include coding, code optimisation, models, frameworks, knowledge about database systems and awareness of requirements elicitation, such as functional and non-functional requirements (including accessibility).

L2NC solution development disrupts this paradigm as they are produced in low-code platforms that lower the skills ceiling typically required for solution development by abstracting out complex programming concepts (Gomes & Brito, 2022), and this is done via browser-based, graphical editors (Martínez-Lasaca, Díez, Guerra, & de Lara, 2023). L2NC developers are often called citizen developers, and while there is no consistent term academic term, these individuals are typically business users that are familiar with processes or tasks (Olariu, Gogan, & Rennung, 2016). Thus, the benefits offered (to organisations) by L2NC platforms include reductions in application development time, costs and complexity, and more significant business involvement (Alsaadi et al., 2021).

Unfortunately, accessibility is one of the concepts that is commonly abstracted out programming for the benefit of citizen development. In their L2NC benefits and limitations framework, Martinez and Pfister (2023) make no explicit mention of accessibility. Indeed, several categories, namely B1 (agility), B3 (reduced complexity), B4 (reduced maintenance) and L1 (lack of customisation) pointedly exclude all consideration for inclusive solutions. The consequence of disregarding accessibility is twofold. First, L2NC solutions are more likely to exclude disabled users. Second, due to L2NC vendor specificity, no universal or standardised approach currently exists to redress inaccessible L2NC solutions.

1.2. Importance of accessibility in software engineering

The British Computing Society's 2023 annual report states that disabled people comprised 21% of the UK working-age population in 2021 but only 15% of the national workforce (Runciman, 2023), which the disability charity Scope calculates as 14.6 million people. This group represents £274 billion in annual spending power in the UK, and it remains untapped as only 2% of the internet's top 1 million pages offer full accessibility (Perera, 2022).

The impact of inaccessible web applications in banking (Wentz, Pham, and Tressler, 2017), education (Kane, Shulman, Shockley, & Ladner, 2007), and travel (Teixeira, Eusébio, and Teixeira,

2021) is well documented in the literature. There are, however, other software products that successfully solve accessible questions such as blood-glucose monitors (Uslan, Burton, and Clements, 2008), wearable tech (Moon, Baker, and Goughnour, 2019), and gaming consoles (Brown & Anderson, 2020). The advancement in these technologies demonstrate the positive impact that inclusive software has for disabled people in living their lives.

As society moves toward a ‘digital-first’ perspective, it is ethically appropriate to encourage holistic, inclusive design principles. Inclusive design facilitates the creation of services for all disabled and non-disabled individuals, ensuring that no individual is unfairly barred from accessing a service (Jordan, 2000). Therefore, it is entirely reasonable to expect accessible software development tools and utilities that permit disabled individuals to establish careers within software engineering.

1.3. Research gap, aims, objectives

Accessibility engineers have audited the external Department Y website several times as part of its compliance journey. Methodologically, audits are manual tests that were performed by accessibility engineers (who are disabled) using assistive technologies. Assistive technology describes products that “maintain, increase or improve functional capabilities of individuals with disabilities” (Lahm, 2003, p. 141). Some automated tests, performed via browser-based tools, were also executed. These testing techniques align with Government guidance for accessibility testing (Government Digital Service, 2023).

The application of accessibility audits to L2NC solutions is the juncture at which knowledge gaps in the practice of accessibility testing start to emerge. The accessibility tests and tools endorsed by the UK Government assume that developers possess full access to web-application source code. The recommended tools also only assess rendered/compiled code. As such, it is unclear how useful current accessibility tools are when applied to L2NC platforms or solutions built in them by citizen developers. L2NC platforms offer different granularity of code editability, meaning that fixes suggested by automated accessibility checkers might be difficult or impossible to implement. As such, L2NC solution accessibility was the overall research topic for the collaboration team’s efforts to understanding how they could improve the intranet.

Department Y is heavily invested in a proprietary low-code platform. The collaboration team performed this research academically but still addresses Department Y current accessibility issues through the lens of a low-code solution, a staff directory. Table 1 details the overall research aims and objectives. As no sensitive information was requested of the participants, there are no pertinent ethical implications of this work. A motivating factor for this research is therefore that while significant research on accessibility exists, little within it acknowledges L2NC ecosystems, so the literature review explores accessibility in-depth.

Table 1: Relationship between research topic, aims and objectives

Research topic	To investigate accessibility configuration in L2NC platforms
Research aim	Investigate accessibility configurations for L2NC solutions
Research objective	01 – Investigate digital accessibility challenges faced by disabled users
Research objective	02 – Conduct testing and user studies to investigate the effectiveness of accessibility checkers within a proprietary low-code platform L2NC solutions

2. Literature Review

2.1. Conceptualising accessibility

Since this research pivots around Microsoft technology, it is appropriate to start with a literature review relating to the accessibility of Microsoft Design bundles within its inclusive design ethos. Inclusive design is a methodology that draws upon the full spectrum of human diversity, and accessibility is a professional discipline aiming to “make an experience open to all” (Microsoft Design, 2024). Rather than adhering to a set vocabulary, Microsoft uses personas encompassing motor, visual, aural and verbal impairments.

Singh, Sibi and Bashir (2023) leverage the social model of disability over a medical definition. This model states that attitudinal, physical and informal barriers cause disability and that product development processes should mitigate them where possible. Nelson and Cook (2022) also subscribe to the social model, observing that disability is “measured and defined in multiple ways.”

Neal et al. (2023) perceives web accessibility as a long-standing, all-encompassing design paradigm for producing digital technologies. Like Microsoft's personas, they further define cognitive impairment as an emerging concept in which individuals can face problems digitally if they struggle with complex attention, memory, learning, or language. Nihalani and Robinson (2021) expand on this via their cognitive load theory, postulating that learners have finite cognitive and attentional resources to expend. Lastly, Marcelino et al. (2015) raises the impact of ageing on physical and cognitive capabilities and group impairments analogously to Microsoft.

It should also be noted that a distinction is made in the literature between cognitive impairment theory and cognitive disability. A perceived failing of WCAG guidelines is that there is insufficient coverage for the family of cognitive disabilities, such as autism, dyslexia, and aphasia (Gartland et al., 2022). The success criteria that are included, such as session timeouts and improved error handling fall under AAA standards (Ramkumar, 2025). The W3C, in acknowledgement of WCAG's low level of neuroinclusive guidance has created the cognitive and learning disabilities accessibility task force (COGA), a body that offers guidance for making both content and user agents more accessible to those with cognitive and learning disabilities.

2.2. Education and awareness

Palmer and Palmer (2018) argue that communications practitioners and educators have a role to play in breaking down accessibility barriers (per the social model). They agree with Oswald (2013) in that current digital production techniques are rooted in ableism (discrimination and prejudice against disability). It is only through challenging established practices that cater for “normative” users that a broader culture of awareness and inclusion emerge. Palmer and Palmer feel that existing practices begin with how developers and marketers are taught.

The emphasis on developers traces back to Youngblood's (2012) look at how novice web developers are exposed to the epistemology of accessibility. Youngblood advocates a syllabus that includes WCAG standards, emulating the experiences of disabled people, and dedicated accessibility tools (accessibility checkers and screen-readers). One tool of relevance is WAVE, which shows developers where their code is sub-optimal. Reuschel, McDonnall and Burton (2023) provide examples of the impact of low-quality code noting that 40% of thirty job sites contained code intended for screen readers, which worsened the experience.

Moving beyond web developers, Nelson and Cook (2022) use interviews with advertising students to query the link between digital communicators (as a wider profession) and disability awareness. Their findings reinforce Palmer and Palmer’s discourse, as most interviewees were unfamiliar with accessibility concepts and felt that the advertising industry could be more inclusive. Conversely, Schmutz, Sonderegger and Sauer (2016) extol the benefits of fully accessible sites for those who are non-disabled, which is evidenced by shorter task times. Neal et al. (2023) demonstrates a similar outcome, proven through lower cognitive loads when perusing complex privacy statements.

2.3. Guidelines, legal and ethics

Naturally, the appropriate means to challenge established practices is knowledge – and specifically knowledge about accessibility guidelines, how disabled rights are enshrined in law and the ethics that underpin these rights.

Table 2: Summary of WCAG 2.2 structure

WCAG 2.2 Principle	WCAG 2.2 Guideline	Guideline Success Criteria
Perceivable	1.1: Text alternatives	1.1 has 1 criterion
Perceivable	1.2: Time-based media	1.2 has 9 criteria
Perceivable	1.3: Adaptable	1.3 has 6 criteria
Perceivable	1.4: Distinguishable	1.4 has 13 criteria
Operable	2.1: Keyboard accessible	2.1 has 4 criteria
Operable	2.2: Enough time	2.2 has 6 criteria
Operable	2.3: Seizures and physical reactions	2.3 has 3 criteria
Operable	2.4: Navigable	2.4 has 13 criteria
Operable	2.5: Input modalities	2.5 has 8 criteria
Understandable	3.1: Readable	3.1 has 6 criteria
Understandable	3.2: Predictable	3.2 has 6 criteria
Understandable	3.3: Input assistance	3.3 has 9 criteria
Robust	4.1: Compatible	4.1 has 3 criteria

The WCAG framework is maintained by the World Wide Web Consortium (W3C) and consists of four principles (Table 2). The four principles encompass thirteen guidelines, and these guidelines are further broken down into eighty-seven checkpoints known as success criteria. WCAG success criteria offer three levels, A (lowest), AA (medium) and AAA (highest), which are accumulative, meaning that all levels reflect different accessibility aspects. The W3C mandates that A and AA success criteria must be met for a guideline to be considered compliant as some guidelines do not have an AAA equivalent. It should also be noted that A and AA compliance is enshrined in several acts of law (Table 3). Both Alim (2021) and Marcelino et al. (2015) document the specific WCAG versions used in their work. As the current WCAG version is 2.2, the collaboration team decided that it was appropriate to use it in their investigation into L2NC accessibility.

Delving into accessibility legislation, Palmer, and Palmer (2018) explore “places of public consideration” in their review of US (United States) case law. Two legal cases involving Southwest Airlines and Netflix determined that websites are not places of public consideration and, thus, exempt from ADA legislation. Conversely, other cases involving Target and Netflix determined the opposite. Reuschel, McDonnall and Burton (2023) comment on how inaccessible job sites are likely in breach of section 508. Youngblood and Lysaght (2015) introduce the 21st-century communications video accessibility act, which explicitly challenges organisations to improve the accessibility of online videos via captions.

Table 3: UK/US legislation concerning accessibility

Act of law/legislation	Region	Notes
Public Sector Bodies Accessibility Regulations 2018	UK	Compels public bodies sites and applications to be AA compliant
Equality Act 2010	UK	Defines disability as a mental or physical impairment that has a long-term negative impact on daily activities. Also, outlaws discrimination against impairments
Americans with Disabilities Act 1990	USA	Commonly referred to as ADA, this act outlaws discrimination against the enjoyment of goods and services within a “place of public consideration.”
Section 508 of the Rehabilitation Act Amendments (1978) 2018 amendments	USA	Commonly referred to as Section 508, this law requires US agencies to be AA compliant
21st Century Communications Video Accessibility Act	USA	Requires online videos to be captioned by broadcasters

Griffith, Wentz, and Lazar (2022) opine that in practice not all WCAG checkpoints are equal, in that some have a more significant impact on the end-user experience than others. They also detect tensions between securing AA compliance vs creating usable sites. Furthermore, Khasawneh et al. (2023) identify a conflict between WCAG standards and section 508 legislation, which they resolve by composing a set of compliance heuristics. This heuristics tool is an evaluative model and accompanying criteria that disposes of jargon.

Lastly, the United Nations has determined, as far as ethics are concerned, that access to the internet is a fundamental human right (Palmer & Palmer, 2018). If inaccessible, the growing digitisation of financial services and utilities negatively impacts the disabled community’s ability to contribute fairly to their work.

2.4. Tools, testing methods, common WCAG violations

Inspecting research methods used by researchers in the literature reveals two distinct investigative routes for WCAG compliance: manual testing and automated testing via online accessibility checkers. Manual testing involves specialised accessibility engineers and assistive software. Reuschel, McDonnall and Burton (2023) deploy accessibility engineers to assess job application sites whereas Alim (2021), Vo, Hewitt and He (2023), Singh, Sibi and Bashir (2023), Bounajim, Henderson and Hewitt (2022), Youngblood and Lysaght (2015), Youngblood (2012) and Sonnenberg (2020) resort to online accessibility checkers. All online accessibility checkers encountered are viewable (Appendix A Table 12).

Attitudes to online accessibility checkers vary, however. Singh, Sibi, and Bashir (2023) use a single tool, justifying its selection by wanting to remain consistent with previous research carried out in the tourism industry. Alim (2021) uses three, articulating that multiple tools provide broader and more in-depth coverage of webpages whilst being significantly cheaper than specialist manual testing. Sonnenberg (2020) uses one tool but combines it with additional CSS and HTML code validators. Ismailova and Inal (2022) review six online checkers against forty-one government sites and conclude that using several tools in tandem yields better results than just one.

All online accessibility checkers identified are either (i) browser plugins or (ii) online code checkers. However, a third toolset has emerged in recent years; Google’s Lighthouse. Lighthouse

offers a suite of analytical packages that audit a website's overall performance, gauging performance, accessibility, SEO, and adherence to best practices (McGill, Bamgboye, Liu, & Kalutharage, 2023)(McGill, Bamgboye, Liu, & Kalutharage, 2023). Lighthouse is invokable from within developer tools in Chrome and Edge but can also be run as a Node.JS module by web-developers. Lighthouse calculates a page's accessibility score as a weighted average of all accessibility audits using third party heuristics developed by Deque (Google, 2019).(Google, 2019). Unlike the other performance audits available in Lighthouse, an assessed page will fail an accessibility audit completely, if a single violation of that specific assessment is detected. Deque's heuristics validate against WCAG versions 2.0, 2.1 and 2.2 although they do not specifically pair off to each specific standard. Despite the relative youth of Lighthouse, it has appeared in recent research that investigates the performance of university websites (Ogbuju, Ayodeji, & Azeez, 2022) .

On WCAG violations encountered, some success criteria checkpoints are broken more frequently than others. However, not all papers name them explicitly. Griffith, Wentz, and Lazar (2022), Alim (2021), and Vo, Hewitt, and He (2023) document their most common violations by WCAG checkpoint reference. Singh, Sibi, and Bashir (2023) and Youngblood and Lysaght (2015) also provide WCAG references that pivot towards different checkpoints due to the visual nature of their investigations. Schmutz, Sonderegger and Sauer (2016) manipulated ten specific WCAG standards that have been documented for completeness. A full breakdown of the 23 WCAG violations identified is presented in Table 4.

What Table 4 does not detail are which WCAG violations are specific to dynamic content and advanced user interfaces that have been developed in JavaScript, HTML5 and similar technologies. The W3C has authored a separate set of web standards known as WAI-ARIA (Web Accessibility Initiative - Accessible Rich Internet Applications) that are primarily aimed at web developers not low-code application authors. Several studies in the literature explore the applicability of WAI-ARIA guidelines (Abu Doush, Alkhateeb, Maghayreh, & Al-Betar, 2013; Thiessen & Russell, 2009) in the production of accessible applications but not within a low-code environment.

Table 4: Common WCAG violations

WCAG criteria violated	WCAG version(s)	WCAG Principle & Checkpoint
1.4.11: Non-text contrast	2.0, 2.1	Perceivable – Distinguishable
2.4.1: Bypass blocks	2.0	Operable – Navigable
4.1: Parsing	2.0	Robust – Compatible
1.4.1: Use of Colour	2.0	Perceivable – Distinguishable
2.1: Keyboard navigable	2.0	Operable – Keyboard accessible
1.4.5: Images of text	2.0	Perceivable – Distinguishable
2.4.6: Headings and labels	2.0, 2.1	Operable – Navigable
2.4.4: Link Purpose (in-context)	2.0, 2.1	Operable – Navigable
1.4.3: Contrast (Minimum)	2.0, 2.1	Perceivable – Distinguishable
1.1.1: Non-text content	2.0	Perceivable – Text Alternatives
1.3.1: Info and relationships	2.0	Perceivable – Adaptable
1.4.3: Contrast minimum	2.0	Perceivable – Distinguishable
1.4.4: Resize text	2.0	Perceivable – Distinguishable
1.4.8: Visual presentation	2.0	Perceivable – Distinguishable
2.4.3: Focus order	2.0	Operable – Navigable
2.4.7: Focus Visible	2.0	Operable – Navigable

WCAG criteria violated	WCAG version(s)	WCAG Principle & Checkpoint
2.4.10: Section headings	2.0	Operable – Navigable
3.2.3: Consistent navigation	2.0	Understandable – Predictable
3.2.4: Consistent identification	2.0	Understandable – Predictable
3.3.1: Error identification	2.0	Understandable – Input assistance
3.3.3: Error suggestions	2.0	Understandable – Input assistance
2.5.3: Labels in name	2.1	Operable – Input Modalities
4.1.2: Name, role label	2.1	Robust – Compatible

2.5. Gaps & relevance

Several journal articles discuss the productivity gains offered by Power Apps but fail to mention accessibility (Boonrit et al., 2024; Diksha & Sandhu, 2021; Fifolt, Baker, Menefee, Kidd, & McCormick, 2024; Khenfer, 2023; Sharma & Gupta, 2021) . Likewise, L2NC benefits and limitations models fail to discuss accessibility concerns (Martinez & Pfister, 2023). As such, this research project conducted in this paper aims to fill the gap by investigating whether the tools and techniques discussed convey any utility to L2NC solution development.

Lastly, the proprietary low-code platform offers its own in-IDE app-checker that makes rudimentary accessibility checks, but it is extremely limited as it only caters for ten specific accessibility issues (Microsoft, 2022) . None of the low-code platform’s accessibility categories align directly with WCAG 2.2 checkpoints.

3. Methodology and implementation

3.1. Research methodology

Saunders research onion was consulted to ensure appropriate conventions were followed as this research is the first academic endeavour attempted by the collaboration team (Saunders et al., 2019).

A pragmatist *philosophy* was considered appropriate for the work as it encourages using the best tools available to explore the relationship between accessibility and L2NC platforms. Positivism was considered an unhelpful approach in this context as its binary depiction of knowledge (as true or false) matches poorly against the fluidic concept of accessibility (per the social model). Conversely, interpretivism leans too much into social and cultural factors to be applicable. This study is rooted in the relationship between technology and accessibility and does not focus purely on how disability is defined. For the *research approach* abductive reasoning is preferred as the study only seeks plausible answers to research objectives (Shani, Coghlan, & Alexander, 2019) rather than “cause and effect” (deductive) explanations or data-adaptable theorems (inductive).

This study utilises two *research strategies*, action, and exploratory research. Action research places participants as the beneficiaries of their study (Whitehead, Taket, & Smith, 2003) whereas exploratory research adds definition to academic areas that lack it (Haile, 2023)(Haile, 2023). If citizen developers can be trained in building them and if they are accessible, L2NC solutions are beneficial to all users and not just those who are disabled. Likewise, this study may catalyse further investigation into the phenomena of low-code accessibility. The topic’s lack of academic framework rules out case-study and archival approaches as no material exists to draw upon. The *time horizon* is cross-sectional because the abductive nature of this study removes chronology as a factor.

Research choices and *data collection/analysis* are the final components of the research methodology to discuss. This study utilises a mixed-method concurrent nested strategy that collects quantitative performance data alongside qualitative data concentrating on the “look and feel” of L2NC solutions. Qualitative research is often confirmatory of statistical data (Olds, Moskal, & Miller, 2005), hence the choice of concurrency over a sequential design. The study population is randomised amongst the staff at Department Y but does not consist of 100% disabled staff members. The organisation maintains a staff network, called “Disability and You” that does not have enough members within its ranks to provide a sizable population. Lastly, collected data is analysed quantitatively to produce descriptive statistics and qualitative data is thematically analysed (Braun & Clarke, 2006) . These analytical methods are selected due to the small population size. A summary of the study’s research design is contained in Table 5.

Table 5: Summary of research design

Saunders Characteristic	Design
Research philosophy	Pragmatism
Research approach	Abductive
Research strategy	Action Research/exploratory research
Choices	Mixed-method concurrent nested
Time horizon	Cross-Sectional
Data collection/analysis	Randomised Dep. Y staff, descriptive & thematic

3.2. Staff directory L2NC application

The utility that the collaboration team settled on to explore L2NC accessibility was a staff directory search application; a common tool within enterprise intranets (Pedley, 2003; Warunek, Gruver, Bartko, & Blair, 2024). Two versions of the staff directory were constructed: one accessible and the other inaccessible. The inaccessible staff directory included the nine most common WCAG violations identified during the literature review. Both versions of the staff directory were then assessed against two online accessibility checkers (identified in the literature review) to gauge their effectiveness with the proprietary L2NC solutions. The two tools selected were WAVE and Lighthouse.

Table 6: Final list of staff directory requirements

Staff directory requirement	MosCoW
Ensure staff personal data is not exposed	Must
Show a list of staff and their contact details	Must
Staff can records staff directory record to view further information	Must
Allow Department Ystaff to filter staff by department	Must
Ensure application is WCAG 2.2 compliant	Must
Provide an edit facility for staff to update their records	Should
Provide a report of all staff and their department/location	Should

As the staff directory application fulfilled an actual need for the Department Y, the collaboration team planned its development under agile project management principles. Staff directory requirements were elicited via user stories to understand which features were deemed valuable by staff. Department Y staff were identified through internal communication channels (Viva Engage, internal newsletter and Intranet support inbox) and interviewed for their perspectives. The requirements were then sorted via MosCoW according to what the collaboration team felt would be achieved quickly and collated into a requirements database as per Figure 2 (Cadle,

2014). Finally, Table 6 lists the features deemed essential for an MVP, which included search and retrieval functions as well as WCAG 2.2 compliance. More advanced components, such as self-edits and departmental reports were deemed optional.

3.3. Data collection & survey instruments

Automated testing on both staff directories was performed using WAVE (W3C, 2024), the most frequently utilised online accessibility checker identified during the literature review (Ismailova & Inal, 2022). Some researchers advocate using two checkers for increased WCAG violation coverage (Alim, 2021; Vo, Hewitt, & He, 2023). This study opted against doing so because of the exploratory nature of the research. Furthermore, the low-code platform accessibility checker incorporates some accessibility checks. Thus, using a singular online checker is deemed sufficient as it allows a more direct comparison as to the efficiency of both utilities.

As well as assessing the two staff directory applications against online accessibility checkers, usability tests with Department Y staff were conducted using survey instruments containing both qualitative and quantitative questions. Lastly as the sample population consists entirely of Department Y staff members that have volunteered their time, they are considered as a self-selecting group that offer nothing inferential for the wider organisation. All participants provided informed consent prior to taking part in the study, and no sensitive or personally identifiable information was collected

3.4. Staff directories build and test process

The staff directory application is architected through a micro-service approach, using specific services for precise functions as per Table 7. Power Apps, as the staff directory user interface, is the only component to be assessed for accessibility. Power BI charts and reports are not tested for accessibility as they are outside the scope of this research.

Table 7: Staff Directory technology components

M365 Service	Usage
SharePoint Online Lists	Data storage for staff application data
Power Automate	Scheduled workflow to synchronise Active Directory changes with SharePoint
Power Apps	L2NC tool that staff directory application interface is built in
Power BI	Data visualisation tool for reports pertaining to staff office and/or directorates

To begin, a copy of Active Directory (corporate directory service) was taken and converted into a SharePoint list, which simplified the removal of personal information not fit for public consumption. Secondly a Power Automate workflow was created to keep the SharePoint list coordinated with updates performed in active directory. Both the accessible and inaccessible versions of the staff directory application utilise the SharePoint list, so a singular data source was sufficient. Lastly a Power BI dashboard was created that ingested the SharePoint list data and rendered a dynamic table. Although the Power BI dashboard is viewable by staff, it was not gauged for accessibility as data visualisations are not produced by intranet content editors.

Within the low-code, the staff directory is a single screen canvas application. A canvas application is a blank screen (canvas), in which developers add content from a series of drag and drop components including labels, buttons, images and more (Rajaram et al., 2022a). The alternative

model is model-driven, which generates a multi-screen application from a data-source. The collaboration team settled on a canvas application as it affords greater customisation and design options for simple, mono-screen entities. All solutions within the Department Y intranet are canvas applications.

The accessible staff directory (Figure 1) was created first with initial configuration involving data source initialisation, and the addition of background visuals and two galleries in which user data is rendered. The top gallery was further set-up to render a single user profile when selected in the lower one (the users gallery). Further components (buttons, free text search, icons) were added and configured to filter and update the users gallery. Directorate and office filters were programmed against button OnSelect events. Lastly, the search input field was configured as a dynamic filter against the user's gallery to return results that match a name or job title search. For usability purposes, filter buttons and user gallery entries were configured to visually demonstrate when they had been interacted with. Upon completion, this build reported zero accessibility issues within the low-code platform IDE and is referred to as Version 1.

Figure 1: Accessible staff directory (version 1)



The build for the inaccessible staff directory began by cloning the accessible version, which provided a functional application build to work on. Specific changes were made to incorporate the accessibility issues identified during by the literature review (Table 4).

Adobe's colour contrast analyser was used to create a low contrast colour scheme that violates WCAG guidelines. The background colour was determined by a sampling a screenshot of the accessible version and is #b9e8fd with text set to #3D7BFF for a contrast ratio of 2.93:1. A second colour scheme for buttons was generated in which the background colour is #0000D9 and text colour of #367CFF and a contrast of 2.74:1. These colour schemes were applied visually to the application's background, button, labels, icons and text.

Most text was resized to font-size 16 and applied consistently to all labels. Text labels were also stripped of any properties that gave them specific meanings for screen readers. Non-visual changes included the removal of tooltips, accessibility labels from user galleries and icons, and OnFocus settings that indicate which user interface (UI) element is currently selected. The completed inaccessible staff directory is depicted in Figure 2 and compiled in the low-code platform IDE reporting 28 accessibility errors and is referred to as Version 2.

Figure 2: Inaccessible staff directory (version 2)



For usability testing, both versions of the staff directory were embedded in unique SharePoint Online pages for easier distribution. Aside from the M365 navigation, no other content was included within the SharePoint Online pages. These page links were then inserted into user testing surveys and distributed to testers. The surveys contained both qualitative and quantitative queries that asked testers to perform three searches, namely locating colleagues by name, job title, directorate, or region. The population of testers was a self-selecting group that volunteered responses to a request for testers through organisational communications channels.

For automated testing, both versions of the staff directory were assessed outside of SharePoint Online pages. Each canvas application provides a direct URL that will load only the compiled app into browser, without any additional M365 features. WAVE was invoked by inserting each of the staff directory canvas app links into the online accessibility checker by W3C (2024a). Following WAVE testing, browsers were restarted and the staff directories reloaded. Both staff directories were assessed using Lighthouse, which was initialised from the browser's development tools.

Both user testing (Department Y staff) and automated testing (collaboration team) were performed on organisational laptops, which were Microsoft Surface Pros loaded with Windows 11 22H2 operating system and Chrome build 114.

4. Results & Analysis

The aim of the study is to satisfy the two research objectives as outlined in Table 1. Objective one aspires to investigate and understand the challenges faced by disabled users in their digital lives. This knowledge contextualises what is learnt via objective two, which is an investigation of the effectivity of accessibility tools and checkers when applied to the proprietary low-code platform. The full results of automated testing on both staff directories are presented in Table 8. Secondly, user testing produced a variety of results, which are presented in Appendix B Tables 13 - 24. These results are discussed in detail in this chapter.

4.1. Online accessibility checkers are ineffective with proprietary low-code platform solutions

All three tools (WAVE accessibility checker, Lighthouse, and the in-IDE low-code platform app checker) are inefficient at accurately detecting WCAG 2.2 violations. Staff directory version 2

contained eight of the nine common WCAG violations identified in the literature as detailed in Table 8. An accessibility violation for 1.4.4 is not examinable as label/button text scales appropriately when tested against OS settings, browser font-size settings and webpage settings.

Table 8: WCAG 2.2 violations implemented in staff directory version 2

WCAG criteria violated	Implemented in staff directory version 2	Detected in low-code platform IDE	Detected in Wave	Detected in Lighthouse
1.1.1: Non-text contrast	Setting Accessible Label property on both galleries to null	Yes	No	No
1.3.1: Info & relationships	Removed hint text and default text from search box	No	No	No
1.4.3: Contrast minimum	Set app background colour to #b9e8fd and text to #3D7BFF for a contrast of 2.93:1. Also set button background colour to #0000D9 and text to #367CFF for a contrast of 2.74:1	No	No	No
1.4.4: Resize text	N/A – Text resizes appropriately when staff directory app is zoom is used	N/A	N/a	N/a
1.4.8: Visual presentation	Removed default text from search engine	No	No	No
2.4.3: Focus order	Added random integers to the Tabindex property of user galleries and form controls	Yes	No	No
2.4.6: Headings & labels	The Text.Role properties on labels are set to TextRole.Default. This control can be set to H1-H4 for screen-readers	No	No	No
2.4.7: Focus visible	Setting the FocusedBorderThickness property to 0	Yes	No	No
2.4.10: Section headings	Set all section headers to font size 16 in the app. Gallery fonts were also set to 16. Text role properties not used.	No	No	No

The low-code platform app checker reports on accessibility violations in three categories; errors (E), warnings (W) and tips (T). Upon execution, version 2's app checker reported 24 accessibility errors and four accessibility tips. The 24 errors detected consist of 22 instances of "Focus isn't showing" and two "Missing accessibility labels." All four accessibility tips are 'Check the error of the screen items' notifications. Demonstrably, the low-code platform's app checker only detects accessibility violations that are resolved using specific parameters on form controls. This is best demonstrated via the IDE's inability to detect the inappropriate colour contrasts configured within staff directory version 2. The app checker for staff directory version 1 reported no accessibility issues.

Both versions of the staff directory were then tested via the WAVE facility, which checks the compliance of on-screen content against WCAG 2.2. Red icons indicate violations that need resolution whereas green icons hint at areas where improvements can be made. WAVE's reports group findings via errors (E), contrast errors (CE), alerts (A), features (F), structural features (S) and accessible rich intranet applications (ARIA). The WAVE report for staff directory version 1 is Figure 3 and that of staff directory version 2 is Figure 4. Both applications returned identical reports, with one alert, two features, four structural elements and 37 ARIA highlighted. Tellingly, none of these report items apply to the actual staff directory but the ever-present M365 navigation features.

Lastly, in fresh browser sessions both staff directories were assessed with Lighthouse with the following settings: -

- **Mode:** Navigation
- **Device:** Desktop
- **Categories:** Accessibility

Lighthouse returns results in three categories: additional items to check manually (M), passed audits (P) and audits deemed not applicable (N/A). Lighthouse returned a 100% score for both staff directories (Figure 5) highlighting 10 manual checks, 22 passed audits and 35 items deemed not applicable. The full breakdown of Lighthouse's report is presented in Appendix B Table 13.

Figure 3: WAVE report on accessible staff directory version 1

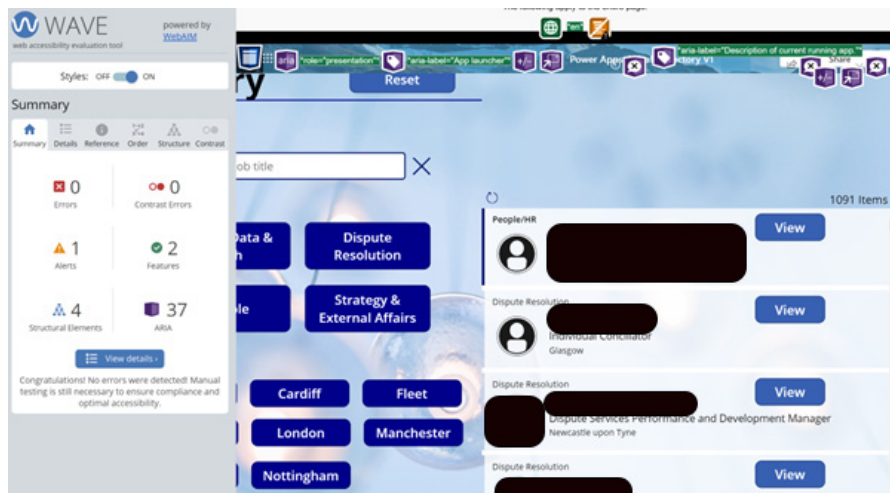


Figure 4: WAVE report on inaccessible staff directory version 2

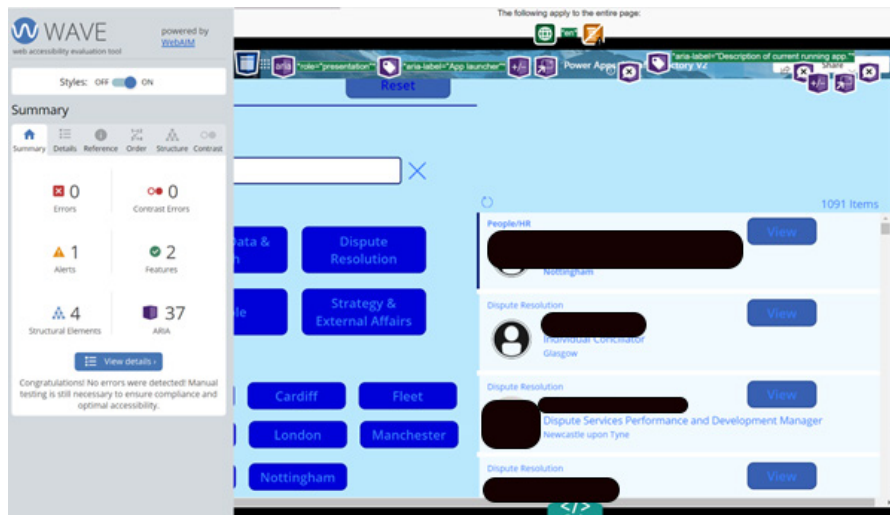
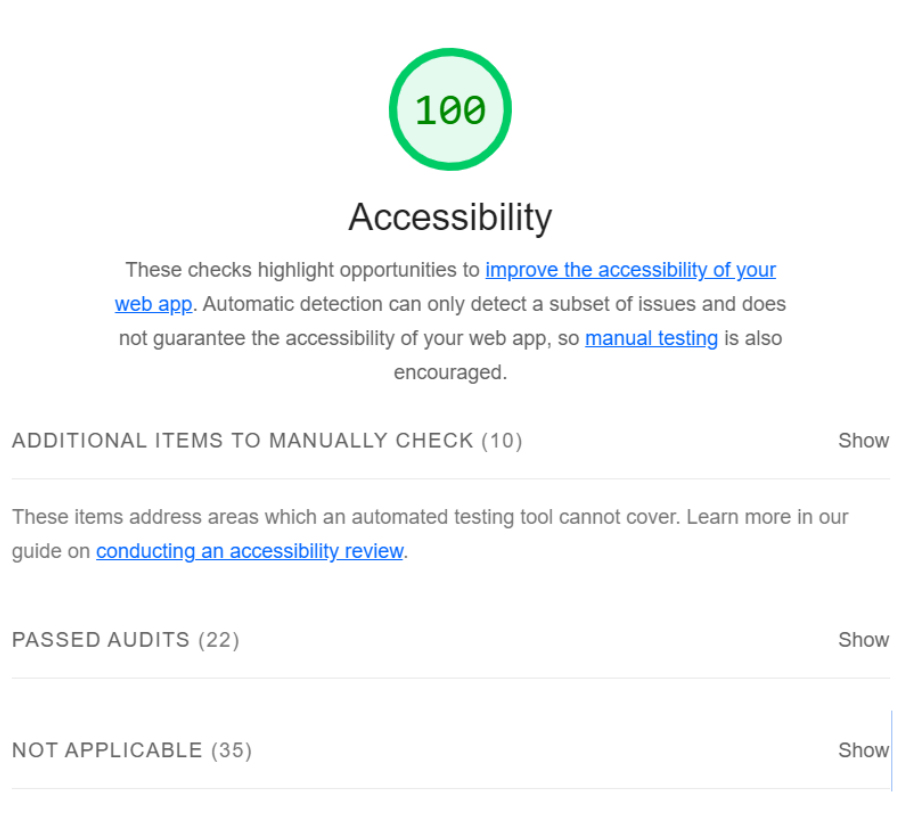


Figure 5: Lighthouse accessibility audit results for both staff directories



A full summary of accessibility violations detected by all automated checkers is presented in Tables 9 through 11.

Table 9: Accessibility violations detected by Wave

Staff Directory	Errors	Contrast Errors	Alerts	Features	Structural Elements	ARIA
Version 1	0	0	1	2	4	37
Version 2	0	0	1	2	4	37

Table 10: Accessibility violations detected by the IDE

Staff Directory	Errors	Warning	Tips
Version 1	0	0	0
Version 2	24	0	4

Table 11: Accessibility violations detected by Lighthouse

Staff Directory	Manual	Passed Audits	Not Applicable
Version 1	10	22	35
Version 2	4	22	35

4.2. User testing on staff directories

A total of thirty-four users were sourced from within Department Y and divided into two groups of seventeen thus ensuring that each staff directory was tested equally. Figure 8 reveals that the search facility in staff directory version two was marginally harder to use successfully. However,

this trend does not continue with tasks two and three. Testers for both tasks skew more to the lower scale of the difficulty ratings in version 2 of the staff directory.

Figure 6: Testing results for Q1

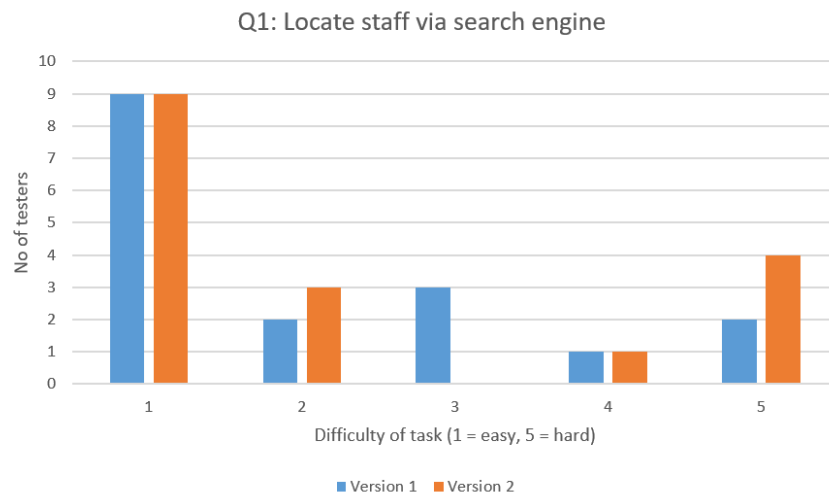


Figure 7: Testing results for Q2

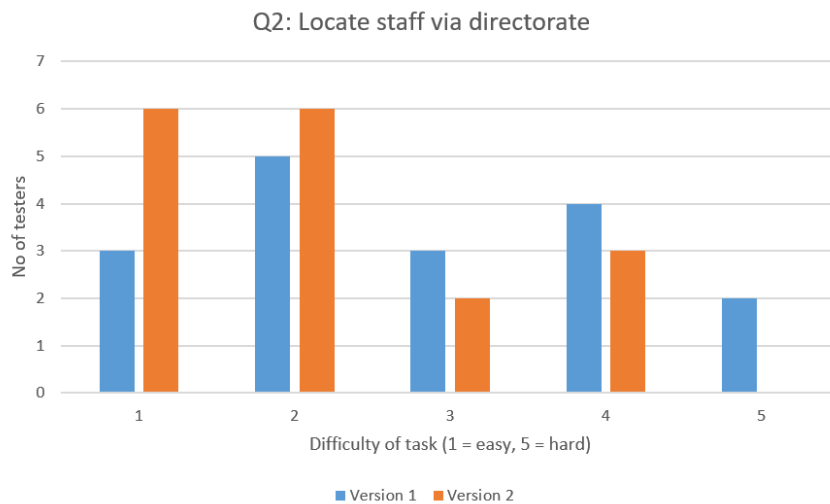
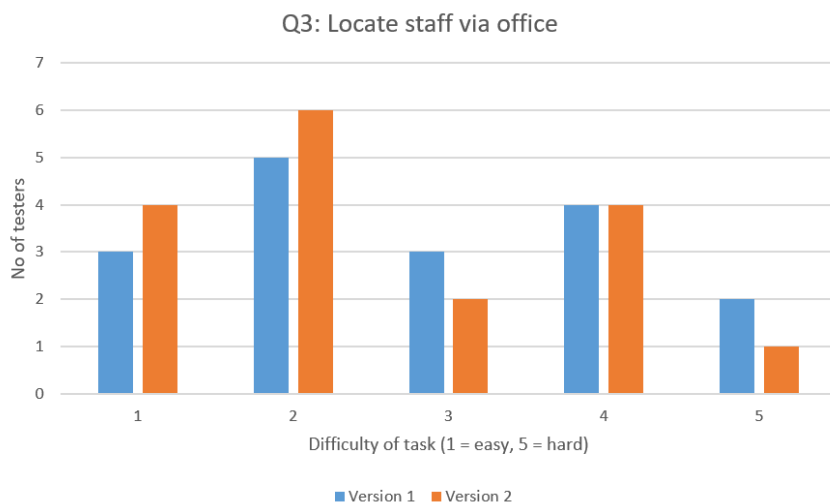


Figure 8: Testing results for Q3



5. Critical Evaluation of Results

5.1. Research objective 1: Investigate digital accessibility challenges

The line of enquiry for this research objective is underpinned by a principle that Griffith, Wentz and Lazar (2022) establish in their efforts to quantify the cost of accessibility barriers for the blind. They draw attention to what they perceive as the tension between meeting WCAG AA compliance versus genuine efforts to make websites accessible and inclusive. The same authors also state that not all WCAG checkpoints are equal in the levels of discomfort that their violations cause disabled users.

This perspective is validated by trends observed in the literature review in which 23 specific WCAG categories are identified (Table 4) as being more prevalent than the remaining 64 (Table 2). This effectively means that less than one third (26.4%) of WCAG 2.2 checkpoints are more disruptive to the digital experience of disabled users than the remaining 73.6%. Lastly, of these 23 checkpoint violations, most of them fall into WCAG perceivable or operable principles, meaning that visual and aural impediments are more common than neurocognitive or mobility issues.

Interestingly, one standard has been identified as having a simple resolution; standard 1.3.1, which is answered by simply using the HTML alt tag for the benefit of screen readers (N. E. Youngblood & Lysaght, 2015). Whilst, in a vacuum, this fix is simple, it represents the sort of intrinsic knowledge that is gained “on the job” by digital communicators, including developers and L2NC solution builders

Intrinsic knowledge then, speaks to the awareness and education of digital communicators and what they should be taught, inclusive of legal obligations and accessibility regulations. It is a legal requirement for public bodies to make their digital platforms and sites accessible (Nisbet, 2020). As intranet platforms are considered part of the modern digital communications realm (Joglekar, Purdy, Brock, Tandon, & Dong, 2022) it is reasonable to assume that Department Y L2NC solution developers should learn about legislation and accessibility alongside how to accommodate them, which leads into research objective two.

5.2. Research objective 2: Effectiveness of accessibility configurations with the proprietary low-code platform

In his exploration of video game accessibility, Anderson conceptualises the ground floor approach to digital accessibility, a metaphor grounded in architectural practices for accessible buildings (2024). Just as a building needs minimal features to accommodate wheelchair users, so digital products need to be fully inclusive. The literature review raised similar thoughts as one specific paper investigated how non-disabled individuals also gain from inclusive design principles when applied to websites (Schmutz, Sonderegger, & Sauer, 2016). Currently, a “ground floor” approach is hard to achieve with L2NC applications constructed in the proprietary low-code platform, due in part to the inefficiency of existing tools.

As presented in section four, both WAVE and Lighthouse are unable to identify any accessibility issues within the staff directory version 2. The most severe item reported in WAVE is an alert over the lack of headings within the M365 application launcher, a shared facility across all M365 applications that has nothing to with the staff directory solutions. Lighthouse returns a score of 100% (Figure 5) including a successful audit for background and foreground colour ratio, which is

patently untrue for staff directory version 2. Lighthouse, at least, does encourage manual accessibility checks and provides specific examples what to check.

Furthermore, the accessibility rules built into the low-code platform's IDE only fire in specific scenarios – when explicit properties of the canvas app's drag and drop controls are set inappropriately. This then leaves Department Y L2NC solution developers with weak and inconsistent tooling to confidently build inclusive applications for the intranet. This fact is offset by the results of the usability testing, which highlighted minimal differences in task difficulty, especially with questions two and three, the button-orientated tasks. It would be foolish however to generalise anything from these findings, as the Department Y community has been clamouring for a staff directory for some time, meaning that the testers mustered more enthusiasm than they would have for an unfamiliar L2NC solution that was not in demand.

5.3. Applicability of findings

The value generation of this study's output for Department Y is something of a double-edged sword. The catalyst for the project was an acknowledgement that internal digital products, including the intranet and its embedded L2NC solutions are inaccessible. The collaboration team that monitors and develops the collaboration platforms have no experience or training with resolving accessibility issues. This juncture is where the study outcomes are positive, as the collaboration team now possesses both a very defined problem and an understanding of the limitations of existing automated tools.

This research clarifies both accessibility guidelines and the legal obligations inherent in attempting to resolve them. This knowledge ensures that the current intranet violations can be understood and addressed sufficiently. Conversely, however, are the difficulties in cleanly developing accessible solutions within the low-code platform, which may stunt the growth and evolution of the intranet platform. The existing L2NC solutions within the Department Y intranet will need refactoring to ensure that a proper “ground floor” approach is achieved.

6. Further Work

6.1. Research limitations

As with any piece of academic enquiry, this study's conclusions are tempered by limitations in design and methodology. To discuss where this study could be further developed, the limitations of the research methodology must be explored. Once these constraints have been stated and understood, future possibilities can be appropriately contextualised.

To begin this research, user testing was performed on a simple, uncomplicated low-code canvas utility. Although the product's App Checker has clear limitations regarding detecting inaccessible configurations, its existing rules could have been examined further, especially as Microsoft's literature provides some detail on how to cater for visual and audio materials (Microsoft, 2022)(Microsoft, 2022). This could be best explored through the development of more ambitious L2NC application such as a learning management system (Rajaram et al., 2022b), expense submission systems (Monteiro, Abrantes, & Ratinho, 2024) or activity trackers (Fifolt et al., 2024). A more ambitious L2NC that contained more violations from the WCAG 2.2 “understandable” and “robust” principles could also yield a more comprehensive understanding of the limits of the low-code platform IDE.

Secondly, none of the thirty-four members in the testing group/population were disabled themselves. Returning to Anderson's work in the gaming industry, he constantly acknowledges that "nobody knows the practical implications of disability as well as people with disabilities" (Anderson, 2023). His view, aside from being ethically appropriate, is portable to all aspects of digital accessibility, including L2NC solution development. The potential involvement of disabled users could be extended to including professional accessibility engineers. Involving either community could radically alter the data generated in L2NC accessibility testing and thus paint an entirely different picture of L2NC solution accessibility.

Next, the ratings used in the user testing survey were also subjective and may not be enough to gauge complex concepts like aesthetics or inclusivity in L2NC applications. Using a modified methodology that combines subjective performance metrics with objective measures could provide more insight. For example, Neal's look at cognitive impairment demonstrates the advantage of using objective measurements in an investigation via their use of reading scales, such as the common European framework of reference to assess readability and linguistic complexity. This framework provides a common metric by which linguistic complexity can be universally framed (Neal et al., 2023). A second study from the literature review uses an objective measurement scale devised by NASA for investigating low colour palettes for individuals with low visibility (Hewitt & He, 2022).

Lastly, none of the studies within the literature discussed the most recent WCAG guidelines, which is guideline 2.2. Although some articles are circulating that mention them (Dias, Carvalho, Rocha, & Barroso, 2022; Engeset, Pfuhl, Orten, Hendrikx, & Hetland, 2022; Filipe, Pires, & Gouveia, 2023), they only refer to the draft guidelines. Eleven new accessibility criteria have been added to WCAG 2.2 (from 2.1) that have yet to be examined academically, which means that they could potentially disrupt the perceived order of most disruptive accessibility violations.

6.2. Broad view for further work (industry)

Every year commercial research firms, such as Gartner or Forrester, produce reports that discuss and rank software products of various form and function. Gartner, for instance, publishes a magic quadrant, a Boston matrix diagram that groups products as leaders, challengers, niche players or visionaries. The Gartner report for 2023 discussing L2NC applications ranked this proprietary low-code platform alongside sixteen other products.

An additional sixteen low-code development platforms exist that may have the same accessibility restrictions as this proprietary low-code platform. It would make sense for an industry-wide framework or standard to evolve so that the needs of disabled users do not play a secondary role to proprietary approaches to solving accessibility issues. WCAG 2.2 is already vendor and platform agnostic, thus meaning that no product would gain or lose more than their rivals. Once a standard is agreed upon, the benefits of such a standardisation are plentiful but exhibited best by the productivity gains made in the UML community (Chaudron, Heijstek, & Nugroho, 2012; Chonoles, 2017).

6.3. Narrow view for further work (UK civil service)

Many of the limitations (of L2NC solutions) that have already been discussed open further ways in which Department Y could benefit from extending this research. A different profile of the proprietary low-code platform solution would give the collaboration team more opportunity to explore and investigate L2NC accessibility, establish a "ground floor" approach and successfully comply with legal requirements.

Secondly, the development of a training syllabus for L2NC solution developers and volunteer editors as well as the possible provision of free accessibility tools would help. Youngblood's exploration of a training syllabus for web developers is over a decade old but still holds some validity today (S. A. Youngblood, 2012). A training syllabus that accepts, acknowledges, and guides both intranet editors and L2NC solution developers on the disconnect between online accessibility checkers and low-code can only be a positive thing. A syllabus would need to address the confusion produced by trying to combine (and meet) the ideologies of WCAG compliance and anti-discriminatory legislation. One study has already produced a heuristic, evaluative model for software developers (Khasawneh, Gallagher, Jacobson, & Riley, 2023), that whilst too complex for L2NC solution developers, could be simplified for them.

Lastly, the potential of cross-government collaboration is very possible. Multi-department co-operation is common within the UK government for research, statistics, policy and so on, but not necessarily for information technology. One group that does exist is the Government Intranet Network (GIN), a collection of civil servants (of various trades) that meet monthly to exchange information on various intranets. Accessibility is a common topic of discussion that is yet to yield any productive solutions or modes of thinking. This research could catalyse further work within government circles.

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9. Appendices

9.1. Appendix A: Literature Review

Table 12: Online WCAG accessibility checkers in the literature

Tool	Studies mentioned
WAVE	(Alim, 2021; Bounajim et al., 2022; Sonnenberg, 2020; Vo et al., 2023; N. E. Youngblood & Lysaght, 2015; S. A. Youngblood, 2012)
TAW	(Alim, 2021; Singh et al., 2023; Teixeira et al., 2021)
EIII Page Checker	(Alim, 2021)
Mauve ++	(Ismailova & Inal, 2022; Vo et al., 2023)
Bobby	(N. E. Youngblood & Lysaght, 2015)
AChecker	(Ismailova & Inal, 2022; McGill et al., 2023; Schmoelz, 2023; Vo et al., 2023; N. E. Youngblood & Lysaght, 2015)
Vamola Validator	(Ismailova & Inal, 2022; Teixeira et al., 2021)
Access Monitor	(Ismailova & Inal, 2022; Teixeira et al., 2021)
Examinator	(Ismailova & Inal, 2022)
Cynthia Says	(Ismailova & Inal, 2022)

9.2. Appendix B: Results & Analysis Tables

Table 13: Results of Lighthouse accessibility audit on both staff directories

Lighthouse Category	Lighthouse feedback
Additional item to check manually	Interactive controls are keyboard focusable
Additional item to check manually	Interactive elements indicate their purpose and state
Additional item to check manually	The page has a logical tab order

Lighthouse Category	Lighthouse feedback
Additional item to check manually	Visual order on the page follows DOM order
Additional item to check manually	User focus is not accidentally trapped in a region
Additional item to check manually	The user's focus is directed to new content added to the page
Additional item to check manually	HTML5 landmark elements are used to improve navigation
Additional item to check manually	Offscreen content is hidden from assistive technology
Additional item to check manually	Custom controls have associated labels
Additional item to check manually	Custom controls have ARIA roles
Passed Audits	[aria-*] attributes match their roles
Passed Audits	[aria-hidden="true"] is not present on the document <body>
Passed Audits	[role]s have all required [aria-*] attributes
Passed Audits	[aria-*] attributes have valid values
Passed Audits	[aria-*] attributes are valid and not misspelled
Passed Audits	Buttons have an accessible name
Passed Audits	Image elements have [alt] attributes
Passed Audits	[user-scalable="no"] is not used in the <meta name="viewport"> element and the [maximum-scale] attribute is not less than 5
Passed Audits	ARIA attributes are used as specified for the element's role
Passed Audits	[aria-hidden="true"] elements do not contain focusable descendants
Passed Audits	Elements use only permitted ARIA attributes
Passed Audits	[role] values are valid
Passed Audits	Background and foreground colors have a sufficient contrast ratio
Passed Audits	Document has a <title> element
Passed Audits	<frame> or <iframe> elements have a title
Passed Audits	<html> element has a [lang] attribute
Passed Audits	<html> element has a valid value for its [lang] attribute
Passed Audits	No element has a [tabindex] value greater than 0
Passed Audits	Touch targets have sufficient size and spacing
Passed Audits	Uses ARIA roles only on compatible elements
Passed Audits	Deprecated ARIA roles were not used
Passed Audits	Image elements do not have [alt] attributes that are redundant text
Not Applicable	[accesskey] values are unique
Not Applicable	button, link, and menuitem elements have accessible names
Not Applicable	Elements with role="dialog" or role="alertdialog" have accessible names.
Not Applicable	ARIA input fields have accessible names
Not Applicable	ARIA meter elements have accessible names
Not Applicable	ARIA progressbar elements have accessible names
Not Applicable	Elements with an ARIA [role] that require children to contain a specific [role] have all required children

Lighthouse Category	Lighthouse feedback
Not Applicable	[role]s are contained by their required parent element
Not Applicable	Elements with the role=text attribute do not have focusable descendents.
Not Applicable	ARIA toggle fields have accessible names
Not Applicable	ARIA tooltip elements have accessible names
Not Applicable	ARIA treeitem elements have accessible names
Not Applicable	The page contains a heading, skip link, or landmark region
Not Applicable	<dl>'s contain only properly-ordered <dt> and <dd> groups, <script>, <template> or <div> elements
Not Applicable	Definition list items are wrapped in <dl> elements
Not Applicable	ARIA IDs are unique
Not Applicable	No form fields have multiple labels
Not Applicable	Heading elements appear in a sequentially descending order
Not Applicable	<html> element has an [xml:lang] attribute with the same base language as the [lang] attribute
Not Applicable	Input buttons have discernible text
Not Applicable	<input type="image"> elements have [alt] text
Not Applicable	Form elements have associated labels
Not Applicable	Links are distinguishable without relying on colour
Not Applicable	Links have a discernible name
Not Applicable	Lists contain only elements and script supporting elements (<script> and <template>)
Not Applicable	List items () are contained within , or <menu> parent elements
Not Applicable	The document does not use <meta http-equiv="refresh">
Not Applicable	<object> elements have alternate text
Not Applicable	Select elements have associated label elements
Not Applicable	Skip links are focusable
Not Applicable	Tables have different content in the summary attribute and <caption>
Not Applicable	Cells in a <table> element that use the [headers] attribute refer to table cells within the same table
Not Applicable	<th> elements and elements with [role="columnheader"/"rowheader"] have data cells they describe
Not Applicable	[lang] attributes have a valid value
Not Applicable	<video> elements contain a <track> element with [kind="captions"]

Table14: Age demographic for accessible staff directory

Age range	Count	Percentage
18-24	0	0.00
25-34	3	17.65
35-44	6	35.29
45-54	5	29.41
55-64	3	17.65
64+	0	0.00
Prefer not to say	0	0.00
Total	17	100.00

Table 15: Age demographics for inaccessible staff directory

Age range	Count	Percentage
18-24	0	0.00
25-34	3	17.65
35-44	7	41.18
45-54	6	35.29
55-64	1	5.88
64+	0	0.00
Prefer not to say	0	0.00
Total	17	100.00

Table 16: Gender demographics for accessible staff directory

Gender	Count	Percentage
Man	5	29.41
Woman	12	70.59
Non-binary	0	0.00
Prefer not to say	0	0.00
Total	17	100.00

Table 17: Gender demographics for inaccessible staff directory

Gender	Count	Percentage
Man	7	41.18
Woman	10	58.82
Non-binary	0	0.00
Prefer not to say	0	0.00
Total	17.00	100.00

Table 18: Difficulty of T1 for accessible staff directory

Difficulty of task	Count	Percentage
1	9	52.94
2	2	11.76
3	3	17.65
4	1	5.88
5	2	11.76
Total	17	100.00

Table19: Difficulty of T1 for inaccessible staff directory

Difficulty of task	Count	Percentage
1	9	52.94
2	3	17.65
3	0	0.00
4	1	5.88
5	4	23.53
Total	17	100.00

Table 20: Difficulty of T2 for accessible staff directory

Difficulty of task	Count	Percentage
1	3	17.65
2	5	29.41
3	3	17.65
4	4	23.53
5	2	11.76
Total	17	100.00

Table 21: Difficulty of T2 for inaccessible staff directory

Difficulty of task	Count	Percentage
1	6	35.29
2	6	35.29
3	2	11.76
4	3	17.65
5	0	0.00
Total	17	100.00

Table22: Difficulty of T2 for inaccessible staff directory

Difficulty of task	Count	Percentage
1	9	52.94
2	3	17.65
3	0	0.00
4	1	5.88
5	4	23.53
Total	17	100.00

Table 23: Difficulty of T3 for accessible staff directory

Difficulty of task	Count	Percentage
1	3	17.65
2	3	17.65
3	3	17.65
4	4	23.53
5	4	23.53
Total	17	100.00

Table 24: Difficulty of T3 for inaccessible staff directory

Difficulty of task	Count	Percentage
1	4	23.53
2	6	35.29
3	2	11.76
4	4	23.53
5	1	5.88
Total	17	100.00

Designing Reading Platform UIs and Standardizing Accessibility

A study of digital reading preferences across disability communities that impact the user experience for all readers

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Abstract: In an era where everyone will experience a disability at some point (even if temporary), inclusive design is increasingly vital to information accessibility for all users. This study aims to learn the digital reading preferences of various disability communities and address implications for a design for all approach to improve the digital reading experience for everyone. Method. Research questions systematically guided the exploratory review, resulting in 14 studies that underwent thematic analysis with inductive coding. Results. With a lens from the information science, user experience, and disability studies fields, this paper presents five themes identified across the studies. Digital reading preferences of people with and without disabilities and recommendations for digital reading designs are discussed. Conclusion. Culture, assumptions, and misperceptions of accessibility, disability, technology, and literacy play a part in how society and social accessibility impact people with and without disabilities. This paper presents preliminary findings, gaps, and limitations that provide future steps for this project and other research directions. The viewpoint of disability communities may help increase the accessibility, usability, and enjoyment of digital reading more broadly, where design for all can be the tool for standardizing accessibility, which benefits everyone.

Keywords: accessibility, disability, digital reading, web reading, inclusive design, design for all, universal design, user experience, information retrieval

1. Introduction

Reading has many purposes: for education, employment, and enjoyment. Books are read worldwide, in various languages, and by people of varying ages, among other identity characteristics. Everyone has preferences, including genres or mediums, such as physical printed or digital books. This literature review sought to learn the digital reading preferences of the disability community and addresses implications for the design for all approach. Although there are many categories of disability—including sensory (e.g., vision, hearing), motor, cognitive/learning, and temporary—this review is focused on the larger, broad population to identify any overlapping preferences among disability types. This knowledge can inform recommended practices in user experience design and web design for creating screen-based reading platforms from the perspective of a person with a disability. This topic is of importance as 1.3 billion people worldwide (16%) have a disability, and everyone will experience a disability at some point in their life, even if temporary (CDC, 2023). For example, a broken wrist is a temporary motor disability, a person undergoing eye surgery will have temporary vision impairment, and cognitive decline affects people as they age. Additionally, with 25% of the U.S. population (and 16% worldwide) having disabilities (CDC, 2023), it is mainstream enough that

digital books should be designed with accessibility and usability from the start. A digital book (or web book) is a book that can be read by electronic means, whether as a digital PDF that is read on a computer or tablet, HTML pages, e-reader device that reads a file format such as epub, or another medium that involves the use of the internet (the web) or downloadable file format to read a book with a screen.

Though there is debate about when the first digital book appeared (Koepnick, 2016; Wilber, 2023), many inventions have aided people's ability to read books in digital format. Such digital formats have been instrumental to the increased access to materials that people with disabilities can read for work, school, and personal enjoyment.

1.1. Background and Definitions

Definitions helpful to this paper include the following:

- Disability is 'an interaction between an individual with an impairment and the environment rather than as a deficit of an individual' (NCD, 1998).
- Accessibility involves the design of a product that enables people with a disability to use and enjoy products just as well as someone without a disability. Usability is more about the design of a product and how effective, efficient, and satisfying it is to use. (ADA, n.d.; IDF, n.d.; Schaller, 2021; WHO, 2023).
- Inclusive design and universal design take the design for all approach to cater to the broadest range of people, making it more inclusive or universal (Norman, 2013). Inclusive design also considers the full range of human diversity concerning ability, language, culture, gender, age, and other identity characteristics (IDF, n.d.).
- An electronic book (ebook) is a digital representation of a printed book and is read on devices such as smartphones, tablets, computers, or e-readers (Roden, 2023). Ebooks are typically created in PDF, HTML, or EPUB formats (though there are others). The ebook format allows for flexible formatting and navigation between pages. Ebooks use an e-reader device that either reads proprietary file formats (e.g., MOBI, AZW, PDF) and requires device-dependency or open file formats (e.g., EPUB and DAISY), which are device-independent (can be read on any device) (Junus, 2012).
- An audiobook is a sound recording of a book (previously referred to as a book on tape) played on a compatible device, where some would argue that you are 'listening' to the book rather than 'reading' it (Moyer, 2012).
- Assistive technology is any item or piece of equipment used to increase, maintain, or improve the functional capabilities of people with disabilities (Schaller, 2021). Some examples include screen magnifiers, text-to-speech software, and screen readers. A screen reader is an interactive software used to read ebooks (Grammenos et al., 2009). Popular examples include JAWS and NDVA.

This paper uses 'digital books' to refer to all electronically-enabled books (ebook, audiobook, reading on the web) whether online or offline and regardless of format: PDF, HTML, EPUB, sound file, etc. This paper also considers the social model of disability. According to the social model of disability, disability is one aspect of a person's identity, a natural part of human diversity (Olkin, 2022). Scholars in the disability field argue that disability is often misread by assumptions that people without disabilities make concerning the lived experience of disability (Olkin, 2022; Kasnitz, 2020; Mankoff et al., 2010). Additionally, disability is often misread by affordances, a

perception of need or accommodation, whether one is even wanted or asked for by a person with a disability (Kasnitz, 2020). Assumptions and affordances are also crucial to the user experience (UX) design field, especially the subfield of human-computer interaction (Norman, 2013; Croon, 2022). A human makes assumptions when interacting with technology (e.g., what a user expects to happen when a specific button is clicked). The layout or design of technology gives the user a compelling indicator of a function (or affordance) to help them understand that technology or interaction expectation (e.g., clicking on a hyperlinked chapter two heading in the table of contents would take the user to the beginning of chapter two). It is through these disability and human-centered design lenses that digital reading preferences are explored in this paper.

2. The research problem and research questions

Disability studies and UX / human-centered design disciplines focus on accessibility and are concerned with improving the lived experience of people with disabilities. Additionally, these fields advocate that universal or inclusive design helps everyone, not just people with disabilities (IDF, n.d.; Norman, 2013; Mankoff et al., 2010; Stephanidis, 2014). Another applicable field is information science, which has the foundations for information retrieval through reading digital books. This paper applies these frameworks to the inquiry of digital reading preferences of the disability community (reading of books, e.g., via HTML webpages, PDF, epub, etc.). This paper aims to learn about the digital reading preferences of disability communities to improve the digital reading experience through inclusive design and screen-based interfaces and interactions.

With a framework of universal design, accessibility, and inclusive design, the following research questions are addressed in this paper:

1. What are the digital reading format preferences of members of the disability community, and the reasons for these preferences?
2. What assistive technologies, if any, do readers use when reading digital books?
3. How do/can these preferences also benefit people without disabilities?

3. Methodology

A systematic review protocol was used to conduct this review following the eight common literature review steps, as demonstrated by Xiao and Watson (2019). Once these research questions are answered, the lessons learned will be applied to the author's next phase that includes a study on digital reading preferences of people with disabilities. This paper's exploratory review is the necessary precursor to development of a future survey protocol.

The databases and search engines used in this study included Library Literature and Information Science Full Text, Scopus, ERIC, and Google Scholar. The search string included the following keywords: (web OR electronic OR digital) books; (web OR electronic OR digital) reading; preferences; reading platforms; inclusive design; disability OR disabilities; web technologies; and assistive technologies.

Screening for inclusion applied time limiters since digital books require technology, a ubiquitous and evolving medium. Thus, the literature review focused on articles, book chapters, and web resources from no earlier than 2000, excluding earlier studies that may have outdated information, as web platforms and technologies have changed drastically in the past two decades. Studies in English were sought, and sources with survey instruments were given special consideration. A scoring rubric helped screen for inclusion and assess the quality of the studies,

which resulted in 14 studies that underwent analysis, as seen in Table 1 (An accessible list version of Table 1 is in Appendix A.1).

The list of 14 studies is broken down by disability type or topic, and some sources may be in multiple categories, which helps address the goal of this review, which is to identify digital reading preferences among disability communities.

Table 1. List of studies broken down by disability type or topic

Author and Year	Disabilities in general	Blind, low vision focus	Deaf, hard-of-hearing focus	Learning, Autism focus	Motor, print* focus	Audiobook, Ebook, and e-reader formats
Alonzo et al. (2022)			X			
Grammenos et al. (2009)		X				X
Junus (2012)				X	X	X
Knight et al. (2015)				X		
Lee et al. (2023)		X				X
Mason (2012)		X			X	X
Maatta & Bonnici (2014)					X	X
Moyer (2012)	X			X		X
Mune & Agee (2014)					X	X
McNaught & Alexander (2014)					X	X
Orim et al. (2021)	X					X
Park et al. (2022)		X				
Romen & Svanaes (2008)				X	X	
Stephanidis (2014)	X		X			

3.1. Descriptive Data of Studies Reviewed

The 14 studies were published from 2008 to 2023 and were conducted by authors in the following countries: (2) Greece, (1) Nigeria, (1) Norway, (1) South Korea, (1) United Kingdom, and (8) United States. The studies included articles and book chapters, case studies, user testing, reviews or evaluations of digital reading devices, platforms, or products, and various methods, including surveys, interviews, and accessibility or usability testing.

Table 1 also shows the 14 studies broken down by disability type or topic, which includes the following foci: (3) disabilities in general, (4) blind or low-vision, (2) Deaf or hard-of-hearing, (4) learning or Autism, (6) motor or print which combines visual, hearing, physical, and learning, and (9) audiobook, ebook, or e-reader formats. The review performed a thematic analysis of the data using open coding methods to seek trends or themes in the literature.

4. Results

The review identified five recurring themes across the literature: challenging reading aspects, common accessibility barriers, and workarounds, social accessibility issues including perceptions and assumptions, universal and design for all implications, and reading preferences. The themes identified in each study are listed in Table 2, along with the author's country affiliation, as region diversity is important in addition to diversity across source types (case study, accessibility evaluation, review, etc.) and disability type. The rest of this section highlights summaries and features of the studies according to each theme.

Table 2. Themes found in the literature by author and country affiliation

Author/Year	Country Affiliation	Themes
Alonzo et al. (2022)	United States	Challenging reading aspects Common accessibility barriers and workarounds Social issues, assumptions, and perceptions Universal design, design for all (benefits)
Grammenos et al. (2009)	Greece	Challenging reading aspects Social issues, assumptions, and perceptions Preferences
Junus (2012)	United States	Common accessibility barriers and workarounds
Knight et al. (2015)	United States	Challenging reading aspects Preferences
Lee et al. (2023)	South Korea	Challenging reading aspects Preferences
Mason (2012)	United States	Common accessibility barriers and workarounds Universal design, design for all (benefits) Recommendations
Maatta & Bonnici (2014)	United States	Common accessibility barriers and workarounds
Moyer (2012)	United States	Challenging reading aspects Preferences
Mune & Agee (2014)	United States	Common accessibility barriers and workarounds
McNaught & Alexander (2014)	United States	Common accessibility barriers and workarounds Universal design, design for all (benefits)
Orim et al. (2021)	Nigeria	Common accessibility barriers and workarounds Social issues, assumptions, and perceptions Preferences
Park et al. (2022)	United States	Challenging reading aspects Common accessibility barriers and workarounds Preferences
Romen & Svanaes (2008)	Norway	Common accessibility barriers and workarounds
Stephanidis (2014)	United States	Challenging reading aspects Common accessibility barriers and workarounds Social issues, assumptions, and perceptions Universal design, design for all (benefits)

4.1. Challenging Reading Aspects

Challenging reading aspects are seen across several studies with notable concern on complicated text and overwhelming or overloaded feelings of information density that impact the reader's

comprehension and literacy skills. For example, according to Knight et al., 2015, students with autism spectrum disorder (ASD) experience difficulty comprehending science content due to the background knowledge as abstract and figurative language are needed to comprehend the material. One intervention to aid comprehension and tested by Knight et al. (2015) is the supported electronic text (eText), which helps to focus content with increased font sizes and contrasts, clarifying concepts through hyperlinks to other digital pages, providing graphics and vocabulary definitions, and the use of reading text aloud (text-to-speech). Text-to-speech was also a helpful solution for the challenges of digital reading in the literature for print disabilities (Junus, 2012) and for people who are blind (Grammenos et al., 2009).

Another type of cognitive or learning disability is dyslexia. Ann Milani et al. (as cited in Moyer, 2012) conducted a study on reading challenges and found that students with dyslexia who used audiobooks significantly improved reading accuracy compared to other book formats. Some studies tested these information-dense and overloaded information contexts (Lee et al., 2023; Park et al., 2022; Romen & Svanaes, 2008). For example, Romen and Svanaes (2008) conducted usability testing of this issue, which showed people with disabilities had more problems using websites than people without disabilities, citing the number of links and amount of text on a page as specific challenges.

Relatedly, academic papers tend to be information-dense, which challenges all readers. Research has shown that the inaccessibility of academic papers is still relatively high, and navigating an academic paper with low vision has significant challenges, for example, small fonts that decrease legibility, the ability to easily check references and follow references across the article is challenging for screen readers, and complex layouts impact how accurately a PDF parses an article (Park et al., 2022). With a focus on low-vision readers, Park et al. (2022) explored the design of academic paper interfaces to enable readers to navigate papers. They sought to understand the experiences of these low-vision readers by using a tool that helps address easier navigation and interface preferences. The information load of an academic paper is overwhelming. Low-vision users have a limited amount of screen they can view at a time, which requires extra time to parse out relevant information, as explained by one participant in the study:

My rate of reading was incredibly slow [...] And [...] because I was reading so slowly as well, I would lose track of the central idea, so it was just not working for me (Park et al., 2022).

To illustrate this, there is no easy way to check a citation and get back to where the user left off reading. Despite trying some strategies to deal with navigation challenges, three of six users gave up on navigating a paper, which proved rather challenging (Park et al., 2022).

Lee et al. (2023) conducted a study to improve and propose an accessible digital comic book reader for people with visual impairments. The researchers conducted a formative online survey about ebook and audiobook experiences with 68 participants who were blind or had low vision. This study informed the design of the AccessComics prototype, which received feedback on scene description and sound effects (e.g., 'Bam' and 'Pow') preferences as these aspects are challenging for visually impaired readers to grasp as their descriptions are often left out of comic books that are converted to digital format.

Alonzo et al. (2022) discussed the reading experiences and interests of people who are Deaf or hard-of-hearing that work in the computing industry. Through a survey and interviews, Deaf and hard-of-hearing participants were asked about their experience and use of automated text simplification (ATS) tools that automatically rewrite complex text to simplify reading. Striving to

make reading less of a challenge is essential as approximately 15% of the U.S. population are Deaf or hard-of-hearing, and while many are strong readers, it has been suggested that 17% of deaf adults have low literacy (Alonzo et al., 2022).

Grammenos et al. (2009) devoted a chapter to challenging reading aspects in *The Universal Access Handbook* (edited by C. Stephanidis), introducing electronic books to provide accessible educational materials to blind students. In general, a blind student will access computers with two basic technologies: text-to-speech (which allows for the dynamic reproduction of text in a human-like voice) and Braille displays (a writing system that uses patterns of six to eight raised dots to represent letters and numbers). 'Braille displays work complementary to text-to-speech. It is generally considered that speech is for speed and Braille is for accuracy' (2009, p. 50.2). Screen readers only present one word at a time with either method; thus, it is hard for a blind person to get an overview. Hence, electronic books (ebooks) have a crucial advantage over print books in that the accessibility of speech synthesizers, renditions on Braille displays, and hands-free access help blind people read more easily. However, ebooks have different file formats (e.g., plain text, HTML, PDF, Mobi, DAISY, etc.) that complicate their accessibility. Grammenos et al. (2009) found that existing ebooks that are indeed accessible to blind people are typically novels designed for a single user to read and not educational textbooks that have varying features such as questions, exercises, and annotations.

4.2. Common Accessibility Barriers and Workarounds

Romen and Svanaes (2008) state that the number of links on a page and the amount of text on a page is a reading challenge for people with disabilities. A common solution or aid is text-to-speech software, which helps people on the autism spectrum (Knight et al., 2015), people with print disabilities (Junus, 2012), and people who are blind (Grammenos et al., 2009).

Alonzo et al.'s (2022) study on automated text simplification (ATS) as an assistive reading tool yielded a prioritized list of frequently used workarounds by the Deaf and hard-of-hearing community to overcome complicated texts (e.g., looking up words, finding other texts with similar content) and design considerations for assistive reading tools which include expanding user autonomy with tool use and addressing the social accessibility perception of the technology (a societal issue discussed in detail later).

Complicated text workarounds were discussed in the literature, focusing on visual impairment. For example, to overcome the reading challenges of low-vision readers, Park et al. (2022) looked at using an organic crowdsourcing technique that allows users to leave traces of reading paths for others to leverage. Overall, low-vision users want an interface to help orient their reading and digestion of complex concepts. Some design considerations for accessibility barrier workarounds in academic papers were presented in (Park et al., 2022), including problems specific to low-vision users:

1. Persistent feature access.
2. Equal access to original text.
3. Interfaces that have independence in mind.
4. Destination clarity of linked content.
5. Personal benefits such as adding bookmarks.

The literature addressed accessibility barriers related to device and file formats in depth (Junus, 2012; Romen & Svanaes, 2008; Mason, 2012; Maatta & Bonnici, 2014; McNaught & Alexander, (2014). The rest of this section summarizes these accessibility barriers. According to Junus (2012),

people with print disabilities have great potential to use ebooks if the devices used are well designed, use open formats, and are compatible with assistive technologies. However, the digital publishing industry has made so many formats and e-readers that are inaccessible to people with visual, hearing, or learning disabilities. Mason (2012) agrees that many ebooks are still inaccessible. Accessible ebooks benefit everyone, but the e-reading platforms and devices (and their hundreds of combinations of file formats) result in various levels of accessibility and modes of access; plus, the ebook market rarely provides the accessibility feature information needed to assess the ebook before purchase (Mason, 2012). Mason (2012) continues her evaluation of the pros and cons of various ebook reader hardware: Apple iOS software, Mac, and Windows PC support, noting that at the time of her review, the Nook and all Android platforms tested failed to be accessible. Mason (2012) also discussed the advantages and areas for improvement for Biblio, CourseSmart, EPUB, Adobe Digital Editions, OverDrive, Google Books, iBooks, Kindle, and PDF. With concluding advice and hopes, Mason (2012) states,

In an ideal world all the major ebook technologies would be accessible to print-disabled and blind users. These book platforms would allow users to browse, purchase, and consume content in the most comfortable and appropriate manner for the user's needs and the type of content consumed. All ebook platforms are falling short of this laudable goal. Some options work fairly well and allow reasonable access to text, but all of the platforms discussed in this article need improvement.

To put this into perspective, ebooks are either open or proprietary file formats. EPUB and DAISY are open formats, meaning they are device-independent (they can be read with any e-reader that supports open formats). In comparison, proprietary format ebooks (MOBI, Amazon Kindle's AZW, PDF) may have been originally based on an open format but ultimately configured only to work on a specific e-reader. "In general, open format e-texts are far more accessible than proprietary formats" (Junus, 2012).

Maatta and Bonnici (2014) examined the usability of three electronic reading (e-reader) devices: the Apple iPad 2, Amazon's Kindle Fire, and Barnes and Noble's NOOK tablet. Though upgraded models of these devices are available today, their implications for the study and historical perspective are important, including a lack of studies on e-reader usability testing with diverse users. Common issues discussed among all usability study participants (n=8) included concerns for device weight, location of the power on/off button, Bluetooth capability, acceptance of EPUB formats, and the location and ability to find the device settings to change accessibility features. Maatta and Bonnici (2014) describe several instances where universities and public libraries were being sued (circa 2000-2012) for either requiring e-readers as textbooks or making ebooks available that were not accessible (Matta & Bonnici, 2014). This is perhaps due to the rapid development of the e-reader market at the time, where Maatta and Bonnici (2014) note that there have been limited studies on e-reader usability with members of the disability community, particularly users with print disabilities (e.g., low vision, no vision, and dyslexia). These researchers also found that two of the three devices offered no accessibility features for people with print disabilities requiring assistive technologies. The iPad was found to be accessible for individuals with mild-to-moderate print disabilities but not for people with a higher severity level, as it had limitations in locating the device settings to customize accessibility features.

Similarly, Mune and Agee (2016) tested 16 academic ebook platforms against the features most print-disabled users use and rely on. Their study found that most platforms offered text resizing or zoom capabilities, while only one provided page reflow. None of the platforms allowed user

adjustments to the fonts' color, size, or style. For a document to be fully accessible, an alternative text description for every image or table is required, and only six vendors did this consistently. Only 7 of the 16 vendors had a Voluntary Product Accessibility Template (VPAT), a statement completed by the vendor to demonstrate its compliance with Section 508 requirements. Additionally, three of 16 vendors did not allow the ebook to be downloaded or printed, which is helpful for users who want to read offline. Mune and Agee (2016) recommend standardizing the file format of all books offered, using both the EPUB 3 and PDFs, as the former is preferred for screen reader compatibility, and the latter allows a balanced approach to downloading, printing, and copying (though the PDFs must never be just images).

Romen and Svanaes (2008) sought to validate the usefulness of the Web Content Accessibility Guidelines (WCAG) as a heuristic for website accessibility. Using a controlled usability test with people with visual, motor, or dyslexic impairments ($n=7$) and without disabilities ($n=6$), Romen and Svanaes (2008) found that only 27% of the identified accessibility problems were identified through the use of WCAG alone and testers with disabilities experienced a significantly larger number of problems using the website compared to testers without disabilities. Notably, the high number of links on a page and the amount of text on a page were issues for people with visual and motor impairments. For all disability types, there were too many navigation levels and a lack of instructions for advanced functions or form use. The most frequent accessibility problems experienced by the three disability types (visual, motor, and dyslectic) are outlined as follows:

- Problems specific to visually impaired users:
 - Links that start with the same letter and almost read the same. These are difficult to distinguish.
 - Links with identical spelling that point to different places (e.g. "Click here to go to A and here to go to "B").
 - High number of links and redundant links.
- Problems specific to motor-impaired users (tremors, etc.):
 - The screen element/menu/button's surface was larger than the clickable surface.
 - Mouse-over menus that disappear when the user no longer hovers disrupt navigation.
 - Small font sizes and many links placed closely together increase the risk of erroneous clicks.
- Problems specific to motor-impaired users (tremors, etc.):
 - The screen element/menu/button's surface was larger than the clickable surface.
 - Mouse-over menus that disappear when the user no longer hovers disrupt navigation.
 - Small font sizes and many links placed closely together increase the risk of erroneous clicks.
- Problems specific to dyslectic users:
 - Positioning of links and navigational mechanisms.
 - Web pages crowded with a lot of text and links become confusing and difficult to read and navigate.

With Romen and Svanaes's' (2008) study, it is important to note that at the time of this writing, WCAG 1.0 was used (as of 2024, WCAG 2.2 is in use). Despite the older version of WCAG, the study's finding demonstrates that WCAG alone cannot guarantee website accessibility. The study used the two groups of users to test against accessibility (problems experienced only by testers

with disabilities) and usability (problems experienced by both groups) differences on two websites. Romen and Svanaes (2008) found that, on average, testers with disabilities experienced a significantly larger number of problems using the website and conducting the tasks than testers without disabilities (17.1 average problems vs. 9.3).

McNaught and Alexander (2014) argue that the publishing industry should mandate vendors to label the range of accessibility features offered in their products (like labeling is done in the food industry). According to McNaught and Alexander (2014), if the right format and construction of the ebook becomes the standard in ebooks, they will be accessible to a range of users, including people with print disabilities. McNaught and Alexander (2014) also discuss common accessibility barriers:

- File format choices (e.g., PDF documents that are images of text that cannot be read aloud, recolored, or reflowed to fit larger font sizes, and flipbooks struggle with magnified reflowable text and text-to-speech).
- Lack of accessible production decisions (e.g., tagging headings for semantic meaning)
- User interface of delivery platforms lacking the ability to change fonts and background colours.
- Lack of information on accessibility features for a product.

According to McNaught and Alexander (2014), the right format and the right construction of the ebook can offer (p. 35-36): Magnification with text reflow (line lengths can reflow when text is magnified so that the line still fits the width of the screen, improving reading speed); colour contrast changes (helps people with visual impairments or dyslexics with scotopic sensitivity and people working in very dark or very light environments); text-to-speech support; alternative texts for images/tables (helping blind readers and sighted readers in their interpretation of the information); and compatibility with assistive technology devices.

Orim et al. (2021) discussed an important financial and circumstantial dependency that can impact accessibility and preferences for digital reading. Orim et al. (2021) found that a person's level of computer literacy and the ability to pay for the technology is a barrier to ebook use. It is challenging for most students with disabilities (in the Orim et al. study at a public university in Nigeria) as the students come from economically disadvantaged families.

4.3. Social Accessibility Issues (Culture, Assumptions, and Perceptions)

Culture affects everyone's reading habits and preferences. For example, the interpretation of symbols, colors, and gestures have different cultural interpretations. Green and yellow are sacred in certain religions, while the reading direction (left to right, right to left) is based on geographic region (Stephanidis, 2014). Culture also plays a part in disability types and society's perception of what it means to have a disability (Grammenos et al., 2009; Stephanidis, 2014; Alonzo et al., 2022; Orim et al., 2021).

In previous decades, it was common for students with disabilities to be segregated into separate, special classrooms or schools for students with the same disability. According to Grammenos et al. (2009), this practice negatively impacted the student's ability and opportunity for inclusion in society; currently, many countries take a more open approach to inclusive education. Today, students with disabilities can participate in the mainstream classroom alongside students without disabilities, which provides better opportunities for inclusion but also creates a challenge for

getting the same educational materials to students with disabilities in a format that is accessible to them.

This challenge of access to accessible books can have larger societal implications that can affect a culture's literacy rate. Orim et al. (2021) claim that a positive reading habit among students, including those with disabilities, will produce a literate and developed society. Thus, accessibility of books is critical to culture regardless of disability status. There is also a perception of disability and intellectual competence found in some societies, which impacts the social dimensions of culture.

Alonzo et al. (2022) found that Deaf and hard-of-hearing adults prefer reading with automatic text simplification (ATS) technology, though there are social accessibility concerns. People want to be seen as competent and reliable; however, using assistive reading tools or technologies may conflict with their desired image as public perspectives of assistive technology use imply low intelligence or reading levels. Alonzo et al. (2022) also posit this assistive reading tool could be useful to the general population (rather than just for the Deaf community), which would help mitigate negative perceptions of tool use if more people were using it.

Interactions with any computer or device involve reading or writing text. According to Stephanidis (2014), *'Deaf users, at first glance, would not appear to be disadvantaged in their ability to read and write. However, interfaces requiring reading and writing also have the potential to disenfranchise many deaf users'*. This demonstrates another misperception or assumption of the disability community. Studies have shown that most U.S. deaf high school graduates have a fourth grade reading level; thus, sign language interfaces are critical for that subset of the Deaf population who have difficulty reading texts (Stephanidis, 2014). American sign language (ASL) is a natural language distinct from English because it is not based on spoken language. ASL is a visual language where the signer's facial expressions, utilization of the space around them, and movements of the eyes, head, arm, shoulder, and hand convey linguistic information (Stephanidis, 2014). This reading challenge of being able to use sign language in interfaces is lacking in some digital reading platforms.

Culture, along with assumptions and misperceptions of education and literacy, play a part in how society and social accessibility impact people with disabilities. Examples were seen throughout the literature review. It is perhaps summarized best in Stephanidis (2014), which describes the disability spectrum broadly (e.g., difficulty with perception, motion, cognition, and age) to discuss challenges around social issues (barriers to technology, poverty, educational opportunities, social status, etc.) and computer use among these user types and how universal design can benefit everyone.

4.4. Universal Design and Design for All Implications

According to Stephanidis (2014), addressing web accessibility puts universal design factors into perspective regarding how user interfaces (including ebooks) can be designed with accessibility as a foundation for creating a better reading platform for all. Accessible books benefit print-disabled and blind readers because *'when an ebook is presented in an accessible format on an accessible ebook reader, the user can choose to read the book using text-to-speech, Braille, or magnification. Furthermore, accessible ebooks in an open market benefit everyone'* (Mason, 2012). Although advances in publishing and education now show how an accessible book is better, there are still opportunities for change, including accessible books becoming the mainstream product. According to McNaught and Alexander (2014), the Accessible Publishing Best Practice Guidelines for Publishers will help the publishing industry at large create better,

more accessible books. “The more accessible the mainstream product becomes, the fewer costs will be incurred meeting specific learning needs” (2014), which benefits all readers.

Specific examples of accessibility adaptations for people with disabilities also help people without disabilities are found in the literature (Lee et al., 2023; Park et al., 2022; Alonzo et al., 2022). For example, Lee et al. (2023) found people with and without disabilities had the same preferences for real sound effects over spoken word sound effects in digital comic books. Park et al. (2022) discussed how academic papers are information-dense reading for all users. Alonzo et al. (2022) found that a preference for using tools that make it easier to read (simplified text) helps everyone, not just people with hearing impairments.

A notable universal design application in Alonzo et al. (2022) is the Deaf communities’ perspective on how the ATS assistive reading tool is relatable to people who use English as a second language (ESL). Additionally, while not all people who are Deaf or hard-of-hearing use ASL, the study saw the cultural wealth connections between ASL and ESL as a participant explains,

Some deaf hard-of-hearing people or people of color or immigrants...may not know English either, and so they may know another language, or maybe they just only know how to communicate in ASL, so they don’t have the opportunity to practice English so that could impact their reading (Alonzo et al., 2022, p. 16:23).

Other participants saw these shared experiences could not only help ASL and ESL communities, but also international students, people with intellectual disabilities, and children. Accessible design is just better design, helping readers worldwide and of varying ages.

4.5. Reading Preferences

The literature highlights reading preferences from different perspectives, including hard-of-hearing (Alonzo et al., 2022), cognitive/learning (Knight et al., 2015), blind or low vision (Moyer, 2012; Grammenos, et al., 2009; Lee et al., 2023; Park et al., 2022; Orim et al., 2021) discusses preferences more broadly with a circumstantial lens. Some reading preferences were discussed in earlier themes presented, including how all readers prefer less complicated text when reading (Park et al., 2022) and people who are Deaf or hard-of-hearing prefer simplified text, which also helps other people, explicitly mentioning ESL learners, international students, and children (Alonzo et al., 2022). Knight et al. (2015) also found, from a cognitive or learning perspective, that users preferred eText over print books as it helps with comprehension.

In Knight et al. (2015), results showed that middle school science students with ASD enjoyed and preferred the eText format over traditional print-based books. The additions of the hyperlinks to the glossary/definitions and coaches (embedded avatars that explained concepts) were found to be the most beneficial resources. Reading platform use and preferences were also discussed in Grammenos et al. (2009), which tested a platform for creating and reading such books (called Starlight), and the user testers suggested that the platform should include accessible images (magnification options and navigable descriptions), in-line sounds to annotate text, HTML pages (with preference for Starlight over reading on a web browser), and mathematics reading improvements.

Lee et al. (2023) identified accessibility issues of reading comics by people with vision impairments. Based on the preferences of this disability community, design implications for future accessible comics include using various voices, reading speed customization, auto-reading, filtering types of information to be played, scene descriptions, and sound effects. There was

nearly equal preference between the audiobook and ebook formats, though having either format still requires it to be accessible. Most participants preferred a human voice over a synthesized-voice because it helped understand context through emotions, created an immersive experience, and helped make the character voices distinguishable. Additionally, textual sound effects in comics (e.g., ‘BOOM,’ ‘SNAP,’ ‘POW’) provide an animated expression for the story; however, these are often ignored when converted into accessible forms like eBooks (Lee et al., 2023). During testing, most participants (people with and without disabilities) found the scenic descriptions useful and favoured sound effects over spoken word-based sound effects.

Moyer (2012) provides a literature review on audiobooks and ebooks, including digital book formats and accessibility implications. For example, ‘many visually impaired readers who listen to audiobooks often have the same preferences and needs as sighted patrons who enjoy audiobooks’ [Elkin, as cited in Moyer, 2012, p. 342]; and Ann Milani et al. (2010) [as cited in Moyer, 2012, p. 345] found students with dyslexia who used audiobooks experienced significant improvements in reading accuracy. However, Moyer (2012) also notes some opposition to using audiobooks. For example, people who learn Braille and ‘read’ texts prefer this reading method over ‘reading’ by listening to an audiobook, where ‘some researchers are concerned that those who only listen may fail to develop certain areas of the brain’ (Aviv, 2009, as cited in Moyer, 2012, p. 346).

Advances in e-reading technology have substantially changed the reading culture, especially because of ebook portability, ease of sharing, accessibility, and convenience. However, according to Orim et al. (2021), a nation’s development and the digital divide among students with disabilities may also determine whether the traditional or ebook format is preferred. For example, Orim et al. (2021) studied the book format preferences of 60 students with disabilities at a public university in Nigeria and found that students with disabilities choose a book format preference based on their skills, the severity of special needs conditions, the learning environment, and the affordability of the book format. Some level of computer literacy and the ability to pay for the technology is needed for ebook use, which was challenging for most students in their study as they come from economically disadvantaged families. This makes the question of book format preferences of students with disabilities difficult to navigate as there are other variables at play.

5. Discussion

There are many challenges across disability types, and the design to create accessible reading platforms for people with learning disabilities is largely applicable to the other disability types, as well as for people without disabilities. In a similar comparison (and relating to RQ2 and RQ3), the assistive reading tool for text simplification could be useful to a broader population (rather than just the learning disability or Deaf community). Other assistive tools like magnification, text-to-speech, and screen readers (which also help people without vision or learning impairments) would help mitigate negative perceptions of assistive technology use and social accessibility assumptions or other cultural issues.

Magnification was widely discussed as magnifiers for digital reading are helpful for visual impairments but are also very limiting as the viewport’s size makes reading and comprehending difficult. This is an example of an assistive technology that helps a person with disabilities access a text. However, true accessibility remains a challenge because of the electronic format used. ‘*The digital revolution is allowing for a wider range of content to be made available in a more timely and cost-effective fashion*’ (McNaught & Alexander, 2014, p. 39). Yet, the literature found various ebook and e-reader formats, with none truly accessible.

Culture also plays a part across disability types, including how communities interpret color, symbols, and gestures (Stephanidis, 2014). Distinctive cultural aspects, including societal perceptions and social accessibility, also play an important role in digital reading practices and preferences (RQ1). For example, there seems to be a unique connection between ASL and ESL experience and learning environments. The Deaf and heard-of-hearing community studied by Alonzo et al. (2022) shed light on assistive technology tools useful to immigrants, ESL learners, and international students. This has translanguaging pedagogical theory implications as there are dynamic ways for learning, meaning-making, reading, and writing for multiple communities (Hoffman et al., 2017). Translanguaging is a pedagogical theory and language practice in cultural pedagogy (education) and critical theory studies that *“conceptualizes the dynamic ways in which bilinguals use their linguistic repertoire and language practices for learning and meaning-making”* (Hoffman et al., 2017).

Digital reading preferences are disability-centric (RQ1): Low-vision users want interfaces that help orient reading and digestion of complex concepts (Park et al., 2022). However, preferences are also hard to determine as there is a preference by disability constraint vs personal choice (Orim et al., 2021). ‘Starlight’ (book platform) was preferred over reading on a web browser for people who are blind or have low vision (Grammenos et al., 2009). Lee et al. (2023) found a preference for accessible comics included having various voices, reading speed customizations, auto-reading features, and using scene descriptions and sound effects. Nearly equal preference for audiobook vs ebook, and most testers with and without disabilities preferred actual sound effects over spoken word sound effects). Moyer (2012) also found that many people with visual impairment who use audiobooks have the same preference as sighted people who use audiobooks.

Several digital book design recommendations are similarly helpful to various disability types, addressing the implications that universal design can benefit people broadly (RQ3). Appendix A.2 offers a curated collection of recommendations or advice in the review. This includes Mason’s (2012) extensive list of recommended accessibility improvements that are helpful to people broadly. Her plea for digital book creators to make accessible books the standard, rather than just special accessible versions, is a sentiment echoed in the literature as *‘these books make it possible for print-disabled readers to enjoy a novel, get an education, advance in their careers, learn new skills, and join in all of the other activities enjoyed by the book-reading public’* (Mason, 2012). Accessibly books are simply better.

5.1. Research Gaps

Although advances in publishing and education now show how an accessible book is better, truly accessible books are still not commonplace on the market. This is a gap in the industry; we continue to wait for technology developers to make accessibility a standard reality. For example, not all academic ebook platforms provide the correct formats or features the disability community requires (Mune & Agee, 2016). As technology frequently changes, so do standards and compliance levels of accessibility, as well as the market conditions that create competition among developers of reading devices and formats—both of which are gaps in the literature.

Moyer (2012) generally addresses digital book formats and implications, including some references to accessibility impacts among people with disabilities. She importantly notes the lack of research-based literature on ebooks and formats (compared to audiobooks that have a longer history), which is foreshadowing the topic of this literature review on digital reading preferences. Stephanidis’ (2014) design for all best practices complement Moyer’s (2012) reference to the disenfranchisement of people with disabilities and inaccessible interfaces. Additionally, most

studies involving e-reader usability are concentrated on devices for trade publications and commercial products (e.g., iPad and Kindle), which have mixed accessibility results that are 'largely dependent on the configuration of the device, browser, and publisher' [Huthwaite et al., as cited in Mune & Agee, 2016, p. 274]. More research is needed on default device settings and devices for a broader range of publication types.

5.2. Limitations

The literature review was conducted by one researcher, where subjectivity could be seen as a limitation. However, an external reviewer unrelated to the study reviewed aspects at various stages—methods, data extraction, analysis, and readability—as a reliability measure. Additionally, the author has personal or observed lived experiences of various disabilities but did not consult people with disabilities on their digital reading preferences in this study. That type of interview or focus group discussion would add value to the study and is considered the next phase in this research. This literature review was the first phase, exploring what is known to date and considering implications for learning about the digital reading preferences of people with disabilities.

6. Conclusion

Digital books apply to education, employment, and enjoyment or hobby reading, but not all books are created with accessibility or usability. This paper sought to gain insights into previous studies on digital reading preferences across various disability communities. Specifically, this review's research questions sought knowledge about format preferences, assistive technologies for digital reading, and how such preferences benefit people without disabilities. This paper uncovered five themes across 14 studies in the literature: the challenges of digital reading by members of the disability community, common accessibility barriers and workarounds, social accessibility issues including perceptions and assumptions, universal design and design for all implications, and reading preferences among people with various disabilities. Culture, along with assumptions and misperceptions of education and literacy, play a part in how society and social accessibility impact people with and without disabilities. Examples were seen throughout this literature review. Reviewing these studies also leads to identifying gaps or limitations that provide possible future research directions, including the author's future co-designed survey for a digital reading preferences study. This knowledge can help address the limitations and advantages of making digital books more inclusive by addressing their design and accessibility among disability characteristics. Assistive reading tools and accessible books help cultures learn and work. The interactions, modalities, and techniques to address a person's unique needs are important to the design of such information communication technologies, including digital reading platform interfaces. The viewpoints of the disability community on digital reading may help increase the accessibility, usability, and enjoyment of digital reading more broadly, which is a call to action emphasized by the disability studies and user experience design fields: Accessible books are better books, where design for all can be the tool for standardizing accessibility which benefits everyone.

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Appendix A: Study Breakdown by Disability or Topic

Study breakdown by disability or topic. Note: This information was also presented in Table 1. This is an accessible list version.

Disabilities in general

- Orim et al. (2021)
- Stephanidis (2014)

Blind, low vision focus

- Grammenos et al. (2009)
- Lee (2023)
- Mason (2012)
- Moyer (2012)
- Park et al. (2022)

Deaf, hard-of-hearing focus

- Alonzo et al. (2022)
- Stephanidis (2014)

Learning and Autism focus

- Junus (2012)
- Knight et al. (2015)
- Moyer, (2012)
- Romen & Svanaes (2008)

Motor and Print focus

Note that print disabilities include visual, hearing, physical book holding, learning: dyslexia, and ADHD.

- Romen & Svanaes (2008)
- Junus (2012)

- Mason (2012)
- Maatta & Bonnici (2014)
- McNaught & Alexander (2014)
- Mune & Agee (2014)

Audiobook, Ebook, and e-reader formats

- Junus (2012)
- Grammenos et al. (2009)
- Lee et al. (2023)
- Mason (2012)
- Maatta & Bonnici (2014)
- McNaught & Alexander (2014)
- Moyer (2012)
- Mune & Agee (2016)
- Orim et al. (2021)

Text-to-speech

- Autism focus in Knight et al. (2015)
- Print disability focus in Junus (2012)
- Blind or low vision focus in Grammenos et al. (2015)

Appendix B: Recommendations

This is a curation of recommendations or advice found in the literature review. The list is alphabetical by author.

Junus (2012) provides advice related to e-reading devices. Many e-reading devices come equipped with standard features useful to readers with disabilities; for example, the text-to-speech feature dictates text aloud. The chapter discusses and compares several available ebook formats and e-readers. Still, people with print disabilities only have a limited number of accessible options and offer the following advice as of 2012:

- DAISY, EPUB, and TXT are the most accessible ebook formats, while accessibly designed PDFs and simple HTML documents provide generally accessible e-text formats.
- Apple handheld products outfitted with iBooks are the most accessible software-based e-reader devices.
- Software-based e-readers such as Blio and the Kindle app either are becoming equipped with text-to-speech capabilities or are relatively compatible with screen readers. Still, the accessibility features on dedicated devices and mobile apps must often be “enabled,” which requires additional steps to configure a device because it is not accessible out of the box.

- There is a general lack of accessibility features in the most popular dedicated e-reader devices.

Mason (2012) provides an extensive list of example areas for improvements related to digital reading, including:

- Migrate old, inaccessible books to accessible technologies.
- Ensure that books are clearly marked inaccessible (or image only).
- Follow a book-purchase model allowing users to purchase books from the portal the platform uses.
- E-readers should comply with the standards of the operating system “to allow screen access and magnification software to access the book player’s controls and the text inside the books,” which enables a comfortable way for a user to magnify a chart, read computer commands in Braille, check the spelling, etc.
- Dedicate method for turning any accessibility feature on or off independently.
- Allowing for meaningful interaction with the text (character, word, line, paragraph, section, page, and chapter levels); for book reading platforms to allow for continuous and paginated readings to help with different reading styles and materials.
- Allow for highlighting of words as they are read; the standard features of e-reading platforms (ability to search, highlight, annotate, and bookmark) must be available to blind users.
- Ebook creators should stop creating special accessible versions and just make rolling accessible changes as part of the actual software used by everyone.

Mune and Agee (2016) recommend using both the EPUB 3 and PDFs as the former is preferred for screen reader compatibility, and the latter allows a balanced approach to downloading, printing, and copying (though the PDFs must never be just images).

Other existing web design practices often found in web searches recommend the following:

- Ensure content uses semantic coding, identifying headings, lists, tables, and images with alternative text.
- Avoid justified tests as they are prone to readability issues and affect comprehension.
- Use clean typography, preferably a sans-serif font for digital or screen reading.
- Avoid using all caps; Don’t underline text; reserve it for hyperlinks.
- Support resizing and zoom capability.
- Consider line spacing and line length.
- When content is enlarged, ensure elements don’t overlap.

The impact of digital accessibility on the user experience of people with cognitive impairments

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Abstract: The Internet has become an essential part of everyday life and plays a central role in accomplishing various tasks. Despite existing guidelines and laws on digital accessibility, people with disabilities repeatedly encounter barriers on the Internet that make it difficult for them to use. This work examines the importance of accessible websites and aims to compare the normative guidelines of digital accessibility with the real-world experiences of users with cognitive impairments. To explore how specific aspects of digital accessibility affect the user-friendliness of websites for people with cognitive impairments, we conducted a qualitative study. Twelve semi-structured interviews were carried out to examine the target group's response to three websites that differed in their level of digital accessibility. Three aspects of digital accessibility were examined in more detail: a) easy-to-read language, b) consistent navigation, and c) pause, stop, and hide. The results show that easy-to-read language and clear navigation significantly improve user-friendliness, while moving content has no negative influence. The study results make it clear that there is a lack of understanding of how people with disabilities perceive digital accessibility. The findings of this study can help promote the development of further guidelines for designing accessible websites and enable the digital participation of all users.

Keywords: digital accessibility, cognitive disability, usability, web content accessibility guidelines

1. Introduction

The Internet is an essential part of daily life and plays a central role in education, work, and social participation (Schuppener et al., 2019). However, despite existing legal frameworks and accessibility guidelines, people with disabilities continue to face substantial digital barriers (Botelho, 2021; WebAIM, 2024). This is particularly true for individuals with cognitive impairments, who have long been underrepresented in accessibility research (WebAIM, 2008). This study addresses the gap between normative guidelines and actual user experiences by examining how people with cognitive impairments perceive and navigate websites with varying levels of accessibility. To this end, it investigates how specific accessibility features, i.e., a) *easy-to-read language*, b) *consistent navigation*, and c) *the ability to pause or hide moving content*, impact the perceived user-friendliness of websites for this target group. The central research question of this study is how selected aspects of digital accessibility affect website user-friendliness for individuals with cognitive impairments.

1.1. Basics of digital accessibility

Digital accessibility refers to websites, apps, and technologies that are designed and developed to be accessible to people with disabilities without relying on external support. It is about enabling users to perceive, understand, navigate, and interact with the Internet, regardless of their limitations (Hortizuela, 2022). Cognitive impairments affect various neuronal functions such as perception, memory, language, attention, problem-solving ability, and understanding (Hortizuela, 2022; Seeman & Lewis, 2019). These functional disorders of the brain can be present from birth or the result of adverse events such as an accident or illness, and often remain for a lifetime. The group of people with cognitive impairments comprises individuals with mild learning difficulties, who are often able to live independently, but also those with severe impairments who require extensive support (Cleveland Clinic, 2023). Cognitive disabilities include intellectual disabilities, developmental disabilities, learning disabilities, dyslexia, autism spectrum disorders, mental illnesses, stroke, Alzheimer's disease, and other forms of dementia (Braddock et al., 2013; Hortizuela, 2022; Szabó et al., 2023).

This research focuses on individuals with a learning disability, which is diagnosed when a person shows difficulties in certain areas of school, such as understanding and applying listening, speaking, or writing skills (Hammill et al., 1988). There is, however, no universally accepted definition of this disability, and no precise IQ scores indicate a learning disability (Siegel, 1989, 1999). In the current study, it is often argued that IQ tests do not help diagnose learning disabilities since, in addition to the above-mentioned difficulties, learning disabilities also include mental and developmental limitations in the thinking, remembering, or judgment processes (Blazeska-Tabakovska et al., 2019; Siegel, 1989).

1.2. Internet use by people with cognitive impairments

People with cognitive impairments use the Internet for the same reasons as people without cognitive disabilities: they want to accomplish everyday tasks and engage in activities relating to social participation and personal development. This digital participation covers various areas, such as education, searching for information, entertainment, and building social relationships (Shapiro & Rohde, 2020). One purpose of Internet use is communication: Many use the Internet to stay in touch with family and friends through social media, email, or dating platforms (Glencross et al., 2021; Sallafranque-St-Louis & Normand, 2017). Furthermore, entertainment options such as watching videos, listening to music, and playing online games are common activities the Internet is used for (Ågren et al., 2020; Turner, 2023). The Internet also allows individuals with cognitive impairments to develop their cognitive abilities, such as reading and writing, and enables the expression of personal and romantic needs, for example, through online dating apps (Turner, 2023; Vouglanis & Drigas, 2022). These diverse uses of the Internet show that it plays an essential role in the everyday lives of people with cognitive impairments, just as it is an essential aspect of everyday life for people without disabilities today.

So far, little research has been conducted when it comes to digital accessibility for people with cognitive impairments. This is partly due to the diversity and complexity of the needs of this target group (Small et al., 2005). The barriers experienced online also depend heavily on the type of disability, the web content used, and the goal of usage (Berger et al., 2010). Many users leave websites due to a lack of accessibility (Conway & Mace, 2019). For example, understanding content is a frequently mentioned barrier on the Internet, as many websites use complex language or contain too much information, which makes texts difficult to understand (Dirks et al., 2020).

The barriers that people with cognitive disabilities face online further include difficulties in navigating and orienting themselves on websites (Chadwick et al., 2013). Many options, such as cookie notices, pop-up windows, or advertisements, can confuse and distract the user (Youngsun et al., 2010). Navigating the Internet often requires an in-depth understanding of interactive processes, such as long click paths to get to the desired destination on the website (Chadwick et al., 2013). Complex user interfaces and confusing website structures can make orientation even more challenging (Youngsun et al., 2010). Furthermore, audio-visual content is often inaccessible. Videos without subtitles or content with poor contrast make it difficult to grasp information, especially on small smartphone screens (Bundesministerium des Innern und für Heimat, 2024d). Screens that are visually overloaded with numerous elements, pop-up windows, and animations are distracting and make it difficult to identify relevant information (Chadwick et al., 2013; Marx & Bremer, 2024).

1.3. Guidelines and policies for digital accessibility

Several guidelines and regulations in the European Union govern the rights of disabled people with the aim of enabling them to participate digitally. The Web Content Accessibility Guidelines (WCAG) of the World Wide Web Consortium (W3C) are the basis for many national and European laws (W3C, 2024). Two of the most important regulations in the EU are the EU Directive 2016/2102, which covers the accessibility of websites and mobile applications of public authorities, and the European Accessibility Act (Directive 2019/882; European Union, n.d.; European Commission, n.d.). The European Accessibility Act obliges EU member countries and, starting in 2025, will introduce an obligation for private providers of certain products and services, such as e-commerce and banking. National legislation will implement this regulation (Bundesfachstelle Barrierefreiheit, n.d.). In addition, the EN 301 549 standard defines specific accessibility requirements that serves as a reference for implementing the above-mentioned EU directives. It is primarily based on the WCAG but includes additional requirements for other information and communication products, such as operating systems, self-service terminals, and communication services (European Commission, 2021).

To make the web accessible to everyone, in 1999, the World Wide Web Consortium (W3C) published the Web Content Accessibility Guidelines (WCAG; Hellbusch & Probiesch, 2011). The current version, WCAG 2.2, has been in effect since October 2023. However, only a few guidelines of the WCAG are currently specifically adapted to people with cognitive disabilities or learning disabilities (Bundesministerium des Innern und für Heimat, 2024c; W3C, 2024).

The WCAG comprises principles, guidelines, success criteria, and techniques. The four principles, that is, perceivable, operable, understandable, and robust, serve as the basis of accessibility on the web (Bundesministerium des Innern und für Heimat, 2024c; Hellbusch & Probiesch, 2011). Perceivable means that information is accessible through at least two sensory channels. Operability refers to using the website, e.g., with a keyboard, straightforward navigation, and avoiding flashing lights or sounds. Understandability describes easy-to-read content and simple language. Robustness relates to compatibility with screen readers (Bundesministerium des Innern und für Heimat, 2024b). The four principles are supported by thirteen guidelines and are supposed to define web developers' goals and frameworks. These guidelines are not testable; however, they make it easier to understand the success criteria and techniques (Bundesministerium des Innern und für Heimat, 2024b; Hellbusch & Probiesch, 2011). Moreover, testable success criteria are defined for each guideline. The 61 testable success criteria are further divided into three levels of conformity, providing concrete instructions for implementing accessibility. These three levels of conformity, that is, A, AA, and AAA, each define a specific

degree of accessibility (Hellbusch & Probiesch, 2011). Finally, there are numerous techniques for each of the guidelines and success criteria to implement the minimum requirements of the three levels of conformity (W3C, 2024).

The concepts of plain language and easy-to-read language have different origins. Plain language is used in the legal and administrative context with the goal of making texts easier to understand for the general population (Vollenwyder et al., 2018). Plain language tries to make the content easily understandable by avoiding long and complex sentences. Within the WCAG, plain language is indirectly addressed through success criterion 3.1.5 Reading Level (Level AAA) (W3C, 2024). Easy-to-read language was specifically developed to meet the needs of people with cognitive disabilities (Hellbusch & Probiesch, 2011). Easy-to-read language, however, is not explicitly included in the WCAG. Nevertheless, it represents the most relevant and helpful linguistic concept for people with cognitive impairments, as it provides the highest level of accessibility for this user group (ISO – International Organization for Standardization, 2023). Both plain language and easy-to-read language have the goal of improving text comprehensibility by removing linguistic barriers (Vollenwyder et al., 2018).

Easy-to-read language is a way of expressing oneself that is, in particular, well understood by people with learning disabilities (Hellbusch & Probiesch, 2011). It reduces linguistic barriers and expands the range of information that users can understand and use (ISO – International Organization for Standardization, 2023). A set of rules for easy-to-read language specifies that simple words should be used, words such as ‘not’ or ‘no’ should be emphasized in bold, and sentences should be written on one line, if possible, without commas, for example (Bundesministerium des Innern und für Heimat, 2024a). Easy-to-read language is not explicitly regulated in the WCAG (W3C, 2024). A text in easy-to-read language is usually checked by experts, either trained specialists or affected persons with learning disabilities (Hellbusch & Probiesch, 2011; MSKTC.org, 2014).

Consistent Navigation belongs to the WCAG principle “Understandable” and the guideline “Predictable”. It is assigned to the conformity level AA (W3C, 2024) and specifies that navigation should be consistent and always available throughout the website to make finding content easier. When testing this success criterion, different website areas are opened from the home page using different navigation paths (BIK BITV-Test, n.d.-b). An accessible website requires multiple ways to find content and meaningful headings and labels that help users locate content and understand their position on the website. A good navigation concept should enable an intuitive orientation on the website (Hellbusch & Probiesch, 2011).

Pause, Stop, Hide relates to the conformance level A according to the WCAG and can be assigned to the principle of operability and the guideline “Enough Time”. It is specifically relevant for people with learning disabilities since moving content, such as videos, animations, or flashing text that plays automatically, can distract from other information (Marx & Bremer, 2024). Such content should either be limited to five seconds, or it should be possible for the user to pause, stop, or hide it (BIK BITV-Test, n.d.-a; Blazeska-Tabakovska et al., 2019; Hellbusch & Probiesch, 2011). Pause, Stop, Hide is checked by verifying whether a button is available to stop the movement or clear instructions are given for keyboard control. It must be ensured that the movement does not restart after a certain period (BIK BITV test, n.d.).

1.4. Research objectives and hypotheses

The central research question of this study is: How do selected aspects of digital accessibility affect the user-friendliness of websites for individuals with cognitive impairments? To answer this question, five hypotheses were developed based on prior research and accessibility guidelines.

People with cognitive impairments use the Internet for a wide range of purposes, including communication, entertainment, and information-seeking (Ågren et al., 2020; Glencross et al., 2021, Sallafranque-St-Louis & Normand, 2017, Shapiro & Rohde, 2020). These activities are central to digital participation and underline the importance of accessible online environments for this group.

H1: Despite their limitations, people with cognitive disabilities actively use the Internet for social interaction, entertainment, and information.

Easy-to-read language has been shown to improve the comprehensibility of texts for people with cognitive impairments (Vollenwyder et al., 2018; ISO, 2023). While WCAG guidelines emphasize understandability, they do not yet include formal requirements for easy-to-read language. This leaves a gap in practice, especially for users who struggle with complex syntax and vocabulary.

H2: Websites written in easy-to-read language are easier to understand for users with cognitive impairments.

Difficulties in navigation and orientation are among the most common barriers reported by users with cognitive impairments (Chadwick et al., 2013). Previous studies have found that predictable, consistent navigation structures and clear labels help users understand where they are on a site and how to proceed (Blazeska-Tabakovska et al., 2019; Hellbusch & Probiesch, 2011).

H3: Consistent and clearly structured navigation helps users with cognitive impairments to orient themselves more easily on websites and reduces confusion.

Moving elements such as auto-playing slideshows or animations can distract users with cognitive impairments and impair task focus (Chadwick et al., 2013; Marx & Bremer, 2024). WCAG therefore recommends options to pause, stop, or hide moving content. Even though this aspect of digital accessibility is already included in the WCAG, there is still a lack of in-depth research on how people with cognitive impairments use these websites in real life and what barriers they have to encounter (Gartland et al., 2022).

H4: The ability to pause, stop, or hide moving content helps people with cognitive disabilities avoid distractions.

Finally, digital accessibility enables users with disabilities to perceive, understand, navigate, and interact with the Internet, regardless of their limitations (Hortizuela, 2022). However, empirical research has shown that the mere presence of accessible features does not always translate into a better user experience (WebAIM, 2008; Chadwick et al., 2013). Comparing websites with different accessibility levels thus offers insight into which features truly matter from the user's perspective.

H5: Websites with higher levels of accessibility are perceived as more user-friendly by individuals with cognitive impairments.

2. Method

The study aimed to test the perceived digital accessibility of websites with different levels of digital accessibility. For this purpose, semi-structured interviews were chosen because they combine a clear structure with the flexibility to adapt to individual communication needs. This was particularly important for participants with cognitive impairments, allowing them to express their thoughts freely while ensuring comparability across cases. Creating an open discussion situation was important to gain detailed insights into the perspectives and experiences of people with cognitive impairments, especially with learning disabilities. Three aspects of accessibility were examined in more detail: a) Is the website available in easy-to-read language? b) Is there a predictable and consistent navigation? and c) Is there an option to pause, stop, or hide content that flashes or moves? The perception of user-friendliness of participants with learning disabilities was assessed through tasks that focused on the above-mentioned aspects of accessibility.

An interview guide was created to ensure comparability between the interviews. Before the actual study, a pretest was conducted to check the suitability and comprehensibility of the interview guide.

2.1. Sample

Twelve interviews were conducted with three women and nine men aged 18 and older who had been diagnosed with cognitive disabilities to achieve data saturation (Hennink & Kaiser, 2022). Prior to the interviews, the participants were not tested for their IQ, nor were they asked about their exact learning disability since the participants often did not receive a more specific medical diagnosis. Nevertheless, it was possible to speak of a learning disability since all of them had impaired intelligence, which was confirmed by the supervisors. The individuals had difficulties learning, thinking, and remembering and could not concentrate on a task for an extended period (Blazeska-Tabakovska et al., 2019; Hortizuela, 2022). The requirements for participating in the study were that the participants (1) knew the Internet and (2) had used it in the past. Furthermore, it was necessary that the interviewees (3) could read and (4) write. All twelve participants fulfilled these requirements. Recruitment occurred by contacting various local institutions, whereby supervisors suggested suitable participants. The interviews took place in the interviewees' residential or work facilities to ensure a familiar atmosphere.

2.2. Materials

The selection of the websites examined was based on empirical findings suggesting that participation in leisure activities can improve cognitive functions and quality of life in people with cognitive disabilities (Heister et al., 2023). In addition, studies showed that the Internet plays a central role in the everyday life of this target group (Shapiro & Rohde, 2020). It could be concluded that the Internet and participation in leisure activities serve entertainment purposes, social participation, and information gathering (Glencross et al., 2021; Sallafranque-St-Louis & Normand, 2017). Therefore, an accessible website to inform oneself about a leisure activity is essential for digital inclusion. Despite this relevance, there is limited research on which websites in the leisure sector are actually used by cognitively impaired individuals (Heister et al., 2023). To conduct a study that is as realistic as possible, three leisure websites were selected that differ in their degree of accessibility. The selection was based on the following criteria: firstly, the website had to be highly relevant for cognitively impaired individuals. Secondly, accessibility standards were ensured to varying degrees to identify differences in perceived user satisfaction. Finally, a leisure area that appeals to a broad user base was chosen to comprehensively analyse possible

barriers and potentials for cognitively impaired individuals. The final decision was discussed and confirmed with the participants' supervisors, so that two zoo websites and one outdoor museum website were chosen.

Before the study began, the three websites were evaluated on the key aspects of digital accessibility. The focus was on the criteria of easy-to-read language, consistent navigation, and the option to pause or hide moving images. Publicly available tools such as the WAVE Web Accessibility Evaluation Tool (WebAIM, 2025) and AChecker (Inclusive Design Research Centre, n.d.) were used for objective evaluation. These automated testing tools analyse the websites based on the WCAG guidelines, identify potential problems, and provide recommendations for improving digital accessibility. In addition, a second test process was carried out by BITV-Consult, the official testing centre in the BITV-Test network (Girke, n.d.), and by the agency Gehirngerecht Digital (Gehirngerecht Digital GmbH, n.d.). This enabled the selection of the websites to be validated and the assessment of the accessibility aspects to be confirmed. This targeted approach not only allows individual accessible and non-accessible elements to be identified but also allows their influence on user satisfaction to be systematically recorded. The results of this study provide practical insights into the design of accessible leisure services in the digital space.

2.2.1. Website 1: “High-level accessibility”

Website 1 is theoretically considered a best practice example for an accessible website. It offers a main page in complex language and an additional page in easy-to-read language. The main page features two horizontal primary navigation bars consistent across all subpages. When a user clicks on a category in the lower navigation bar, a dropdown menu appears, indicating the user's current location on the website. The page in easy-to-read language has its primary navigation, displaying the user's current location. Instead of dropdown menus, this page uses a vertical navigation system with embedded links.

2.2.2. Website 2: “Mid-level accessibility”

Website 2 considers some aspects of digital accessibility but has room for improvement. Upon loading the page, an automatically playing slideshow is displayed, which can be stopped by clicking, turning it into a static image. Alternatively, users can navigate through the images using arrows. Like website 1, this website features two horizontal primary navigation bars consistent across all subpages. A dropdown menu appears when a user clicks on a category in the lower navigation bar. However, the current location on the website is not displayed. The upper navigation bar includes a link to a page in simple language and features an eye symbol. This symbol activates an accessibility mode with increased contrast and adjustable font size, which works for both language versions. The page in simple language does not have an own navigation bar. When navigating through the displayed categories, users are redirected back to the page in complex language.

2.2.3. Website 3: “Low-level accessibility”

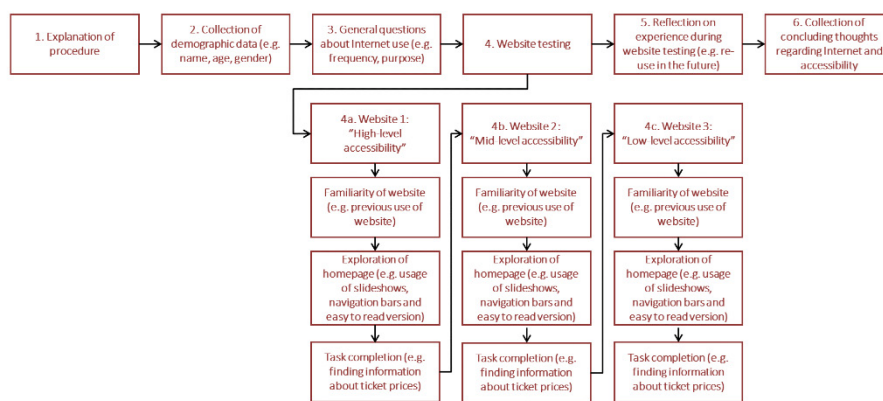
Website 3 has the lowest level of accessibility among the three websites. Upon loading the page, an automatically playing slideshow starts, which can only be temporarily paused by hovering the cursor over the image. A function for permanent pausing is not available. Users can navigate through the images using arrows. The website's navigation is complex and includes a horizontal main navigation bar with a search function and dropdown menus under two categories. These dropdowns lead to five subcategories, each with its vertical navigation bar.

Additionally, a separate vertical navigation bar in the upper right corner contains links that either serve as anchor links or open separate subpages. On subpages, users are guided through a breadcrumb navigation that shows the path from the homepage to the current page. This website does not offer a version in easy-to-read language.

2.3. Study structure and implementation

Participation in this study was voluntary, and participants could quit the interview at any time. The participants signed a confidentiality and informed consent form, which explained the purpose of the study, guaranteed anonymity, and outlined how the data (including video recordings) would be handled. For this purpose, a data protection declaration in easy-to-read language was created. The interview process is described below illustrated in figure 1.

Figure 1: Illustration of the interview process.



First, the procedure was explained to the participants. They were assured that there were no right or wrong answers and that all input would help improve digital accessibility. Demographic data was collected, including name, age, gender, and current living situation. In addition, participants were asked general questions about their Internet use, including frequency, purposes, and perceived advantages and disadvantages.

Second, participants tested three websites with different levels of digital accessibility (high, medium, low). The order was fixed and not randomized. Before beginning, they were asked whether they had used the website before, to control for prior familiarity. Next, participants explored the homepage freely, focusing on key elements such as slideshows and navigation bars. Observations focused on whether users could pause or stop moving content, switch to easy-to-read language versions, and navigate effectively. For each website, participants were then asked to complete tasks such as finding information about ticket prices. When difficulties occurred, support was offered. Third, after testing each website, participants were asked to reflect on their experience, how they felt about using the site, and whether they would consider using it again in the future. The interviews were then concluded with an open-ended question allowing participants to share further thoughts about the Internet and accessibility. Each interview lasted between 45 and 60 minutes. On average, around 10 minutes were spent on each website.

After the interviews, the video recordings were transcribed, anonymized, and analyzed using content-structuring qualitative content analysis (Kuckartz & Rädiker, 2022) with the software MAXQDA (VERBI Software, 2025). In the initial phase, transcripts were reviewed, relevant passages were marked, memos were written, and case summaries were created. In the subsequent stages, a category system with 21 main and 17 subcategories was inductively

developed and applied to the data (see Appendix A). Final interpretation took place in the concluding phase of the analysis.

Ten of the twelve interviews were included in the final analysis. One participant dropped out after the second website, and another required extensive assistance due to nervousness. In the remaining interviews, saturation of themes was achieved. One participant was supported by a supervisor who translated questions into easy-to-read language when needed.

3. Results

Most participants did not experience the situation as stressful or as a test. They often showed a particular pride and great joy that their opinion was being asked for. This made it easy for the participants to answer the introductory questions and report their Internet experiences. It was, therefore, not surprising that all participants answered 'yes' to whether they were interested in the Internet.

3.1. Device and frequency of Internet use

All participants stated in the interviews that their smartphone is their preferred device and that they use it regularly or daily. Half of the participants own a tablet or iPad but rarely use it. The number of people who used a laptop was remarkably low. Only three out of ten respondents use a laptop, often not their own but, for example, one belonging to their parents. One respondent reported having a PC for rare tasks such as printing documents.

3.2. Support with using the Internet

Three of the ten study participants said that they needed support in using the Internet. They mentioned that they are not familiar with the Internet and need support to be more active or get help as soon as they get stuck on a website. This was true for all participants in this study, as some needed help and support during the test. One participant said that:

Mum or Dad help with that, for setting alarms or making appointments, calendars, and other similar tasks. But when it comes to Netflix, my brother helps me (Interviewee 3).

3.3. Positive aspects of the Internet

Half of the participants mentioned the possibility of gathering information as a positive Internet feature. The participants also mentioned that "it is the successes that you get out of it (from a website)" (Interviewee 4) and that they love learning something on the Internet. Another positive aspect mentioned was "that it (the Internet search) is quick when you need something urgently" (Interviewee 5). One respondent said: "Seeing the whole thing (the website) is just fun" (Interviewee 9). From this, it can be deduced that the respondents consider it important to use the Internet smoothly. Two participants mentioned the opportunity to contact people as a positive aspect of the Internet. One respondent preferred WhatsApp "because I have friends there with whom I can write a lot" (Interviewee 8). Another test person found it positive that appointments could be made, saying, "It's always so cool that anyone can write, meet people, or whatever; it's great" (Interviewee 7).

3.4. Negative aspects of the Internet

When asked about negative aspects, it was interesting that none of the participants mentioned barriers while using the Internet. Instead, the issue of security was present for all of them. A total of 60% of the participants reported concerns about interactions with strangers, e.g., through hacker attacks, telephone fraud, or bullying when uploading pictures. Two participants described their own experiences with hacking attacks, but they could prevent the worst from happening by acting correctly.

3.5. First impression of the websites

3.5.1. Website 1: “High-level accessibility”

Important observations about the high-level accessibility of the website were made during the first navigation on the website. The participants mostly noticed the images first, as they were easy to understand without reading about them. Three participants initially focused on the navigation bar. They stated that they first had to “plan their visit” (Interviewee 9) or wanted to “take a quick look” at where they were (Interviewee 6). When shown the option for easy-to-read language, four out of ten participants recognised it. Two of them were positively surprised and relieved that the website offered a version in easy-to-read language, while the others found this less relevant. One participant was particularly enthusiastic:

Easy-to-read language helps many people – whether they are older or have a disability. It helps everyone (Interviewee 3).

Only one participant noticed the option for easy-to-read language without being prompted. This could be because the participants had never used such a function before and did not look for it. One participant was not aware that websites in easy-to-read language even existed. Furthermore, two participants asked what a navigation bar was, and one preferred larger text.

3.5.2. Website 2: “Mid-level accessibility”

The results for the mid-level accessibility website were similar. Here, the images were also the first thing the participants noticed – both on the page with complex language and on the page with simple language. On the page with simple language, some participants noted that real photos would be better than illustrations. One positive aspect compared to the high-level accessibility website was that three participants independently noticed the option for simple language in the navigation bar. It remains unclear whether this is due to a learning effect from the first website or whether the category was better placed on this website. Only one participant recognised the option for simple language when prompted and was surprised by this function. However, the term ‘simple’ was confused, as the participants were more familiar with ‘easy-to-read language’ than ‘simple language.’ One participant expressed this confusion by saying:

I’ll have to look now. It does not say “easy-to-read language” anywhere. How do I get there? Maybe by clicking on “simple”? (Interviewee 1).

One participant who had not recognised the navigation bar on the previous website immediately noticed that “the sentences are up there again. The words. That you can click on them” (Interviewee 6). A particularly positive aspect that was noticed was the font size on the page, which could be adjusted using simple language.

3.5.3. Website 3: “Low-level accessibility”

The participants perceived the low-level accessibility of the website very differently, both in terms of initial navigation and use of the website. One participant appreciated the shorter navigation bar, while another discovered the search function but was disappointed when it did not work reliably. Opinions also differed on the layout of the website. While one participant found it easy to navigate the website, another had difficulties finding their way around and felt overwhelmed. One participant said, “I have to see what is on the website first” (Interviewee 10). When scrolling, they discovered widgets they found very interesting and helpful for orientation because they displayed “both the question and the answer” (Interviewee 10). By this, they meant they could see the main category – like in the top navigation bar – and the corresponding detailed information was displayed directly below it. They did not have to open a new page or navigate through an additional menu, as all the relevant information was available immediately.

3.6. Internet use in the areas of social interaction, entertainment, and information (Hypothesis 1)

The first hypothesis states that despite cognitive limitations in learning, people with cognitive disabilities are interested in the Internet and use it for social interaction, entertainment, and information. The participants said that they use the Internet for a variety of purposes. The interviewees most frequently mentioned WhatsApp (70%), Google (70%) and YouTube (70%) as activities they do on the Internet. It was mentioned that WhatsApp is used to stay connected with friends and family, arrange appointments, or meet new people. Facebook was also mentioned as a platform for staying connected with friends, as the respondents can send and accept friend requests there and congratulate people on their birthdays. These two apps can be categorised as social interaction and communication. Seven participants mentioned that they use Google to search for information. They search for sports results, cinema programs, and news. However, they also google special interests such as recipes on ‘Chefkoch,’ information about holiday destinations, diseases, or plant care instructions. Two people mentioned that they often use the voice function as an additional support. In the entertainment sector, 90% of the participants were able to report something since the social media platforms Instagram (50%), TikTok (30%), and YouTube (70%) are used by the test persons on their smartphones. Some of them post photos or videos themselves. Only two participants use the Internet for shopping, mainly via Amazon, for example, to buy gifts. Furthermore, 40% of the test persons mentioned other topics such as weather forecasts, traffic situations, or apps to learn a language. Since 100% of the participants said they were interested in the Internet and the above results lead to the conclusion that the categories of entertainment, information-seeking, and communication are the main areas of Internet use, hypothesis one can be confirmed.

3.7. Websites in easy-to-read language (Hypothesis 2)

To confirm the second hypothesis, it is assumed that users with cognitive disabilities will better understand a website's content if formulated in easy-to-read language. When searching for ticket prices on the high-level accessibility website, 70% of the participants chose the version in complex language, while only 30% used the version in easy-to-read language. Among those who used the complex language page, only four out of seven completed the task, whereas all participants using the easy-to-read language succeeded. The participants received the large font, short words, and structured layout positively. Comments such as “Yes, this is perfect for reading. It is really good. Perfect for reading” (Interviewee 5) and “because the letters are big enough. And because I can

read it very well" (Interviewee 6) highlighted the high readability of the texts. Participants who compared both versions stated that the page in easy-to-read language was easier to understand. However, three participants noted that the easy-to-read language page contained too much information, making it feel cluttered.

On the mid-level accessibility website, most participants preferred the page in easy-to-read language. All of them found the texts easy to understand, while only two out of five participants could clearly understand the texts in complex language. One participant commented on the version in complex language by saying, "That was difficult" (Interviewee 7), while the same participant read and liked the text in easy-to-read language. Some participants understood the complex language texts but felt that they could be easier to read.

The text is well written and clearly structured – except for that one word I could not pronounce (Interviewee 1).

But I would instead use this page (in simple language) because it is easier (Interviewee 5).

On the low-level accessibility website, which does not offer any content in easy-to-read language, the participants' opinions on text comprehensibility were mixed. While half of the participants understood the content, the other half had difficulties and would have liked to see an extra page in easy-to-read language or a larger font size to improve readability.

The results show that providing texts in easy-to-read language is essential for accessible and user-friendly websites. From the analysis, hypothesis 2 is confirmed.

3.8. Website navigation (Hypothesis 3)

To test the third hypothesis, the participants' orientation on the three websites is analysed and evaluated to confirm that consistent and clear navigation helps cognitively disabled users find their way around a website and reduces the risk of confusion.

On the high-level accessibility website, participants had access to two different navigation bars, depending on whether they used the complex or easy-to-read language version. Half of the participants found navigating the complex language page confusing. A key problem was the drop-down menu, which contained too much information, making navigating difficult. In contrast, four out of ten participants found the easy-to-read language page very clear, especially with simple and unambiguous categories such as 'animals.' One participant commented, "I clicked on 'animals.' Then I saw sheep. That was a bit simple" (Interviewee 7). However, participants had difficulties following longer navigation paths, for example, when searching for ticket prices. Some participants did not recognise the link to the prices. Participants who initially used the page in complex language required significantly more time to orient themselves on the website. They clicked on the wrong categories in the navigation bar more often, which led to confusion. In one case, a participant actively asked for help after losing orientation. However, the same person could immediately find the information they were looking for after switching to the website in easy-to-read language. By contrast, initially, participants who used the page in easy-to-read language had significantly fewer difficulties. They understood the navigational structure more quickly and could complete tasks more efficiently.

The analysis of the mid-level accessibility website revealed significant issues with navigation and clarity. Only one participant rated the simple language page as transparent, while three others criticized it as illogical and described it as "so fragmented" (Interviewee 10). The website in

complex language was also seen as problematic, with five participants expressing concerns about the clarity of the navigation. Because the simple language page was integrated into the navigation of the complex language page, there was only one subpage with a great deal of scrolling depth for participants to use. This design caused many to feel frustrated. The participants expected to find information about ticket prices in the 'Tickets' section of the simple language page. Still, the price information was further down the page, requiring them to scroll down far. As one participant accurately pointed out, "Why don't they put that there? It is silly. They should put it right there (just below the title), not down" (Interviewee 1). The sheer number of ways to navigate the website also caused confusion. Three participants were initially misled by a pop-up that they thought would take them to ticket prices but instead redirected them to the online store, where they gave up on their search. A clear 'pricing' category in the navigation bar would have significantly reduced this problem.

The low-level accessibility website performed better overall, with 60% of the participants rating the navigation as easy. A key advantage was the menu in the upper right corner with the labelled 'Tickets & Prices' category. Half of the participants recognised this immediately and were thus able to find the information they were looking for quickly. However, others who did not notice this navigation bar were more likely to get frustrated and could not find the ticket prices. The website offered too many ways to find the ticket prices. The main navigation with the drop-down menu confused some participants because it displayed too much information simultaneously. The most frequently used menu was in the upper right corner, as one participant explained:

I clicked on it, and the page with all the prices appeared immediately. This is how it should be on every website (Interviewee 6).

Consistent and clear navigation helped people with cognitive impairments navigate the three websites and reduced the risk of confusion, thus supporting the hypothesis.

3.9. Pause, stop, and hide content (Hypothesis 4)

For evaluating the fourth hypothesis, which states that the ability to pause moving content helps users with cognitive impairments avoid distractions, website 2 and website 3 were used, as website 1 does not feature any slideshows.

On the mid-level accessibility website, 40% of the participants were bothered by the slideshow, saying, "The image change is too fast" (Interviewee 1). However, three of these participants knew how to stop the slideshow independently. Most participants (60%) were not bothered by the slideshow and did not feel the need to stop or pause the moving images. One participant commented, "It (the slideshow) is not necessary, but if people like it, why not" (Interviewee 10). The participants were familiar with other platforms, where they could "click through the images with the arrows" (Interviewee 8) at their preferred speed.

The participants who found the slideshow distracting on website 2 had similar concerns about the low-level accessibility website. Four participants found the slideshow distracting, while the remaining six did not perceive it as distracting. The main issues were the fast slide-change speed and the arrows for navigating through the slides, which were only displayed when the mouse pointer was moved over the image. As a result, some participants clicked on the arrows, which took them to the corresponding subpage, but the slideshow did not advance to the following picture. None of the participants realized that the slideshow could be paused by moving the mouse cursor over the picture.

Since most participants did not find the moving content distracting and saw no need to pause or stop it, the fourth hypothesis is not confirmed.

3.10. Comparison of the three websites (Hypothesis 5)

To test hypothesis 5, stating that the higher the degree of digital accessibility of a website, the more user-friendly it is for users with cognitive impairments, participants were asked whether they would use the website again and to describe what they liked or disliked about each website. The goal was to determine whether the website with the highest level of digital accessibility – in this case, website 1 – was perceived most positively by the target group.

However, the results showed a more differentiated picture. While nine out of ten participants said they would use the website once again, several participants mentioned that they would need support to do so. In particular, navigating and finding one's way around the website was perceived as problematic. In the final evaluation of the general user-friendliness of the three websites, only two participants ranked the high-level accessibility website first. In contrast, half of the respondents put it in second place. These results show that although the website is considered accessible in theory, there is still plenty of room for improvement for the target group.

In comparison, the mid-level accessibility website received the most positive feedback. The accessible contrast mode was particularly highlighted as it made using the website easier and better. Only two participants saw no advantage in this mode. No participant rated this website in last place, and three participants even placed it first in the overall usability rating. Eight people would use the website again, with only one saying they would need help.

As with the previous assessments of the low-level accessibility website, the ranking showed quite different results. Five participants rated the website in the first place, while the remaining five put it in the last place. Although it had the lowest accessibility among the three websites, it was voted into first place the most times. However, several barriers were identified that conflicted with aspects of digital accessibility and that participants had to deal with. For example, the ticket shop opened in a new tab, which meant that the universal return button in the upper left corner of the browser no longer worked. Pop-ups distracted participants from their search for information, the animated navigation in the drop-down menu was perceived as too fast, and the search function did not work reliably. Despite these issues, the website impressed some participants with its navigation and overall perception, with seven participants stating that they would use this website again. Only one person said they would need help if they used it again.

In summary, the degree of accessibility alone was not crucial for user-friendliness. Certain aspects of digital accessibility were more important to those affected than others. The hypothesis can, therefore, not be confirmed.

4. Discussion

This study evaluated the three aspects of digital accessibility and perceived user-friendliness on websites. Through a qualitative research design with semi-structured interviews, the following research question was addressed: How do selected aspects of digital accessibility impact the user-friendliness of individuals with cognitive impairments? The observation focused on cognitive disabilities. Given the wide range of cognitive disabilities, this study specifically focuses on individuals with learning disabilities.

4.1. Themes and findings

Hypothesis 1 states that many people have an interest in the Internet despite cognitive disabilities, particularly in the areas of social interaction, entertainment, and information search. The study results confirm this. WhatsApp and Facebook are used for communication, while Google is used for research. Platforms such as Instagram, TikTok, and YouTube are used for entertainment. These findings are consistent with previous studies by Ågren et al. (2020), Glencross et al. (2021), and Sallafranque-St-Louis & Normand (2017). These show that digital media are important for people with cognitive impairments to maintain social contacts, search for information, and enjoy themselves. It should be emphasized that the target group uses the Internet in the same way as people without disabilities. This illustrates the importance of digital inclusion and the need for accessible services.

The study results confirm hypothesis 2: content in easy-to-read language is better understood by people with cognitive disabilities. Previous research shows that complex language creates barriers that can be reduced by easy-to-read language to expand the range of information (Dirks et al., 2020; Vollenwyder et al., 2018). The interviews make it clear that content in easy-to-read language is easier to understand on accessible websites. On the low-level accessibility website, some participants would have wished for a version in easy-to-read language. Easy-to-read language significantly improves text comprehension but is not always sufficient for people with severely limited reading ability. Cognitive competence plays a crucial role. Participants with higher cognitive competence often prefer complex language, which indicates that the needs within the target group vary greatly.

The third hypothesis, that consistent and clear navigation improves user-friendliness for people with cognitive limitations, is confirmed by the interviews. Previous research by Chadwick et al. (2013) and Blazeska-Tabakovska et al. (2019) shows that straightforward navigation improves orientation. The WCAG also emphasizes the importance of consistent navigation in the success criterion 'Consistent Navigation' (W3C, 2024). The interviews confirm that confusing navigation and unclear category labels are perceived as a problem. The WCAG recommendation to offer multiple navigation paths cannot be confirmed by the user tests, which leads to confusion. Instead, accessibility should be achieved through intuitive navigation and meaningful categories. This makes it clear that guidelines such as WCAG must be adapted to the needs of users in order to improve accessibility.

The interviews do not support the fourth hypothesis that the ability to pause moving content helps cognitively impaired users avoid distractions. Studies by Chadwick et al. (2013) and Marx and Bremer (2024) show that animations, overloaded screens, or automatic videos on websites are distracting and make it difficult to perceive relevant information. The WCAG, therefore, recommend limiting such content to five seconds or making it possible to pause it (BIK BITV test, n.d.-a; W3C, 2024). However, most study participants do not find the slideshows distracting or know how to stop them. Even rapid image changes are hardly perceived as distracting. While the WCAG criterion is important for people with epilepsy, it has been shown that moving content is usually not a problem for people with learning disabilities. For this target group, pausing, stopping, or fading out is less crucial for user-friendliness.

According to hypothesis 5, a higher degree of website accessibility should improve user-friendliness for people with cognitive impairments. This hypothesis is not confirmed. The study by Chadwick et al. (2013) shows that people with cognitive impairments often encounter online barriers. Although the WCAG aims to improve user-friendliness, the interviews show a more differentiated picture (Blazeska-Tabakovska et al., n.d.; WebAIM, 2008). The theoretically

accessible high-level accessibility website shows that there is still room for improvement. This is reflected in the ranking of general user-friendliness: only two people put the website in first place, while half of the sample sees it in second place. By comparison, the mid-level accessibility website performs better, with three top rankings and no bottom rankings. It is surprising that the low-level accessibility website, although it has the least accessibility, performs best in the user ratings. This suggests that other aspects of accessibility play a more significant role for users.

Regarding the research question, it can be concluded that individual aspects of digital accessibility have a different impact on user-friendliness for people with cognitive impairments. As the results show, the use of easy-to-read language and clear and concise navigation increases user-friendliness. At the same time, moving images do not have a negative impact on user-friendliness.

4.2. Implications of the results

Using easy-to-read language on websites makes it easier for people with learning disabilities to use them. Easily readable fonts and short, comprehensible phrases are viewed positively. An important suggestion for improving websites is introducing a version in easy-to-read language to reduce barriers. Since such offers are rare, many users are unaware of their existence. To improve digital accessibility overall, more websites should provide content in easy-to-read language.

The study shows that a well-structured navigation is essential for the user-friendliness of websites. A clear and comprehensible categorization is particularly well received, as it simplifies orientation. A clearly visible and logically structured navigation can help users to find information more quickly. To further improve accessibility, websites with simplified language should have a structured navigation bar to avoid long scrolling and to present content clearly and concisely.

There is room for improvement in optimizing moving images on websites. Although slideshows are not perceived as annoying by all users, user-friendliness can be increased by integrating a way to pause or stop them by clicking and keeping the navigation arrows visible. In addition, introducing specific pause and play buttons could provide a simple control option and thus further improve usability.

4.3. Limitations

The sample size and the recruitment of the participants are limitations of this study. The sample size is at the lower limit of what would have been desirable for the study. At least 15 subjects would have been ideal (Hennink & Kaiser, 2022). Recruitment of subjects proved extremely difficult, as only a few responses were received despite contact with around 20 institutions. The specific target group presented an additional hurdle. Another limitation is the unclear definition and differentiation of disabilities. It turned out that different definitions of cognitive or learning disabilities are used. Often, a cognitive disability was diagnosed in childhood without any differentiation being made in later years. It was, therefore, challenging to identify subjects with an apparent learning disability.

People with cognitive impairments rarely use laptops and are mainly active with their smartphones, as phone calls with supervisors during the recruitment process revealed. Furthermore, the study was initially designed to test online shops. It turned out that this was irrelevant for many participants. These unexpected circumstances led to the study being modified. The compromise was that the participants should be able to use a laptop, while the websites were adapted to the needs of the target group to reflect their reality better.

5. Conclusion

In today's society, access to the Internet has become fundamental for education, employment, and social relationships (Schuppener et al., 2019). Yet, even with established accessibility standards and legal requirements, many barriers remain online – especially for individuals with cognitive impairments (WebAIM, 2024). Much of the existing accessibility research has been conducted with participants with disabilities other than cognitive impairments, which limits the extent to which current findings address the needs of all users (e.g., Cinquin et al., 2019; Henni et al., 2022; Hortizuela, 2022; Mack et al., 2021). The aim of this research was thus to address this research gap and explore real-world experiences of users with cognitive impairments on the Internet and compare these experiences with normative guidelines of digital accessibility.

We conducted qualitative, semi-structured interviews with 12 individuals diagnosed with learning disabilities. The participants were presented with three websites related to leisure activities, yielding different degrees of digital accessibility (high-level, mid-level, and low-level accessibility; Inclusive Design Research Centre, n.d.; WebAIM, 2025). Participants were asked to test the websites by completing a specific task (e.g., gathering information about ticket prices) and were then interviewed about their user experience with the websites. Thereby, we focused on three aspects of digital accessibility: a) easy-to-read language, b) consistent navigation, and c) pause, stop, and hide.

Our results revealed several noteworthy findings, contributing to the understanding of how individuals with cognitive impairments use and experience the Internet. First, we find that digital services and the Internet are essential for individuals with cognitive impairments, specifically for communication, information search, and entertainment. Participants also reported primarily using mobile devices (i.e., smartphones and tablets) rather than laptops. Second, our results show that easy-to-read language significantly improves user-friendliness, as easy-to-read language helps individuals with cognitive impairments to understand the website texts more easily. However, we also find that the wish for easy-to-read language differs within the target group depending on the individual's cognitive abilities. Third, consistent and clear navigation significantly contributes to user-friendliness by supporting orientation on the website, as does clear labelling of website content by the means of clear categories. Multiple navigation paths, as proposed by the WCAG (W3C, 2024), however, did not enhance user-friendliness and instead led to confusion, suggesting that digital accessibility guidelines may need to be revised to reflect user needs of individuals with cognitive impairments. Fourth, contrary to previous studies (Chadwick et al., 2013; Marx & Bremer, 2024), we do not find that moving contents undermine perceptions of user-friendliness of individuals with learning disabilities; for example, slideshows were generally not found to be distracting. Finally, our results do not support the assumption that websites with higher levels of digital accessibility necessarily improve user-friendliness (Blazeska-Tabakovska et al., n.d.; WebAIM, 2008). In fact, the low-level accessibility website was ranked highest for overall user-friendliness by our target group, while the website that should theoretically offer the highest accessibility received top ratings from only two participants, indicating that additional aspects of digital accessibility, not examined in our research, may strongly influence perceptions of user-friendliness. easy-to-read language

The main limitations of this research relate to the sample size and participant recruitment. Due to one participant withdrawing during the interview and one needing substantial assistance due to nervousness, two interviews had to be excluded from the analysis, reducing the number of cases. Additionally, participants were recruited from institutions, but many institutions were unresponsive to our inquiry to conduct interviews as part of this study, limiting the pool of

participants. Finally, the varying use of the terms learning disability and cognitive ability led to some uncertainty in the final classification of the participants' diagnoses.

The findings of our research have implications for both future research and policymakers. For future research, it would be useful to examine in more detail how different subgroups within the spectrum of cognitive impairments perceive and interact with digital interfaces, as their needs can vary widely within a group (Droutsas et al., 2025; Small et al., 2005). In addition, given how many participants in our study mainly used smartphones, mobile-first digital accessibility appears to deserve particular attention. For individuals with visual impairments (e.g., Alajarmeh, 2022; Schmutz et al., 2017) or individuals with limited attentional resources (Carlbring, 2020), for example, studies have explored how WCAGs can help to improve user-friendliness on mobile devices. In a similar vein, future research could specifically explore how individuals with learning abilities may benefit from WCAGs designed to improve user-friendliness on smartphones. Finally, as immersive technologies such as augmented and virtual reality will become more relevant for digital participation, future studies should also examine how WCAG principles can be adapted to these environments to ensure accessibility for individuals with cognitive impairments (Creed et al., 2023). On the policy side, our results point to the importance of integrating user perspectives of groups with varying cognitive disabilities into accessibility standards—especially with regard to easy-to-read language and navigation design. As the needs of individuals with cognitive impairments are still underprioritized when it comes to policy implementation regarding digital accessibility (Gartland et al., 2022; Mason et al., 2022), clearer guidelines should be considered. These could include the mandatory implementation of specific features such as plain or simplified language to reduce barriers and support full participation in the digital world. Through this, the topic of digital accessibility can receive more attention, more intensive discussions can be conducted and as a result, the digital inclusion of all users can be promoted.

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Appendix A: Category system

Table 1: Interview introduction

Main category	Subcategory	Explanation (if needed)
Interest in the internet	-	
Frequency of internet use	-	
Medium of internet use	-	Captures the preferred devices or technologies for internet access
Purpose and intention of internet use	-	Areas of application of the Internet
Positive aspects of the internet	-	
Negative aspects of the internet	-	
Support in using the internet	-	

Table 2: High-level accessibility website

Main category	Subcategories	Explanation (if needed)
Awareness of the website	-	Possible previous experience with this website
(First) orientation on the website	Page in plain language Default setting of the website Font size Images	Noticing the assistance, testing the page with plain language
Search for ticket prices	Use of difficult language Navigation and orientation Use of plain language	Comprehensibility, no switch to the website with plain language Find their way around the website Comprehensibility, switch to the page with plain language
Search for animal information	Use of difficult language Navigation and orientation Use of plain language	Comprehensibility, no switch to the website with plain language Find their way around the website Comprehensibility, switch to the page with plain language
Suggestions for improvement	-	Suggestions that users have for improving the website.

Table 3: Mid-level accessibility website

Main category	Subcategories	Explanation (if needed)
Awareness of the website	-	Possible previous experience with this website
(First) orientation on the website	Slideshow	Perception of the slideshow, irritation, distraction
Search for ticket prices	Use of difficult language	Comprehensibility, no switch to the website with plain language
	Navigation and orientation	Find their way around the website
	Use of plain language	Comprehensibility, switch to the page with plain language
Suggestions for improvement	-	Suggestions that users have for improving the website.
Accessible mode		Perception , Readability

Table 4: Low-level accessibility website

Main category	Subcategories	Explanation (if needed)
Awareness of the website	-	Possible previous experience with this website
(First) orientation on the website	Slideshow	Perception of the slideshow, irritation, distraction
Search for ticket prices	Language used	Comprehensibility of the language used
	Navigation and orientation	Find their way around the website
Suggestions for improvement	-	Suggestions that users have for improving the website.

Roadmap to inclusive Artificial Intelligence for persons with intellectual disability

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Abstract: The rapid evolution of Artificial Intelligence (AI) poses significant opportunities and challenges for historically discriminated groups, such as persons with intellectual disabilities. This article proposes a conceptual framework that enables an inclusive and accessible approach to designing generative AI systems. Based on an exhaustive review of legislative, socio-health, and technological sources, key concepts such as disability, accessibility, and usability are defined and related, with intellectual disability serving as the central objective of this work. The need to apply principles of Universal Design (UD) and User-Centred Design (UCD) is highlighted to ensure products, environments, and services that are understandable, usable, and customisable. Finally, specific challenges are identified in the development of generative AI tools in Spain for persons with intellectual disabilities, and specific recommendations are proposed to promote inclusive AI for all.

Keywords: person with disabilities, disability, intellectual disability, inclusion, accessibility, artificial intelligence, Universal Design, User-Centred Design.

1. Introduction

The research and development of products, environments, and services based on Artificial Intelligence (AI) are currently experiencing a significant increase. There is a danger that these advances will increase the access gap for groups that have historically been discriminated against, such as persons with intellectual disabilities. To reduce this gap, it is essential to consider these persons' needs, capabilities, and aspirations from the earliest stages of AI solution design and development. With this objective, four universities (Universidad Carlos III de Madrid, Universidad Complutense de Madrid, Universidad Nacional de Educación a Distancia and Universitat Politècnica de Catalunya) have joined forces in a common project: HumanAI. The HumanAI project (Human-Centred AI: Towards Accessible and Personalised Language Models) aims to develop generative AI tools in Spain, specifically designed for persons with intellectual disabilities.

To advance within the project, it is essential from the beginning to establish a shared conceptual framework that clarifies and relates the key concepts involved. Although these concepts converge

on a common approach, they come from diverse contexts (legislative, technical, and socio-health), which require systematic integration.

This article proposes an analytic structure focused on two principal axes: the person (the user of AI-based systems) and the action or service (that AI-based systems offer to the user). From there, two fundamental dimensions are addressed: disability (as a characteristic of the person) and accessibility (as a quality of the action or service), while also considering the role of legislation, technical standards, and users' own experiences. These contributions should be understood as complementary, with interactions analogous to those proposed in the index for inclusion (Booth & Ainscow, 2002), reflecting the three basic dimensions: cultural, political, and practical.

The aim of this article is therefore to provide a framework to guide the design of more inclusive, useful, and understandable AI systems for all persons, including those with intellectual disabilities. To this end, the following sections will define and relate the concepts introduced, starting with the methodology used for writing this article (Section 2). Section 3 defines the key concepts related to persons with disabilities (fundamentals, accessibility and regulations), and Section 4 specifies the use case of Artificial Intelligence applied to products, environments and services. Finally, Section 5 presents the conclusions of the work and a compilation of key recommendations.

2. Methodology

The main objective of this research is to identify the challenges in developing accessible and inclusive Artificial Intelligence from the perspective of persons with intellectual disabilities based on a literature review. To this end, it is necessary to compile the main reference documents in the field of persons with intellectual disabilities and Artificial Intelligence.

The bibliographic review is carried out based on the following criteria:

- Analyse the concepts of "person with disabilities", "accessibility", "Universal Design", "User-Centred Design", "Information and Communication Technologies", and "Artificial Intelligence", using them simultaneously as keywords in the bibliographic search.
- To focus the review on the legislative, socio-health and technological fields in Spain.
- Consider references of national and international scope.
- If there are different versions or multiple modifications in successive documents, the most recent will be considered.

The primary documentary sources include: in the legislative field, the United Nations (UN), the European Union (EU), and the Government of Spain (through the official national gazette, BOE – Boletín Oficial del Estado); in the social and health field, the World Health Organization (WHO), and the American Psychiatric Association (APA); in the technological field, the European Telecommunications Standards Institute (ETSI), the Spanish Association for Standardization and Certification (AENOR), and the World Wide Web Consortium (W3C). Sources from the associative movement have not been included, as we consider that the analysed sources incorporate their perspective.

Based on this documentation, a conceptual analysis has been conducted to identify, define, and relate key terms concerning intellectual disability and accessibility. The result is a structured proposal of fundamental concepts, intended to serve as a framework in the design of inclusive

AI-based technologies. The analysis is intended for development teams working on AI-based products, environments, and services for persons with intellectual disabilities.

Although we aimed to minimise bias or interpretation by including direct quotations from the original Spanish texts, the act of translating them into English for clarity may have affected the precision or impact of their meaning. Therefore, readers are encouraged to consult the original texts, as cited in the corresponding bibliographic references.

3. Fundamentals

This section defines the key concepts in the field of persons with disabilities. Based on the analysis of the meaning and evolution of the terms presented, a network of conceptual relationships has been established to help understand their interaction in the development of inclusive technologies. The analysis starts by including the user at the centre of the design. From there, the evolution of the concept of disability is traced, which has shifted from an exclusively health-based perspective to a broader one that also incorporates social and technological dimensions. Intellectual disability, the central focus of this work, is explored in depth, followed by an examination of how persons interact with systems. Finally, emphasis is placed on the technical standards that define the essential elements for ensuring the proper functioning of AI-based products, environments, and services, some of which have already become established standards.

3.1. The person with a disability

The starting point of this analysis is the person as a central element to understand the concepts related to disability. Addressing the term "disability" requires examining it in its broadest sense, considering not only its health dimension, but also the social, legislative and technological aspects that surround it. Understanding what it means to live with a disability implies recognising the barriers faced by persons with disabilities and considering the principles of equal opportunities, autonomy and inclusion as fundamental elements in designing truly accessible and inclusive technologies.

3.1.1. Disability

Until 2001, the concept of disability did not exist in its current form. Disabilities were strictly considered within the health field, and their scope of action could be found in the *International Statistical Classification of Diseases and Related Health Problems, ICD-10* (WHO, 1992) of the World Health Organisation (WHO).

In fact, the concept of disability was consolidated internationally because of its incorporation into the *International Classification of Functioning, Disability and Health (ICF)* by the WHO in 2001 (WHO, 2001). A significant advance was achieved by integrating the social and health spheres and conceiving disability as a situation affecting persons, rather than as part of a disease. Therefore, both ICDs and ICFs are complementary since then until today, with the latest version of the ICD being revision 11, ICD-11 (WHO, 2023). The ICF approaches the concept of disability by addressing three interrelated aspects: the deficiency of a bodily structure or function (health domain) limits a person's daily activities (individual level) and restricts this person's participation in society (social level).

The current framework on disability is based on the *United Nations Convention on the Rights of Persons with Disabilities*, adopted in New York on 13 December 2006, CRPD (UN, 2006). This convention lays the foundations for the principles and rights of persons with disabilities:

- "The principles of the present Convention shall be:*
- (a) Respect for inherent dignity, individual autonomy including the freedom to make one's own choices, and independence of persons;*
 - (b) Non-discrimination;*
 - (c) Full and effective participation and inclusion in society;*
 - (d) Respect for difference and acceptance of persons with disabilities as part of human diversity and humanity;*
 - (e) Equality of opportunity;*
 - (f) Accessibility;*
 - (g) Equality between men and women;*
 - (h) Respect for the evolving capacities of children with disabilities and respect for the right of children with disabilities to preserve their identities."*

In Spain, the rights of persons with disabilities were ratified through the *Instrument of Ratification of the Convention on the Rights of Persons with Disabilities*, signed in New York on 13 December 2006 (BOE, 2008). This entails a commitment to ensure and promote the whole exercise of all human rights and fundamental freedoms of persons with disabilities, without any discrimination based on disability.

The concept of disability, as it is currently understood, is defined in Royal Legislative Decree 1/2013, of 29 November, which approves the *Recast Text of the General Law on the Rights of Persons with Disabilities and their Social Inclusion*, RDL-1/2013 (BOE, 2013):

"Disability is a situation that results from the interaction between people with foreseeably permanent impairments and any type of barriers that limit or prevent their full and effective participation in society, on equal terms with others."

This situation, whether temporary or permanent, reinforces the need to promote the autonomy of persons with disabilities. The concept of personal autonomy, inspired by the Independent Living Movement, which emerged in the United States in the 60s, was incorporated into the Spanish legal framework, specifically in RDL-1/2013 (BOE, 2013):

"Persons with disabilities have the right to free decision-making, for which information and consent must be made in appropriate formats and in accordance with personal circumstances, following the rules set by the principle of universal design or design for all, so that they are accessible and understandable to them."

The concept of equal opportunity is one of the pillars underlying the concept of disability. In the *CRPD* (UN, 2006), it is established as one of the general principles of the Convention, coming from the social context. RDL-1/2013 (BOE, 2013) provides the current legal definition of the term:

"Equality of opportunity: means the absence of any discrimination, direct or indirect, on the ground of or based on disability, including any distinction, exclusion or restriction which has the purpose or effect of impeding or rendering ineffective the recognition, enjoyment or exercise on an equal basis by persons with disabilities of all human rights and fundamental

freedom the political sphere, economic, social, labour, cultural, civil or other types of work. Likewise, equal opportunities are understood as the adoption of positive action measures."

Analogous to equal opportunities, social inclusion is one of the general principles of the *CRPD* (UN, 2006). Both contribute to the social character of the concept of disability in a complementary manner. Similarly, RDL-1/2013 (BOE, 2013) defines the term as follows:

"Social inclusion: is the principle by virtue of which society promotes shared values aimed at the common good and social cohesion, allowing all persons with disabilities to have the opportunities and resources necessary to participate fully in political, economic, social, educational, labour and cultural life, and to enjoy living conditions on an equal basis with others."

The term "social inclusion" replaces "social integration", as used in *Law 13/1982, of 7 April, on the social integration of the disabled* (BOE, 1982). This terminological change reflects a significant evolution in the cultural and conceptual approach to persons with disabilities. The substitution is not merely lexical: it responds to social advances that have, in turn, influenced the legislative level. There is a shift from a model focused on incorporating persons into the existing system (integrating) to one that promotes their full participation on equal terms (including). This paradigm shift is essential to guarantee a truly inclusive society.

3.1.2. Persons with disabilities

Based on the general definition of disability, RDL-1/2013 (BOE, 2013) specifies who is considered a person with disabilities:

"Persons with disabilities are those who have physical, mental, intellectual or sensory deficiencies, foreseeably permanent, which, when interacting with various barriers, may prevent their full and effective participation in society, on equal terms with others."

In addition, this definition introduces a quantitative criterion to determine who can benefit from the rights and benefits provided by law. Specifically, the following are considered persons with disabilities, for legal purposes:

"... for the purposes of this law, persons with disabilities shall be considered to be those who have been recognized as having a degree of disability equal to or greater than 33 per cent."

The term "person with disabilities" is included in the current legal framework, replacing the obsolete terms "disabled" and "handicapped" established in *Law 13/1982, of 7 April, on the social integration of persons with disabilities* (BOE, 1982). This change reflects an important advance in the way of understanding disability, focusing the term on the person rather than their limitations. The order of the terms, with "person" preceding "disability", highlights this perspective focused on individual rights and dignity. Note the relevance of the noun "person" in the first place, and the adjective "disability" in the second place.

In this context, it is important to note that the term "functional diversity", although used in some associative and informative environments, is not formally recognised in the legislative framework. Its broad scope, which encompasses aspects such as gender, culture, food, or social position, makes it a challenging concept to define for the implementation of specific policies. For this reason, in the legal and technical frameworks, the name "person with disability" is maintained as a clear and shared reference at the international level.

The determination of the degree of disability is officially regulated by Royal Decree 888/2022, of 18 October, which establishes the procedure for recognising, declaring, and qualifying the degree of disability, RD 888/2022, (BOE, 2022). This decree is based on the principles of the *International Classification of Functioning, Disability, and Health (ICF)* and incorporates a social perspective into the evaluation process. To do this, four scales are applied that analyse different dimensions of the person's situation:

- Body impairment: assessed using the Scale of Body Functions and Structures or Global Impairment of the Person.
- Limitation in activity: measured with the Scale of Assessment of Abilities or Limitations in Activity.
- Participation restriction: collected through the Performance Evaluation Scale or Participation Restrictions.
- Environmental contextual factors: analysed using the Scale for the Assessment of Contextual Factors or Environmental Barriers.

The information obtained from these four scales is synthesised in two global and complementary indicators, the profile of functioning and disability and the final degree of disability of the person:

'The global dimension of the person's functioning problem will finally be represented by a "Final Degree of Disability of the Person" and by a "Global Profile of Functioning and Disability".'

The global profile of functioning and disability offers a simplified view of the person's disability situation, including the origin of the disability and its level of incidence. This profile has a qualitative character and serves as a general orientation. The global profile of functioning and disability also includes information on the type of impairment that gives rise to the disability. RD-888/2022 (BOE, 2022), following the recommendations of the ICF (WHO, 2001) and ICD-11 (WHO, 2023), establishes specific terminology to identify these deficiencies. It is important to note that a person may have more than one impairment that contributes to their disability status. When there are multiple relevant impairments -for example, an intellectual impairment together with a sensory or physical impairment- the concept of multiple disabilities applies. This term suggests that it is not a single cause, but rather a combination of factors that collectively pose barriers to persons with disabilities.

On the other hand, the final degree of disability given in Spain is a quantitative value that is calculated from the four scales described above. This degree is expressed as a percentage, which can range from 0% (minimum affectation) to 100% (maximum affectation) and provides an official recognition to the user.

Both indicators complement each other: the profile qualitatively describes the person's situation, while the degree allows it to be quantified. To facilitate interpretation, the percentages are grouped into five levels: null (0-4%), mild (5-24%), moderate (25-49%), severe (50-95%), and total (96-100%). It is essential to note that this assessment is based on the person's ability to perform daily activities, as reflected in the ICF. Additionally, the qualitative values of the profile may vary depending on the scope of evaluation, allowing for some flexibility in its representation.

The European Union incorporates mechanisms for the standardisation and homologation of legislation in its member states in the field of persons with disabilities. To this end, it has established a strategy on the rights of persons with disabilities for 2021-2030 (EU, 2021; AccessibleEU-2, 2023).

3.1.3. Intellectual disability

This section focuses on defining Intellectual Disability (ID) as one of the specific types of "foreseeably permanent impairments" mentioned in the general definition of disability in RDL-1/2013 (BOE, 2013), presented in the previous section.

The procedure for recognising and assessing this disability, including the degree and profile of disability, is detailed in RD-888/2022 (BOE, 2022), which integrates criteria of the American Association on Intellectual and Developmental Disabilities (AAIDD) with the general criteria of the ICD and the ICF on disability.

From a health perspective, the ICD-11 (WHO, 2023) categorises aspects related to impairments in body structures and functions associated with intellectual disability under the category of Intellectual Developmental Disorders (6A00). It is relevant to note that the ICD-11 has updated its terminology with respect to the ICD-10, explicitly using the term "intellectual" and leaving aside the term "cognitive" that was previously associated with the term "intellectual".

The ICF (WHO, 2001) incorporates Intellectual functions (category b117) in the section on mental functions and addresses the following concepts:

"General mental functions, required to understand and constructively integrate the various mental functions, including all cognitive functions and their development over the life span. Inclusions: functions of intellectual growth; intellectual retardation, mental retardation, dementia Exclusions: memory functions (b144); thought functions (b160); higher-level cognitive functions (b164)."

In turn, the AAIDD defines the concept of intellectual disability in the *Diagnostic and Statistical Manual of Mental Disorders, fifth edition, DSM-5* (AAIDD, 2022). It is framed within the intellectual development disorder and proposes the following concepts:

"Intellectual developmental disorder is characterised by deficits in general mental abilities, such as reasoning, problem solving, planning, abstract thinking, judgment, academic learning, and learning from experience. The deficits result in impairments of adaptive functioning, such that the individual fails to meet standards of personal independence and social responsibility in one or more aspects of daily life, including communication, social participation, academic or occupational functioning, and personal independence at home or in community settings."

It should be noted that the formulation of this definition articulates the socio-health aspects related to disability, beyond the purely health aspects that can be observed in the ICD-11. The basic factor traditionally considered to establish intellectual deficiencies has been IQ (comprehension), while communication and social participation are currently considered. For all these reasons, RD-888/2022 (BOE, 2022) assumes the term Intellectual Disability (ID); it is incorporated into the qualitative profile through borderline intellectual capacity, mild ID, moderate ID, severe ID, and profound ID; and formalises it synthetically as follows:

"A disability characterised by significant limitations in intellectual functioning and adaptive behaviour that manifests itself in conceptual, social, and practical adaptive skills"

3.2. Accessibility

For products, environments, and services to be truly inclusive, it is not enough to focus solely on the person in their design. It is also necessary to pay attention to how the person interacts with them and the experience they will have. This section discusses the key principles that should guide the design, development, and use of these elements to ensure equal access and opportunity.

Two major philosophies offer complementary solutions to this challenge. While Universal Design focuses on the end-user's experience of products, environments, and services, Universal Accessibility focuses on their actual implementation, reinforcing the idea of access for all. Difficulties tend to emerge from the interaction between these two perspectives. To solve them, the priority must be placed on adapting products, environments, and services rather than on adapting persons to them.

Through concepts such as Universal Design, Universal Accessibility, Cognitive Accessibility, Infoaccessibility and Usability, a comprehensive approach is proposed, one that places user experience at the centre, from planning to implementation. These principles are essential for transforming everyday actions into real opportunities for participation.

Spanish Royal Decree 193/2023, of 21 March, which regulates the basic conditions of accessibility and non-discrimination for persons with disabilities in accessing and using goods and services available to the public (BOE, 2023), currently legislates this aspect based on the concepts described below.

3.2.1. Universal Design

Once a product, environment or service is already in use, it is costly to make the necessary changes to ensure equal opportunities and inclusion for its users. Therefore, it is essential to adopt a user-centred design approach from the outset, one that considers users' real needs and prevents the creation of barriers to use. This approach represents a profound shift in the way we think about design: it is no longer just about creating functional solutions but about ensuring that they are accessible and non-discriminatory for all users.

The *Convention on the Rights of Persons with Disabilities (CRPD)* (UN, 2006) was a great step forward in defining the concept of Universal Design:

"Universal design means the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design. Universal design shall not exclude assistive devices for particular groups of persons with disabilities where this is needed."

Its definition highlights two key ideas: first, it describes what this approach consists of; second, it clarifies that although the goal is to create solutions accessible to everyone, specific adaptations will still be necessary for persons in extreme situations.

Subsequently, RDL-1/2013 (BOE, 2013) recast and refined this definition, updating some key terms. It shifted from talking about "technology" to "product", from "help" to "support", and replaced "universal" with the more inclusive expression "for all persons". These changes reflect a greater focus on personal autonomy and independent living, reinforcing the idea that design should always put persons first:

"Universal design or design for all: it is the activity by which environments, processes, goods, products, services, objects, instruments, programs, devices

or tools are conceived or projected from the beginning, and whenever possible, in such a way that they can be used by all people, to the greatest extent possible, without the need for adaptation or specialised design. 'Universal design or design for all' shall not exclude assistive products for particular groups of persons with disabilities, when they need it."

This approach has influenced numerous inclusive design models and practices that are now considered benchmarks, having incorporated its core conceptual principles. On one hand, methodologies such as User-Centred Design (Norman & Draper, 1986), Emotional Design (Norman, 2004) or Design Thinking (Brown, 2008) stand out by structuring the design process around placing the person at the centre. On the other hand, key principles and frameworks, such as the Principles of Universal Design (CUD, 1997) and User Experience (Norman & Nielsen, 1998), provide criteria and perspectives for creating more accessible, useful, and satisfying products.

3.2.2. Universal Accessibility

The concept of accessibility has evolved significantly, moving from a narrow focus on "availability of use" to a broader emphasis on "interaction in use". In the WHO's *International Classification of Functioning, Disability and Health (ICF)* (WHO, 2001), accessibility is recognised as a fundamental requirement of the environmental factors (physical, social and attitudinal) that affect persons' lives. Although the ICF does not provide a formal definition, it emphasises the importance of having available resources to facilitate participation.

The CRPD (UN, 2006) incorporates accessibility as one of its general principles. But it is not formally defined, and its scope is not evident. In the article on accessibility, there is an explicit reference to "access" for persons, and in other articles to "accessibility" of services. This uncertainty remains unresolved in the document General Comment No. 2 of the *United Nations Convention on the Rights of Persons with Disabilities* (UN, 2014) and, therefore, is open to debate.

The formal definition of accessibility is materialised in RDL-1/2013 (BOE, 2013), where the concept of universal accessibility is introduced to underline its integral scope:

"Universal accessibility: it is the condition that environments, processes, goods, products and services, as well as objects, instruments, tools and devices must meet in order to be understandable, usable and practicable by all people in conditions of safety and comfort and most autonomously and naturally possible."

Note that the concept of accessibility provides a characteristic to products, environments and services, while the concept of disability provides a characteristic to persons. From the interaction between persons and products, environments and services arises the concept of accessibility. Therefore, the lack of accessibility can lead to the concept of disability in persons. In addition, the philosophy of Universal Design is assumed to avoid this. Moreover, in any case, it is complemented using assistive products by persons with disabilities.

In 2019, the EU launched Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on accessibility requirements for products and services, DEU-2019/882 (EU, 2019). This directive aims to contribute to the proper functioning of the internal market by harmonising the laws, regulations, and administrative provisions of the Member States regarding the accessibility requirements for products and services. In Spain, it is ratified by Royal Decree 193/2023, of 21 March, which regulates the basic conditions of accessibility and non-

discrimination for persons with disabilities in accessing and using goods and services available to the public, as per RD-193/2023 (BOE, 2023).

"Public administrations shall ensure respect for the right to equal opportunities and non-discrimination of persons with disabilities in accessing and using goods and services available to the public, and any type of discrimination on the grounds of or based on disability in this area shall be prohibited, in the terms provided for in the Consolidated Text of the General Law on the Rights of Persons with Disabilities and their social inclusion."

Truly universal accessibility is a highly honourable social objective, but it is very difficult to achieve. For this reason, the development of "reasonable accommodations" that achieve progress in terms of non-discrimination is contemplated. They refer, therefore, to modifications or adaptations that can be made to products, environments and services to improve the level of accessibility and ensure greater inclusion of all potential users. The term "reasonable" refers precisely to the fact that these adaptations should not be disproportionate either in terms of cost or the resources required for their implementation; however, they are essential to eliminate barriers that prevent the full participation of all persons with disabilities.

3.2.3. Cognitive accessibility

Among the characteristics encompassed by the concept of universal accessibility, those related to understanding, communication and interaction can be grouped under the category of cognition. RDL-1/2013 (BOE, 2013) establishes this in the following text:

"Universal accessibility includes cognitive accessibility to allow easy understanding, communication and interaction for all people. Cognitive accessibility is deployed and made effective through easy reading, alternative and augmentative communication systems, pictograms and other human and technological means available for this purpose."

These characteristics, encompassed by cognitive accessibility, are useful for all persons; necessary to varying degrees for persons with different disabilities; and essential for those with intellectual disabilities.

3.2.4. Infoaccessibility

The term "accessibility" can take on different nuances depending on the context in which it is used, whether referring to disability or relating to different types of products, environments, or services. When applied to the field of Information and Communication Technologies (ICT), the dimension of understanding, communication and interaction, which constitutes the core of these technologies, becomes particularly relevant. In this context, accessibility is given specific names such as infoaccessibility, web accessibility or ICT accessibility. All of them refer to the ability of digital systems to be used by all persons, including those with different types of disabilities. It should be noted that both infoaccessibility and cognitive accessibility share fundamental principles and common objectives: to eliminate barriers, facilitate understanding, ease of use, and ensure full participation in digital environments. In the case of cognitive accessibility, ICTs can incorporate strategies such as language simplification, the use of visual aids, or guided navigation, thereby facilitating access to information and digital services for persons with comprehension or processing difficulties.

Directive (EU) 2016/2102 of the European Parliament and of the Council on the accessibility of websites and applications for mobile devices of public sector bodies, DEU-2016/2102 (EU, 2016), stresses the need to guarantee and standardise the criteria for infoaccessibility. It states that:

"Member States shall ensure that public sector bodies take the necessary measures to make their websites and mobile applications more accessible by making them perceivable, operable, understandable and robust."

Spain incorporated this directive through RD-1112/2018 (BOE 2018), which establishes the objective of ensuring that public sector websites and applications comply with digital accessibility requirements:

"This royal decree aims to guarantee the accessibility requirements of websites and applications for mobile devices of public sector bodies."

Both the directive and the royal decree are implicitly incorporated into the subsequent regulations of the DEU-2019/882 (EU, 2019) and RD-193/2023 (BOE, 2023), also known as the universal accessibility law in Spain. These regulations reinforce the regulatory commitment to digital accessibility, extending its application beyond the public sector. A key aspect of this legislation is that it refers to specific technical standards to detail the specific requirements that ICT products and services must meet. In this sense, the regulatory reference is the European standard EN 301 549 V3.2.1 (2021-03), *Accessibility requirements for ICT products and services* (ETSI, 2021), and its Spanish counterpart, UNE-EN 301549 V.1.1.2:2015 *Accessibility requirements for ICT products and services applicable to public procurement in Europe* (UNE, 2022). These standards establish the technical criteria that must be met in the design, development and acquisition of accessible technologies and are based on the W3C Web Content Accessibility Guidelines (WCAG), which constitute the international benchmark for the accessible design of websites and digital content.

3.2.5. Usability

From the ICT field, there is a concept closely related to accessibility, but that should not be confused with it: usability. Usability is an indicator that considers the ease of use of a product, environment or service and the satisfaction of the user. Consequently, when an element is not usable, it is also not accessible. However, both concepts do not have the same scope, as accessibility is suitable for all persons, without any exclusion. The UNE-EN ISO 9241-11:2018 standard, *Ergonomics of human-system interaction. Part 11: Usability. Definitions and concepts*. (UNE 2018) defines it in this way:

"The degree to which specific users can use a product to achieve a goal effectively, efficiently, and satisfactorily in a specific use context."

The characteristic of usability is analogous to practicability, a term generally used in the field of universal accessibility. In both cases, the variable to be analysed is interaction. In practice, usability allows for the assessment of the function to be incorporated alongside interaction, making accessibility and usability complementary characteristics.

Usability measures how quickly and easily a group of persons can perform specific tasks using a particular product, environment, or service. Therefore, it is the users, not the designers or developers, who determine when it is simple and effective to use. Usability presupposes that the product, environment or service has been developed with the user in mind to meet their needs, and that the developer possesses extensive knowledge of the context and modes of use of the product or service.

User experience is therefore a key concept related to usability. It encompasses the range of factors that influence a person's sensations or reactions when using a product, environment, or service in a specific context. In the field of ICT, this includes various aspects such as the user's interaction with screen elements (menus, tabs, buttons), the activation of images, videos or sounds, colours, the contrast between text and background, font types, the number of clicks required to reach desired information, and the dynamic or unexpected appearance of components and drop-down menus on web pages.

3.3. The standard

Just as the spelling, grammatical, semantic and lexical rules of a language must be respected in creating a correct sentence, the corresponding rules must also be considered in the development of products, environments and services. Technical standards should be understood as guides to good practice that define the essential elements required to ensure the proper functioning of products, environments and services. When sufficient consensus is reached, they become standards, and compliance may become mandatory if required by law.

Many countries already have a legislative framework that ensures equitable access to information systems for users with disabilities. In Europe, all countries are required to transpose directives into their national legislation. To ensure coherence and effective standardisation in the field of accessibility, specific reference frameworks are established in the field of accessibility (AccessibleEU-1, 2023).

3.3.1. The user experience

As previously explained, the person should be at the centre of accessibility and inclusion, with the aim being to ensure the best possible interaction when using a product, environment, or service. To achieve this, it is essential to incorporate the user experience at all stages of a product, environment, or service's life cycle. In this context, the User-Centred Design (UCD) methodology, included in the standard UNE-EN ISO 9241-210:2019. Ergonomics of human-system interaction - Part 210: Human operator-centred design for interactive systems (UNE, 2019). This standard defines UCD as follows:

"An approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques."

The UCD methodology is characterised by the active involvement of users, a clear understanding of their needs and tasks, an appropriate allocation of functions between users and technology, the iterative development of design solutions, and a multidisciplinary approach to design.

3.3.2. The WCAG

The Web Content Accessibility Guidelines (WCAG) are the most important international effort to establish a standard for accessible design in ICT and to provide guidance on accessibility for persons with disabilities. These guidelines were originally developed for web environments and have gradually evolved to encompass all ICT products, environments, and services. WCAGs are based on four fundamental principles (W3C, 2024).

" Perceivable - Information and user interface components must be presentable to users in ways they can perceive."

Operable - User interface components and navigation must be operable.

Understandable - Information and the operation of user interface must be

*Robust - Content must be robust enough that it can be interpreted reliably
by a wide variety of user agents, including assistive technologies.”*

Since their origins in 1999 in the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C), these guidelines have been progressively refined through successive versions, from 1.0 to the current 2.2. Since 2014, they have been formalised as standards through technical standards (ETSI, 2021; UNE, 2024). In September 2018, Royal Decree 1112/2018 of 7 September 2018 on the accessibility of websites and mobile applications in the public sector (BOE, 2018) came into force, transposing European Directive 2016/21022 (EU, 2016) into Spanish law.

The guidelines outlined in the WCAG are categorised into three levels: A, AA and AAA. Level A guidelines encompass the most basic requirements, enabling a minimum degree of accessibility to be achieved. Level AA includes features necessary to achieve an acceptable level of accessibility, while level AAA comprises the most stringent and comprehensive accessibility criteria. When all the characteristics of a level have been met, the product, environment, or service is considered to comply with the respective A, AA, or AAA certification. Currently, it is mandatory to pass an AA certification in public sector products, environments and services (BOE, 2018).

3.3.3. The WAI-ARIA

The WAI Accessible Rich Internet Applications Suite (WAI-ARIA) define the means to incorporate semantic information into ICT content and applications (W3C, 2023). Assistive products utilise this information to facilitate interaction between persons with disabilities and ICT products, environments, and services. These guidelines are complementary to WCAG, providing an ontology of roles, states, and properties that define interface elements and controls developed with Ajax, HTML, JavaScript, and their related technologies. It allows you to define what role or function an item has and indicate its status and properties, which can be dynamically modified so that assistive products (such as screen readers) can announce changes that occur dynamically (e.g., a drop-down list that opens and shows all the options to choose from).

3.3.4. The COGA

The Cognitive Accessibility Guidance (COGA) focuses its scope of action on persons with intellectual disabilities and learning disorders (W3C, 2021). These guidelines articulate their recommendations beyond the usability of the interface, considering formal aspects of the design, context, structure, language and other applicable factors.

The COGA guidelines identify a set of key points:

- Help users understand what things are and how to use them, find what they need, avoid mistakes, and focus.
- Incorporate clear content, such as text, images and multimedia, into systems and processes that rely on memory, while also providing adaptation, personalisation, help, and support.
- Involve persons with intellectual disabilities and learning disorders in the process of researching, designing, and implementing products, environments, and services.

3.3.5. Easy reading

Effective communication is one of the key factors in the interaction of persons with intellectual disabilities. Within the framework of cognitive accessibility, the UNE 153101:2018 EX. Easy to read. Guidelines and recommendations for the elaboration of documents (UNE-1, 2018) defines and formalises the concept of easy-to-read:

"Method that includes a set of guidelines and recommendations related to the writing of texts, the design/layout of documents and the validation of their comprehensibility, aimed at making information accessible to people with reading comprehension difficulties."

Easy reading is included in RD-1112/2018 (BOE, 2013) as one of the necessary mechanisms to achieve cognitive accessibility:

"Establishing that cognitive accessibility is deployed and made effective through easy reading, alternative and augmentative communication systems, pictograms and other human and technological means available for this purpose."

3.3.6. Products and support

Legislation related to persons with disabilities (BOE, 2008; BOE, 2013; BOE, 2018; and BOE, 2023) highlights the use of products and assistive devices as complementary tools to achieve accessibility in products, environments, and services.

Although the products and assistive devices must comply with their specific regulations, it is important to understand how they are structured and defined. This understanding helps consider their interaction with the products, environments and services they complement, as well as the requirements arising from the application of relevant standards.

The UNE-EN ISO 9999:2023 Assistive Products - Classification and terminology (UNE, 2023) provides this information and offers a comprehensive definition of assistive products in its broadest sense:

"Product that optimises a person's functioning and reduces their disability... Supporting products include devices, instruments, equipment and software."

4. Considerations for an inclusive generative Artificial Intelligence

This section outlines the fundamental concepts introduced in the previous section, applying them specifically to the use case of Artificial Intelligence in products, environments, and services. If the concept of service is understood in its broadest sense, encompassing both products and environments, then two key aspects emerge as essential: the use of the service and the understanding of how it is used. In RD 193/2023 (BOE, 2023), the concepts of products (goods) and services are defined as follows:

"(b) Goods: Items, articles and products, in particular goods, particularly those whose provision does not constitute a service, and which are made available to the public in the ordinary course of an open market."

"(c) Services: Publicly available services provided by a natural or legal person, whether or not there is remuneration for them."

In turn, the concept of Artificial Intelligence can be defined according to the European Commission's Independent High-Level Expert Group on Artificial Intelligence in the document "A definition of AI: main capabilities and disciplines" (EU-1, 2019) as follows:

" Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.

AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications). "

Regulation 2024/1689 of the European Parliament and of the Council of 13 June 2024 (EU, 2024) specifies the characteristics to be considered in the field of Artificial Intelligence. AI systems must include, at a minimum, a user interface and an AI model. The AI model within the system determines its scope of action. As stated in the regulation:

" The notion of general-purpose AI models should be clearly defined and set apart from the notion of AI systems to enable legal certainty. The definition should be based on the key functional characteristics of a general-purpose AI model, in particular the generality and the capability to competently perform a wide range of distinct tasks. These models are typically trained on large amounts of data, through various methods, such as self-supervised, unsupervised or reinforcement learning."

These models have evolved to reach the ability to dynamically generate content during interactions with users; these are known as generative AI models:

" Large generative AI models are a typical example for a general-purpose AI model, given that they allow for flexible generation of content, such as in the form of text, audio, images or video, that can readily accommodate a wide range of distinctive tasks."

From these initial definitions, it is essential to consider the ethical, legal, formal, social, and other relevant dimensions that will shape the resulting systems based on Artificial Intelligence. These considerations should be understood as guiding recommendations for the multidisciplinary teams involved throughout the entire AI lifecycle, including development, deployment, and exploitation.

This section is structured into three subsections. The first focuses on ethics and outlines the fundamental principles and requirements that reliable AI systems, those that respect human rights, must fulfil. The second examines the implications of disability explicitly, identifying the risks of exclusion and the necessary safeguards to guarantee equal opportunities in AI. Finally, the third addresses the specific accessibility requirements that AI-based products, environments and services must satisfy, with special attention to cognitive accessibility and personalisation. This division responds to the need to integrate complementary perspectives to move towards a truly inclusive design.

4.1. From ethics

The European Commission, through the Independent High-Level Expert Group on Artificial Intelligence, in the document *Ethical Guidelines for Trustworthy AI* (EU-2, 2019), proposes a set of considerations on AI. They are based on the concept of AI reliability. In other words, the systems and the persons who make them up prove to be worthy of the trust of their users:

" Trustworthy AI has three components, which should be met throughout the system's entire life cycle: (1) it should be lawful, complying with all applicable laws and regulations (2) it should be ethical, ensuring adherence to ethical principles and values and (3) it should be robust, both from a technical and social perspective since, even with good intentions, AI systems can cause unintentional harm. Each component in itself is necessary but not sufficient for the achievement of Trustworthy AI. Ideally, all three components work in harmony and overlap in their operation. If, in practice, tensions arise between these components, society should endeavour to align them."

To this end, reliable AI must comply with the fundamental principles of human rights, and particularly those of persons with disabilities:

" Develop, deploy and use AI systems in a way that adheres to the ethical principles of respect for human autonomy, prevention of harm, fairness and explicability. Acknowledge and address the potential tensions between these principles."

From these, it must incorporate seven requirements necessary to guarantee reliable AI:

" Ensure that the development, deployment and use of AI systems meets the seven key requirements for Trustworthy AI: (1) human agency and oversight, (2) technical robustness and safety, (3) privacy and data governance, (4) transparency, (5) diversity, non-discrimination and fairness, (6) environmental and societal well-being and (7) accountability."

As well as evaluating their performance beyond mere evaluation lists:

" Ensuring Trustworthy AI is not about ticking boxes, but about continuously identifying and implementing requirements, evaluating solutions, ensuring improved outcomes throughout the AI system's lifecycle, and involving stakeholders in this."

4.2. From disability

The 2022 Report of the Special Rapporteur on the Rights of Persons with Disabilities to the United Nations Human Rights Council (UN, 2021) identifies a set of key elements to make AI tools truly inclusive. First, the report identifies a set of legal areas that are particularly sensitive in relation to the use of AI tools:

" The rights and core norms of the Convention on the Rights of Persons with Disabilities form the basic yardsticks by which to assess the risks and opportunities presented by artificial intelligence. The relevant rights and corollary obligations include, among others, privacy, autonomy, independent living, employment, education, health and in particular the overall guarantee of equality and non-discrimination."

AI tools must respect the privacy of persons with disabilities, as any infringement could pose a significant risk of social exclusion:

" Rights to privacy and data protection are fundamental to human dignity. The right to privacy is protected under article 22 of the Convention and article 31 sets out parameters for the protection of disability data and statistics. Data belonging to persons with disabilities refers to the content they create, the information collected about them and what is inferred through algorithms."

Both the algorithms and the data corpora used in the training of AI tools must not contain systemic biases that lead to discrimination against persons with disabilities:

" There is documentary evidence that there is an inherent bias in some facial recognition algorithms against persons with disabilities who were judged untrustworthy because their face did not conform to the standard programmed into the artificial intelligence system."

"Proposed fixes to systemic bias should be treated with caution, as disability inclusion in artificial intelligence requires an understanding of not only the data sets used but also of the decision-making process of the artificial intelligence system to avoid discrimination. "

Competent bodies should be able to assess the risk of AI tools generating discriminatory situations. To this end, the algorithms, data corpora and systems involved in the evaluation process must be accessible:

" Major barriers to transparent artificial intelligence systems include the confidentiality of the code in algorithms and the system itself."

Reasonable adjustments must also be implemented at all stages of research, development, and deployment of AI tools:

" Insist on the obligation of reasonable accommodation in the operation of artificial intelligence systems, including by incorporating reasonable accommodation into artificial intelligence tools."

In addition, the accessibility of AI products, environments and services is the basis for avoiding situations of discrimination and exclusion:

" While artificial intelligence does indeed raise a range of accessibility concerns, the core concern of the Special Rapporteur in the present report is how artificial intelligence tools impact persons with disabilities. Front and centre is the question of equal treatment or discrimination."

Finally, it is essential to incorporate persons with disabilities and their representative organisations in all stages of research and development of AI products, environments and services:

" Owing to the lack of consideration for and involvement of persons with disabilities in the development of artificial intelligence, these systems are creating divisions rather than promoting access and supported environments."

4.3. From accessibility

Ensuring accessibility in products, environments, and services based on generative Artificial Intelligence requires a rigorous application of existing regulatory frameworks and a critical review of their limitations in addressing the new challenges posed by these AI-based systems. The WCAG 2.2 guidelines, at level AA, serve as the primary reference for assessing digital accessibility, establishing minimum requirements in terms of perception, operability, comprehensibility, and robustness of content. These guidelines are complemented by other initiatives such as WAI-ARIA, which incorporate essential semantic information to facilitate interaction with assistive products.

However, in the specific case of intellectual disability, these normative tools are necessary, but not sufficient. The COGA guidelines address this dimension with a more specific approach, aimed at minimising cognitive barriers, facilitating navigation, reducing memory load, promoting language clarity, and providing visual and structural supports. Similarly, the UNE 153101 standard on easy reading provides a set of guidelines for writing, layout and validation of texts aimed at persons with reading comprehension difficulties. Incorporating these principles is essential to ensure that generative AI systems are accessible and usable for persons with intellectual disabilities.

Despite the existence of these recommendations, several recent studies indicate that their implementation in generative AI-based tools remains very limited. An accessibility analysis conducted on 50 generative AI applications (Acosta-Vargas et al., 2024), following WCAG 2.2 criteria, revealed significant problems in all interfaces evaluated. Contrast errors, inappropriate structures, incorrect use of ARIA tags and other technical alerts that directly affect the interaction were detected. Additionally, the content generated by these systems often exhibits a high reading level, understandable only to users with a university education, partly due to the biases present in the training corpora. Added to this is the opacity of the algorithms, which makes it challenging to evaluate and correct these barriers properly.

This lack of transparency is further accentuated by the change in interaction brought about by the emergence of generative AI, which is transforming the way persons interact with technology. Nielsen (2023) refers to this approach as "intent-based specification of results": the user informs the system of their desired outcome, and the AI determines the most effective way to achieve it. This apparent simplification, which can benefit many users, introduces new challenges for those with cognitive difficulties, as algorithms take over part of the control of the interaction. As Weiser (1999) pointed out, technology can become "invisible" in its use; however, this can make it difficult for the end user to understand the system. This is especially problematic when transparency and control are requirements for accessibility.

Likewise, this new form of interaction requires users to learn how to formulate precise instructions (known as prompt engineering). This skill can pose a significant barrier for persons with intellectual disabilities if adequate support is not provided. Moreover, conversational interfaces (whether written or spoken), if not well designed, risk being exclusionary and perpetuating traditional models of digital exclusion.

Moving towards truly accessible generative AI requires an inclusive approach from the very beginning. This implies adopting appropriate methodologies, such as User-Centred Design, which guarantee that solutions are adjusted to the real needs of the collective. Furthermore, the tools used throughout the process must themselves comply with established accessibility requirements.

Studies indicate that persons with intellectual disabilities particularly benefit from systems offering multimodal interaction, combining voice, text, and images, as these channels enhance content comprehension and facilitate the expression of intentions (Roomkham & Sitbon, 2024). Improvement in comprehension occurs primarily through the visualisation of images, then through text-to-speech, and finally, through written text, which also encourages the user's engagement with these tools (Liu et al., 2023). This approach is already recognised in the CRPD (BOE 2008), which advocates the use of alternative and augmentative means of communication:

"Communication' shall include languages, text display, Braille, tactile communication, large print, easily accessible multimedia devices, as well as written language, auditory systems, plain language, digitised voice media and other augmentative or alternative modes, media and formats of communication, including easily accessible information and communication technology."

In summary, achieving effective accessibility in generative AI systems requires: the direct participation of persons with intellectual disabilities; the incorporation of multimodal interaction strategies (text, voice and images); the simplification and progressive adaptation of language; and the possibility of customising communication modes. Additionally, it is essential to ensure that tools used during the design and evaluation process meet accessibility criteria, thereby preventing barriers from being replicated from the earliest stages of development.

Only through this comprehensive approach -combining regulations, participatory methodologies and technical solutions adapted to cognitive diversity- will it be possible to develop truly inclusive generative AI technologies.

5. Conclusions

Moving towards truly inclusive Artificial Intelligence requires a change of approach that places persons with intellectual disabilities at the centre of the design, development and evaluation of these technological systems. This paper proposes a conceptual framework that articulates three complementary dimensions -ethics, disability and accessibility- as fundamental pillars to identify challenges and guide solutions in this area.

Throughout the article, the main concepts necessary to understand the specific needs of this group have been defined, as well as the barriers they face when interacting with generative AI technologies. These concepts, integrated from legislative, socio-health, and technological perspectives, offer a common language for multidisciplinary teams involved in creating accessible products, environments, and services. This framework is especially useful for researchers and developers who are new to this field, as it provides a systematic view of the key elements to be considered to generate truly inclusive technological solutions. The literature review has identified a collection of a set of forty-two key documents, offering comprehensive insight into the context of persons with disabilities and their interactions with ICT products, environments, and services, as well as their engagement with artificial intelligence systems. Among these, seventeen documents pertain to legislation, four to social and health fields, and twenty-one to technology. All of them have maximum relevance, as well as national and international reach.

On this basis, key recommendations have been formulated to help developers of AI-based products, environments, and services appropriately contextualise systems, algorithms, and training corpora to the needs of persons with intellectual disabilities. These recommendations go beyond mere regulatory compliance, emphasising the importance of inclusive methodologies,

multimodal strategies, and a critical assessment of the current limitations inherent in conversational interfaces and generative models.

Ultimately, this work is part of a broader research agenda focused on developing real and sustainable solutions. The HumanAI project (Human-centred Artificial Intelligence: Towards Accessible and Customisable Language Models), funded by the State Research Agency in the 2023 call for Knowledge Generation projects, aligns with this goal. The project seeks to create generative AI tools in Spanish explicitly designed for persons with intellectual disabilities. To achieve this, it adopts a User-Centred Design methodology that actively involves users throughout all phases –from customising language models to designing cognitively accessible interfaces – adhering to a human-in-the-loop approach. This collaborative approach, developed by teams from the Universidad Carlos III de Madrid (UC3M), Universidad Complutense de Madrid (UCM), Universidad Nacional de Educación a Distancia (UNED) and Universitat Politècnica de Catalunya (UPC), will allow empirically validating many of the conceptual proposals formulated here and represents a step forward towards a truly inclusive AI for all.

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Reconceptualizing Accessibility: From the Right to the City to Independent Mobility for Persons with Reduced Mobility

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Abstract: Accessibility is an essential human right for enabling individuals to access urban services. The spatial configuration of urban environments must facilitate unimpeded passage along all potential routes, eliminating barriers stemming from legal, societal, administrative, and physical factors. This paper explores the intersection of accessibility and the Right to the City, highlighting their interconnectedness in fostering independent mobility. Grounded in theoretical frameworks, this study underscores the foundational role of the Right to the City in conceptualizing urban accessibility. The Right to the City posits that cities are inclusive spaces accessible to all individuals. Central to this concept is the notion of unrestricted movement between urban activities and land uses, underscoring the pivotal role of accessibility in realizing this vision. Examining the city's accessibility levels reveals critical insights into who can fully participate in and benefit from urban life. Factors such as the quality of pedestrian infrastructure and public transportation systems significantly influence individuals' ability to navigate and utilize urban spaces. However, disparities in accessibility often result in marginalized groups facing social exclusion and limited independent mobility.

Through an in-depth review and analysis, this paper argues that accessibility is inherently tied to human rights principles, with independent mobility as a prerequisite for realizing the Right to the City for all. This study contributes to ongoing discussions on urban inclusivity and equitable access to urban environments by unpacking these connections.

Keywords: the right to the city, Accessibility, right to access, persons with reduced mobility

1. Introduction

From a right-based perspective, accessibility means more than urban spatial policies to be adopted for people with disabilities within urban mobility and not limited to people with disabilities. Once the right to access is adopted as one of the human rights, it brings to mind the first article of the Universal Declaration of Human Rights (United Nations, 1948), "All human beings are born free and equal in dignity and rights...". The rights and equality dimension imply that accessibility is an outcome of the combination of spatial, societal, and administrative policies and implementations, and accessibility is a matter for not only a specific group of people with disabilities but also for any person having reduced mobility. Once it is accepted that every single person is equal no matter what the cultural, ethnic, socio-economic condition or level of ability to access is, then it becomes certain that the right to access is for all-encompassing needs and demands of different groups of persons with reduced mobility. To ensure the needs and demands of various beneficiaries of accessibility, the platforms to obtain their ideas about what their experiences are considering barriers against the right to access need to be provided by

administrative authorities. Before having such a participatory decision-making platform to discuss their right to access, local and government policymakers must be considerate to PRMs as equally as all others.

The city and one of its main components, mobility, are the rights for all. While establishing the interrelation between mobility and accessibility, it is noteworthy that mobility is a crucial factor in obtaining and maintaining the Right to the City, including the right to work, to have an education, or to purchase a house. Mobility conditions must provide access to education, employment, and leisure activities, including all practices to develop social capital. Therefore, the right to mobility is a prerequisite for the other rights providing accessibility as a precondition (Ascher, 2007). Accessibility is a link between individuals and public space that provides the condition to obtain those rights. Unless providing the required accessible urban environment for all for the right to access and mobility, it is even impractical to mention appropriating urban space, participating in social networks, and the production of urban space. In this regard, the meaning and content of accessibility and independent mobility concepts establish a link between Persons with Reduced Mobility and the Right to the City. Consequently, this discussion aims to constitute a base for the condition that can be phrased with a question: what is the required condition that is necessary to put forth the significance of the motto, “accessibility for all”? Is it accessibility with the help of others or accessibility through independent mobility? The latter is the answer forming the essence of the argument of this research.

The structure of the research starts with the Right to the City concerning the right to mobility and accessibility, along with the additions of the analysis of accessibility and accessibility chain¹ and the affected subject group of the research as people with disabilities -in a broader sense; persons with reduced mobility. In addition to the structure of the article, a final complementary concept is involved as independent mobility to sustain the achieving process of the accessibility chain.

2. The Right to the City and Independent Mobility: An Analytical Framework

Right to the City offers a perspective in which cities belong to all their inhabitants and everyone has the right to shape and access urban environments. Industrialization and urbanization processes have transformed cities, alienating residents from urban spaces and weakening their participation in social and political life. This transformation has created accessibility barriers, especially for people with reduced mobility, making the right to the city a critical framework for addressing urban inequalities. This study aims to move the descriptive approaches in the literature to an analytical level by linking the concept of the right to the city with the argument that accessibility and independent mobility is a universal human right.

Jeekel notes that high trust societies (e.g. Denmark or Germany) are more successful in inclusive transportation systems. By linking Jeekel's vision of inclusive transport to the provision of independent mobility for PRMs, this paper analyzes how accessibility policies can be reconciled with social and environmental justice.

Harvey (2003) sees the right to the city as more than an individual freedom of access, but as a moral demand, and emphasizes that this right requires democratic governance and control of

¹ The accessibility chain is a sequence of interconnected steps that shape a person's travel experience, starting from planning the trip, using the vehicle, reaching the destination, and providing feedback on the journey. Each step, or “link,” is interrelated and contributes to the overall accessibility of the trip (Erçetin, 2024)

urban resources. This perspective supports our argument that accessibility policies should focus not only on physical infrastructure, but also on social and political participation processes. Castells (1977, 2015) discusses the right to the city through urban social movements and argues that these movements are the main determinants of urban change. According to him, the right to the city is a collective right, not an individual one, and involves citizens having a say in shaping the city. Castells' emphasis on urban social movements raises the question of how PRMs' demands for independent mobility can be strengthened through urban social movements.

This study re-evaluates Lefebvre, Harvey and Castells' concept of the right to the city through the right to accessibility and independent mobility. Although descriptive approaches in the literature show that the right to the city offers a powerful framework for addressing urban injustices, it has not been sufficiently deepened in terms of the right to independent mobility of individuals with reduced mobility. In this context, our study aims to fill this gap in the literature by linking the concept of the right to the city with the definition of accessibility as a universal human right and the development of policies to ensure the full participation of PRMs in urban life. For example, the car-centric nature of current urban transportation planning restricts the accessibility rights of PRMs and deepens social inequalities. This study argues that independent mobility can be achieved not only through physical infrastructure, but also through social solidarity and inclusive policies.

In conclusion, the concept of the right to the city offers a powerful theoretical framework for ensuring that urban spaces are accessible and livable for all residents. However, this concept needs to be considered more analytically in the context of the right to independent mobility and accessibility. This paper explores how accessibility policies can be aligned with social and environmental justice goals by redefining the right to the city as a framework to ensure equal participation of PRMs in urban life. Lefebvre (2015) sees the process of industrialization as one of the main sources of the urban problem. The transformative impact of industrialization on society has destroyed the historical and cultural fabric of cities. According to Lefebvre, industrialization and urbanization have destroyed the unique qualities of cities and restricted the participation of residents in urban spaces. By relating Lefebvre's view to the barriers to access to urban spaces for people with reduced mobility (PRMs), this paper interrogates how the concept of the right to the city intersects with independent mobility. Lefebvre's conception of the right to the city involves a political conception of space and argues that urban space is placed at the center of politics (Purcell, 2013). According to him, the right to the city aims to eliminate alienation in urban areas and reestablish social ties among residents. Developing this concept, Purcell (2013) argues that the right to the city offers a radical alternative that redefines the "ownership" of cities: The city belongs to those who occupy it and should be lived collectively by residents as spaces of learning, encounter, play, connection and connectivity. This perspective sets the stage for the central question of our study, "Whose right is independent mobility?" The right to the city is not limited to physical access, but requires equal participation of individuals in urban life.

Lefebvre (2003) argues that urban projects, strategies and policies affect the daily lives of all individuals in society, yet individuals' participation in these processes remains passive. Gentrification and exclusion from urban areas brought about by industrialization has led to the fragmentation of communities and the exploitation of urban spaces. The right to the city includes two fundamental rights: the right to participate and the right to own urban space (Purcell, 2002). Participation is essential for citizens to be directly involved in decision-making processes; however, in current practice, citizens are often only advisors. The right to ownership, on the other hand, refers to the authority of city dwellers to control urbanization processes. By linking Lefebvre's rights to participation and ownership with the right to independent mobility for people with reduced mobility, this paper explores how these rights can be integrated into accessibility policies. For example, the inaccessibility of urban spaces for PRMs prevents them from fully exercising their right to the city.

David Harvey (1973, 2008) and Manuel Castells (1977) develop the concept of the right to the city through capitalist production processes. Harvey (2008) defines the right to the city not as an individual freedom, but as the right to change ourselves by transforming cities. For him, it is a collective right and relies on a shared power to reshape urbanization processes. Harvey argues that cities have been taken away from their rightful owners due to the capitalist cycle, which deepens urban injustices. This study links Harvey's emphasis on collective rights to the identification of accessibility and independent mobility as a universal human right. For example, PRMs' barriers to access to urban spaces are not just an individual problem, but a structural injustice produced by capitalist urbanization processes. Jeekel (2019) discusses how neoliberal policies deepen social exclusion in transportation systems and proposes a radical approach to inclusive transportation. In neoliberal societies, car dependency, spatial segregation and low trust increase accessibility barriers.

Harvey (2003) sees the right to the city as a moral demand rather than an individual freedom of access, and emphasizes that this right requires democratic governance and control of urban resources. This perspective supports our argument that accessibility policies should focus not only on physical infrastructure, but also on social and political participation processes. Castells (1977, 2015) discusses the right to the city through urban social movements and argues that these movements are the main determinants of urban change. According to him, the right to the city is a collective right, not an individual one, and involves citizens having a say in shaping the city. Castells' emphasis on urban social movements raises the question of how PRMs' demands for independent mobility can be strengthened through urban social movements.

This study reassesses Lefebvre, Harvey and Castells' concept of the right to the city through the right to accessibility and independent mobility. Although descriptive approaches in the literature show that the right to the city offers a powerful framework for addressing urban injustices, it has not been sufficiently deepened in terms of the right to independent mobility of individuals with reduced mobility. In this context, our study aims to fill this gap in the literature by linking the concept of the right to the city with the definition of accessibility as a universal human right and the development of policies to ensure the full participation of PRMs in urban life. For example, the car-centric nature of current urban transportation planning restricts the accessibility rights of PRMs and deepens social inequalities. This study argues that independent mobility can be achieved not only through physical infrastructure, but also through social solidarity and inclusive policies.

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2.1. Mobility as A Right

Urban mobility is a fundamental component of social and economic development since it allows people to access facilities in the city such as services, employment opportunities, education, social relations, and other places offering leisure time activities in the city (UN-Habitat, 2012). In this regard, each individual must have the right to mobility and access by default, as Lefebvre, Harvey, Purcell, and other scholars noted. Mobility is a significant element in obtaining the Right to the City in participation and appropriation practices. In this respect, accessibility of urban space and mobility stands as fundamental components for the participation of urban practices and for

having the ability and satisfaction of moving in the city -in other words, the Right to the City itself in its fullest expression (Castaneda, 2019). Consequently, a fundamental link between the Right to the City and mobility emerges interdependently.

As the functional part of the right to the city, a prerequisite factor for the right to appropriation and participation (Verlinghieri & Venturini, 2018), the right to mobility refers to a right to move, to be mobile in urban space, to enable accessibility of urban functions and opportunities. Considering Harvey's approach to the Right to the City as a collective right, since the social needs of individuals and mobility choices are closely embedded with each other, the right to mobility can also be considered a collective right (Sager, 2006; Harvey, 2008). It is evident that to achieve one of the fundamental human rights -the Right to the City- to generate collective acting and thinking, it is necessary to access the urban itself, not only single persons to specific places but each individual has the right to collectively move and access to any place depending on social and individual desires. Therefore, it is noteworthy to state that the Right to the City derives a practical version of another right of its own -the right to mobility-which evidently puts forth the need to access urban itself as a social right – a right for all.

In light of the close link between the right to mobility and accessibility, moving to or in-between urban services, social capital, and public spaces are at the core of participation in urban processes through accessing them and experiencing appropriation of urban space. From a more primary perspective, being in public is an exercise of democracy through experiencing the city and society. In other words, mobility is a means to access the urban (Castaneda, 2019; Ferreira & Batey, 2007). Fundamentally, each individual in society has the right to access any urban asset and resource that makes the right to mobility cover the right to accessibility. Considering the production processes of urban space, the right to mobility widens the path of the Right to the City to proceed a few steps further because without being mobile and accessing the urban assets and the city itself, it is not possible to take part in the production of space as a collective action (Hannam, Sheller, & Urry, 2006). Therefore, there is one of the human rights as the basis of experiencing the city, but the question phrase is “for whom”?

2.2. Whose Right to Mobility?

The discussion on the concept has been about to generate a critical question: who currently owns the Right to the City? The answer is supposed to be the entire society, every single individual, but in a collectively owned and utilized manner. To reveal an evident fact related to contemporary urbanization practices, Harvey (2008) highlights the relationship between that who owns the ‘right’ and urban issues. In line with his approach, the Right to the City has been obtained by private interests restricted to a small group of people from political or economic management elites of cities that has the risk for the urban development to be shaped conforming to their own desires. The most prominent sub-issues of the concept—the right to appropriation and participation—stand out as significant human rights that have the dispute to be neglected and ignored in the current agenda.

Right to the City is an interdependent concept closely linked with the right to mobility and accessibility. In theory, the right to mobility belongs to all—to every single individual in society. However, in practice, other externalities take part in realizing the right to the city. Those external factors vary regarding economic condition or political power, physical ability to be mobile, or affording a car more simplistically. Therefore, this brings to the discussion that individuals are unequal in terms of physical abilities and economic capabilities. For example, considering an imaginary urban square and its car-oriented connections surrounded by vehicular traffic with

narrow sidewalks, one might have the economic power to obtain a car to enjoy the beautiful urban square; another might have the desire to do the same but not afford to drive; moreover, one another might afford driving, have the same desire to have that experience, but not have the physical ability to move without a wheelchair. Thus, a fact arises specifically to this example: to enjoy this beautiful urban square having weak sustainable pedestrian connections, only a few ‘fortunate’ persons would have the chance to access it through an unsustainable mobility mode; that is, have the right to mobility and to access in practice independently by car. The question is that the right theoretically and conceptually seems to be for all, but in practice, to whom does this right belong?

Recent scholarship reframes this question by positioning mobility itself as a human right, closely tied to the realization of broader socio-economic, civil, and political rights. Coggin and Pieterse (2015), for instance, argue that public transport is not merely a technical service but a critical enabler of social and spatial justice, particularly for marginalized groups such as low-income migrants in South African cities. Their rights-based approach demonstrates that exclusion from mobility directly undermines the ability to exercise the “right to the city.” While Coggin and Pieterse (2015) state that mobility is critical for social and spatial justice, Kett et al. (2020) extend this discussion to low- and middle-income countries. Inclusive transport planning in low- and middle-income countries requires a stronger recognition of the intersection between disability, mobility, and accessibility barriers. Kett, Cole, and Turner (2020) highlight that persons with disabilities often face systemic exclusion from mobility systems due to inadequate infrastructure, limited policy attention, and persistent socio-economic inequalities. Their thematic review emphasizes that transport is not merely a technical service but a critical enabler of participation in education, employment, and social life. By framing mobility as both a rights-based and developmental issue, the authors underline the importance of inclusive policies and investment strategies that prioritize the needs of marginalized groups. Such an approach situates inclusive transport planning at the core of sustainable urban development, aligning accessibility improvements with broader goals of equity and social inclusion. These studies show that mobility is not only a technical service, but also a fundamental right to social inclusion. Similarly, Lassance and Figueira (2020) caution against assuming that expanding mobility options automatically produces inclusion; depending on context, mobility interventions may reinforce inequalities by deepening dependency on urban cores or perpetuating socio-spatial segregation. Lassance and Figueira (2020) note that mobility interventions can reinforce inequalities, while Poltimäe et al. (2022) address similar challenges in a rural context. Recent research on rural mobility highlights the challenges of providing inclusive, economically viable, and environmentally sustainable transport solutions outside urban contexts. Poltimäe et al. (2022) show that single mobility solutions rarely meet the diverse needs of rural populations, which include both permanent and temporary residents. Their study identifies semi-flexible and flexible demand-responsive transport, car-sharing, and ride-sharing as key categories of novel mobility solutions, emphasizing that combining these solutions generates spatial and temporal synergies critical for accessibility. Furthermore, success depends on clear information systems for routing, booking, and ticketing, as well as cooperation, trust, and shared values among stakeholders. These findings underscore the importance of integrating diverse user needs and adopting flexible, connected transport networks to achieve socially inclusive and sustainable mobility in rural contexts. These studies show that inclusive mobility policies need to be adapted in different geographical contexts. These insights emphasize that mobility cannot be understood solely in distributive or infrastructural terms, but must also be analyzed as a normative claim—“whose mobility is being enabled, and under what conditions?”

This broader framing connects with earlier contributions on transport disadvantage and social exclusion, such as studies of unequal access to opportunities among marginalized groups (Kain, 1968; Wachs & Kumagai, 1973), uneven distribution of transport benefits and burdens (Hodge, 1988; Pereira et al., 2019), and gendered spatial entrapment (Hanson & Pratt, 1995). Lucas (2012) further highlights the intersection between transport disadvantage and processes of social exclusion, while research on motility (Kaufmann, 2002; Adey et al., 2014; Sheller, 2018a) extends this understanding by analyzing not just infrastructural access but also embodied experiences and social capabilities. Alando (2017) further extends this discussion to users of non-motorized transportation. Inclusive transport planning notes that current planning approaches, which typically prioritize motorized vehicles, often exclude the poor majority who use non-motorized transport such as bicycles in many cities. This exclusion stems from inadequate infrastructure, dangerous traffic conditions, and policies that equate modernization with motorized transport. In this context, the concept of social exclusion can be used as a tool to highlight the disadvantages faced by cyclists and to provide a framework for addressing these issues. Therefore, inclusive transport planning should aim to create street space and traffic conditions where cyclists can travel, thereby increasing accessibility and mobility for those who need it most. This approach not only meets the needs of cyclists but also ensures a more equitable and sustainable use of urban spaces (Alando, 2017). This framework suggests that accessibility policies should be designed to include not only PRMs but also other marginalized groups such as cyclists. Alando (2017) applies the social exclusion framework to cyclists, while Bjerkan and Øvstedal (2020) deepen this concept for people with disabilities. Transport-related social exclusion significantly affects the participation of people with disabilities in economic, social, and civic life. Bjerkan and Øvstedal (2020) emphasize that functional requirements in transport systems—such as accessible design, service reliability, flexibility, affordability, and safe travel environments—are essential to mitigate social exclusion. Their review of empirical studies highlights that mobility barriers extend beyond physical access to include time constraints, economic costs, fear, and limited control over transport options. By addressing these multifaceted barriers, inclusive transport solutions can facilitate participation in education, employment, and social activities, reinforcing mobility as both a fundamental human right and a social enabler. This perspective underscores the need for systematic, rights-based planning approaches that prioritize accessibility, reliability, and user-centered design in transport services to ensure social inclusion of persons with disabilities. These studies emphasize the need for inclusive policies, addressing not only the physical but also the social and economic dimensions of mobility barriers. Building also on Sen's capabilities approach (1993, 1999), subsequent work (Pereira et al., 2017) has stressed that mobility must be seen as a crucial enabler of valued social activities, contingent upon both personal and contextual conversion factors.

Recent theoretical diversification extends beyond distributive concerns to include procedural and recognition-based justice. Transport justice perspectives have underscored the importance of inclusive decision-making and respect for diverse mobility needs (Young, 1990; Fraser, 1996), while empirical studies have revealed systemic power inequalities shaping mobility outcomes, for instance in post-disaster mobility or cycling policies (Cook & Butz, 2015; Schwanen, 2020). Mobility justice, as conceptualized by Sheller (2018b), situates these issues across multiple scales—from embodied practices to urban spatial systems to planetary mobilities—emphasizing ethical responsibilities and relational understandings of movement (Nikolaeva et al., 2019; Davidson, 2020; Karlsson, 2018). Collectively, these contributions underscore that framing mobility as a right requires attending simultaneously to material infrastructures, embodied

capacities, and social recognition, as well as to the political and procedural processes through which mobility access, control, and participation are structured.

The basis of this review is that mobility and accessibility are human rights and must be for all. One of the contributors to the problem of allocation of the Right to the City for all, in theory, is that the concept remains quite abstract. It is not clearly perceived by individuals in practice—daily life—how to obtain the Right to the City, what the barriers are against it, and how mobility problems contribute to that problem. Şengül (2015) phrased the perception of the concept in practice and its relationship with the problem of inclusion of all. Once the concept of the Right to the City is rephrased as the right to public space or the right to housing, or the right to access urban services to make it more concrete since the essence of the concept mostly remains abstract, those rights in question will inevitably be insufficient to bring together different segments and groups of people in the city. On the other hand, the Right to the City covers the entire group of individuals living in the city. It, as a right to reproduce urban space and self-actualization in the city, covers marginal groups, migrants, low-income people, and people who are not satisfied with urban daily life (Şen, 2012; Şengül, 2015). Therefore, it is necessary to be a right for all; however, society is not homogenous to obtain the right to mobility as well as the right to access any urban service. One of the most remarkable reasoning for the failure of allocation of the right to access through independent mobility is to be built clearly upon existing social exclusion.

Excluding a person or a group of people from a specific urban place, process or activity is to be expressed as a process in which the ones are prevented from participating in daily urban activities (Raje, 2007). Urban mobility is a significant part of this process of social exclusion. According to research by Mackett and Thoreau (2015), creating and sustaining barriers to accessibility is one of the main factors affecting urban daily life negatively that contributes to social exclusion through creating and accepting barriers against it. Those are the barriers preventing a part of society from reaching and experiencing urban space that put forth the fact that mobility-related social exclusion exists. In this manner, it is remarkable to mention that accessibility is a crucial indicator for people to be included in economic, social, and political life. Accessing social services and business networks in daily life is a prominent factor that makes the ‘urban’ belong to all as a right that needs to be ensured through sufficient mobility opportunities and alternatives for the whole society (Kenyon, Lyons, & Rafferty, 2002).

The discussion so far aims to investigate the question: to whom does this right belong? Is it for the ones who have a car, or for the people having the ability to walk-hear-see, or for the ones at an early age without any difficulty moving? People with disabilities (Edwards, 2001) and people having reduced ability of mobility have been exposed to stay as external social beings in the production of urban space and decision-making processes as a significant part of participatory policy making. Therefore, the right to mobility, as Soja (2010) noted, does not simply belong to all in practice; society varies by means of different factors disabling perception. The main goal is to form cities having inclusive urban mobility patterns for the production of space; that is, the co-production of space along with inclusive mobility systems as a collective right. Increasing accessibility opportunities for the whole society will enable the capability of people to reach all urban social activities and to the city itself as a right to avoid unequal conditions in urban transport, for primarily related to the disadvantaged group of people in society. We all have been living in a world of social exclusion caused partly by problems in urban accessibility that makes the right to access not for all but for the fortunate ones to have a chance to be mobile.

3. Accessibility: A Right for All

Considering the social aspect of the discussion regarding each link of the accessibility chain, an urban mobility system, expected to be free from any spatial and physical barriers, needs to be correspondingly free from social exclusion (Hawas, Hassan, & Abulibdeh, 2016). Mobility-led social exclusion is highly related to the participation of persons in social life as well as economic and political activities. Barriers to accessibility contribute to mobility-related social exclusion, even in cities with high mobility (Kenyon, Lyons, & Rafferty, 2002). Cities sometimes call themselves as serving high mobility, which means rapid transport between urban services by predominantly motorized vehicles. In this respect, it is necessary to take the term mobility into account along with pedestrian movement in urban public spaces, including the ones having reduced mobility. To prevent our minds from perceiving mobility as a mere and individual action of going from one place to another, accessibility of the urban environment and sustainable modes must be inclusively designed, which also contributes to experiencing the urban through independent mobility.

Accessibility is a concept to be considered as a chain with links that are composed of different segments of the trip. Each single trip-leg link of the chain needs to be inclusively accessible. The accessible mobility structure of this chain comprises the accessibility of sidewalks, crossings, stations/stops, information systems, and many other features that must be designed in an inclusive manner for persons with reduced mobility (Ling Suen & Mitchell, 2003). Therefore, accessibility is for all -for each segment of society, no matter how the income levels, physical condition, or level of social well-being of individuals vary. Accessibility is not only a theoretical right, but also a principle that needs to be implemented through practical means. The AMELIA software developed by Mackett et al. (2008), aims integrating social inclusion into transport planning requires tools that assess policy impacts on disadvantaged groups linking transport policies to measurable accessibility benchmarks and cost-effectiveness. It showed that small interventions, like adding benches, can significantly improve accessibility for the elderly, highlighting the value of evidence-based tools in guiding inclusive transport decisions. Such tools contribute to making urban areas more inclusive, especially for vulnerable groups such as the elderly, by measuring the impact of accessibility policies.

Accessibility is a right guaranteed by globally embraced rules and principles. There are many national and supra-national documents and studies related to the rights of people with disabilities and their well-being, which stands out as one of the fundamental human rights. An inclusive society is a crucial component that has the capacity to welcome the rights and well-being of people with disabilities. Therefore, there is a need for an effectively working inclusive society structure in which each individual is treated equally with an equal right to participate in economic, social, and political life. In this framework, accessibility of information, education, housing, the city, and other services is vitally significant, and the term accessibility significantly covers the group of people having special needs, which considerably includes people with disabilities (United Nations, 2013a). It is noteworthy to mention that accessibility is a prominent key factor for an inclusive society that put forth equality as one of the fundamental principles of human rights. The emphasis on an inclusive society that is highly related to accessibility is seen in The Millennium Development Goals Report (United Nations, 2005) as “the need for persons with disabilities to be guaranteed full enjoyment of their rights without discrimination.” In this respect, accessibility plays a critical role in the establishment of a society having an equal basis for all as a precondition to participating in daily urban life activities for persons with disabilities (United Nations, 2013b).

Accessibility and persons with reduced mobility are a right recognized by supranational documents and reports of international institutions such as the European Union, United Nations, World Bank, and World Health Organization. Along with countries' commitment, accessibility is accepted as one of the most significant components of human rights, which constitute the ontological base of the relationship between the Right to the City and independent mobility. To mention that a wide range of documents notes accessibility as a right directly or indirectly, Table 1 states the names, years, and the founder institution of the documents.

Table 1. Supranational Documents with Terms Noting Accessibility as a Right

The name of the document/report	Year	Related institution
European Convention on Human Rights	1953	Council of Europe
The World Programme of Action Concerning Disabled	1982	United Nations
The United Nations Standard Rules for the Equalization of Opportunities of Persons with Disabilities	1994	United Nations
World Health Organization (WHO) Mental Health Declaration for Europe	2005	World Health Organization
Council of Europe Action Plan to promote the rights and full participation of people with disabilities in society 2006-2015	2006	Council of Europe
United Nations Convention on the Rights of Persons with Disabilities	2006	United Nations
European Pact for Mental Health and Well-being	2008	European Union
European Disability Strategy (2010-2020)-A Renewed Commitment to a Barrier-Free Europe	2010	European Commission
2011 White Paper on Transport	2011	European Commission
The Charter of Fundamental Rights of the European Union	2012	European Commission
European Accessibility Act	2015	European Commission

Table 1 shows that accessibility is a universal right supported by international instruments. In this context, Fian and Hauger (2020) provide a comprehensive framework for inclusive mobility. Drawing on the principles of Universal Design, the UN Convention on the Rights of Persons with Disabilities, and the Sustainable Development Goals, Fian and Hauger (2020) propose a comprehensive conceptual framework for building inclusive mobility systems. Their model allocates mobility and accessibility requirements to four major sectors—government, private industry, academia, and civil society—reflecting a quadruple helix of shared responsibilities. Within this framework, eight inclusive components are identified, covering vehicles, built environments, digital trip management, personal assistance, organizational practices, regulatory standards, public awareness, and funding. These components demonstrate that inclusive mobility requires not only technological solutions but also coordinated social, institutional, and financial measures. Moreover, the authors emphasize that automation and digitization, if aligned with accessibility objectives, can significantly enhance equality and inclusion in future mobility systems (Fian & Hauger, 2020). This model emphasizes the importance of implementing accessibility policies through a multi-stakeholder approach. The table also demonstrates that the two concepts, accessibility and people with disabilities, are taken into account by the most prominent supranational institutions, meaning that accessibility along with one of the most fundamental rights -the Right to the City- is an interdependent concept to be perceived with one of the most disadvantaged groups of parts of the society -persons with reduced mobility. It means that not

only people with disabilities, low-income people, or only children are the subject of the discourse. Accessibility is a right for all as a matter for all persons with reduced mobility to experience in an independent manner.

4. Independent Mobility

Accessibility rights must be ensured for not a single trial of an accessibility chain but for the whole journey and for every single member of persons with reduced mobility. In this respect, there is a need for the right to access without being in need of help for any link of the chain. Thinking of a person with a wheelchair, getting out of home, reaching the bus stop, and getting the necessary information for the arrival of the bus without any help is a process to be called what theoretically accessibility is. However, once this person was in need of help to get on the bus due to the level difference between the pedestrian sidewalk and the bus door, the accessibility chain would have been broken due to a lack of independent mobility. Therefore, accessibility indispensably requires ensuring independent mobility.

As another example, a person decides to go to the theatre with a ticket in the front row. First, s/he checks the schedule of the bus to reach the theatre from the internet by herself/himself, then goes out and walks on the sidewalk, gets on the bus by herself/himself, enters the theatre building and the hall by walking down the stairs by herself/himself. This part of the trip represents the combination of links of a successful accessibility chain with an emphasis on managing every single link 'by herself/himself,' which means without seeking any help, and that means independent mobility. Independent mobility has been a significant complementary concept of the right to access since the beginning of the research. It means having the capability to access urban services without seeking any help from others. Therefore, everybody has the right to access that needs to be ensured with independent mobility. However, ensuring the right to access is not the only precondition. Spatially sustainable right to access and societally sustainable right to access are the two others -and related -components. Firstly, urban space, along with its public transport infrastructure, needs to be accessible, which represents spatial accessibility. If the right to access is not ensured by enabling spatially sustainable accessibility, the accessibility chain is frequently interrupted for PRMs, which results in frequent failures in urban trips. Therefore, PRMs become unwilling to go out in time, which means unsociability consequences emerge. Secondly, socially sustainable accessibility means achieving accessibility chains without facing socially unwilling consequences sourced by inaccessible urban space. Independent mobility is a critical factor in enabling social sustainability through accessibility.

For persons with reduced mobility, independent living and seamless participation in daily life are one of the ultimate aims to enable equality in terms of human rights sustainably. In this respect, accessibility is a significant factor to be ensured by local, governmental, and international policy-making authorities (United Nations, 2008). Under the umbrella of precisely defined rules, the independence dimension of mobility brings quite significant practical and psychological positive outcomes for persons with reduced mobility. In practice, reaching a bus stop or having a rest in a park without getting any help makes people reflect on their personal will to urban space by utilizing, affecting as well as changing it. In this way, there will not be any difference between any individual in social life, meaning that they will be able to live urban setting in practice. As a consequence, the self-determination of human psychology of any individual having mobility difficulty will be registered to urban social life successfully. As a more simplistic statement, practically, the ability of, i.e., stepping from the sidewalk to crossing by using an ideally designed ramp as any other able-bodied individuals do in their daily routine, and the positive self-

determination feeling gained by this action collaboratively composes the concept of independent mobility.

To prevent deprivation and isolation from social life for people with disabilities as one of the most vulnerable groups of persons with reduced mobility, they need to have their mobility right independently and efficiently in urban areas (Falkmer, Fulland, & Gregersen, 2001). In this sense, independent mobility is the core of the Right to the City and the right to mobility. Ahmad (2015) puts forth similarly that “once the right of independent mobility is ensured, the feeling of being handicapped and disabled could vanish, albeit the existing impairment.” Enabling independent mobility is not limited to physical infrastructure; technological innovations also play a critical role. For example, the Viana+Acessível app developed by Silva et al. (2023) draws upon a multi-objective optimization model, which is a mobile application designed to promote inclusive mobility in urban environments. Developed in response to increasing traffic congestion and a growing focus on urban sustainability, the system aims to enhance the physical and psychological well-being of citizens with temporary or permanent reduced mobility, including visually impaired individuals, wheelchair users, pregnant women, and the elderly. Unlike standard navigation software that typically offers the fastest route, this application evaluates four distinct criteria—path length, slope, accessibility, and duration—to provide safer and more accessible alternatives with minimal difference in travel time. This approach ensures a better user experience by prioritizing safety and ease of movement for the most vulnerable populations (Silva et al., 2023).. Such technologies support independent mobility, enabling PRMs to move around urban areas more safely and autonomously. Technological innovations play an important role in supporting independent mobility. Silva et al. (2023) discuss Viana+Acessível, while Matyas (2020) discusses how MaaS promotes behavioral change, which investigates how Mobility as a Service (MaaS) can facilitate behavioural change by promoting multimodal transport use and reducing reliance on private vehicles. Using in-depth interviews in London, the study highlights that users categorize transport modes offered via MaaS into ‘essential,’ ‘considered,’ and ‘excluded,’ with the greatest potential for behavioural change lying within the ‘considered’ modes. Key barriers to adoption include safety concerns, service characteristics, trust, administrative burdens, and strong attachment to personal vehicles. MaaS platforms can address these issues by offering integrated, user-friendly digital interfaces, centralising booking and payment, and enabling targeted interventions for different socio-demographic groups. Overall, the findings suggest that while MaaS alone may not overcome all individual barriers, it can raise awareness of alternative modes, simplify multimodal journeys, and indirectly encourage reductions in private vehicle use, provided supporting policies and infrastructure are in place.. Such platforms support independent mobility by increasing accessibility for PRMs.

The emphasis here on the self-feeling of being disabled or handicapped can be annihilated through independent mobility for all. In addition, in the Convention on the Rights of Persons with Disabilities (United Nations, 2012), there is an emphasis on independent mobility by ensuring accessibility for independent living, effective participation in society, and freedom to experience personal mobility without facing any barriers. In addition, accessibility has the capacity to contribute well-being of persons with reduced mobility and participation in the society that develops a sense of belonging, social and economic sustainability and elimination of poverty. Similarly, Olkin and Pledger (2003) state the significance of independence in daily life for persons with disabilities as that disability studies are highly related to the independent living approach by putting emphasis on increasing their self-determination enabling full access to social, educational, and political aspects of life.

Independent mobility is a matter of human rights. It is particularly for persons with disabilities as a citizenship right and a matter of equity in urban mobility for promoting disability rights in practice (Ahmad, 2015). In this respect, some of the core principles forming the core EU passenger rights are about independent mobility and about the significance of accessibility of persons with reduced mobility (European Commission, 2011), which are;

- right to non-discrimination for the accessibility of urban transport,
- right to mobility, including accessibility and assistance,
- right to full application and effective enforcement of EU law.

Urban transport passengers need to indispensably have accessible urban transport modes without any discrimination, and urban mobility needs to be considered a human right for all. It should be guaranteed by EU legal documents. In this sense, Çağlar (2012) notes that accessibility for people with disabilities is not only a means of exercising their rights but also a condition for living independently and fully participating in all areas of social life. For people with disabilities to lead an independent and dignified life, they must have equal access to the physical environment, transportation, information, and communication, including information and communication technology, and other public facilities and services, on an equal basis with other members of the society. In line with this statement, the fact that most human rights are to be used through participation in social, political, economic, and cultural life has led to the discussion that accessibility must be accepted as an independent right beyond being a prerequisite for participation.

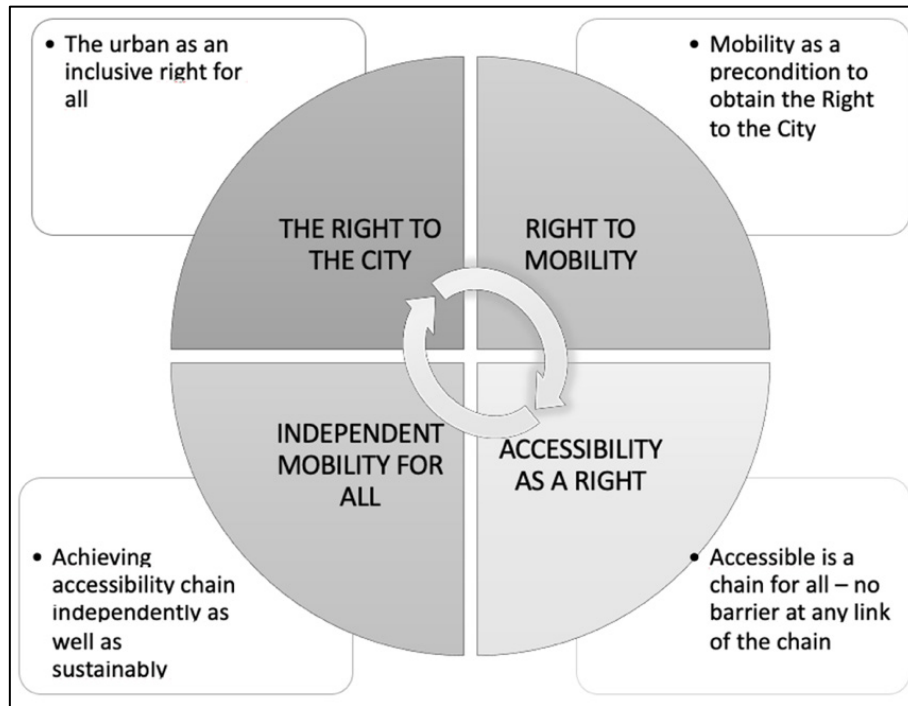
5. Conclusion

This study begins by arguing that accessibility is a human right for all and discusses the genesis of this claim. The theoretical framework is shaped around the ideas that cities should be seen as a right for all individuals, that cities are valued as a commodity and can be reclaimed through social movements. In this context, although accessibility is defined as the ease or difficulty of accessing an urban service, a rights-based approach questions the underlying causes that prevent access. For example, reaching a destination may be considered an "accessible" route, but in the case of inaccessibility, deeper reasons come into play, such as the lack of independent mobility, even though the main determining factor often seems to be urban space.

Accessibility is a matter for not only able-bodied persons and persons with disabilities but for anyone with mobility difficulty. To achieve this universal right -emphasized in universal design principles as "equitable use"- in a sustainable manner, the mobility practices need to enable independent mobility. Figure 1 illustrates the conceptual framework of this research, highlighting the sequential linkage of key concepts. The research is initially inspired by the notion of the Right to the City, which asserts that urban spaces should be accessible to all. Realizing this right requires the ability to move freely between activities and urban land uses. In this context, the city's accessibility determines who can fully utilize and benefit from urban settings, walking environments, and public transport facilities—elements that form the subcomponents of the so-called "accessibility chain" of urban mobility. This raises the question: whose right is this? Theoretically, it is the Right to the City for everyone, including persons with reduced mobility; yet, in practice, significant social inclusion challenges remain due to accessibility barriers. Accordingly, accessibility concerns not only able-bodied individuals or persons with disabilities, but any individual experiencing mobility difficulties. Achieving this universal right in a sustainable

manner—aligned with the universal design principle of “equitable use”—requires mobility practices that enable independent movement for all.

Figure 1. A Relational Representation of the Conceptual Research (Source: Author's Own Contribution)



Accessibility for persons with disabilities is a fundamental human right that ensures equal use of the city. This includes the urban physical environment (parks, squares, roads, buildings and entrances), urban mobility (walking facilities, public transport and stops), information and communication technologies and other publicly available services. In other words, the equal rights of persons with disabilities as part of society cannot be ignored, neither by an individual, nor by an institution, nor by the city itself. Therefore, urban space should enable equal mobility for all in all processes, such as home-to-destination transportation, information systems, walking, use of public transport, use of recreational spaces and returning home.

In a socially sustainable urban setting, the matters need to be human rights, accessibility, urban mobility, and participation. The point to be referred to here is that accessibility must be enabled through the independent achievement of mobility as a chain at any time and any place. For instance, using an urban bus system at a specific stop needs to enable a person with a wheelchair to arrive and get on the bus by himself/herself, which is independent mobility. In this respect, persons with reduced mobility must have the right to independent mobility, except for persons having the condition of being gravely disabled.

Accessibility must be regarded as a conjoint concept with the inclusiveness of urban space that highlights the social dimension of the discussion. It is an inclusive right and, unquestionably, must be guaranteed for all -for the entire society covering every individual of Persons with Reduced Mobility. As a consequence, inextricable cycles of inaccessibility prevent PRMs from having their right to access independently. Unless a right-based approach embedded in the right to access is adopted for accessibility policies, it could not be possible to live in cities where accessibility chains would be able to achieve without any barriers.

To ensure independent mobility, the right to access must be ensured along with spatially and societally sustainable urban mobility trips. Taking the fact that everybody is equal as given, then groups such as people with disabilities, elderly people, and parents with a baby stroller are expected to access any urban service independently. However, it is worth noting that helping as an ordinary habit in some cultures sometimes causes deprivation of a fundamental human right in urban mobility for PRMs. Therefore, the spatial and societal structure must provide independent mobility for all.

This paper argues that accessibility is a universal human right and that this right should be ensured for all through independent mobility. The question "Whose right to mobility?" reveals that mobility is not only the act of getting from one place to another, but also a fundamental tool for participation in social, economic and cultural life. Existing transportation planning often prioritizes motorized vehicles and excludes people using non-motorized transport such as bicycles or individuals with reduced mobility, deepening social inequalities. In particular, groups such as people with disabilities, the elderly, and parents with strollers have difficulty accessing urban areas due to physical, economic and psychological barriers, which limit their participation in education, employment and social activities. This shows that the right to mobility is not limited to urban areas, but needs to be addressed equitably in rural areas as well.

Ensuring independent mobility should be supported by innovative solutions. For example, mobile applications designed for people with reduced mobility can promote autonomous mobility in urban areas by providing safe and accessible routes. Similarly, multimodal transport platforms can integrate different transport options, reducing private car dependency, but such systems need to overcome barriers such as trust, safety and user-friendly interfaces. Furthermore, small-scale infrastructure interventions, such as adding benches in public spaces, can improve accessibility for groups such as the elderly. Inclusive mobility needs to be achieved not only through physical infrastructure, but also through an approach that requires the joint efforts of government, the private sector, academia and civil society. This multi-stakeholder model strengthens urban inclusion by bringing together the digital, institutional and social dimensions of accessibility.

Neoliberal policies leading to car dependency and fragmented urban planning undermine social cohesion and increase mobility inequalities. Inclusive transport should not only prevent social exclusion, but also offer a vision that strengthens social solidarity and promotes environmental sustainability. In this context, the right to mobility should be provided equitably for all, in line with universal design principles. In urban and rural contexts, inclusive transport policies, supported by technological and social innovation, can ensure that cities become accessible and livable spaces for all. This lays the foundation for a more equitable, sustainable and inclusive urban future for all of society, including people with reduced mobility.

In conclusion, the literature review shows that the concepts of right to the city, right to movement and right to accessibility have an important place in urban justice debates. While the right to the city has been discussed within the framework of collective ownership of urban spaces and participation in urbanization processes, the right to movement and the right to accessibility have mostly been discussed indirectly. Existing transport systems are observed to deepen social exclusion and inclusive transport practices are still limited; in particular, the independent mobility of people with reduced mobility has not been systematically integrated with these concepts. While the relationship between the three rights provides a strong theoretical foundation, concrete policies and field studies to ensure their full participation in urban life are lacking. This study addresses this gap by presenting an analytical approach that combines the rights to

accessibility and mobility within the framework of the right to the city and emphasizes the need for field-based research to develop inclusive transportation policies.

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Adequacy of the national building code (2006) in promoting Universal Design practices in Nigeria.

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Abstract: Universal design seeks to develop environments that are accessible to all users, fostering inclusivity and equal opportunity for everyone. Therefore, effective building regulations are essential to support and advance universal design in developing the built environment. This study examined accessibility provisions of Nigeria's National Building Code (2006), which is an extensive document that provides set standards for how buildings should be designed, constructed and maintained in Nigeria. The National Building Code was examined to identify gaps hindering inclusivity in the built environment, thereby determining their adequacy in promoting universal design practices, towards enabling individuals to participate in society without physical barriers. The study is a review article that employed qualitative research methods to gather, analyse, and present data. A systematic textual analysis was conducted using secondary sources, including the NBC (2006), the 7 Principles of Universal Design, and key accessible design standards. The data were grouped into themes, and the content was analysed. A descriptive approach and thematic categories were employed to explain the findings. To achieve its findings, the study used two objectives, it examined the existing accessibility provisions of the National Building Code in relations to the requirements of Universal Design Principles and used the provisions found to determine the adequacy of the Code in promoting universal design practices in the development of the built environment. The findings revealed that although the Code contained some relevant accessibility provisions, several of them were vague, lacked detailed specifications or dimensions needed to ensure inclusivity. The study submitted that in its current state, the National Building Code (2006) operational in Nigeria is inadequate in promoting the ideals of universal design. The study recommends a detailed systematic revision of the code to address the identified shortcomings relating to accessibility.

Keywords: Universal Design, Accessibility, Usability, National Building Code, Physically Challenged, People with Disabilities, Nigeria.

1. Introduction

Studies show that an estimated 1.3 billion people are living with a significant disability, which is about 16% of the world's population, or 1 in 6 people (World Health Organization, 2025). An environment can have a significant impact on a person's experience and extent of disability. An inaccessible environment can create a sense of disability simply by creating obstacles to participation and inclusion (WHO Team, 2011). Inaccessible environments can stand as a

hindrance to the inclusion of people living with disabilities economically and in a social context (Izobo-Martins and Azoom, 2019).

Historically, efforts have been made to improve the built environment for users of all abilities through inclusive design guides and concepts (Olodeoku M. A., 2024). Designing for all addresses inaccessibility by creating inclusive, usable spaces for diverse users (Sharma, 2025), with universal design emerging as a widely adopted approach.

The term “universal design” was coined in the United States by Ron Mace, who was an architect who focused on the design of accessible housing. Mace’s approach to UD made way for accessible building codes, standards and guidelines present in the US. His philosophy stems from the approach of designing an inclusive environment that favours all kinds of people (Centre for Excellence in Universal Design, 2025). The introduction of UD into architecture has transcended barriers and boundaries by adopting a more human-focused perspective. UD has helped to prioritize accessibility and inclusivity in the design process, thereby eliminating barriers and promoting equal opportunities amongst users while fostering social interactions. (UGREEN, 2025).

Disability laws and acts are means through which countries prohibit discrimination against people with disabilities (PWDs) to eliminate barriers, promote inclusion in society and educate these people about their rights to equality (United Nations, 2025). Thus, many countries have enacted regulations and building codes to promote equal opportunities for every individual in society. Some of these regulations include the Americans with Disability Act of 1990 which was amended and revised in 2010 used in the United States; The Equality Act (2010), used in United Kingdom; Services and Supports to Promote the Social Inclusion of Persons with Developmental Disabilities Act (2008), passed into law in Canada; Law of the People’s Republic of China on the Protection of Persons with Disabilities, used in China; Persons with Disabilities Act (2016), in operation in India; Basic Act of Persons with Disabilities (2011), of Japan; Persons with Disability Act (2006) [Act 715], used in Ghana; Code of Good Practice: Key Aspects on the Employment of People with Disabilities (2002), operational in South Africa; and The Discrimination Against Persons with Disabilities [Prohibition] Act (2019), adopted in Nigeria (United Nations, 2025). In countries where disability laws have been enacted, it is illegal to discriminate, segregate or mock anyone on the premise of disability. Such countries must take appropriate measures to ensure that they modify or remove existing laws that may constitute discrimination. There is also a need to create policies that will protect and promote the rights of persons with disabilities (United Nations, 2025).

Nigeria's 2019 Discrimination Against Persons with Disabilities Act mandates accessibility in public buildings, with penalties for non-compliance and a 5-year grace period for retrofitting (Ewang, 2025). While the law supports inclusion, it remains unclear if development laws like the NBC adequately promote UD, as empirical research on this is limited (Sholanke et al., 2019).

Empirical studies continue to reveal that PWDs are widely marginalized in the development of the built environment in Nigeria due to lack of adequate provisions made to accommodate their needs. Such studies include: (Sholanke et al., 2019; Izobo-Martins and Azoom, 2019; Agada, Guobadia and Ojo, 2024; Adewale, Jegede and Sogbetun, 2022; (Maduagwu and Saidu, 2018). In addressing this issue, the starting point would be to critically assess the adequacy of development regulations in promoting social inclusion in Nigeria.

Against this backdrop, the study examined accessibility provisions in Nigeria’s NBC (2006) to identify gaps that may hinder inclusivity and assess their adequacy in promoting Universal Design.

It was guided by two objectives: to review the code's accessibility provisions and evaluate their effectiveness in supporting UD practices.

The study investigation was limited to accessibility provisions of general spaces, including accessible toilets. The study examined 12 key accessibility features of the general spaces commonly used by all individuals while making use of public buildings and environments were investigated. The general spaces refers to spaces commonly used by the occupants or users of the facilities. The features include parking, exterior walkways, handrails, stairs, ramps, floor surfaces, entrances, doors, corridors, elevators, escalators, and signage. The Nigeria's NBC that was examined is a document established in 2006 containing laws, guidelines and regulations establishing the minimum standard for the design, construction and maintenance of buildings in Nigeria (National Building Code, 2006).

By examining the accessibility provisions found in the NBC relating to UD principles and then determining if those provisions were adequate in the promotion of UD practices in the built environment, the study was able to highlight areas in Nigeria's NBC (2006) that support inclusivity, identify key gaps, and offer recommendations for improvement. These key gaps in the NBC were the accessibility provisions being vague and a lack of detailed specifications and required dimensions. The study raises awareness among built environment professionals on integrating UD from the design stage and supports advocacy by disability rights groups. The paper contributes to global and local UD knowledge, offers a basis for future research, and aligns with SDG 11, which promotes safe, inclusive, and sustainable cities.

2. Literature Review

2.1. Overview of Universal Design

In the early 1950s, the concepts of accessible design started as a response to a large number of soldiers who returned home from World War II with disabling injuries. The evolving of the accessible design concepts was a driving factor in the introduction of equal rights and anti-discrimination legislation established by the government (Centre for Excellence in Universal Design, 2025). By 1968, the US Congress passed the Architectural Barriers Acts (ABA), which required that public buildings designed, built and altered for the government must be accessible for people with disability (U.S. General Services Administration, 2025). In San Diego, the Congress passed the Rehabilitation Acts of 1973, which prohibits discrimination against PWDs (City of San Diego, 2025).

By 1974, Ron Mace facilitated the movement for a barrier-free environment. Mace was an American architect who coined the term "universal design" in 1985. He advocated for a built environment that was aesthetically pleasing yet usable to a diverse range of people (The UD Project, 2025). Ron Mace had contracted polio as a child and was wheelchair-bound. His personal experiences were a driving force for the accessible building codes and standards in the United States (UGREEN, 2025). His first accessible building code was adopted by North Carolina in 1973. His work later set a guideline for the Fair Housing Amendments Act of 1988 and the Americans with Disabilities Act of 1990. By 1989, Ron Mace had created the Centre for Universal Design in North Carolina, formerly the Centre for Accessible Housing (The New York Time, 2025).

The US Congress passed the Americans with Disabilities Act of 1990 (ADA), which prohibited discrimination and established accessibility requirements for the design, construction and alterations of public buildings (U.S. General Services Administration, 2025). By 1997, the "Principles of Universal Design" were developed at the Centre for Universal Design (Rocky

Mountain ADA Center, 2025). By 2010, the Department of Justice amended the Americans with Disabilities Act of 1990 (ADA) and published the most recent ADA Standards for Accessible Design, which were based on the ADA guidelines (U.S. Department of Justice, 2025)

Universal Design has evolved to emphasize inclusivity and adaptability, prompting global adoption of accessibility policies and smart, barrier-free environments (HEWI, 2025). Innovations like automated doors, sensors, voice controls, and IoT-enabled devices have enhanced responsive design. Features such as adaptive lighting and fall detection systems further support diverse user needs. As technology advances, architects must redefine accessibility to meet evolving standards (Team Kaarwan, 2025)

As a result of the momentous movement of UD, the “7 Principles of Universal Design” were developed in 1997 by Ron Mace in North Carolina State University. These principles were created as guidelines for the design of the built environment, products, learning and communication. The principles can serve as a guide for designers and consumers in the design stage of their environment and products. They can also be used to evaluate and assess existing designs in a bid to make them more usable (Centre for Excellence in Universal Design, 2025; NC State University, 2025; Building and Construction Authority, 2025; UGREEN, 2025; University at Buffalo, 2025). The principles and their guidelines are examined as follows:

The First principle - Equitable Use: For a design to be of great value, there must be equal use opportunities for all users. The design must avoid segregation or stigmatization of any users. Provisions of privacy, security and safety should be equally available to all users. The design must also be equally appealing to all users.

The Second Principle - Flexibility in Use: A design must be able to cater for a diverse set of people, their individual preferences and abilities. For this to be achieved, there must be a variety in the way people can use a design. The design should allow for right or left-handed users to have equal access. It should be adaptable to the user’s pace while making it easier for users to be precise and accurate in using it.

The Third Principle - Simple and Intuitive Use: The design must be easy to understand despite the user’s background, proficiency in language, literacy or level of focus at the given moment. The design must be void of unnecessary complexity, it must provide a means for effective prompting and feedback during and after use while meeting the users’ expectations and intuitions.

The Fourth Principle - Perceptible Information: The design needs to successfully convey adequate information to the user regardless of the environment or the user’s sensory capabilities. The use of different modes of presenting essential information, such as pictorial, verbal or tactile formats. The design can be made compatible with different techniques and devices used by users who have sensory limitations.

The Fifth Principle - Tolerance for Error: The design should mitigate risks and negative consequences of inadvertent actions. It should provide fail-safe features, warnings and alerts for errors. An example of such is the undo feature in computer software that allows users to undo and correct their mistakes without consequences.

The Sixth Principle - Low Physical Effort: Designs that can be used easily and effectively with little to no strain are encouraged. The designs should be used with minimal operating force, minimal physical effort, and minimal repetition of actions while allowing the user to maintain a neutral body position, just like the touch sensors on faucets, lamps and switches.

The Seventh Principle - Size and Space for Approach and Use: Irrespective of the size of the user, their posture or mobility, adequate size should be provided for approach, reach and manipulation. To achieve this, there must be a clear line of sight for both seated and standing users. Important elements should be within reach for both seated and standing users. The design should be able to accommodate the varying hand and grip sizes of users, and there should be provisions for sufficient space for assistive devices and personal assistance.

Achieving Universal Design requires understanding the diverse abilities of all user groups. (Building and Construction Authority, 2025) developed guidelines to help designers address the needs of users such as infants, expectant mothers, the elderly, wheelchair users, individuals with mobility, visual, or hearing impairments.

2.2. Overview of Building Code Requirements

Building codes are a set of regulations put in place to specify the minimum requirements for various aspects of the building, which include architectural, structural, plumbing, heating, ventilation and air conditioning (HVAC) systems and accessibility (NIST, 2025). These codes are enacted by the various tiers of government and are established to regulate the design, construction, renovation, repair and maintenance of buildings (Grimsley, 2025). These codes try to mitigate poor designs, structural failure and the use of unregulated materials (Max Migold, 2025). By having codes in place, quality and safety are ensured while promoting Universal Design by mandating an inclusive and barrier-free environment (Perlo Construction, 2025). The goal is to protect the users and occupants of the building, support sustainability and uphold the standards of the building industry (The Builders Association, 2025). The NBC was developed in November 2005 and formally published in August 2006 after deliberations dating back to 1987 when the defunct National Council of Works and Housing requested for it

The NBC is Nigeria's regulatory framework for the design, construction and maintenance of structures, the NBC also covers fire safety, energy efficiency, structural integrity and accessibility. It was created to address poor construction practices and the frequency of building collapses (NHM Staff, 2025).

In evaluating the adequacy of the NBC of Nigeria in promoting Universal design practices, it is essential to compare its relevant provisions with international standards that effectively support inclusivity and usability for all individuals in the built environment. This study identified the building codes of the USA and Singapore as appropriate references and analyses their accessibility provisions. Specifically, it examines the 2010 ADA Standards for Accessible Design issued by the United States Department of Justice (U.S. Department of Justice, 2025) and the 2016 Universal Design Guide for Public Places by Singapore's Building and Construction Authority (BCA) (Building and Construction Authority, 2025). These globally acknowledged standards were employed as benchmarks for evaluating how regulatory frameworks can promote inclusivity in the built environment and guide policy review efforts within the Nigerian context. The accessibility provisions of both building codes are examined as follows:

2.2.1. Accessible Car Park

The BCA (2016) and ADA (2010) recommend that parking spaces should have minimum width of 2440 mm with a provision of an access aisle of 1525 mm minimum. The floor surface should be stable, firm and non-slip. This is in line with the first principle of UD which stipulates that the design should allow for equitable usage for all users.

2.2.2. Accessible Routes, Corridors and Paths

Accessible routes are recommended by the BCA (2016) to be at least a minimum of 1800 mm, this allows for two wheelchairs to pass side by side or for a baby stroller to pass by. The route should also have a waiting area or passing space at every 50 m where users can rest and take a break. The ADA (2010) recommends a minimum of 1525 mm clear width with a passing space at every 61 m. Based on these recommendations, an accessible route should be between 1525 mm to 1800 mm with a passing space of between 50 m to 61 m. The BCA (2016) mandates that access routes should have no protrusions or projections, but ADA (2010) made an allowance of 100 mm for protrusions or projections except for handrails, which can be 115 mm maximum. These guidelines align with the first and seventh principles of UD, which emphasize equitable use and adequate space for approach, reach and manipulation, respectively. Therefore, for a route to be deemed accessible, it needs to be usable and appropriately sized to accommodate all users.

2.2.3. Floor Surfaces

The BCA (2016) and ADA (2010) specify that floor surfaces should be firm, levelled, durable and non-slip without any sudden drop in levels or holes. Floor surfaces are also expected to be non-slip in any condition, either wet or dry. The BCA (2016) specifies that floor surfaces should be completely level, but ADA (2010) provides an allowance of 6.4 mm as the maximum height difference where changes in level are needed. Any change in level greater than 13 mm should be linked with a ramp. Floor surfaces are expected to align with the safety requirement of the UD principles and conform with the sixth principle of UD, which recommends a stress-free usage while maintaining a neutral body position.

2.2.4. Entrances

According to both the BCA (2016) and ADA (2010), all entrances should be levelled and free from any change in level. The BCA (2016) mandates that doors should be automated to help with ease of access for users and should provide a manoeuvring space of 1500 mm by 1500 mm with a 600 mm clearance adjacent to the door for pull doors to allow easy access for wheelchair users in conformity with the first principle of UD that requires equal opportunity use for everyone. But for push doors, the code stipulates a manoeuvring space of 1200 mm by 1200 mm with a 300 mm clearance. Entrances are required to be visible from the exterior and interior and should be provided with signage, directories and tactile indicators. All glass doors should be marked with visible motifs to avoid collisions. ADA (2010) stipulates that at least 60% of all public entrances should be accessible. This allows for equal access opportunity for mobility impaired users alongside abled bodied individuals.

2.2.5. Doors

The minimum effective width for doors as recommended by the BCA (2016) is a minimum of 850mm, while the ADA (2010) stipulates 815 mm as a minimum. This suggests that the minimum effective width of doors should be within 815 mm to 850 mm, which in turn aligns with the first principle of UD This principle promotes accessibility and usability for all users.

2.2.6. Ramps

A gentle gradient of 1:20 to 1:15 is preferred for ramps by the BCA (2016) to avoid users finding it difficult to navigate and manage their balance. Whereas the ADA (2010) stipulates a maximum gradient of 1:12, with 1:10 being the worst possible situation where space limitation exist. To accommodate a wide range of users, the range of the gradient should be between 1:20 and 1:12. This aligns with the first principle of UD, which provides for equal opportunity for all users. Also,

the low ramp gradient makes descending and climbing it convenient for most people, as well as enable the use of minimal physical effort in alignment with the sixth principle of UD.

2.2.7. Elevators

According to the BCA (2016), the preferred size of an elevator car should be 1200 mm width by 1400mm depth. This is large enough to accommodate wheelchair users, older persons with bulky mobility aids or families with children in baby carriages. On the other hand, ADA (2010) specifies that the width of an elevator car should measure at least 915 mm, while the depth should be minimum of 1370 mm, in addition to adhering to the A17.1 safety code. This is to accommodate all users in line with the first principle of UD that entails that a design should make provision for equal use opportunity for all users. ADA 2010 specifies that the lift car control buttons should be 1015 mm minimum height from the finish floor level, whereas BCA (2016) recommends between 900 mm to 1200 mm for easy access for wheelchair users. Both the ADA (2010) and BCA (2016) require that control dimensions, braille, audio and emergency backup systems should be provided. This provides equal usage opportunity for a wider range of people.

2.2.8. Escalators

The ADA (2010) recommends that escalators should align with the ASME A17.1 safety code and have a minimum clear width of 815 mm. The BCA (2016) mandates that escalators should have a clear width of between 580 mm to 1100 mm, depending on the traffic volume. Moving railings at a height of 900 mm must be provided on both sides of an escalator. Escalator steps should not be more than 210 mm to 240 mm, and three flat steps must be provided at the start and end of escalators. Signage, tactile and visual cues must be provided to indicate headroom warning and directions to align with the first principle of UD which mandates equal use opportunities for everyone.

2.2.9. Stairs

According to the ADA (2010), risers dimension should be between 100 mm and 180 mm, while treads should be 280 mm minimum. Open risers are not permitted, and the maximum projection for stair nosing should be 38 mm. But the BCA (2016) stipulates that a riser should measure 150 mm maximum, while treads should be 300 mm minimum for public buildings. For residential buildings, treads are required to be 275 mm maximum and 165 mm minimum. Open risers are not permitted, and the stair nosing projection should be between 50 mm to 65 mm. These design requirements help ensure minimal operating force, ease of use, and clear communication of information to all users, aligning with the sixth, third, and fourth principles of UD, respectively.

2.2.10. Handrails

The ADA (2010) stipulates that the maximum distance between the top of the handrail to the bottom of the finished floor should be between 865 mm and 965 mm. Handrails should be provided on both sides of stairs and ramps. The regulation also specifies lower railings measuring 710 mm from the finished surface, with a clear space of 230 mm minimum between the railings. BCA (2016) recommends that the height of the handrails should be from 800 mm to 900 mm, and the lower railings should be 600 mm to 750 mm in height from the finished floor level. This helps to accommodate children, persons with short stature, as well as conforms with the first and seventh principle of UD that require equal use opportunities for everyone and for important elements to be equally reached for everyone either in seated or standing positions, respectively.

2.2.11. Signage

Signs should provide direct and clear information, and should have tactile characters, visual cues, braille, pictograms and the symbols of accessibility. Signage must be provided in accessible parking spaces and must be uniform and visible. Signage in elevators must have the international symbol of accessibility, the text telephone symbol (TTY), braille and the volume control telephone symbol as recommended by ADA 2010. BCA 2016 recommends that signage showing the building directory in text, braille and map must be provided and be visible upon entry. These signs must be clear, concise and readable from a distance. They must have good contrast between characters and background and be multilingual. They must be placed at key points such as emergency exits, around elevators, escalators and toilets. Both BCA 2016 and ADA 2010 recommend that signage must show a direct message which aligns with the third and fourth principles of universal design, which are simple and intuitive use and perceptible information, respectively.

2.2.12. Toilets

According to the ADA (2010), the centreline to a wall should be at least 405 mm to 485 mm to the sides of the wall for an accessible toilet compartment, while BCA (2016) stipulates 350 mm to 400 mm to the sides of the space. A clear space of 1420 mm (length) and 1525 mm (width) is required by the ADA (2010) as the minimum size of an accessible toilet. The BCA (2016) recommends a clear internal dimension of at least 1750 mm by 1500 mm which is suitable for all user groups, including PWDs.

The BCA (2016) recommends that grab bars should be provided on both sides of a water closet (WC) in toilet. Urinals are expected to have a clear floor space of 750 mm in width and should be wall-hung with low-lip. The rim should not be higher than 400 mm from the finished floor level. The ADA (2010) recommends that urinals are wall-hung, positioned at 430 mm from the finished floor level and 345 mm deep. ADA (2010) indicates that WCs should be mounted at 430 mm to 485 mm from the finished floor, while BCA (2016) specified between 250 mm to 350 mm for children, but nothing explicitly specified for adults. ADA (2010) recommends 865 mm as the maximum height from the finished floor to the counter surface, while BCA (2016) specified a height of 550mm for children.

Additionally, grab bars are recommended to be installed at a horizontal position of 840 mm to 915 mm. But if the grab bars are to be installed for children's use, ADA (2010) recommends 455 mm to 685 mm. The BCA (2016) mandates that grab bars should be placed at 800 mm, which should make usage easier for wheelchair users and ambulant physically challenged users in line with the first principle of UD which requires equal use opportunities for all user groups.

3. Methodology

This study centred on examining the Nigeria's NBC (2006) to ascertain whether the accessibility provisions of the current code effectively support the promotion of universal design practices. As a review paper, it utilizes qualitative research methods to carry out the investigation. The data utilized for the research were gathered mainly from secondary sources including, Nigeria's NBC (2006) and the globally acknowledged seven principles of universal design. Supportive data were also obtained from development regulations of advanced countries that had integrated accessible standards in their building codes. Such sources include accessible standards published in the 2010 ADA Standards for Accessible Design by the Department of Justice of the United States and the Universal Design Guide for Public places by the Building and Construction Authority of

Singapore (2016). The relevant provisions of these documents along with the seven principles of UD were the principal assessment framework for the study.

To evaluate the adequacy of the NBC (2006) in encouraging UD practices, its accessibility provisions of general spaces were compared with the international accessibility standards to determine their adequacy. The assessment was carried out on accessibility provisions made for general spaces that are commonly used by the occupants or users of the facilities, including lobbies and accessible toilets. The study itemized the 12 key accessibility features in the 7th paragraph of the introduction were critically assessed.

Textual analysis was employed to extract data revealing UD-related provisions in the NBC (2006), to evaluate their sufficiency in promoting UD practices. The extracted data were coded, organized into themes, and subjected to content analysis. The findings were then thematically categorized with clarity and presented descriptively to enhance understanding.

4. Results and Discussion

This study was conducted to ascertain the adequacy of Nigeria's NBC (2006) in promoting UD practices towards ensuring that everyone can participate fully in society without encountering design solutions that constitute physical barriers or obstacles. To accomplish the aim, two specific objectives were established, as outlined in the seventh paragraph of the introduction. The findings are presented in alignment with the objectives in the following sections.

4.1. Accessibility Provisions of Nigeria's National Building Code (2006)

The first objective of this study is to examine the accessibility provisions of the Nigeria's NBC (2006) in relation to the requirements of UD principles. The features investigated are car parks, exterior walkways, handrails, ramps, stairs, floor surfaces, entrances, doors, corridors, elevators, escalators, signage and toilets. The findings are outlined in the subsequent sections.

4.1.1. Car Parks

All parking materials are expected to be non-combustible to prevent fire hazards. Parking spaces are specified to have at least 20% of the exterior walls open to bring in natural ventilation, and if enclosed, mechanical ventilation must be provided. In a multi-tier parking lot, a minimum height clearance of 2.1m is required. Each tier must have at least two exit stairways for emergencies and safe evacuation. Guardrails are mandated to be installed on all open edges in the parking decks unless there is a loading deck.

4.1.2. Exterior Walkways

The minimum width stated for all walkways is 1100 mm to accommodate pedestrian movement, including wheelchair users. The maximum stretches the walkway is allowed to span is 91.4 m to the nearest exit. But if there is a sprinkler system available along the walkway, it can extend to 122 m. The walkways are required to be constructed from non-combustible materials unless in the case of low-risk buildings. Walkways serving as emergency exits are required to lead to public areas entirely void of obstructions, protrusions and obstacles.

4.1.3. Handrails

Handrails are stipulated to be between 864 mm and 965 mm from the finished floor level or up to 1067 mm if they are part of a protective guard. To avoid obstruction, handrails are not allowed to project more than 89 mm beyond a ramp or stair width. For additional support, handrails are

required to extend beyond the last stair tread or ramp edge. The handrail's cross-section is specified to be 67 mm maximum for a comfortable and firm grasp.

4.1.4. Stairs

The minimum width for exit stairway is required not to be less than 914 mm. Riser heights are to be between 100 mm to 180 mm, while the minimum allowable tread depth is 280 mm. Stairways are to have continuous guards and handrails on both sides. Stairways that are more than 2235 mm in width are required to have an intermediate handrail in between. Each division should not be less than 1118 mm. Minimum headroom clearance of 2100 mm is allowable to accommodate all users. Treads and risers are mandated to be consistent throughout the building with a maximum tolerance of 10 mm. Materials used in the construction of the stairs are required to be consistent with the main building structure. All staircases are to lead to open spaces with direct access to exits in the event of emergencies.

4.1.5. Ramps

Ramps are expected to be at least the width of the corridors they are connected to. The maximum gradient of a ramp is specified to be 1:12 unless a shorter ramp below 150 mm is necessary. A landing is required to be provided at all ramps turns and at doorways for users to rest, including wheelchair users. The landings are required to have a flat surface. The minimum headroom clearance of 2100 mm is allowable to accommodate all users.

4.1.6. Floor Surfaces

Toilet floor surfaces are required to be smooth, hard, non-slip and non-absorbent and must extend at least 127 mm up the wall for splash protection; similar for the shower walls. They are expected to extend at a height of at least 1.8 m.

4.1.7. Entrances and Doors

There should be at least 813 mm clear width for door openings. The entrance doors are also to comply with the required width, in addition to being unobstructed and opened in the direction of high-traffic areas. Thresholds should be bevelled or low enough to allow wheelchair access. In public and institutional buildings, automated doors or wide double-leaf doors are recommended.

4.1.8. Corridors

Corridors are stipulated be wide enough to allow simultaneous movement of users in two different directions. Their minimum width is specified to be 1100 mm or the same as the width of the ramp connected to it.

4.1.9. Elevators

Elevators are required to comply with international codes such as the ASME A17.1 safety code. Elevators are mandated to have braille signage, auditory floor indicators, emergency power backup and sufficient manoeuvring space for wheelchairs.

4.1.10. Escalators

Escalators are also expected to comply with international codes like the ASME A17.1 safety code and must not be the main means of emergency exit. Escalators must have emergency stop buttons, non-slip steps, non-slip handrails and visual contrast strips on step edges.

4.1.11. Signage

Signage is required to display its use, occupancy classification, fire grading, floor load limits, and installer or owner's information. Signage is required to be available in braille, pictograms and high contrast in toilets, elevators and egresses. Signage is also required to follow zoning and permit requirements.

4.1.12. Toilets

Toilet stalls are required to have a clearance space of at least 762 mm side space and 600 mm in front of fixtures. These stalls must be able to accommodate the manoeuvring of wheelchairs. All accessories must be sealed to the walls to prevent water damage and mole. Toilets are required to be provided on every floor of public buildings and must be accessible to physically challenged users.

4.2. Adequacy Level of Accessibility Provisions of Nigeria's National Building Code (2006) in Promoting Universal Design Practices

This second objective was to determine how adequate are the relevant provisions of the NBC (2006) in promoting UD practices in the development of the built environment. To achieve this, accessibility provisions of the NBC were compared with established and widely recognised standards including BCA (2016), ADA (2010) and UD principles. The outcome of the comparative analysis revealed notable limitations in several areas. The result of the analysis is presented in the subsequent sections.

4.2.1. Car Parks

The NBC recommends that accessible parking should be provided to accommodate PWDs but gave no specifications on the dimensions as recommended by the ADA (2010) and BCA (2016). These codes specify 2440 mm width for parking lots and an accessible aisle of 1525 mm wide in-between car parks. The absence of specific details, such as car park dimensions, may result in poorly designed parking spaces that do not accommodate all user groups, thereby conflicting with the first principles of UD that stipulates "equal opportunity use" and the seventh principle that mandates "adequate size and space for approach and use."

In the light of the evaluation, the provisions made in the NBC largely fail to meet standard and accessible parking requirements, hence adjudged largely inadequate in promoting UD practices.

4.2.2. Exterior walkways

The NBC specifies that the width of pedestrian walkways should not be less than 1100 mm, and the maximum length should be 91.4 m. This is less than the recommended width of between 1525 mm to 1800 mm, with a passing space at 50 m to 61 m intervals, stipulated by BCA (2016) and the ADA (2010) standards. A walkway width of 1100 mm is barely adequate for a wheelchair user but not sufficient for two wheelchair users to pass side by side. This is inconsistent with the first UD principle guideline that promotes "equitable opportunity uses" and the seventh principle that advocates for "adequate size and space for approach and use."

In addition, there is no mention of passing spaces or resting areas where users can stay to rest after a long stretch of travel on a lengthy walkway in the NBC guidelines. The maximum length recommended by the NBC is 50% more than what was recommended by BCA (2016) and ADA (2010). Walking on a lengthy walkway without provisions for resting areas at suitable intervals could be tiring for certain categories of people, including the aged, pregnant women and

individuals with heart conditions. This violates the sixth principle of UD, which emphasizes "low physical effort."

Based on the evaluation, the external walkway guidelines of the NBC are considered largely inadequate for supporting the practice of UD.

4.2.3. Handrails

The NBC recommends that handrail heights should be between 864 mm to 965 mm from the finished floor level, which is reasonably within the range of 800 mm to 900 mm recommended by ADA (2010) and 865 mm to 965 mm recommended by BCA (2016). This allows for the reach and protection of users of different heights including the physically challenged such as wheelchair users. However, no mention was made of the height or provision of a lower handrail for children or people with short stature in alignment with accessible design standards. ADA (2010) recommends a lower handrail of 710 mm height from the finished surface, with a minimum clear space of 230 mm between the two handrails. Whereas the BCA (2016) stipulates that the height of the lower handrail should be 600 mm to 750 mm from the finished floor level. Not making provisions for a lower handrail in the NBC violates the first principle of UD which advocates for "equal use opportunities" and the seventh principle which emphasizes "accommodating the varying hand and grip sizes of users."

According to the evaluation, the NBC handrail provisions are to a large extent judged inadequate for encouraging UD practices.

4.2.4. Stairs

The NBC specifies that step risers should be between 100 mm to 180 mm and have a minimum tread depth of 280 mm. This aligns with the dimensions of the riser and tread recommended by ADA (2010) and within the range of the dimensions specified by BCA (2016) which stipulates the height of risers to be between 150 mm to 165 mm and the depth of threads to be between 275 mm to 300 mm. These dimensions make climbing and descending stairs not only convenient for most people but also enable the use of "minimal physical effort," aligning with the sixth principle of UD.

In light of the analysis, the stairs guidelines in the NBC are considered reasonably adequate towards promoting UD practices.

4.2.5. Ramps

The maximum gradient of a ramp stipulated by the NBC is 1:12 with an expectation of a shorter ramp. This conforms with 1:20 specified by ADA 2010. BCA 2016 recommends a gradient of 1:20 to 1:15. Just like the stairs, the gradient specified for ramps make descending and climbing it not only convenient for most people but enable the use of "minimal physical effort" in alignment with the sixth principle of UD. The low gradient ensures usability for a wider range of users, in alignment with the first principle of UD, which advocates for "equal opportunity for all users."

Based on the evaluation, the provisions made for ramp in the NBC are adjudged adequate enough to support UD practices.

4.2.6. Floor Surfaces

The NBC recommends that floor surfaces are levelled, non-slip and non-absorbent. This conforms with the recommendations of the BCA (2016) and ADA (2010), in alignment with the safety requirement of the principles of UD, particularly the sixth principle which emphasizes a "stress-free usage while maintaining a neutral body position."

In the light of the analysis the floor surface provisions stipulated in the NBC meets standard requirements, hence adjudged reasonably adequate for promoting UD practices.

4.2.7. Doors

The minimum door width specified by the NBC is 813 mm. This is slightly lower than 815 mm specified by the ADA (2010) and 850 mm recommended by BCA (2016). Nevertheless, the difference is marginal and insignificant. The door size is adequate to accommodate a wide range of users, including people on wheelchair, aligning with UD first principle that promotes “equal opportunities use” for everyone.

The evaluation indicates that the door guidelines of the NBC are reasonably adequate for supporting UD practices.

4.2.8. Corridors

The NBC recommends that corridors should have a minimum width of 1100 mm, which falls short of the 1525mm recommended by ADA (2010) and 1800 mm mandated by BCA (2016) which is suitable for two wheelchair users to pass side by side or a baby stroller to pass by. A minimum of 1100 mm allows just a wheelchair user to pass at a time, hence not adequate towards aligning with the requirement of the seventh principle of UD that emphasizes the need for “adequate size and space to approach and use” a facility comfortably.

The analysis points that the existing corridor provisions within the NBC are largely inadequate for supporting UD practices.

4.2.9. Elevators

There are no specific dimensions in the NBC for elevators, except that they should adhere to the ASME A17.1 safety code for such devices. However, the NBC specifies that provisions should be made for braille signage, auditory floor indicators, emergency power backup and sufficient manoeuvring space for wheelchairs. This is in alignment with the requirements of both the BCA (2016) and ADA (2010).

In addition to specifying that elevators should align with the ASME A17.1 safety code, the BCA (2016) recommends that the minimum width of elevator should be 1200 mm while the depth should not be less than 1400 mm. The ADA (2010) stipulates a minimum width and depth of 915 mm and 1370 mm, respectively. These extra specifications help to ensure a universally accessible built environment through accommodating a broader range of user needs, to enhance, safety, comfort, and independence for everyone, including PWDs in alignment with the requirements of the UD principles, particularly the first and seventh principles that advocate for designs to provide “equal opportunity use” and “adequate size and space for approach and use,” respectively.

Given the analysis, the NBC guidelines for elevators are viewed as fairly adequate for promoting universal design practices due to the minor shortcomings that calls for improvements.

4.2.10. Escalators

Again, just like the elevator, the NBC clearly specifies that escalators should adhere to the ASME A17.1 safety code for escalators, in conformity with the recommendations of both the BCA (2016) and ADA (2010). However, other requirements specified by these regulations such as minimum width size, moving handrail heights, step requirements, the provision of signage, tactile and visual cues, are all not specified in the NBC. These additional specifications help to provide enhanced safety, accessibility, and usability for a wider range of users, including the physically challenged in conformity with the UD principles.

According to the analysis, the NBC guidelines for escalators are also judged to be fairly adequate for promoting UD practices as there appears to be room for improvement.

4.2.11. Signage

The NBC guidelines indicate that signage must be direct, concise and clear. It should also be available in multiple languages, braille, pictograms and symbols. This aligns with the guidelines of both BCA (2016) and ADA (2010), as well as in alignment with the fourth principle UD that recommends the “use of different modes of presenting essential information, such as pictorial, verbal or tactile formats,” ensuring wider reach.

In the light of the analysis, the signage guidelines of the NBC are considered sufficient for purpose, hence adjudged adequate for supporting UD practices.

4.2.12. Toilet

According to the NBC requirements toilet floors should be smooth, hard and non-absorbent. A minimum width of 1100 mm and length of 1250 mm should be provided for users with disabilities. This falls short of the recommended width of 1420 mm to 1750 mm and length of 1500 mm specified by ADA (2010) and BCA (2016). The dimensions specified by the NBC though adequate to accommodate most user groups, is not sufficient to for a wheelchair user that requires at least a clear space of 1500 mm by 1500 mm to conveniently turn around to navigate to use a facility, based on accessible design standard requirement. This contravenes the seventh principle of UD that advocates for “adequate size and space to approach and use” facilities and the first principle that requires “equal opportunity use” for everyone.

However, with regards to provision of grab bars in accessible toilets, the NBC guidelines align with the standards of ADA (2010) and BCA (2016). The NBC specifies that grab bars shall be 850 mm to 950 mm from the finished floor level and 1200 mm long with a diameter of 35 mm. According to the BCA 2016, towel and disposable fixtures should be between 1000 mm and 1200 mm from the finished floor surface and a minimum diameter of 380 mm.

From this analysis, it appears that the NBC toilet guidelines are sufficient in portions but have notable gaps, hence adjudged partially inadequate for promoting universal design practices.

4.3. Discussion

This study was conducted to examine relevant portions of Nigeria’s NBC (2006) that relates to accessibility, to determine any gap or limitation that could hinder inclusivity in the built environment, thereby determining their adequacy in promoting UD practices, towards ensuring that all individuals can fully take part in society without encountering physical barriers or obstacles.

The first objective involves a critical evaluation of the accessibility provisions of the building code through the lens of universal design principles, focusing on key architectural elements such as car parks, external walkways, ramps, stairs, handrails, floor surfaces, entrances, doors, corridors, elevators, escalators, signage, and toilets. The results reveal that despite the fact the NBC comprises explicit technical and dimensional specifications intended to enhance accessibility, such as maximum slopes, minimum widths, and safety standards, these elements usually prioritize structural integrity and adherence to functionality, rather than holistic accessibility, usability and practical inclusiveness. When compared to the BCA (2016) and ADA (2010) standards, the NBC falls short in terms of specifications and essential detailed guidelines. This affirms UGREEN (2025) position that UD requires more than minimum compliance in terms of

regulations and codes. This finding also supports the criticism of previous studies like those of (Olodeoku M. A., 2024) and Sholanke, Opoko, Akpan, and Adigun (2019) that criticized public environments in Nigeria for limited integration of UD. The result buttresses the opinion that instead of approaching accessibility as an integral design ideology, it is often viewed as a secondary consideration. Although the NBC specifies requirements for features such as the heights of handrails and ramp gradients in alignment with international norms, it insufficiently promotes three essential UD principles usually identified in global best practices: “flexibility in use, perceptible information, and intuitive use” (Story, Mueller and Mace, 1998).

The finding that the NBC includes some components of UD criteria, but not sufficient enough to maintain consistency and coordination to fully ensure accessibility for all users, supports the position of Sholanke et al., (2019) and Izobo-Martins and Azoom (2019) that the NBC lacks adequate direction with limited provisions, capable of marginalizing PWDs in the built environment. This position is also similar to the view canvassed by Ikudayisi and Taiwo (2022)) that the compliance of buildings with accessibility requirements was uneven and often weakly enforced in urban centres in Nigeria.

The outcome of this study indirectly substantiates these highlighted concerns through its revelation of code standards that are not adequately contextualized for universal accessibility. Particularly, features such as toilet layouts and signage, while partially compliant, do not completely provide for the various user abilities, particular in terms of sensory and cognitive impairments. This deficiency also aligns with the observation made by Agada et al. (2024) and Maduagwu and Saidu (2018), that there is a lack of critical accessibility standards in Nigeria, as well as ineffective enforcement regulatory bodies.

On the second objective of the study which involves determining the adequacy of the relevant accessibility provisions of the NBC in supporting UD practices, the outcome reveals that although the code attempts to include accessibility features, the provisions prove inadequate in effectively promoting UD practices in the development of the built environment. This aligns with the revelation from prior studies such as Aniekan (2021) and Adewale and Odewumi (2024), which discovered significant shortcomings in the NBC’s ability to satisfy the demands of diverse user groups, especially PWDs. The comparative analysis of the relevant provisions of the NBC with internationally accepted benchmarks, such as the BCA (2016) and ADA (2010), further reinforces that the NBC lacks precise and comprehensive dimensional guidelines, which are central for ensuring accessibility, usability, comfort and safety for everyone. For instance, the lack of specific dimensions for accessible car parks in the NBC corroborates Olodeoku, Adegboye, and Johnson (2024), a study which exposed that due to non-existent or poor technical guidance, public buildings fail to make provisions for usable car parks for wheelchair users in Nigeria. On the contrary, the BCA (2016) and ADA (2010) clearly specify dimensions and guidelines that ensure seamless access. This limitation has wide-ranging implications, potentially preventing mobility impaired users from accessing to use public buildings and their facilities independently and with dignity.

Likewise, the guidelines on corridors and external walkways of the NBC, also reveal a limited interpretation of accessibility, focusing just on minimum passage width. The widths of the walkways and absence of resting or passing spaces, fail to consider the needs of people who are mobility impaired or lack stamina, such as pregnant women or the aged. This agrees with (Anunobi, Folaranmi, Philip, and Omachoko, 2015). The study found that walkways in Nigerian public buildings rarely meet international accessibility standards, leading to discomfort, fatigue, and reduced use of facilities by vulnerable users.

The results on toilets and handrails also reinforce these apprehensions. While the NBC specifies guidelines for grab bars in toilets, and recommends standard height dimensions for handrails, it fails to include critical considerations like adequate turning radii within toilet cubicles and lower handrails for the use of children. Similar issues were reported by Oloruntoba and Adewunmi (2020). The study emphasized that many buildings partially complied with accessibility provisions. This results in partially complaint spaces that lack adequate functionality, and compromises UD principles in the promotion of usability for all users. .

In contrast, some guidelines of the NBC, such as the standards specified for ramps, stairs, signage, and floor surfaces, align reasonably with globally recognised benchmarks. Similarly, an earlier study identified these components as the more developed features of accessibility code in Nigeria, indicating that where detailed guidance is provided in the NBC, such features are more likely to be compliant and functional. However, Anunobi, Folaranmi, Philip, and Omachoko (2015) argued that even in these areas, practical application is not consistent as a result of poor enforcement and low-level awareness among building professionals.

The findings of this study have far-reaching implications which are multidimensional in nature. Firstly, there appears to be a significant deficiency between policy and practice in the built environment regulatory framework in Nigeria. Although as currently formulated, the NBC framework, partially aligns with globally recognised standards, it does not adequately prioritize user experience across all the diverse range of abilities. The potential impact of the NBC's accessibility provisions is further weakened because of limited implementation framework and compliance mechanism. Whereas the NBC promotes accessibility theoretically, it hinders effective implementation of the principles of UD because of its vague and inadequate guidelines.

Secondly, Gaps in the NBC risk excluding people with disabilities and turning the built environment into a barrier rather than an enabler. This also threatens Nigeria's commitments under international frameworks like the United Nations Convention on the Rights of Persons with Disabilities (CRPD). Strengthening the NBC with clear, enforceable universal design standards is therefore essential.

Therefore, there is an urgent need for a strategic reorientation from compliance with minimum code standards to comprehensively integrate UD strategies in building regulations in Nigeria. Such amendments should align with best practices integrated in globally acknowledged accessibility codes and the UD principles. Embedding human-centred design approaches into domestic policy and promoting awareness among stakeholders in the building industry are necessary towards ensuring a built environment that is truly inclusive. For the NBC to reflect the principles of UD in a more precise and context-sensitive terms, policymakers, disability advocates and the built environment design professionals such as, architects and urban planners, must jointly participate to revise and enlarge the scope of the code. This should include not only technical amendments, but training development programmes, compliance assessment mechanisms, and public sensitization efforts to ensure environments designed for inclusivity. In the long run, integrating the ideals of UD into the building code system in Nigeria, will likely result in more equitable access, promote social inclusivity, and foster independence and dignity for a wider range of citizens, including individuals with disabilities.

5. Conclusion

The study was conducted to examine the current NBC of Nigeria, which was passed into law in 2006, with the aim of identifying the gaps and limitations that could hinder the promotion of

inclusivity in the development of the built environment in relation to the principles of universal design. The objectives of the study focused on the assessment of the accessibility provisions in the NBC and evaluated their adequacy in supporting universal design practices.

The study observed disparate adequacy and conformity across the accessibility provisions. Provisions such as staircases, ramps, doorways, floor surfaces, and signage were found to be adequate in terms of promoting universal design practices, while other provisions such as parking, exterior walkways, internal corridors, handrails, and toilets were found to have substantial deficiencies. But most significantly were the deficiencies found in the car park design, outdoor circulation pathways, and toilets. This underscores major barriers to achieving full inclusivity. Due to these findings, there is a crucial need for a major change in just complying with the minimum standards to broadly integrating the universal design strategies. This study recommends that the NBC undergo a centred, and deliberate improvement to address all the shortcomings identified. These specific improvements include amending accessible parking and toilet specifications, improving external walkways and signage provisions to reflect universal design best practices. In addition, improvements should be made to the enforcement mechanisms and compliance monitoring of the guidelines to ensure consistent application. As a literature review, this study is limited to a textual analysis of the NBC without empirical validation. However, it offers a structured, evidence-based evaluation of the code's accessibility elements, highlighting misalignments with universal design principles and emphasizing the need for inclusive strategies in national standards to ensure access for all, especially people with disabilities.

Consequently, future studies should examine how the code is implemented in the development of the built environment, assess user experiences, and compare the framework in Nigeria with international standards such as the Americans with Disabilities Act (ADA) or ISO 21542. Ultimately, achieving a built environment that is universally inclusive in Nigeria entails not only improving building codes but also promoting a broader institutional and cultural commitment to accessible and user-centred design.

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House design for dementia patients

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Abstract: Dementia is related to weakened cognitive abilities, memory, and behaviour. The increasing number of patients is a threat to the future. Therefore, the built environment and services for dementia patients must be adapted. This study generates a survey to understand how to have a better interior environment and adapted place for dementia patients. It was found that people who are diagnosed with dementia seeks familiarity (%55), good amount of natural light (% 15). They prefer more spacious rooms and kitchen (%50). They are sensitive to noise. % 50 of participants complained about noise problem. % 20 of participants mentioned about insufficient natural light. In house % 30 of participants complained about acoustical insulation problems, % 5 of participants complained about ineffective heating system. Depending on the answers of 20 participants, the design guidelines were created to meet the needs of patients.

Keywords: Dementia, Design for Dementia, Inclusive Design, Design for All, Universal Design

1. Introduction

Dementia is an umbrella term to describe a set of symptoms that affect cognitive abilities, memory, thinking, and behavior. Alzheimer's disease is the most common cause or type of dementia, accounting for the majority of cases. It is a progressive neurodegenerative disorder that primarily affects memory and cognitive functions (Silverman, 2023). The condition of dementia includes symptoms such as memory loss and thinking problems. It generally affects elder people whose age is above 65. However, some people are diagnosed with dementia when they are in their 45 or so (Alzheimer's Society, 2024). Cankurtaran and Arioğlu mentioned in their journal about dementia and Alzheimer's that there is %12-18 in the European Union people who are between 45-60 years old (2011). Moreover, the Alzheimer's Society noted that "there are more than 40,000 people in the UK under 65 with dementia" (Alzheimer's Society, 2024). It is obvious from the estimated numbers that, it does not only affect old people, but it also affects people who are in their middle age. Despite the unusual numbers, dementia commonly affects old people. So, by the natural aging process, people tend to lose their sight and their mobility abilities. If the dementia illness is seen at the same time as the ageing process, results can be much more deleterious than it could be. Since it has psychological effects besides its physical effects as well. It is observed that dementia can cause depression, anxiety, and aggression as a side effect. Therefore, it creates big changes in people's lives in terms of behaviours. Desai and Grossberg stated in their study that dementia patients display some behaviours such as aggression, agitation, restlessness, and wandering (2001). Also, there are some psychological problems such as depression, hallucinations, and delusions (Desai and Grossberg, 2001).

Symptoms which are mentioned previously influence patients' well-being and their carers' lives negatively. Additionally, there is no definite cure for this illness. However, the effects of dementia can be minimized. Even though there is no definite cure for this illness, society can learn how to

deal with it by understanding and improving sufferers' lives. The main step of improving patients' lives starts with the improvement of the living environments of these patients. People's living environment is significant because it addresses their needs and interacts with them. It seems that interior designers are highly related to people's needs of living environment and how they experience the place. Designers and architects are mainly concerned about healthy people's living environment. However, some people have neuropsychological conditions such as people with Autism Spectrum Disorder, and some people have neurocognitive conditions such as Dementia. Designing for disadvantaged people is an overlooked topic. There is a big role for architects, interior architects, and designers. Designing for dementia patients is a significant topic in coping with the negative effects of the condition. Since their moods are affected by living environments. In the book called 'Mental Capital and Wellbeing' it is mentioned that physical environment can affect people mentally negatively or positively (Cooper et al. 2008). It implies that "Lack of an appropriate physical environment can stimulate the development of mental illness. Negative impacts are associated, for instance, with an increased level of agitation and anxiety leading to social isolation, disengagement from communal, physical, and educational activities" (Cooper et al. 2008:3). The reason to start this research is to create a positive atmosphere to support dementia friendly interior designs. Therefore, this study is done in the light of questions such as:

1. What are the handicaps in the current house design for dementia patients?
2. How can designers address current design problems?

2. Literature

Place perception affects the experience of the place. Dementia patients' way of seeing and interpreting realities is different than in comparison to healthy people. In the article which is called Improving Alzheimer's and Dementia Care: The Eyes Have it, Bier describes seven types of visual changes that dementia patients experience (PsychCentral 2013). Therefore, visual changes such as inability to perceive dimensionality, shrinking peripheral vision, high color contrast, need for brighter lighting, trouble with glare and shadows, need for greater simplicity, and right eye preference. It shows that sufferers perceive objects closer than they are. Since, their impaired vision they can only see front directions easily. Bier indicated with the experimenter research that "By putting the circled fingers to our eyes like binoculars, we get a good estimation of this limited view; the field of vision is about 12" in diameter in all directions. This means the Alzheimer's patient cannot see something unless it is directly in front of them at just about eye level" (PsychCentral 2013).

Moreover, they need to discern objects from one another which means that they need some contrasting colors or textures to differentiate them more rapidly. It is known that mainly most dementia patients are in the aging process, so they need more light on their impaired perception. However, lighting needed to be arranged according to the standards. Regarding this requirement, Dr. Paul Raia, one of the founders of HT, recommends significantly increasing the intensity of normal household lighting from 30-foot-candle power to 60- or 70-foot-candle power (Raia, 2011). Otherwise, if the specific data are not taken into consideration it may result in glare or shadows that can create confusion for patients. Thus, visual simplicity can be a core precaution to prevent patients' misperceptions and ambiguity. It is conceived that dementia patients' place perception varies in comparison to healthy people. They interpret reality in different ways so this may cause confusion and stress for them which affects their health and well-being negatively.

Since dementia patients have a different place perception. Chmielewski and Eastman mentioned the importance of a home-like environment while designing living spaces for dementia patients

(2014). It is also indicated that enabling residents' independence and understanding their both privacy and community needs are significant (2014). Moreover, Chimelewski and Eastman expressed that places should propose focused and appropriate stimulation, preventing distraction as well as mundane, boring atmosphere for its user (2014). Therefore, the design should be accessible because of their prior situation, and it should prevent the patients from wandering away.

Besides, responding to circulation in a living environment there are also some requirements that dementia patients need. Firstly, dementia patients can easily be "overwhelmed, confused and/or distracted when they are faced with large groups or spaces" (Chimelewski et. al 2014:6). In this case, they need arrangements for their daily routine, activities, and living style. Residents may feel better when they join small groups. According to Chimelewski and Eastman "These small-sized groupings support resident-centered care and personal relationships among the residents, their families, and professional caregivers — an important factor given that social support has long been known to affect an individual's emotional and physical health and general well-being" (Chimelewski et. al 2014:28). Circulation and spatial arrangement have the important role to create accessibility to dementia patients. Even healthy people can have problems accessing spaces if they are not designed precisely, so it is more likely for dementia patients to have some accessibility problems. Accordingly, some zoning systems should be developed to support dementia patients to map out their orientation. This zoning system is called 'wayfinding' in architectural planning. Kelly Bissel describes wayfinding as "Wayfinding is a general term that involves how an individual navigates their environment" (Bissel, 2010:1) Bissel suggests common solutions for wayfinding to create central hubs in spatial arrangements that can stem off from other spaces or creating a single path which looks like random corridor but should flow in building's form (2010). Creating a single path can provide more accessibility because it is hard to become disorientated when walking on one continuous route. It also differentiates flooring between other spaces and the central core. In this way, dementia patients can be much more aware of where they are standing while they are using the places. Dementia patients can have some problems in terms of decision-making. Therefore, if some decisions are made in the interior, it will be more helpful for them to navigate themselves.

Furthermore, In the book *Good Practice in Design of Homes and Living Spaces for People with Dementia and sight loss* there are some suggestions for design for dementia patients (Adams et. al, n.d). Color plays an important role while designing for dementia sufferers. It has a considerable amount of influence to visualize the preferred part of design or detail. Adams suggested that painting bathroom doors differently than other doors makes them more highlighted and it will make users identify more easily than the other ways (Adams et. al., n.d). Commonly, designers apply signage or labelling systems to identify the essential parts of the design. However, using the color method is more memorable and remarkable, especially for people who have cognitive disorders. By the process of aging, older patients' sight is affected. Therefore, it is highly possible for them to not read the signage or labels. In this case, it can seem that applying color and creating identification of elements for its users is a preferred option. There is also another suggestion that recommends using a range of colors on bedroom doors that are like specific users' previous houses' front doors. Also, it suggests getting help from contrasting colors. For instance, locating sockets, and handrails with the contrast color to the wall, makes them more readable and easier to use. Contrasting colors can be applied on furniture while placing it in front of walls. Adams exemplifies the application of contrast color in the bathroom. Since toilet seats are generally colored the same color as the commode 's color. Hence, it can make it not visible. To move

forward, toilet seats can be in contrast color with the toilet to identify and visualize it more accurately.

On the other hand, there are some potential hazards while applying contrast colors to the design. If the application is done not correctly, it will be open to unwanted accidents. Adams mentioned this point “Highlighting sharp edges with color draws attention to the danger that they may pose” (Adams et. al, n.d). Thus, while applying colors some vital parts that may cause hazards should be considered. It is also suggested to make step edges contrasted to stair treads and risers to increase safety.

Another significant design aspect is lighting which depends on the application. Lighting has a vital importance in the living environment, especially for people with dementia. They need more natural light, also more artificial lighting levels that can enhance their visibility. Besides, it positively affects dementia patients' mood. There is a study which is done in the Royal Netherlands Academy of Arts and Sciences, Amsterdam, by Rixt F. Riemersma-van der Lek (Jama, 2008). The study tries to explore the answer of how much bright light with or without melatonin supplements would affect symptoms of dementia (Jama, 2008). The study contains 189 elder people with dementia who are about 86 years old, mostly female at 12 elder care facilities in the Netherlands. Some participants took daily doses of melatonin which is a fake pill to make participants realize the placebo effect. The facilities turned their lights on each day from about 9 am to 6 pm; half of the facilities increased the intensity of their ceiling-mounted lights. After this study, results came up which are:

- Reduced cognitive decline on a mental status exam by a relative 5%.
- Cut depression symptoms by a relative 19%.
- Calmed slow increases in functional limitations by slightly more than half (53%) (Jama, 2008)

It can be understood from studies that the simple measure of increasing the illumination in facilities affects cognition, behaviour, and mood positively. Additionally, the lighting level should be arranged consistently. Since sudden changes may affect dementia patients and it may cause misinterpretation. Therefore, sudden changes in lighting can cause glare, and inconsistent lighting levels on some parts of the components of interiors. If the design has good color rendition, that means it has low glare and uniformity in lighting. So, these features can be considered as dementia-friendly lighting. As mentioned before daylight is important for dementia patients' well-being, and usage of place as well. There are some recommendations about this concern that introduce how to improve daylight in a room. Ricky Pollock suggests that average daylight in a room can be improved if some conditions are accomplished (n.d). For instance, the light transmittance of the windows should be greater; windows should be large enough in comparison to the room's size. In addition, it is suggested by Ricky Pollock that the average reflectance of the interior surfaces is higher (Pollock, n.d). It is known that effective daylighting can be provided up to some extent. In this respect, artificial lighting is essential. The number of lighting fixtures that are used is important. Ricky Pollock mentioned that using 5 fittings of lighting instead of 3 is an essential way to improve lighting in interiors (Pollock, n.d).

Additionally, the Dementia Services Development Centre advises ensuring good signage methods that are mounted for older people (2013). Since ambiguous signage systems may confuse users. Secondly, ensuring the easy perception of the kitchen and bathrooms is highly significant because they are basic needs. Thus, people can see important rooms such as toilets as easily as possible (DSDC, 2013). Also, all doors should be visible enough to provide accessibility. People with dementia have no time or date notion. That is why, they need to remember which date and time

they are living in. In this case, illuminated clocks and calendars can be supplied in the required places.

3. Methods

This study investigates the appropriate way of design for individuals who have Alzheimer's disease in the light of two main questions as below:

1. What are the handicaps in the current house design for dementia patients?
2. How can designers address current design problems?

These research questions were answered through qualitative research methods. Qualitative research is defined as "research in which qualitative data collection techniques such as observation, interview, and document analysis are used, and a qualitative process is followed to reveal perceptions and events realistically and holistically in the natural environment" (Yıldırım and Şimşek, 2008: p.39). The approach of the qualitative method includes interviews, observations, document reviews, and focus group studies. In this study, the research tool is a survey. The data were collected by the survey for dementia patients who have mild levels of Alzheimer's disease. 20 Alzheimer's patients joined the survey through the allowance of their families.

The collected data was analysed by the descriptive analysis method. Analysis was made in the light of design aspects such as acoustics, lighting, and environment. Another category is psychological response to the designed house and environment. It is investigated through some questions, as shown in Table 2. The answers were prepared as an open-ended question type. In this way, more detailed answers could be taken from participants. To reveal the opinions of the participants in-depth, the descriptive analysis method, which is one of the qualitative data analyses, was used (Karataş, 2015: p.73). The findings were obtained from answers to the survey. It was summarized and interpreted using the descriptive analysis method.

Study Group

Alzheimer's disease has some levels which can be mild or severe. To answer questions, participants need to perceive the question and reply accordingly. Therefore, selected participants have mild level of Alzheimer's. 20 participants joined to the study. 12 (%60) of the study group is female and 8 (% 40) are male. 4 (% 20) of participants are over 80 years old. 8 (%40) of participants are over 70 and 8 (%40) of participants are over 60 years old.

In consideration of educational background, 14 (%60) of the participants graduated from high school, 1 (% 20) participant graduated from elementary school and 1 participant (% 20) couldn't get any education. To analyse the suitability of the design, the living duration of occupants is significant. Therefore, 4 (%20) of participants have been living in the same house between 0 to 10 years. 8 (% 40) of the participants have been living in the same place between 20-30 years. Lastly, 8 (% 40) of the participants have been living in the same place between 40-50 years. This study depends on voluntary basis. Therefore, all participants accepted the informed consent.

3.1. Survey

This study is conducted on a voluntary basis. Participants are grandparents and grandmothers of immediate surroundings. To get tangible results from the survey, the severity of Alzheimer's disease is important as well as the participants' willingness to answer. Participants who have mild levels of Alzheimer's answered 17 different types of questions. Questions were designed

according to design aspects such as acoustics, lighting, and environment. Also, questions discover psychological reaction to the designed environment. The first 4 questions related to participants' imprint information such as gender, age, education level, and duration of residence. 5th, 6th, 7th, 8th, and 17th questions are open-ended type of questions to receive more ideas from participants. 9th to 16th questions is designed as a closed-ended questions for certain answer.

The 5th and 6th questions are related to the psychological reaction of participants to the interior design of house. 5th question investigates design-based happiness and 6th question searches what the reasons of design-based unhappiness are. 7th, 8th, and 9th questions try to comprehend the design of the living environment. 7th question is for the participants' interpretation of the house's interior design. 8th question is to understand the limitation of interior design. The 9th question discusses the acoustical aspect of the design. The 10th question discusses lighting. The 11th question is related to the environment, and the 12th question is related to environmental satisfaction. The 13th question is related to the expected interior architecture of the house. The following 14th question discusses the room design satisfaction of the occupant. The last questions which are 15, 16, and 17 discuss wet areas and their accessibility.

Questions are listed below:

- 1st Question: Gender
- 2nd Question: Age
- 3rd Question: Education Level
- 4th Question: Duration of Residence
- 5th Question: What are the things that make you happy to live in this house?
- 6th Question: What are the things that make you unhappy while living in this house?
- 7th Question: What do you think about the interior design of your house?
- 8th Question: What are the handicaps of the current interior design of the house?
- 9th Question: Is there any noise problem in the house?
- 10th Question: Is there enough sunlight in the interior?
- 11th Question: Are there any social areas in the apartment/ house or surroundings?
- 12th Question: Are social areas satisfying?
- 13th Question: How would you like the interior design to be?
- 14th Question: Are you satisfied with your room's design?
- 15th Question: Do you have your own bathroom?
- 16th Question: Can you access and use the bathroom easily?
- 17th Question: What are the handicaps that you experience during the usage of bathrooms?

In the light of questionnaire, it's easy to perceive the limitations and problems of the current design approach. Questionnaire has various aspects such as design factors and its psychological and physical effect. Thus, specific aspects of design such as lighting, acoustic, accessibility were investigated, and solutions can be recommended.

4. Survey Data

The first 4 questions were designed to understand the features of the participants. From the 5th question to the 17th question review of the design for Alzheimer's can be displayed. 5th question (What are the things that make you happy to live in this house?) towards to perceive the atmosphere of the place and identifying which types of atmospheres create happiness in Alzheimer's patients. The participants replied to the 5th question differently. 11(%55) participants answered, "They like familiarity. Therefore, living in a house and district for a long time created

happiness for them". 6 (%30) participants declared that "They like to live with their children in the house". 3 (% 15) participants' answers to 5th question were related to natural lighting in the house. A participant mentioned that in the morning, she likes to watch natural light. So, enough amount of natural light is making her happy.

Controversially, 6th question discusses the factors that make participants unhappy (What are the things that make you unhappy while living in this house?). Mainly, participants complained about noise problems due to the settlement of many buildings in the neighbourhood (%60, 12 participants). 4 (% 20) participants mentioned that their place doesn't have enough natural lighting. The rest of the participants were neutral in their answer (%40, 4 participants). 7th question (What do you think about the interior design of your house?) explores the general attitude of participants regarding to design of their houses. 10 (%50) participants prefer more spacious rooms and kitchens. 6 (% 30) participants complained about insufficient natural lighting and noise. 4 (% 20) participants stated that there are spacious areas in their house to comfortably move.

The 8th question is about limitations of the current interior design of the house (What are the handicaps of the current interior design of the house?) 13 (% 65) participants mentioned about insufficient amount of natural lighting. 6 (% 30) participants mentioned about acoustical problems. For instance, one of the participants mentioned "Open planned house limits me to watch TV in very low voice due to the transmission of voice". Most of the concerns about acoustical problems are noise. Moreover, one of the participants (% 5) complained about the heating system and that she wished her house was insulated.

Acoustical design is significant for Alzheimer's patients' health. 9th question discovers the existence of a noise problem (Is there any noise problem in the house?). 12 (% 60) participants replied to the question as 'No'. 8 (% 40) participants replied as 'Yes'. Another essential design element is natural sunlight. 10th question (Is there enough sunlight in the interior?) towards natural sunlight. 12 (%60) participants think that it is enough, and 8 (%40) participants think it is not enough.

Another improvement in design is the availability of social places in apartments or near surroundings. Staying socially engaged with friends and family has been displayed to relieve stress which leads to better sleep and eating habits (Dementia Care Central, 2023). Availability of social areas was questioned by "Are there any social areas in apartment/ house or surroundings?" in the 11th question. 16 (% 80) participants answered 'No' and, 4 (% 20) participants replied 'Yes'. Additionally, depending on the 12th question's (Are social areas satisfying?) answers, 16 (%80) participants think that existing social areas are not satisfying for the participants. 4 (%20) participants think that social areas are satisfying.

13th question (How would you like the interior design to be?) regarding interior architectural design decisions. 5 (% 25) participants declared that they would like to have a minimal and functionally designed interior. One of participant who gave same answer added that 'Due to the complex design sometimes he loses himself and finds himself in the balcony'. 2 (% 10) participants complained about not having enough social area. It is explained by one of participant that she wished she had a relaxing place to spend time alone and do patchwork. She added that sometimes she confuses rooms so there would be wayfinding elements in interior design. Moreover, the noise problem was another concern. 6 (% 30) participants mentioned that there is a noise problem in the house due to a lack of acoustical insulation. 3 (% 15) participants' concern was related to not having an optimum lighting design and a spacious room and kitchen. The 14th question (Are you satisfied with your room's design?) try to explore the room's design.

Most participants (12 participants, %60) are not satisfied with the room design due to its size. Some of the participants (2 participants, % 10) wished that their window height would be enough to see the view.

Accessibility is significant for all, especially for elder people who are diagnosed with Alzheimer's. Particularly accessing the bathroom easily is an indispensable necessity. The 15th question asks if there is a private bathroom for participants. 12 (% 60) participants said 'No', and 8 (% 40) participants said 'Yes'. The 16th question (Can you access and use the bathroom easily?) is about the functionality and accessibility of the wet area. 16 (% 80) participants replied that they can access and use the bathroom easily. However, depending on the answers of 4 (% 20) participants accessibility and functionality of the bathroom is not easy. To perceive problems of bathroom usage, the 17th question (What are the handicaps that you experience during the usage of bathrooms?) is created. Some participants (16 participants, % 80) need handles in the bathroom. Another handicap is the height of the sink which is not suitable for participants (4 participants, % 20)

5. Analysis

Sustainability isn't only related to the application of recycled materials or the thought of duration of buildings. It is also about providing a home that addresses users' needs and creating a place that makes them live in the real sense. Therefore, empathic design is essential when designing for all and especially designing for groups that need special assistance such as people who are diagnosed with Alzheimer's. Therefore, empathy needs to take place when designing. Thomas and McDonagh (2013) stated that "Designers and developers of products and services need to rely on the importance of developing empathy with users to ensure that these products will resonate with individuals as opposed to the masses".

Closed-ended questions' answers help to draw a certain image of the current design. In terms of acoustical design, participants are mostly satisfied. % 60 of the participants evaluated the houses' acoustics positively (Table 1, Question 9). The lighting design of houses was evaluated by participants same as acoustic design. % 60 of participants are happy with the lighting design. However, % 40 of participants is not happy with the lighting design (Table 1, Question 10). Moreover, having a limited connection with the environment and social areas can affect patients' well-being negatively. % 80 of participants mentioned the unavailability of social areas (Table 1, Question 11). Also, % 80 of participants is not satisfied with the existing social areas (Table 1, Question 12).

Another part of the open-ended question is the examination of house design. In this part, participants were given some detailed answers. According to the 5th question's answer, it was perceived that participants are happy with familiarity (% 55) and a good amount of natural lighting (% 15). In the analysis of 6th question's answer, it was noticed that participants are unhappy about the noise problem (% 60) and insufficient natural light (% 20).

The 7th question discovers participants' thoughts about their houses' interior design. According to the 7th question's answer, which is displayed in Table 4, % 50 of participants require more spacious rooms and a kitchen. % 30 of participants demand more natural light. There are also handicaps or negative ways of design in the living environment. The 8th question's answers demonstrated participants' thoughts about handicaps in the house. The majority (% 65) of participants complained about the insufficient amount of natural light. The second handicap in the design of the house is the acoustical insulation problem. Thus, % 30 of the participants

declared there is an acoustic-based problem. % 5 of the participants think that the heating system is ineffective.

On the 13th question (How would you like the interior design to be?), houses' interior design decisions and their effect on the Alzheimer's patients. % 25 of participants stated that participants prefer minimal and functional interior design. % 10 of participants complained about unavailability of social areas. % 30 of participants mentioned that there is a noise problem in the house due to a lack of acoustical insulation. Lastly, % 15 of participants would like to have more amount of natural lighting and spacious rooms. The 14th question explores (Are you satisfied with your room's design?) room design and its effect on the participants. % 60 of participants are not contented by their room design because of its size. % 10 participants mentioned that window size heightened could be adjusted for seeing the view.

The wet areas are significant components of houses. Thus, lack of a private bathroom creates discomfort depending on the information gained by participants. It is important to have a private bathroom for privacy and a sense of belonging, especially for Alzheimer's sufferers. The 15th question asks if there is a private bathroom for participants. % 60 of participants said 'No', and % 40 participants said 'Yes'. The accessibility to wet areas has utmost importance to meet the users' needs. Hence, the 16th question (Can you access and use the bathroom easily?) is about the functionality and accessibility of the wet area. % 80 of participants mentioned that they can access wet areas easily and % 20 of participants cannot access easily.

Moreover, wet areas can be dangerous for elderly people if it is not designed according to their needs. There are many at-home accidents in wet areas. Home accidents happen, if the risk factor is available. Temel and Vaizoğlu (2018) mentioned that if the design is not accessible and adaptable for users that means there is a risk of home accidents. The 17th question examines, if participants face a problem during the usage of the bathroom. % 80 of participants mentioned that there is a need for handles/bars in the bathrooms. % 20 of the participants complained about dimensional problems of sanitary ware. Therefore, sanitary ware needed to be adjusted for the user.

Table 1. Close-ended Questions Type Answers

Question	Positive Reaction	Negative Reaction
9. Is there any noise problem in the house?	% 60	% 40
10. Is there enough sunlight in the interior?	% 60	% 40
11. Are there any social areas in the apartment/ house or surroundings?	% 20	% 80
12. Are social areas satisfying?	% 20	% 80

Table 2. Close-ended Questions Test

	Variation 1	Variation 2
Mean	40	60
Variance	533,3333	533,3333333
Observation	4	4
Pearson Corelation	-1	
Hypothesis	0	
df	3	
t Stat	-0,86603	
P(T<=t) single tailed	0,225092	
t Critical single tail	2,353363	
P(T<=t) double tail	0,450185	
t Critical double tail	3,182446	

Table 3. Open-ended Questions Type Answers

Question	Answers
13. How would you like the interior design to be?	% 25 of participants prefer minimal and functional house interior. % 10 of participants are not satisfied about unavailability of social spaces. % 30 of participants complained about noise problem. % 15 of participants wish to have more amount of daylight. % 20 of participants was hesitant to answer
14. Are you satisfied with your room's design	% 60 of participants not satisfied % 40 of participants satisfied
15. Do you have your own bathroom?	% 60 of participants replied as 'No' % 40 of participants replied as 'Yes'
16. Can you access and use the bathroom easily?	% 80 of the participants can't access easily % 20 of the participants can access easily

Table 4. Open-ended Questions Type Answers

Question		Answers
Design Based Happiness	5. What are the things that make you happy to live in this house?	Familiarity (%55) Good Amount Of Natural Lighting (% 15)
Design Based Unhappiness	6. What are the things that make you unhappy while living in this house?	Noise Problem (% 60) Insufficient Natural Light (% 20)
House's Interior Design	7. What do you think about the interior design of your house?	Preference of Spacious Rooms and Kitchens (% 50) Demand for More Natural Light (% 30)
Limitations of Interior Design	8. What are the handicaps of the current interior design of the house?	Insufficient Amount Of Natural Lighting (% 65) Acoustical Insulation Problems (% 30) Ineffective Heating System (% 5)
Limitations Of Wet Areas' Design	17. What are the handicaps that you experience during the usage of bathrooms?	Handles/Bar In The Bathroom Is Needed (% 80) Dimensional Adjustment Of The Sanitary Ware Is A Must For Usage (% 20)

6. Recommendation

Depending on the survey, some design aspects are prominent when designing for people with Alzheimer's. It is found from the research that a good amount of natural light and familiarity at home brings happiness to people with Alzheimer's. On the other hand, insufficient natural light and noise make them unhappy. Individuals diagnosed with Alzheimer's prefer more natural light, spacious rooms, and kitchens. In addition to preferences, Alzheimer's patients find insufficient natural light, ineffective heating systems, acoustical insulation problems, not accessible bathrooms as handicaps of house design. In the light of these outcomes, design solutions are created according to the design problems that affect Alzheimer's patients' comfort. The recommendations according to the functions listed in below:

Bedroom: There mustn't be any obstacles such as tables or chairs on the passageway. The personal belongings which are used daily such as clothes should be placed in an open-shelf system to ease the usage. Also, on the nightstand or on the cupboards, names of clothes can be written on the furniture to find them easily. A minimum of 300 lux lighting is needed in bedrooms (Zazarin, M. and Aziz, Z., 2023). Warm colors such as beige can be preferred in the bedrooms to not create glare or any discomfort. Also, familiarity is important for dementia patients according

to the study (Table 4, 5th Question's Answer). Therefore, personal objects such as a picture that makes user happy or an item special for them can be placed in the bedrooms.

Living Room: The living room design needs to address the needs of patients. One of the requests from dementia patients is having good amount of daylight (Table 3 and 4). Therefore, big sized windows can allow ample amount of daylight. Reminiscent decorations (vintage magazines) on side table and shelf help stimulate memory and remind the person about a familiar period from their past (Alzheimer's Foundation of America, n.d.). Safety is the most important thing in living room and in all houses. Thus, sprinkler system must be placed. There is a risk of in-house accidents. Tables' and coffee tables' edges should be bevelled to not cause any harm.

Kitchen: The kitchens are places where motion is dense. Therefore, non-slippery floor materials must be preferred. Also, smart systems must be placed in case dementia patients forget to turn off stove or any other utensils. The functionality of kitchen is essential especially for the dementia patients. Hence, furniture design needed to be re-evaluated. Inside of cupboards need to be visible. Glass cabinet doors should be preferred. Additionally, reminders on closed cabinets or fridges should be used. To ease the usage, frequently used appliances should be placed on the countertop.

Indirect and shadow-free room lighting (500 lux at eye level) prevents visual hallucinations (Braun, A. et. al., n.d.). The kitchen needed to be designed for wheelchair user. Therefore, manoeuvre distance must be arranged. The wheelchair user needs minimum 150 cm x 150 cm area for 360-degree rotation (T.C. Aile, Çalışma ve Sosyal Hizmetler Bakanlığı, 2020).

Bathroom: Safety is highly important in the bathroom. Since wet areas are prone to accidents. Thus, handles inside the bathroom and on the door must be applied. Door handles and commodes' color should be dominant to differentiate them easily. Showers must be accessed without any steps. An emergency call button must be added in case there is a need. Sockets must be water-resistant with covers. A minimum of 300 lux lighting is needed (Burton, J. Dementia Enabling Environments). Clerestory windows can be preferred to let more light inside the place. Moreover, infrared lighting should be placed for nighttime usage.

Dementia patients often feel agitated and anxious. They need to find needed wares easily. Therefore, the open closets should be used to reach products easily (towels, toilet paper etc.). Curtain can be placed in front of the mirror to prevent reflection.

Corridor: The design of the corridor must be barrier free. Corridor walls must be supported with continuous handrails. Handrail should continue even on the doors to not prevent accessibility need of the users. The handrails and steps must be easily visible. This can be achieved by color contrasts. As a result of this application, accessibility will be easy and non-hazardous.

To sum up, safety is crucial for Alzheimer's patients due to the condition of the illness. Non-slippery floor materials such as vinyl, porcelain or ceramic tiles, hardwood, bamboo flooring, etc. can be applied. Handles and bars needed to be placed in wet areas, corridors, and wherever that user needed to walk for a particular time. Fire alarms and emergency buttons needed to be added to the rooms. Also, the smart house system can be useful for Alzheimer's patients. For instance, motion sensors on stoves will help to prevent in-house accidents.

Another enabler of accessible design is color. Color has a positive effect on psychology if it is used consciously. The usage of warm colors such as beige, orange, and brown has a positive effect on Alzheimer's patients. Furthermore, color can be used to provide safety. The usage of contrast colors of door handles, and railing with surroundings can make the user differentiate safety tools more easily.

Lighting has the utmost effect on all people, especially Alzheimer's patients. There is a high demand for natural lighting when in consideration of survey results and literature. Therefore, openings in rooms and clerestory windows in bathrooms and kitchens can be provided. Moreover, following the rules for lux levels of lighting is essential when designing for dementia. In the bedroom and bathroom, a minimum of 300 levels of lux is needed. In kitchens, a minimum of 500 lux level is needed.

In addition to all design factors, furniture design is crucial. Furniture can be built-in furniture or mobile. The furniture's corners should not be sharp. Bevelled corners of furniture prevent damage for users if they fall or crash into the furniture. Furniture design should depend on usage frequency. Therefore, kitchen cabinets and wardrobes should have open parts for daily usage of stuff. The usage of glass cabinet doors can be an alternative for visibility of stuff that makes easy access and less complication for the user. The reminders on closed cabinets can be useful. So, the place of reminders can be designed in furniture as well.

Depending on the literature and findings, Alzheimer's patients would like to find familiarity in their houses. Also, they frequently mention about their past. Therefore, some objects, colors, textures, and photos can be used as a reminiscence element while designing. Designing for dementia patients has some personal aspects as well as objective ways. The personal aspect of design is related to patients' past and their preferences. When considering answers, it is perceived that most dementia patients need acoustically insulated built environments, more natural light, and spacious rooms.

7. Conclusion

It is found that Alzheimer's patients enjoy having familiarity in house. They also prefer minimal, functional house interior. The participants also complain about unavailability of social spaces. Therefore, they are not satisfied by social aspect of the places. Moreover, they would like to have more spacious areas and good amount of daylight in interior. There are accessibility problems in bathrooms. It is declared that they can't access bathrooms easily.

Regarding to these handicaps in house interior design, all the design solutions were mentioned on the previous section (Recommendation). Before improving all the aspects of design at houses, it is beneficial to understand that personalization is essential for Alzheimer's patient when designing house for them. Since each patient is different. Therefore, learning what is familiarity for them, what are the things that they don't want to see is key for interior architects while applying standard design guideline.

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Patients' hotel design attributes based on aspects of a healing environment framework and patients' preferences

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Abstract: The lack of access to advanced medical services forces some patients to travel to medical destinations, which raises concerns about health equity. One of the main challenges for both medical travelers and medical centers is ensuring access to lodging facilities at medical destinations. This study explores the preferences of medical travelers for the design features of such facilities, known as patients' hotels, which are necessary for areas with a potential medical service. The research used a literature review, questionnaires, and statistical analysis to identify the critical elements of patients' hotel design features under three influential categories: "distinctive features of patients' hotels," "patients' rooms", and "public spaces". According to respondents, the critical elements of the first category are proximity to medical centers, consideration of patients' physical and spiritual needs in the design, and a homelike environment. From medical travelers' perspectives, patient rooms must have a sense of privacy, additional spaces and amenities, and flexible layouts. The degree of social interaction preferred by patients' companions is "talking to each other" and for patients, it is "participating in a group activity". The spaces preferred for this interaction are "green spaces of the surrounding area", and for decorating public spaces, "using greenery" and "traditional architecture patterns" are preferred.

Keywords: patients' hotel, medical travellers, health equity, design factors, accessibility, healing environment, user preferences

1. Introduction

Access to medical and healthcare services that are affordable, of satisfactory quality, and delivered within a reasonable waiting time has become a global concern. This issue is particularly critical for populations living in remote and underserved areas, where limited access to advanced healthcare services often results in incomplete treatment and raises serious concerns regarding health equity.

A patient hotel is a building concept where independent patients who do not need clinical care can remain at a short distance from the hospital with less staff to follow their medical procedure (Pleijel, 2019). These spaces and family-oriented spaces on the hospital campus also provide emotionally supportive environments (Peters, 2017) and make the care system significantly more efficient and less costly.

Previous studies investigated distinctive attributes, possible outcomes, perceived advantages, and determinants of decision-making to stay at medical hotels from a hospitality industry viewpoint (Chaulagain et al., 2023; Han, 2013; Han & Hwang, 2013; Han & Hyun, 2014; Han et al., 2015). Studies focusing on patient needs and the design features of the patients' hotel are rare and thus there is a gap in the field. A more recent study investigated factors influencing physically disabled people's satisfaction level at a hotel and concluded that inaccessible areas have a negative effect on their satisfaction. People with physical disabilities, powerchair and wheelchair users have been reported to be the most deprived groups in hotels (Tutuncu, 2017). This outcome also highlights the importance of "design for all," which seeks to provide environments that remain functional and equally accessible to all individuals—irrespective of ability or disability— whether in healthcare or hospitality settings (Mosca & Capolongo, 2023).

Hospitals and the hospitality industry by a customer-oriented management approach combine their efforts and share their experiences to attract more patients (E. R. C. M. Huisman et al., 2012; Meesala & Paul, 2018). In fact, hospitals with the provision of hotel-like services for patients and the hospitality industry by targeting different markets such as medical tourism are likely to greatly benefit. However, even though hospitals gain patient satisfaction by providing hotel-like rooms and welcoming lobbies, the hospitality industry has not to date created special room design based on patient travellers' needs. This research aims to achieve the distinctive features of suitable rooms, public spaces, and hotel design attributes for medical travellers in the hospitality industry to fulfil this gap. To investigate related factors in design of a patient hotel, the research focuses on the healing environment's elements that depends on medical travellers' attitudes and needs, rather than ambient features. While different models of offering lodging facilities exist in medical destinations and previous studies mainly focused on the combined functions of hotels, hospitals, and healthcare centres, this study investigates features of freestanding facilities that just offer accommodation for patients and their families near hospitals or on hospital campuses. The main goal is the provision of emotional support and convenience for patients and their families; in other words, it is an effort to make a same experience in healthcare and hospitals and equal opportunity to access to medical services for people in different areas. The term "medical travellers" refers to patients and their families in this research.

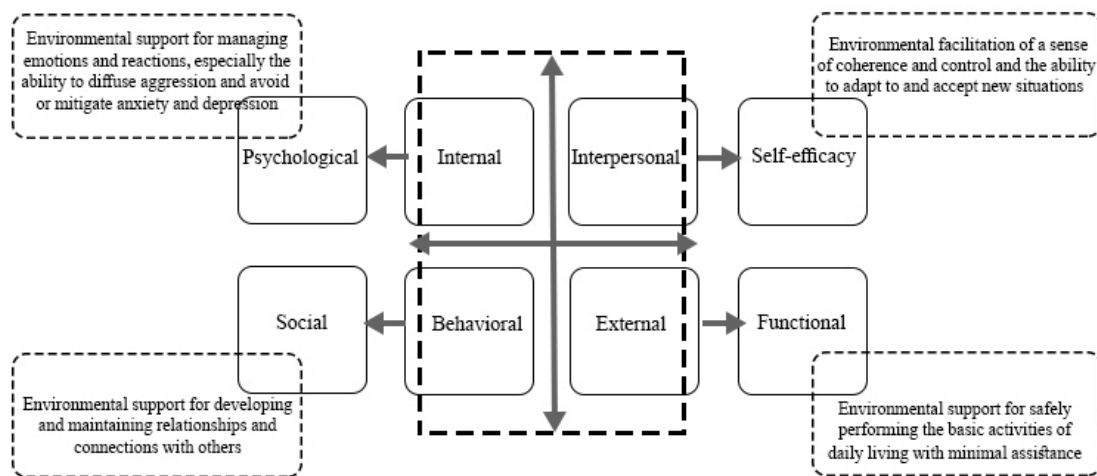
2. Literature Review

Based on intended function (patients' hotel), the literature of supportive healing spaces is reviewed to recognize factors that provide fundamental infrastructure for treatment spaces. Concepts of "the healing environment", "evidence-based design", and "patient- centre design" are in the contexts of healthcare design, which alter traditional attitudes toward healthcare facilities. Thus, contrary to previous practices in healthcare facilities, the focus is not just on technological and medical aspects. A significant number of studies in related literature have implied that ambient environmental factors such as natural light and thermal comfort have beneficial effects on patient wellbeing and recovery (Brambilla & Capolongo, 2019; Salonen et al., 2013; Sklavoua & Tzouvadakis, 2016; Zhang et al., 2019). However, optimal healing environment is defined as an environment where all components of health care such as the social, psychological, spiritual, physical, and behavioural are considered in an efforts to offer support and the achievement of wholeness (van Nijhuis, 2017). Accordingly, for an effective design, all aspects of the environment and influential components should be considered. In a review, DuBose et al. (2016) present a framework for identifying the power of the built environment on better outcomes for patients. This framework of breaking the concept of healing into antecedent

components is represented in Figure 1. In the framework, self-efficacy and functional aspects are largely influenced by patients' physical needs and common concerns and, to a lesser extent, by the culture of a specific context. Therefore, the features associated with these aspects can be considered general attributes. In contrast, psychological and social components are primarily shaped by cultural factors and patients' backgrounds; thus, it is essential to examine these elements in detail within each specific context.

Addressing patient needs in evidence-based designs and in patient-centred designs that holds “interaction with facility users” as a focal point is also a fundamental principle (Elf et al., 2015; Zhao & Mourshed, 2017). Therefore, by reviewing the subset of the four main aspects and finding the appropriate physical solution, practical factors in the design of the patient hotel are evoked and then medical travellers’ priorities are assessed.

Figure 1. Optimal healing environment framework according to DuBose et al. (2016) (Reproduced by authors)



2.1. Control

A fundamental factor in environmental psychology and an initial goal of patient-centre care is acquired through providing choices for patients to gain control over their environment (Devlin & Arneill, 2003; Proshansky et al., 1970). In-patients’ control over their environment are decreased due to their physical condition which is restricted, the imposed environment they must stay in, and the limited choices they are offered. Control helps patients to overcome an undesirable situation by the ability to change or alter settings (Phillips, 2012) or by opportunity to choose their preferred degree of presence of others (Herweijer-van Gelder, 2016). For example, the ambient environment, such as lighting, thermal comfort, and noise, has been found to include important factors for sleep health (Yang et al., 2022); therefore self-supporting systems that enable patients to have control over their environment is a common suggested solution (E. R. Huisman et al., 2012). Other strategies that solve patient restricted abilities include architectural design supporting disabled patient accessibility, wayfinding to reduce disorientation (Iyendo et al., 2016; Molzahn, 2013), and the availability of facilities and services for more convenience (van Nijhuis, 2017). In addition, environmental features that enable patients to obviate undesirable conditions include flexible seating arrangements, control over volume and type of music, single occupancy rooms (Harris et al., 2006), and increased freedom to choose daily activities (Raps et al., 1982). Furthermore, some spatial features including the size of space, brightness, and extent of view,

associated with the effects of crowding (Phillips, 2012) consequently affect sense of control (Chaudhury et al., 2005).

Universal design requirements and strategies that enhance patients' accessibility in circulation and support their control over the environment are broad and multifaceted. Examples include the provision of proper ramps, levelled floors, standard-sized elevators, and barrier-free passages within indoor spaces. In outdoor areas, representative requirements consist of designated parking lots, split curbs with inclined pathways, and the provision of resting zones at regular intervals (Elassal & Ahmed, 2024). These measures illustrate only a subset of the wider accessibility standards that need to be considered in design.

2.2. Privacy

Privacy is a common concern in hospitals and hotel environments. Previous studies on healing environments define privacy as a multi-aspect structure that consists of physical, psychological, social, and informational facets. People based on their expectations, characteristics, and field of activities define privacy differently (Alalouch et al., 2016). Studies relating to hospital environments emphasize physical privacy which includes visual and acoustics privacy (Leino-Kilpi et al., 2001). A domain belonging to an individual (Schreuder et al., 2016), the optional choice of being alone or with others, the possibility to opt for visually and audibly favourable environment, (Herweijer-van Gelder, 2016; van Nijhuis, 2017) are different definitions of privacy. Sometimes a required type of privacy depends on the intended activity. For example, according to Hutton, for activities that have an individual nature and need personal concentration such as reading, a quiet space or room is important (Hutton, 2002). In addition, since poor privacy leads to additional stress, staying in a hotel with the same type of client provides psychological and social privacy of medical travellers.

Acoustic privacy can be controlled by the technical specifications and engineering solutions including sound-absorbing materials and solid walls instead of curtain walls. However, visual privacy seems to be more related to how architects design spaces such as degree of separation and personalization of space (Alalouch et al., 2016; E. R. C. M. Huisman et al., 2012; van Nijhuis, 2017).

2.3. Safety

As safety is a physical and psychological attribute, it means being in a state of calm due to awareness of eliminating potentially dangerous situations and keeping a distance from negative influences. Physical safety deals with aspects that affect physical health such as infections and patient falls. Psychological safety refers to feeling vulnerable against disturbances and disorders while knowing that demands for help will be answered (E. R. Huisman et al., 2012).

Factors related to perceived safety are prospect, refuge and escape. In terms of patient room design, prospect is linked to visual mastery, desirable view and lightning which can detect danger and cleanliness of a room (van Nijhuis, 2017). Refuge can translate as storage space for belongings (hiding valuables and keeping accessories). Escape can be defined as observation of and accessibility to personnel (in addition to companions of patients, personnel are also a source of security for them) (Persson et al., 2014) and ability to call support (Schreuder et al., 2016). Additionally, Many design and construction concepts considered scalability, adaptability, and flexibility of the spaces as safety principles of design for healthcare facilities (Reiling, 2006).

2.4. Social support

Researchers use the term "social support" as the emotional, informational, and tangible support for patients. In one's daily life, social support is received from family and people nearby. When a patient is hospitalized, the need for social support increases because a sudden and stressful situation occurs, but access to this normal support is restricted. Social support reduces the effects of a stressful situation (Herweijer-van Gelder, 2016; van Nijhuis, 2017). In previous studies, two strategies to increase social support have been introduced. The first relates to informal caregivers such as close friends and family by adopting caregiver's role as companions, assistants, representatives, navigators, and planners (Miller et al., 2016). The other strategy refers to social relations that result, for instance, in interaction with other patients. This kind of social interaction might form at different levels, from passive contacts to actual conversations (Mogensen, 2011). Social interactions have been recommended as a bridge from the healthcare environment to the surrounding community in several studies, and design should be a reminder of healing, health, caring, and compassion (Anåker et al., 2017).

Social support can be increased through single-patient rooms, private areas, access to communal spaces, spaces that draw patients out of their single rooms (Anåker et al., 2019), lounges and rooms for group consultation, comfortable and moveable furniture arranged in small flexible grouping (Shepley et al., 2016; van Nijhuis, 2017; Zimring et al., 2004), provision of additional services such as internet (van Nijhuis, 2017), carpeted rooms (Salonen et al., 2013; Zimring et al., 2004) and spaces without predicted or prescribed functions that enable immediate and spontaneous activities (Iyendo et al., 2016).

2.5. Positive distraction and homelike environment

Healing is a gradual phenomenon that is obtained over time. Balance and coordinated set of mind, body, and soul occur in the home, community, and nature (DuBose et al., 2016). A more 'homelike' atmosphere that "break down the formality of a normal hospital" rather than a traditional health facility environment (Payne et al., 2015) is constantly desired by patients (Jellema et al., 2019) and modern care programs (Devlin & Arneill, 2003).

Strategies that evoke a feeling of being at home depend on whether the space is private or public. In public places, creating a familiar atmosphere in a strange and unknown space, "recognizability", is the main factor and is derived through activities or symbols that are memorable (Mogensen, 2011; Öhlén et al., 2014). In private rooms, "personalization" through provision of daily living activities (DuBose et al., 2016; Öhlén et al., 2014), being with family members, pleasant designs using paintings on walls and views from windows, and being surrounded by personal items without disturbing other patients or being disturbed by them implies feelings of being at home (MacAllister et al., 2016; Persson et al., 2014). Jellema et al. suggest seasonal decorations as markers in time to enhance the homely environment (Jellema et al., 2019). For instance, in Maggie centres designs, metaphors of a house- big kitchen table, living rooms, and a fireplace - and small-scale designs are reminders of the concept of the homely environment. (Van der Linden et al., 2016).

Positive distraction is associated with a new approach shifting patient's attention away from the institutional environment of hospitals and painful procedures to visual stimulation and small set of environmental features that reduce stress (E. R. Huisman et al., 2012; Zimring et al., 2004). It has been well established that internal and external perspectives of green areas (Capolongo, 2016), indoor plants (Dijkstra et al., 2008; Jamshidi et al., 2020), artworks and its aesthetic aspects

(Awtuch & Gębczyńska-Janowicz, 2017; Iyendo & Alibaba, 2014), furniture (mainly providing more comfortable chairs) (Luo, 2017; Selami Cifter & Cifter, 2017), softer lighting, and colour (Salonen et al., 2013) improve patient mood and provide a supportive environment.

A summary of the aforementioned factors and related physical solutions are presented as follows:

Effective factors and related physical aspects/design strategies:

Control:

- The proper size of space, brightness, and extent of view can decrease effect of crowding
- Flexible seating arrangement; control over the temperature, light, and the volume and type of music in their rooms; architectural design that supports accessibilities for disabled patients; design healthcare layout and wayfinding to reduce disorientation
- Freedom to choose daily activities and allow access information
- Considering universal design requirements in circulation

Privacy:

- Private rooms or spaces
- Solid walls instead of curtain walls

Safety:

- Provide prospect, refuge and escape
- scalability, adaptability, and flexibility of the spaces

Social support:

- Single-patient rooms, private areas
- Lounges and rooms for group consultation, communal areas
- Comfortable and moveable furniture arranged in small flexible grouping
- Provision of additional services such as internet and the provision of decent meals for families
- Carpeted rooms
- Spaces without specific or prescribed functions

Positive distraction and homelike environment:

- Single patient room (personalization in private space)
- Recognizability, memorable functions, activities, or elements, (in public place)
- pleasant design with lighting, views, exposure to nature (view of nature from a window, images of nature, and indoor plants), colour, and artwork, comfortable furniture, seasonal decorations

Strategies and solutions mentioned in the literature review are the result of different contexts studies and mainly consider a variety of cultures and choices. For instance, in regards the issue of privacy in hospital design, some cultures prefer single patient rooms while others prefer multi-patient rooms. For such contradictory results, a combination of single and multiple- patient rooms for various preferences and purposes is suggested as a middle ground (Taylor et al., 2018). In addition to estimating the main preferred option in each context, providing an optional choice is

essential. Another instance is using of culture and context affecting preferences is positive distractions such as pictures of nature suggested by earlier studies. Abstract forms might be attractive for some people but irritating for others. Thus, further research in each context is necessary to approximate patients' preferences of overall atmosphere of their lodgings.

It is crucial to underscore the significance of environmental factors, which are considered fundamental in healthcare design and are frequently highlighted in the literature as determinants of positive healing outcomes. For example, the integration of natural light in patient rooms has been demonstrated to increase quality of sleep, mitigate symptoms of depression, and decrease hospital length of stay (Aries et al., 2015; Park et al., 2018). Similarly, acoustic quality plays an important role and can be improved through the use of sound-absorbing flooring and ceiling tiles, as well as architectural strategies that physically separate patient rooms from high-noise areas. In addition to these, air quality and adequate ventilation are vital components that further enhance the healing environment (Zhang et al., 2018). Collectively, these design considerations substantially contribute to promoting patient well-being and accelerating recovery.

3. Method

The study used a qualitative method to discover effective factors and a quantitative method to select preferred physical solutions among possible and recommended methods of obtaining satisfactory results. First, the basic principles of healing environments framework for attaining stress-less and supportive environments were reviewed in the existing literature. Since there was a variety of related physical aspects, a questionnaire was used to find users' choices and preferences. This research was part of a larger study where the post occupancy evaluations of three buildings with the same function were explored. Therefore, different characteristics of those buildings inspired some options used in the questionnaire. Initially, a draft open-ended questionnaire (meaning descriptive questions) on medical traveller needs was prepared and distributed in limited numbers. Based on the aforementioned process, a comprehensive multiple-choice questionnaire was created. The final format included three categories of questions: the first category asked questions on the main differences and characteristics of the patient hotel, the second category investigated patient room features, while the third covered questions on social spaces.

In the next step, to investigate the validity of the questions, the questionnaire was re-edited and approved under the supervision of three experts in architecture, urban planning, and health policy management.

3.1. Data collection and participants

The questionnaire was prepared in two languages: Persian and Kurdish. The survey was conducted with 112 participants from 2 hostels and a hotel for medical travellers in Sanandaj, Zanjan, and Tehran (three of the medical tourism destinations in Iran). Medical travellers were mainly patients and families from deprived regions who had travelled to have access to hospitals and care in more advanced cities.

Figure 2 shows the interior spaces of the Nikan Hotel in Zanjan, Iran and the figure 3 shows the patients' room. This hotel, which is a part of Mehraneh Clinic, is particularly for patients' who suffer from cancer.

Figure 2. interior spaces of Nikan Patients' Hotel in Zanjan, Iran (reference: www.mehranehcharity.ir)



Figure 3. Rooms of Nikan Patients' Hotel in Zanjan, Iran (reference: www.mehranehcharity.ir)

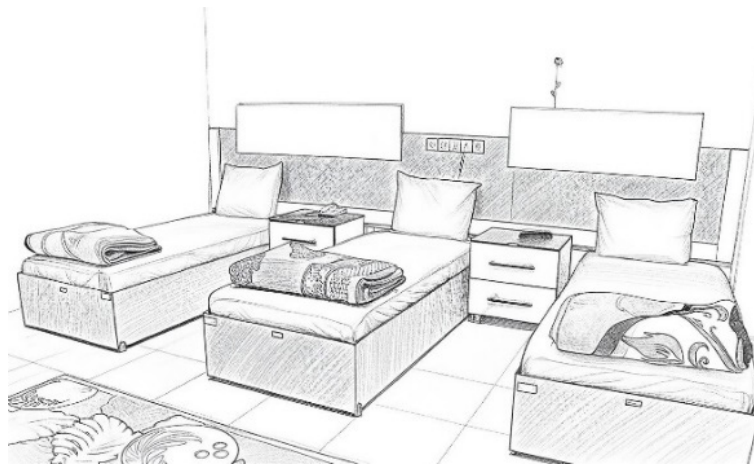


Table 1. Demographic profile of participants.

variable	Scale/ category	N	%
Role	patient	30	26.78
Role	Patient family	75	66.96
Role	Not mentioned	7	6.25
Age (yr)	15-25	13	11.60
Age (yr)	26-35	38	33.92
Age (yr)	36-50	39	34.82
Age (yr)	50 and Older than 50	13	11.60
Age (yr)	Not mentioned	9	8.03
Gender	Male	59	52.67
Gender	Female	48	42.85
Gender	Not mentioned	5	4.46
Reason for residence	Cancer radiotherapy	59	52.67
Reason for residence	Accompany child patient	12	10.71
Reason for residence	Sterility and infertility	4	3.57
Reason for residence	other	3	2.67
Reason for residence	Not mentioned	34	30.35
Residence duration	Less than 7 days	1	0.89
Residence duration	7-30	17	15.17
Residence duration	30 and more than 30 days	68	60.71
Residence duration	Not mentioned	26	23.21

4. Results

The demographic profile of the respondents is presented in Table 1. Of the 112 respondents, 59 (52.67%) were male, and 48 (42.85%) were female. 75 (66.96%) of the participants were patient companions, and 30 (26.78%) were patients. Fifty-nine respondents (52.67%) were cancer patients undergoing radiotherapy.

4.1. Special features of the patient hotel

Figure 4 illustrates the preferences of medical travellers as regards the specific features of the patient hotel. The first question asked the possible advantages of a patient hotel, and the main reason for using these hotels from the user's point of view in Iran. The majority of respondents (54%) emphasized that staying in a patient hotel saves time and money by enabling access to medical treatment and recovery in an adjacent area. Other responses included safety due to access to medical services (33%), ensuring the quality of recovery (23%), and stay in a hotel in a hotel with a greater privacy (2%).

The second question concerned the main differences in the design of this type of hotel from other hotels. The most frequent response (45%) highlighted patients' physical needs as a critical design concern. Psychological support and the provision of spaces for group consultation accounted for 26% of responses, existence or absence of special functional spaces accounted for 23%, while increase the size and features of the room was cited by 17%.

The last question investigated preferable theme in the design of these hotels. The largest proportion of respondents (42%) indicated a preference for a home-like environment, 26% emphasized integration with the therapeutic environment, (22%) prefer integration with natural environment, and 21% highlighted the importance of improving the social support environment.

Figure 4. Percentage of each option in patient hotel attributes questionnaire.

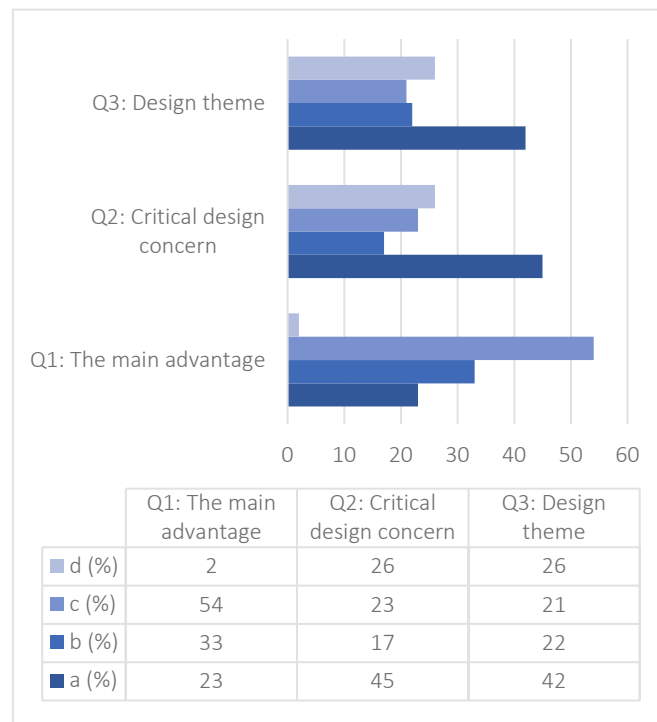


Figure 5 and 6 show the differences between patients and their companions' viewpoints about question 1 and 2 respectively. Items a, b, c, and d in figures are the very items in figure 4.

In figure 5, among patients, responses were distributed across three main options: quality of recovery period and facilitation of long-term treatment (a: 20%), safety due to access to medical services (b: 40%), and saving time and money for treatment and recovery in an adjacent area (c: 40%). None of the patients selected privacy as the main advantage (d: 0%).

By contrast, patients' companions emphasized option c (saving time and money by receiving treatment and recovery together in an adjacent area), which accounted for nearly 50% of their responses. Option b (safety due to access to medical services) received 24%, while 22% valued the quality of recovery period or facilitate the long-term treatments. Only 2% considered privacy (option d) as the most important advantage.

Figure 5. Differences between preferences of medical travellers' opinion

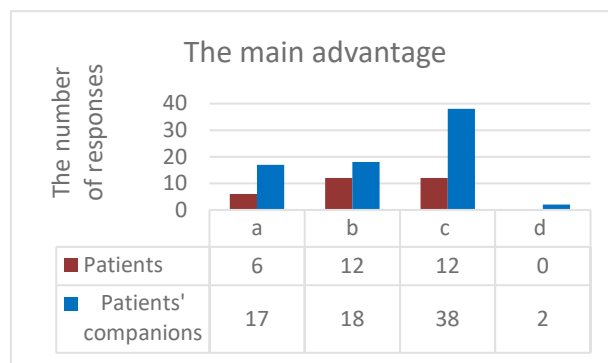
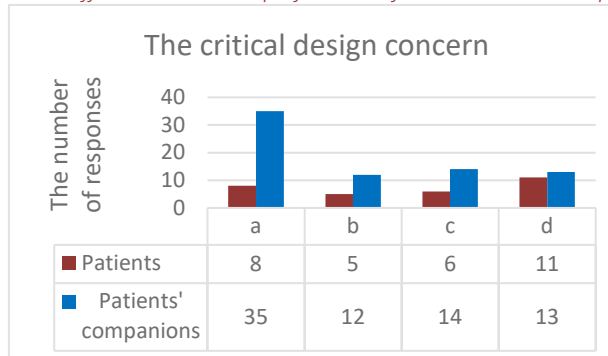


Figure 6 presents that, among patients, 26% emphasized option a (design according to patients' physical needs), while smaller shares selected option b (increasing the size and features of the room, 16%), option c (existence or absence of special functional spaces, 20%), and option d (the presence of a counselor and increased psychological support, 36%). In comparison, patients' companions strongly prioritized option a, with 47% emphasizing the importance of designing according to patients' physical needs. The other concerns received relatively similar levels of attention: option b (16%), option c (18%), and option d (17%).

Figure 6. Differences between preferences of medical travellers' opinion



4.2. Accommodation

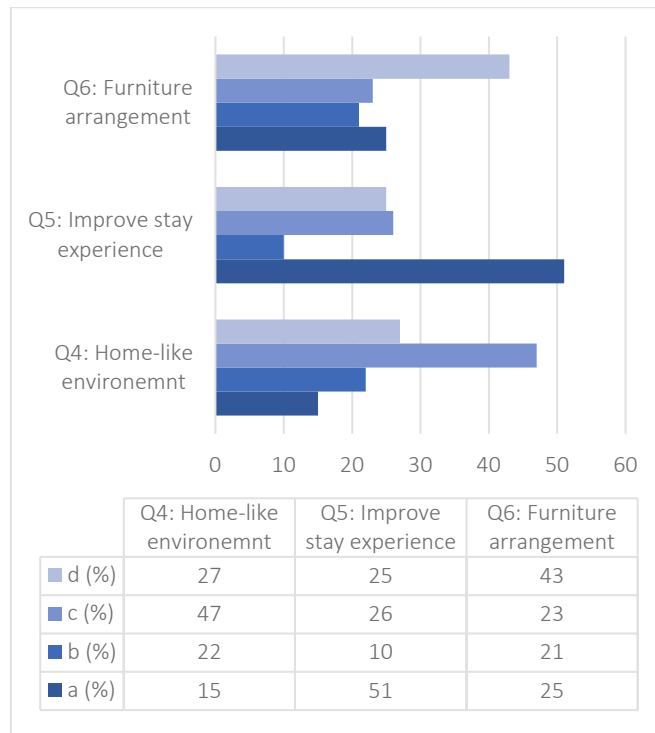
Participants in the present study were questioned on room design considerations such as the arrangement of furniture, the improvement of the accommodation experience, and the creation of a home-like atmosphere. The preferences of the respondents in regards possible physical solutions and options are presented in Figure 7.

For Question 4 which asked what makes medical travelers feel at home, nearly half of the respondents (47%) emphasized the importance of privacy as the key factor in creating a sense of being at home. Comfortable furniture, natural materials, and textures were mentioned by 15%, while 22% highlighted the possibility of engaging in daily activities, and 27% pointed to the need for more options for family or supporters.

In Question 5 preference regarding improving the stay experience was asked. The most frequent response (51%) referred to the addition of more spaces and amenities, such as mini-kitchens or storage areas. 26% of participants emphasized the open/close space syntax, 25% chose the use of artworks and plants in the room, while 10% highlighted the value of incorporating self-supporting systems into rooms.

For Question 6 regarding the proper furniture arrangement, 43% of respondents preferred flexible arrangements that allow furniture to adapt to different uses. Fixed arrangements accounted for 25%, while 21% of participants suggested multifunctional furniture, and 23% supported room partitioning to create adaptable zones

Figure 7. Percentage of each possible physical solutions in the room's design consideration.



4.3. Public spaces

Figure 8 provides respondents' preferences and opinions on public spaces, the degree of social interaction, and the style of details and decorations ("recognizability" in public spaces for creating a home-like atmosphere).

For Question 7, decoration and details' style related question, 42% of respondents preferred the use of plants, while 32% highlighted patterns inspired by traditional architecture. In contrast, abstract forms received only 5% of responses, and 30% supported the use of natural patterns.

Regarding Question 8 which seeks the degree of social interaction that respondents preferred, 44% of participants expressed a preference for "talking with others" as the most desirable form of interaction. Group activities such as participating in shared tasks were chosen by 35%, while

15% preferred to sit and observe others and being seen by others, and another 17% highlighted the option of see others without being seen.

For Question 9 explore social interaction spaces and public places that attract medical travelers, the majority of respondents (51%) emphasized surrounding areas and green spaces as the most important settings for interaction. Designed pavilions in the open spaces were selected by 26%, while 21% preferred lounges and interior public spaces, and only 11% highlighted the use of green roofs and public terraces.

Figure 8. Percentage of each option or physical solution regarding public spaces.

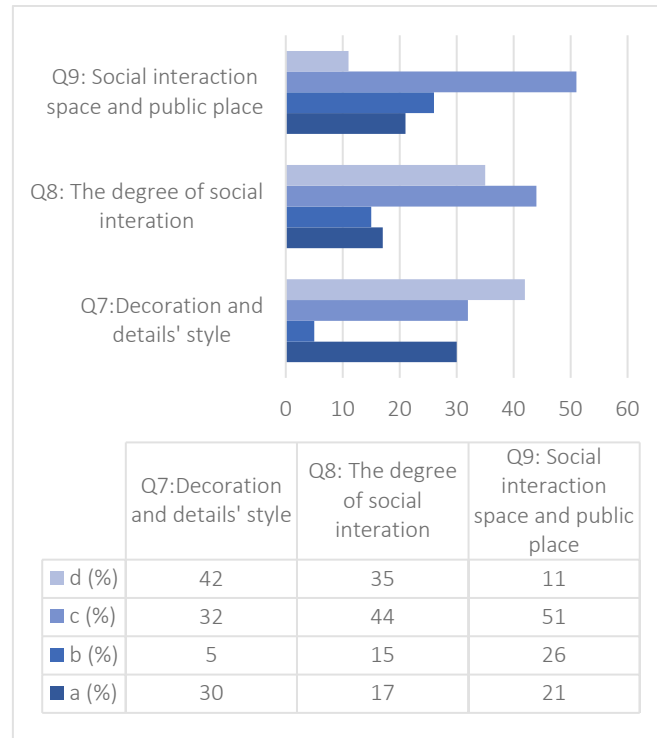


Figure 9 and 10 show the differences between patients and their companions' viewpoints about question 7 and 8 respectively. Items a, b, c, and d in figures are the very items in figure 8.

Figure 9. Differences between preferences of medical travellers' opinion

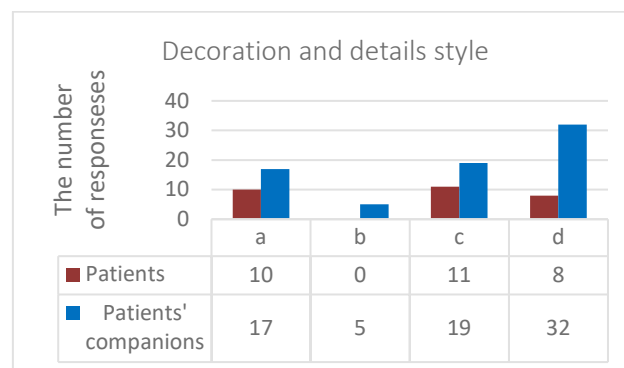


Figure 9 shows that, among patients, the most frequently selected option regarding decoration and detail style in patient hotels was c (applying traditional architecture), chosen by 36%. This was followed by a (forms derived from natural patterns, 33%), d (using plants, 26%), and b (applying abstract forms), which received no responses. In contrast, patients' companions

showed a different pattern of preferences. The highest proportion (43%) highlighted the use of plants (option d), followed by applying traditional architecture (option c, 26%), and forms derived from natural patterns (option a, 23%). Only 6% of companions supported abstract forms (option b).

Figure 10. Differences between preferences of medical travellers' opinion

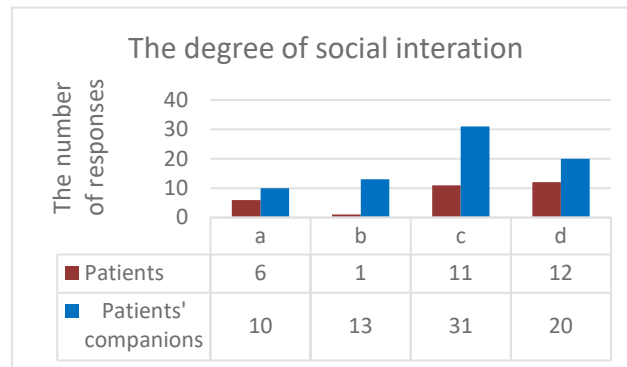


Figure 10 summarizes the responses of patients and their companions regarding the most desirable types of social interaction spaces. Among patients, the most frequently selected option was d (green roofs and public terraces), chosen by 12 participants. Options c (surrounding area and green spaces) and a (lounges and interior public spaces) followed closely with 11 and 6 responses, respectively, while only 1 participant selected option b (designed pavilions in open spaces). Patients' companions, however, placed a stronger emphasis on outdoor spaces. A total of 31 respondents (option c) preferred surrounding areas and green spaces, followed by 20 who emphasized green roofs and public terraces (option d). Lounges and interior public spaces (option a) received 10 responses, and designed pavilions in open spaces (option b) were selected by 13 companions.

Except for questions 1, 2, 7, and 8 in other questions, the preferences of patients and their companions match with each other.

5. Discussion

In the first question which the main advantage of staying in a hospital hotel compared to other hotels was asked, near half of respondents believed that staying in a patient hotel saved both time and money due to receiving medical services and recovery in an adjacent area. According to patients' answers patients' hotel adjacency result in access to facilities and medication, provide emergency care and safety for them, that's another reason for them to prefer to stay in a patients' hotel. These insights underscore the critical importance of spatial proximity between the patient hotel and the hospital, suggesting that hospital campuses and their surrounding neighborhoods are among the most strategic locations for establishing patient hotel as an independent facility. Nevertheless, despite the strong preference for adjacency, combining the hotel and hospital within a single building may reduce the restorative and hospitable qualities of the hotel while disrupting the functionality of the medical environment. Therefore, it is important to maintain a location that is close enough to ensure accessibility, yet sufficiently independent to preserve both functions.

In the second question, respondents were asked to identify the most critical design concern in a patient hotel. The greatest concerns (40.17% of responses) related to patients' physical needs, such as installing handrails in corridors and sanitary spaces. Accordingly, as mentioned in the

literature review, meeting the requirements of universal design and addressing issues such as minimizing floor-level differences in planning, providing appropriately sized corridors and lifts for comfortable movement, ensuring sufficient signage and accessible entry and exit points, supplying shower chairs or benches and accessible sanitary fittings in toilets, and providing beds and furniture that support people with disabilities must be addressed to meet patients' needs (Piramanayagam, Pritam, & More, 2019).. Moreover, in addition to these physical requirements, patients highlighted the importance of spiritual and psychological support for example through the presence of consultants or counsellors. Therefore, compared to a typical hotel, allocating spaces for supportive care functions rather than leisure facilities appears to be a necessary consideration in patient hotel design. In the analysis of Question 3, which explored the essential components of hotel design that contribute to improving patients' mood, the most frequently reported factor was the presence of a home-like atmosphere (37.5%). This finding highlights that patients value continuing their treatment in environments that evoke a sense of home, thereby fostering comfort and psychological relief. Such results are consistent with human-centered design approaches, which emphasize that highly formal environments are less effective in reducing stress, whereas familiar and home-like settings enhance emotional well-being. Importantly, this question serves as a key indicator in identifying the proper theme for patient hotel design, demonstrating that a home-like and supportive atmosphere should guide the overall design direction in the analysis of Question 4, which addressed the creation of a home-like atmosphere, the respondents most frequently emphasized privacy (41.96%) as the factor that best evoked a sense of home. This suggests that patients and their families associate privacy with comfort and emotional security, making it a cornerstone of home-like design in patient hotels. Based on these findings, it can be inferred that lodging facilities resembling hostels for medical travellers are perceived as less effective in meeting patients' needs compared to facilities designed in the form of hotels, where privacy is more strongly embedded in the spatial layout.

In the analysis of Question 5, which focused on improving the patient hotel stay experience, the most frequent response (45.53%) referred to the addition of spaces and amenities such as a mini-kitchen and study area, thereby enhancing the functional capacity of the room. Providing greater functionality within the room creates an adaptable environment for different situations and strengthens patients' and families' sense of control and safety. These findings suggest a hierarchy of needs in accommodation spaces: privacy—primarily ensured through private rooms—represents the foremost priority, followed by the functionality and capabilities of the room, and subsequently aspects such as positive distractions and other supportive features.

In the analysis of Question 6, which addressed room arrangements within a fixed area, 38.39% of respondents preferred a flexible layout in which the bedroom could be transformed into a living room during the day. Given the number of rooms in a hotel, providing diverse layouts according to users' preferences and needs appears to be a practical solution. Observations further suggest that flexible arrangements not only enhance the sense of control and enable a wider range of activities but also significantly strengthen social support, as medical travellers often gather and visit one another in their rooms. This finding also highlights the difference between a hospital room and a patient hotel room: there is no need for the same degree of functionality as in a hospital room, nor for the luxury associated with a hotel room. Rather, what is required is flexibility—allowing a room to shift seamlessly between daily occupancy and restful recovery. Such adaptability optimizes the use of limited space while simultaneously enhancing patient comfort and satisfaction. In the analysis of Question 7, which focused on details and decorative styles for public and private spaces, most of the responses (37.5%) highlighted the use of plants and greenery. Patients also expressed a preference for design styles inspired by

traditional architectural patterns in both public and private areas. These findings are consistent with previous studies that recommend incorporating plants and natural or familiar patterns. In contrast, abstract forms and patterns were less preferred by respondents, a result that is also supported by prior research presented in the literature review.

In the analysis of Question 8, which addressed the desirable degree of social interaction, the majority of respondents (39.28%) indicated that “talking with each other” was most important. As communication with other medical travellers represents a key source of social support, incorporating sociopetal rather than sociofugal settings in public spaces should be an essential design consideration. In addition, patients emphasized the value of participating in group activities, such as growing plants. This interpretation aligns with previous definitions of public spaces as “freely and publicly accessible places” that encourage and facilitate social interactions and activities (Ferwati et al., 2021). In particular, the provision of spaces for horticultural activities has been recommended by prior studies, while creative, substantial spaces for artwork and other social activities also appear to be effective in patients’ hotel contexts.

In the analysis of Question 9, which addressed creating spaces for social interaction, 45.53% of respondents preferred the use of surrounding green spaces and grass lawns. While existing studies have highlighted the positive effects of outdoor areas on patients’ well-being, further research is needed to identify the most effective strategies for designing healing gardens and green areas in patient hotels. Moreover, applying universal design principles in outdoor spaces is essential to ensure accessibility and usability for all patients and their families. Principles such as maintaining appropriate path length and width, providing seats with arms and backrests at specific intervals, creating separate paths for service and emergency vehicles, designing curb stones with inclined side surfaces at pedestrian crossings, and ensuring the availability of proper indicators and handrails represent essential considerations in outdoor design for medical travellers.

6. Conclusion

Ensuring health equity requires equitable access to advanced medical services. However, patients in disadvantaged or remote areas often encounter substantial barriers, such as long travel distances and high lodging costs, which may force them to delay or even discontinue care. These challenges highlight the need to develop dedicated patient hotels that provide a more supportive experience than conventional hospitality facilities. Hotels for medical travellers must be distinguished from hotels designed for the general public. The questions in this study revolved around three main design dimensions: (1) the overall design theme of patient hotels and their key differences from other types of hotels, (2) the features of patient rooms, and (3) the outdoor areas and design details. The findings of this research are summarized as follows:

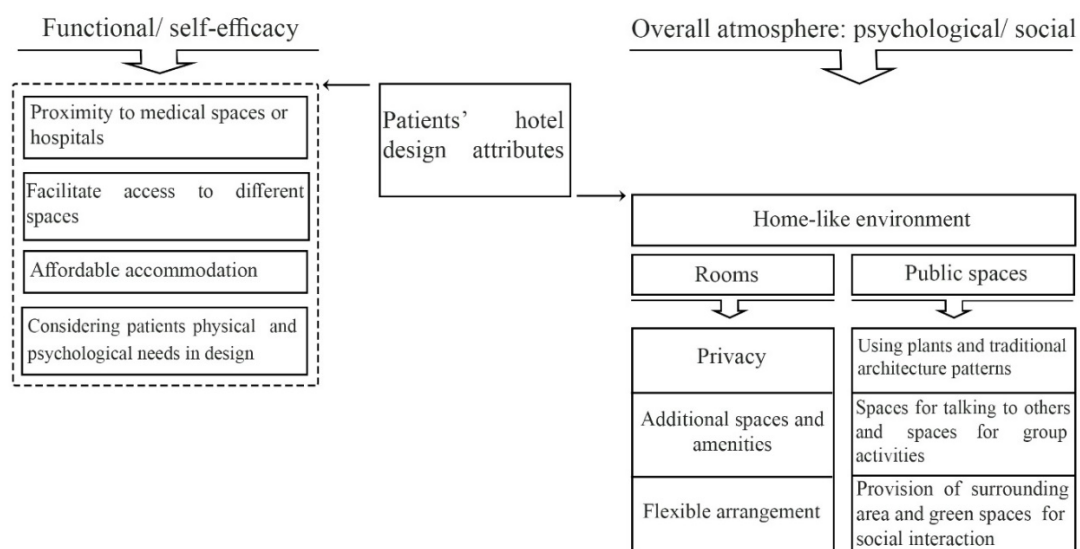
-These hotels, based on the medical travellers’ perspective, should be affordable. Therefore, instead of providing luxuries such as those in leisure hotels, it is essential that patient hotels are designed to meet patients’ physical and mental needs. Based on the literature, addressing patients’ physical needs requires design solutions that comply with the principles of accessibility and design for all. In particular, ensuring that furniture, amenities, pathways, and parking facilities meet universal standards can directly support usability and comfort for diverse patient groups. Also, patients’ answers shows that they need spaces for more mental support which is aligned with recent approaches of designing hospitals and healthcare’s that focus on human-centre environments, healing environments and meditate formal environments.

-In addition to the patient room's physical standards such as natural light, ventilation, and acoustics, rooms should have a flexible layout and have a greater number of amenities such as mini-kitchens and storage space. Such design strategies create a restorative environment while simultaneously allowing patients to maintain aspects of routine daily life within a limited area which according to previous studies increase control and patients' comfort.

-Moreover, responses show that these hotel buildings should be in harmony with the surrounding nature or have enough green space to create the desired view and access for users' social interactions. Participants preferred familiar and nature-based patterns in design, while showing little interest in abstract forms—an outcome that is consistent with the recommendations of other studies.

Figure 11 presents the conclusions based on the findings in diagrammatic form for wider use.

Figure 3. Classification of medical travellers' preferences for patients' hotel attributes (reference: authors)



Regardless of the fact that a patient hotel encounters users with different backgrounds, functional aspects of the patient hotel must be formed based on the patient's physical and other needs, which are mostly constant. On the contrary, preferences about the overall atmosphere of the patient hotel vary according to different contexts and backgrounds; however, considerations such as increasing the choice and use of natural elements in the design, which is compatible with most human preferences, can generalise the results. In other words, features that mentioned the overall themes and features of patients' hotel in functional aspects can consider as general principles, while some other choices that are presented as psychological and social aspects can be vary based on cultural values. Therefore, studies that evaluate different context or other samples of patients' hotel which provide more information and valid interpretation are needed.

Patient hotels can play a vital role in ensuring equitable access to advanced medical services, although their design needs to be affordable, align with universal design principles, and applying user preferences regarding healing environment concept.

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Appendix

Questionnaire format

- 1) Which of the below is the main advantage of a patient hotel in comparison with an ordinary hotel?
 - a) Quality of recovery period or facilitation of long-term treatment.
 - b) Safety due to access to medical services.
 - c) Save time for medical treatment and recovery by staying in an adjacent area.
 - d) Stay in a hotel with greater privacy.
- 2) What is a critical design concern in designing a patient hotel?
 - a) Design according to patient physical needs (e.g., handrails for corridors and sanitary spaces).
 - b) Existence or absence of special functional spaces (e.g., library, gym, ...).
 - c) Increase the size and features of the rooms.
 - d) The presence of a counselor and increased psychological support.
- 3) Which of the following design theme do you find most effective in designing a hotel to improve your mood?
 - a) Homelike environment.
 - b) Integration with the natural environment.
 - c) Improving the social support environment.
 - d) Integration with the therapeutic environment.
- 4) What makes you feel at home?
 - a) Comfortable furniture, natural materials and texture.
 - b) Possibility of various daily activities.
 - c) A sense of privacy.
 - d) More possibilities for family accompanying.
- 5) Which of the following options is a priority to improve your experience of staying in this room?
 - a) Additional spaces and amenities for increasing living capacity of the room (e.g., mini kitchen or studying space)
 - b) Using self-supporting system for greater control over lighting, acoustic and environmental conditions.
 - c) Open and close space syntax (personal terrace for each room).
 - d) Use artworks and plants in rooms.
- 6) Which of the following furniture arrangement is best suited for your needs in a fixed-size room?

a) Fixed arrangement.

figure 12. the concept of fixed arrangement



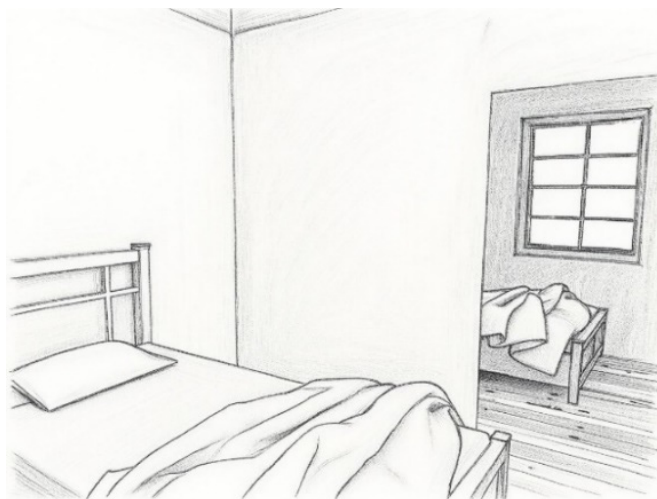
Multifunctional furniture (a couch which can be converted into a bed).

figure 13. the concept of multifunctional furniture



b) Room partitioning for different daily activities.

figure 14. the concept of defining different zones within a room by a partition



c) Flexible arrangement.

figure 15. the concept of flexible arrangement in the restorative setting alternative.

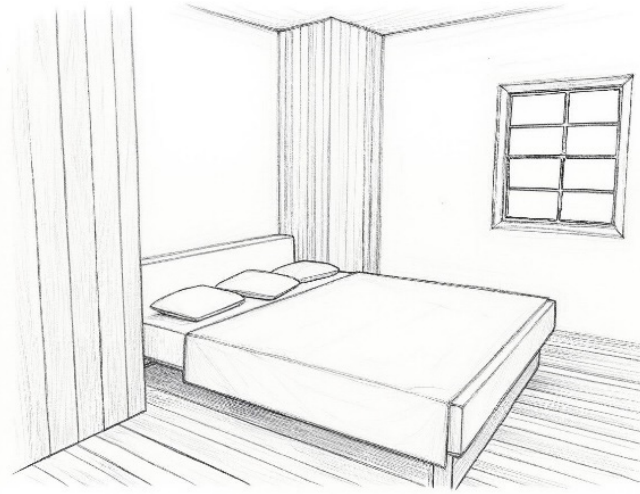
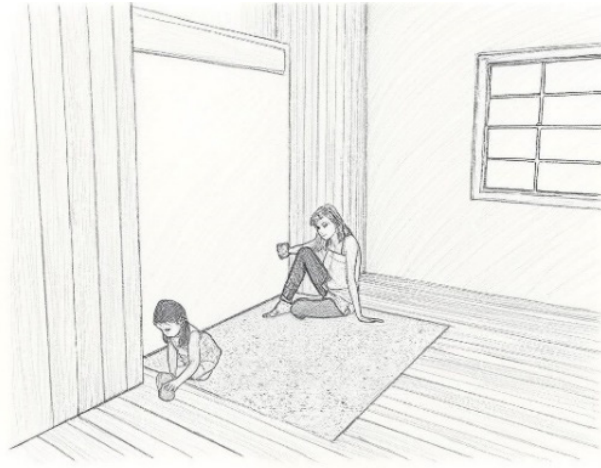


figure 16. the concept of flexible arrangement in the social and family interaction setting



- 7) Which style do you think is more appropriate for details and decorations in public and private spaces?
 - a) Forms derived from the natural pattern.
 - b) Applying abstract form.
 - c) Applying traditional architecture.
 - d) Using plants.
- 8) What degree of social interaction do you prefer?
 - a) Sit somewhere and see others.
 - b) See others and they see me.
 - c) Talk to others.
 - d) Participate in a group activity.
- 9) Which of the following spaces do you prefer to use for social interactions?
 - a) Lounges and interior public spaces.
 - b) Designed pavilions in open spaces.
 - c) The surrounding area and green spaces.
 - d) Green roofs and public terraces.

Novel method to explore the efficiency of e-commerce websites for persons with disabilities

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Abstract: With an expanding number of e-commerce websites, many people with disabilities rely largely on online purchasing because they find it difficult to travel freely. However, many users, including those with disabilities, are unable to access the website's content, creating an inequitable barrier for people with visual impairments. Many websites are sometimes accessible, but it takes a while to understand what the website's effectiveness means. Therefore, this paper proposes a novel method entitled AMEEW (A Method to Examine the Efficiency of Websites), which computes the efficiency of websites for persons with disabilities. The purpose of the paper is to evaluate the most popular e-commerce sites and provide guidance to website designers on how to create effective websites that are easy to use for all user groups, including those who are disabled. Initially, the data are analysed using four plots, including a run sequence plot, lag plot, histogram, and normal probability plot. The experiment's findings indicate that 5.08% of top e-commerce websites are ineffective for those with visual impairments.

Keywords: Accessibility, Readability, E-Commerce, Efficiency, Exploratory data analysis, People with Disabilities

1. Introduction

E-commerce has altered the way that companies and consumers communicate on a global scale. While providing consumers with the ease of purchasing at any time and from any location, it enables businesses to sell globally. By eliminating the need to visit physical locations, internet shopping can benefit persons with impairments. According to (*International Trade Administration, U.S., 2024*), it had an 18% proportion of all worldwide retail sales in 2020 and is expected to rise at a rate of over 1% annually, reaching a roughly 22% share of all global retail sales by 2024, depicted in Figure 1. Because increasing accessibility attracts a wide range of visitors, regardless of their disability, it helps e-commerce companies continue to grow. Additionally, accessible e-commerce platforms help people with disabilities avoid physical infrastructure constraints. Around 15% of the world's population, of which 2-4% have serious functional challenges, live with a disability, according to the (*World Report on Disability, 2018*) study. Globally, 2.2 billion people live with near or distance vision impairment, and at least 1 billion of these cases could have been prevented or remain unaddressed due to gaps in access to eye care, affordability, or awareness (*WHO, 2023*).

Figure 1: Global retail e-commerce sales worldwide from 2014 to 2024 (in billion USD)



Universal accessibility stands as a foundational principle of the World Wide Web, as articulated by its creator, Tim Berners-Lee. This principle demands that e-commerce platforms maintain fully accessible interfaces, ensuring equal access for users regardless of disabilities. Tim Berners-Lee believes that the web's strength lies in its ability to be accessed by everybody, regardless of disability (Berners-Lee, T., 2013). Accessibility aims to create products or web content enabling everyone to perceive, comprehend, engage with, navigate, and interact with all aspects of the real and digital environment (Sonowal, 2023). Accessibility enables persons with visual impairments to explore, communicate, and engage autonomously in a world built for the sighted.

Additionally, a key feature of the website is its readability. However, a persistent challenge remains: while many websites strive to be accessible, not all users can comprehend the language in which the content is presented. Thus, readability estimates a text's quality by determining how simple it is to read. The content offered by numerous websites is often difficult to comprehend due to poor readability. Therefore, readability ensures that information is clear and understandable, allowing people with visual impairments to conveniently access content via screen readers, magnifiers, or Braille displays.

It can be observed that readability and accessibility are considered crucial elements in achieving the standards of a practical website for persons with visual impairments. In addition, accessibility and readability are not limited to people with visual impairments; they also include people with cognitive disabilities. Clear design, plain language, and predictable navigation allow people with dyslexia, ADHD (attention-deficit/hyperactivity disorder), memory problems, or learning difficulties to participate independently and confidently.

In recent years, there has been growing recognition of the importance of website accessibility and readability for people with disabilities, reflecting a broader commitment to inclusive design as a fundamental human right (Sonowal, 2025). Existing literature has proposed diverse methodologies to enhance website accessibility and readability, along with guidelines to address existing shortcomings. However, to the best of our knowledge, no prior study has systematically evaluated the efficiency of websites in meeting the needs of users with disabilities. In this context, we define efficiency as the extent to which a website concurrently fulfils accessibility and readability criteria, thereby reducing the time required for users to accomplish tasks. To address this gap, we introduce a novel metric for quantifying website efficiency, derived from the harmonic mean of standardised readability and accessibility error scores.

The objectives of this study are

- To evaluate website accessibility using AChecker, a standardised web accessibility evaluation tool;
- To assess readability through six established readability algorithms;
- To analyse data patterns using four diagnostic plot methods (run sequence, lag plot, histogram, and normal probability plot);
- To propose and validate the novel AMEEW (Accessibility and Measured Effectiveness Evaluation for Websites) methodology by comparative analysis with existing approaches.

The structure of the paper is given below: Section 2 conducts a systematic review of the literature on web accessibility and readability, analysing their critical role in removing barriers to digital inclusion for diverse users. The proposed method of the paper is explained in Section 3. Section 4 analyses the data under four key assumptions: random sampling, fixed distribution, fixed location, and fixed variation. The result of the experiment is shown in Section 5. Section 6 discusses the issues of the proposed method while evaluating and depicting the conclusion of the paper shown in Section 8.

2. Related Works

The literature on website accessibility outlines a variety of problems based on inaccessible website content and offers a large selection of strategies to lessen the force of the obstacles.

(Akgül, 2024) evaluated 112 national e-government websites in Turkey, focusing on public values such as accessibility, public participation, transparency, security, service quality, and accountability. It also assesses usability through criteria like bounce rate, design optimisation, and page response time. Readability is measured using Flesch–Kincaid Reading Ease, Grade Level, and Gunning Fog Index. Findings indicate significant shortcomings in e-government services in Turkey, with poor usability, performance, readability, and security. The study highlights critical implications for policy and practice, suggesting that current Turkish e-government websites need substantial improvement in design, usability, and public engagement to enhance overall effectiveness.

(Campoverde-Molina et al., 2023) conducted a systematic literature review (SLR) to consolidate, analyse, and interpret accessibility findings from 42 studies on university websites. Using Kitchenham’s SLR methodology, the review examined 38,416 web pages, 91,421 YouTube videos, and 28,395 PDFs from 9,140 universities across 67 countries. Evaluations employed manual, automated, and combined methods, with most sites assessed against ISO/IEC 40500:2012 and Section 508 standards. Commonly violated accessibility guidelines include adaptable, compatible, distinguishable, and keyboard accessible. The review reveals widespread accessibility issues in university websites and media, highlighting critical trends and areas for improvement in global higher education institutions.

(Macakoğlu et al., 2023) analysed the accessibility, performance, and security of prospective student web pages from 330 universities across Europe, North America, and Oceania. The universities were chosen based on the Webometrics ranking, and automated online testing tools were used for the evaluation. Findings reveal that North American universities scored highest in accessibility and usability, followed by institutions in Oceania and Europe. Compliance with WCAG 2.0 guidelines was generally low across all regions. While no major usability or security issues were detected, several areas for improvement were identified. The study provides

recommendations for developers and administrators to enhance accessibility, usability, and security, ensuring equitable information access for all users.

The expansion of mobile devices has shifted user interaction from desktop to mobile platforms, introducing challenges in usability and accessibility. When desktop websites or applications are rendered on mobile devices, smaller screens and different interaction methods often increase cognitive load, user dissatisfaction, and disengagement. Moreover, many sites fail to cater to users with varying accessibility needs, exacerbating barriers. (Fipke, 2024) Addressed these issues by reducing cognitive load in mobile applications and enhancing accessibility, making systems more user-friendly for all. It specifically investigates the usability improvements and challenges of adapting a student help system from a desktop to a mobile-friendly version, highlighting the need for accessible design to meet diverse user requirements.

(Acosta-Vargas et al., 2022) analysed fifty of the best-ranked 50 e-commerce websites based on the e-commerce DB classification. They used an automatic review technique based on a modification of the Website Accessibility Conformance Evaluation Methodology (WCAG-EM) 1.0 to assess the online accessibility of e-commerce sites. The Web Accessibility Evaluation Tool (WAVE) was utilised to assess accessibility. The results showed that, according to Spearman's Rho, there is a low positive correlation (0.329) between the ranking of e-commerce websites and accessibility barriers. Furthermore, the WAVE analysis showed that Nike, Sainsbury's Supermarkets, Walmart, Target Corporation, Macy's, IKEA, H&M Hennes, Chewy, Kroger, and QVC are the top ten most accessible websites. The majority of accessibility obstacles are related to contrast errors, which need to be fixed for e-commerce websites to be made as accessible as possible. Perceivable accessibility is the most neglected principle, accounting for 83.1% of all accessibility, followed by operable accessibility (13.7%), robust accessibility (1.7%), and understandable accessibility (1.5%).

(Macakoğlu & Peker, 2022) provided an analysis of 58 Turkish university hospital websites' accessibility. Two distinct online automated testing tools were used to analyse the websites of the chosen university hospitals for this purpose. The findings indicated that, in terms of WCAG 2.0 compliance, university hospital websites in Turkey had low levels. Even the minimal requirements for compliance level A were not met by the majority of the websites. Approximately one-third of the websites experienced issues with mobile device access, and nearly all of them had broken links. Furthermore, this study also discusses a few significant hints that highlight issues with website accessibility. Using a sample of 65 websites from different ministries, Paul (2023) evaluates the accessibility of Indian e-government websites using the WCAG 2.1 standard. They discovered that most e-government websites do not comply with WCAG 2.1 at Level A. According to the results, to achieve universal accessibility, e-government website designers and developers should give accessibility features careful consideration while creating these websites.

(Balaji & Kuppusamy, 2016) carried out yet another investigation of accessible websites. Achecker, WAVE (Web Accessibility Evaluation Tool), and EvalAccess were all used in the author's investigation of the Indian Railway websites under WCAG 2.0 requirements. The majority of websites were seen to be inaccessible by this paper, which also included an accessibility recommendation.

(V.Balaji & K.S.Kuppusamy, 2017) addressed another intriguing issue about the accessibility issue for those who are visually impaired when browsing the multilingual web. People with visual impairments were used in this study's preliminary study while they browsed multilingual web pages. A 22-question online survey was created for this purpose and placed in the AccessIndia

online community for people with visual impairment. Based on the feedback, it was concluded that the multilingual website had accessibility problems, and recommendations were given for using the internet without any barriers. Digital technologies are being used by a lot of teachers to deliver online courses

(Sonowal, 2021) Zoom is a widely used digital technology that many institutions utilised during the lockdown. Sharing information is a very comfortable process for both the teacher and the student. While regular students seem to be quite happy with this tool, visually impaired students encountered some challenges here. This essay looks at the Zoom app for students who have vision problems. Based on the analysis, it is necessary to improve the Zoom app for students who have visual impairments.

(Kurt, 2017) employed evaluative techniques based on the World Wide Web Consortium and observed that many home pages did not adhere to the minimum criteria for web accessibility. This study specified that every university website consists of at least one of a variety of elements that make the website inaccessible to some users.

Another interesting exploration was prepared on the top universities in Kyrgyzstan, Kazakhstan, Azerbaijan, and Turkey using automated assessment tools by (Ismailova & Inal, 2018). The outcomes demonstrated that university websites are more prevalent in Turkey, and in Turkish universities, developers provide careful consideration to the performance of the websites, followed by websites of Azerbaijani, Kyrgyz, and Kazakh universities. Most of the university websites in the investigation did not meet the WCAG 2.0 accessibility criteria. In light of the outcomes, it was resolved that colleges incorporated into the present examination require giving more weight to building their websites to be more accessible for their customers.

One more assessment of the government websites of Kerala based on Indian government guidelines and the five-point investigation of accuracy, authority, objectivity, currency, and coverage (S & B.I, 2016). This study conducted experiments on four categories of twenty government websites: secretariat departments, directorate/Commissionerate's, government institutions, and local self-governance.

The effectiveness and usability of Indian health information websites on the World Wide Web are examined. Cross-sectional research of Indian health information websites was conducted by (Raj et al., 2016) Out of fifty (50) websites evaluated for quality (LIDA Tool) and readability (Flesch Reading Ease Score, Flesch-Kincaid Grade Level, and SMOG), it was found that only thirty-two (32) websites were exclusively focused on providing health information. Only three sites had high LIDA scores, and only five sites met the required readability level for sixth grade, according to the results.

The aforementioned literature shows that many studies were done based on accessibility and readability, but they did not mention the efficiency of the website in accessing. Hence, this paper proposes a novel method to explore the efficiency of the websites so that the developers pay attention to designing the websites more efficiently for everyone, irrespective of persons with disabilities

3. Methodology

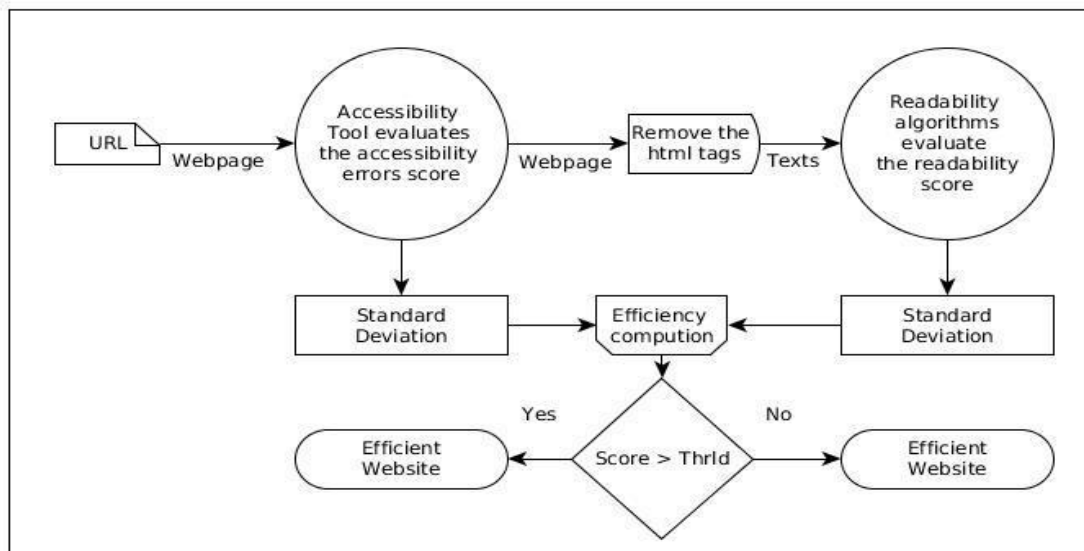
The proposed method, accessibility score evaluation, and readability score evaluation are all included in this section. The proposed method provides details for determining the efficiency of

the website. The method needs readability and accessibility scores to determine efficiency. In this section, the approach is covered in great detail.

3.1. The proposed method

In this section, the proposed method is explained, which is applied to evaluate the efficiency of the website, and the architecture of the computing method is shown in Figure 2. The method initially computes the accessibility error score using AChecker to collect and categorise errors (Known Problems, Likely Problems, Potential Problems, HTML Validation, and CSS Validation) across pages, then computes the standard deviation (σ) of these errors to measure consistency rather than relying solely on total error counts. This σ -based approach enables fair comparisons across websites of varying sizes and technologies by normalising results. For instance, a large website (100+ pages) with 200 total errors and low σ (1.0) demonstrates better accessibility consistency than a small site (10 pages) with fewer total errors (50) but high σ (5.0), indicating erratic error clustering. By focusing on error distribution rather than absolute numbers, this method provides a more accurate assessment of true accessibility compliance, effectively identifies problematic error concentrations, and helps prioritise remediation efforts where they are most needed, making it particularly valuable for comprehensive accessibility audits across diverse web properties. Similarly, the method computes the readability score of the websites and subsequently computes the standard deviation of the scores. Finally, the efficiency method is applied to compute the efficiency of the website and compare it with the threshold value. If the efficiency score is above the threshold value, then the website is regarded as inefficient; otherwise, it is efficient. It is known that a more readable website leads to a more accessible website, which implies fewer accessibility errors. Thus, the accessibility error scores increase, then the readability score decreases, and both scores are inversely proportional to each other. Therefore, the method computes the harmonic mean of both scores to evaluate the efficiency of the website.

Figure 2: Architecture of the proposed Method



Assume, for a website (W), the method computes the accessibility scores $A = \{a_1, a_2, \dots a_n\}$ and the readability scores $R = \{r_1, r_2, \dots r_n\}$. Subsequently, the method computes the efficiency using equation (1).

$$AMMEW(W) = 2 \times \frac{\sigma(A)(R)}{\sigma(A)+\sigma(R)} \quad (1)$$

Where the (σ) denotes the standard deviation.

Assume the scores $X = \{x_1, x_2, \dots, x_n\}$ and the ($\sigma(X)$) is defined by (2).

$$\sigma(X) = \sqrt{\frac{\sum_{i=1}^n (x_i + \bar{x})^2}{n-1}} \quad (2)$$

Where the $\bar{x}$ denotes the mean of X , which is given by (3).

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad (3)$$

3.2. Accessibility Score Evaluation

The accessibility of a website page is assumed to as an imperative aspect of everyday life. Accessibility refers to the design of the website for persons with disabilities. The Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C) has developed the Web Content Accessibility Guidelines (WCAG). There are currently two versions of the guidelines: the 1995 publication of the first, WCAG 1.0 (Web Content Accessibility Guidelines 1.0, 1999), and the 2008 release of the second, WCGA 2.0 (Web Content Accessibility Guidelines (WCAG) 2.0, 2008). Besides, WCAG 2.1 was published on 5 June 2018, and WCAG 2.2 is scheduled to be published in 2021(Kirkpatrick, A. et al., 2018). Accessibility contains four principles: Perceivable, Operable, Understandable, and Robust.

3.2.1. Perceivable

The term “perceivable” describes a user’s capacity to recognise and comprehend the information displayed on a website or application. This includes making sure the material is accessible to those with various disabilities, such as vision or hearing impairments, and that it is offered in a variety of formats, including text, audio, and video. To make the content easy to read, readability also entails offering clear and consistent navigation and content structure, as well as using the right colour contrasts and font sizes.

3.2.2. Operable

Operable describes a website’s or application’s capacity to be used by a user to navigate and interact using a variety of input methods, including a keyboard, mouse, or touchscreen. This includes making sure that all functionality is accessible via a keyboard, offering simple and reliable navigation, and avoiding content that flashes or moves quickly because it may induce seizures or other health difficulties for some people. Along with allowing users to pause, halt, or hide any time-based media, operability also entails giving them enough time to read and interact with the information.

3.2.3. Understandable

The term “understandable” describes a user’s capacity to comprehend and decipher the information and features of a website or application. This entails speaking plainly and succinctly, refraining from using jargon and technical phrases, explaining difficult ideas, and making sure that the layout and design are uniform and easy to understand. Additionally, to aid users in navigating and comprehending the information offered, intelligible content should be structured logically and predictably with headings, lists, and other visual cues. Providing alternative formats or

translations for users who might have trouble understanding the primary language or format of the content is another aspect of comprehensible accessibility.

3.2.4. Robust

A website or program is said to be robust if it can be accessed and utilized by a variety of assistive devices, including screen readers, braille displays, and voice recognition software. Ensuring that the website or application is accessible with multiple assistive technologies entails following accepted coding practices and web standards and guidelines, such as the Web Content Accessibility Guidelines (WCAG). Providing users with additional access points to functionality or content, such as keyboard shortcuts or alternative navigation techniques, is another aspect of robust accessibility. This makes it possible for users who have restrictions or disabilities to access the website or application and use it in the way that best meets their needs. The accessibility tool assists users in measuring the accessibility error of the website so that the website can be refined to be accessible to all categories of users. AChecker is one of the leading accessibility evaluation tools that work based on a variety of international accessibility guidelines (Gay & Li, 2010). The tool checks for compliance with the Web Content Accessibility Guidelines (WCAG) 2.0 and 2.1, which are international standards for web accessibility. It checks for issues such as missing alt text on images, improper use of headings, and insufficient colour contrast. AChecker identifies the barriers of the website, which are classified under three categories: known problem, likely problem, and potential problem. Assume, the $A_i = \{a_1, a_2, a_3\}$ is the problem of the websites; the proposed method evaluates the standard deviation of the problems $\sigma(A_i)$ as explained in section 3. This method implemented the AChecker tool using a Python script using a “Web Service ID”, which is generated once successfully registered into AChecker.

3.3. Readability Score Evaluation

The readability of a text describes how simple or complex it is for a reader to comprehend written material. It considers elements like vocabulary, sentence structure, and overall text complexity. A text with high readability is simple to read and grasp, whereas a text with poor readability may be challenging to understand and demand more work from the reader. To ensure that written content is accessible and understood by a diverse audience of readers, including individuals with varying levels of literacy or language proficiency, readability is crucial. Six significant readability algorithms have been adopted in this paper and are listed below:

- Automated readability index: The Automated Readability Index (ARI) is a formula used to determine the readability level of a written text. It considers the number of characters, words, and sentences in a text to calculate a score that represents the grade level required to comprehend the text (Smith & Senter, 1967). The formula for ARI is shown in equation (4):

$$ARI = 4.71 \left(\frac{C}{W} \right) + 0.5 \left(\frac{W}{S} \right) - 21.43 \quad (4)$$

Where C denotes the characters and numbers, W denotes the words that are, the number of spaces, and S denotes the sentences. The resulting score is typically a whole number between 1 and 14, with higher scores indicating a higher level of readability. For example, a score of 1 would be equivalent to a text written for a first-grade reading level, while a score of 14 would be equivalent to a text written for a college-level reading level.

- Flesch-Kincaid Readability Test: The Flesch-Kincaid Grade Level is another formula used to determine the readability level of a written text. It considers the average number of syllables per word and the average number of words per sentence to calculate a score that represents

the grade level required to comprehend the text (Flesch, 1948). The formula for Flesch-Kincaid Grade Level is shown in equation (5)

$$FKGL = 0.39 \left(\frac{W}{S} \right) + 11.8 \left(\frac{Sy}{W} \right) - 15.59 \quad (5)$$

Where W is the total number of words, S is the total number of sentences, and Sy is the total number of syllables. The resulting score is typically a whole number between 1 and 12, with higher scores indicating a higher level of readability. For example, a score of 1 would be equivalent to a text written for a first-grade reading level, while a score of 12 would be equivalent to a text written for a college-level reading level.

- The Flesch Reading Ease Score (FRES) is a formula used to determine the readability level of a written text. It considers the average number of syllables per word and the average number of words per sentence to calculate a score that represents how easy or difficult the text is to read. The formula for FRES is shown in equation (6)

$$FRES = 206.835 - 1.015 \left(\frac{W}{S} \right) - 84.6 \left(\frac{Sy}{W} \right) \quad (6)$$

Where W are the total words, S is the total sentences, and Sy is the total syllables. The resulting score is typically a number between 0 and 100, with higher scores indicating an easier text to read. For example, a score of 90-100 would be equivalent to a text that is very easy to read, while a score of 0-30 would be equivalent to a text that is very difficult to read.

Gunning Fog Index: An American businessman (Gunning, 1952) created the Gunning Fog Index. The Gunning Fog Index is another formula used to determine the readability level of a written text. It considers the average number of words per sentence and the percentage of complex words (words with three or more syllables) to calculate a score that represents how difficult the text is to read. The following steps are used to calculate the Gunning Fog: The equation of the Gunning Fog Index is shown in equation (7)

$$GFI = 0.4 \left[\left(\frac{W}{S} \right) + 100 \left(\frac{CW}{W} \right) \right] \quad (7)$$

Where W stands for a word, S for a sentence, and CW for a complex word. The resulting score is typically a whole number, with higher scores indicating a more difficult text to read. For example, a score of 12 would be equivalent to a text that is difficult to read, while a score of 6 would be equivalent to a text that is easy to read.

SMOG Index: (Mc Laughlin, 1969) developed this SMOG index, and SMOG is widely used for checking health messages. The SMOG Index is another formula used to determine the readability level of a written text. It considers the number of polysyllabic words (words with three or more syllables) to calculate a score that represents how difficult the text is to read. The equation for Smog to test the readability score is shown in (8).

$$SMOG = 1.0430 \sqrt{P \times \frac{30}{S}} + 3.1291 \quad (8)$$

Where P is the number of polysyllables and S is the number of sentences. The resulting score is typically a whole number, with higher scores indicating a more difficult text to read. For example, a score of 12 would be equivalent to a text that is difficult to read, while a score of 6 would be equivalent to a text that is easy to read.

- Coleman-Liau Index: (Coleman & Liau, 1975) developed the Coleman-Liau Index to calculate the readability score. The Coleman-Liau Index is another formula used to determine the

readability level of a written text. It considers the average number of characters per word and the average number of sentences per 100 words to calculate a score that represents how difficult the text is to read. The equation of the Coleman–Liau index (CLI) is shown in equation (9).

$$CLI = 0.0588L - 0.296S - 15.8 \quad (9)$$

L represents the average letter frequency per 100 words, while S is the average sentence frequency per 100 words. The resulting score is typically a whole number, with higher scores indicating a more difficult text to read. For example, a score of 12 would be equivalent to a text that is difficult to read, while a score of 6 would be equivalent to a text that is easy to read.

The method adopted six readability algorithms to measure the readability of the website. Assume, the $R_i = \{r_1, r_2, r_3, r_4, r_5, r_6\}$ be the readability score of the websites; the proposed method evaluates the standard deviation of the problems $\sigma(R_i)$ as explained in Section 3.

3.4. AMEEW Algorithm

The algorithm of the proposed method is shown in Algorithm 1. The AMEEW algorithm aims to assess and categorise websites as "Efficient" or "Inefficient" according to their readability and accessibility characteristics. Accessibility scoring, readability score (if necessary), and a final combined efficiency assessment are the three sequential evaluation stages it goes through after receiving a URL as input. By taking a tiered approach, the algorithm ensures that websites are evaluated methodically by prioritising accessibility tests before moving on to readability and efficiency assessments.

Algorithm 1: AMEEW algorithm

Input:	URL
Output:	Efficient, Inefficient
1	AMEEW(URL) website $\leftarrow$ eWebsite(URL) A_score $\leftarrow$ eAccessibility(website)
2	if A_score = 0 then
3	return Efficient
4	else
5	cWebsite $\leftarrow$ rWebsite(website) R_score $\leftarrow$ eReadability(cWebsite)
6	if R_score = 0 then
7	return Inefficient
8	else
9	E_score $\leftarrow$ eEfficiency(A_score, R_score) if E_score $\geq$ Threshold then
10	return Inefficient
11	else
12	return Efficient
13	end
14	end
15	end

Using the function `eWebsite(URL)`, the algorithm first extracts and examines the webpage's content. The function `eAccessibility(website)` then assesses the extracted data for accessibility compliance (e.g., conformance to WCAG standards) and produces an accessibility score (`A_score`). The website is instantly categorised as "Efficient," since it satisfies the maximum accessibility criterion without additional assessment if it receives a perfect accessibility score (`A_score = 0`). This stage demonstrates how the algorithm prioritises accessibility as a basic necessity.

The algorithm then evaluates readability if the website's `A_score` is not zero. To make sure the readability assessment concentrates on the most important content, the `rWebsite(website)` function first refines the website's content by eliminating unnecessary components. `eReadability(cWebsite)` then assigns a score to the revised material, resulting in a readability score (`R_score`). An "Inefficient" classification results from a perfect readability score (`R_score = 0`). The last efficiency evaluation is triggered by `R_score` values that are not zero.

The algorithm uses the function `eEfficiency(A_score, R_score)` to calculate a composite `E_score` for websites with both accessibility and readability issues (`A_score > 0` and `R_score > 0`). This score balances the website's readability and accessibility, reflecting its overall effectiveness. When the `E_score` is compared to a predetermined threshold, the resulting categorisation is "Inefficient" if the score is at or above the threshold and "Efficient" if the score is below the threshold.

4. Analyse the data

Four assumptions have been considered to analyse the data: random drawings, fixed distribution, distribution with fixed location, and distribution with fixed variation. If the four underlying assumptions are true, we have reached probabilistic predictability—the capacity to make probability statements about both past and future processes. These procedures are referred to as being “in statistical control” in short (Filliben & Heckert, 2005). To test these assumptions, we have tested four exploratory data analysis techniques, including

- Run sequence plot: The run sequence plot will not drift and will be flat if the fixed location assumption is true. The run sequence plot's vertical spread will be roughly the same along the horizontal axis if the fixed variation assumption is true.
- Lag plot: The lag plot will be random and structureless if the randomness assumption is true.
- Histogram: The histogram will be bell-shaped if the fixed distribution assumption is true, specifically if the fixed normal distribution is true.
- Normal probability plot: The normal probability plot will be linear if the fixed distribution assumption is true, specifically if the fixed normal distribution is true.

As can be observed from Figure 3, the 4-plot depicts a process with a fixed location, fixed variation, and randomness. The normal probability plot indicates that the data is linear, but the histogram is not bell-shaped and displays a right-skew histogram. As a result, the data can be regarded as normal. Nor are there any outliers. The 4-plot depicts a process that is random, has a fixed location, has fixed variation, and appears to have a fixed approximately. The data is linear, as indicated by the normal probability plot, even though the histogram is not bell-shaped and displays a right-skew histogram.

Figure 3: The 4 plots for Accessibility data

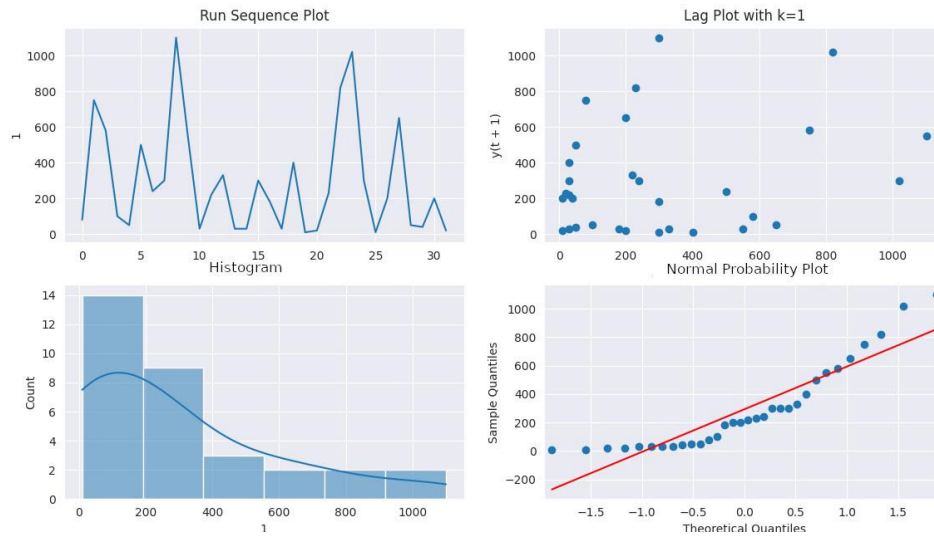
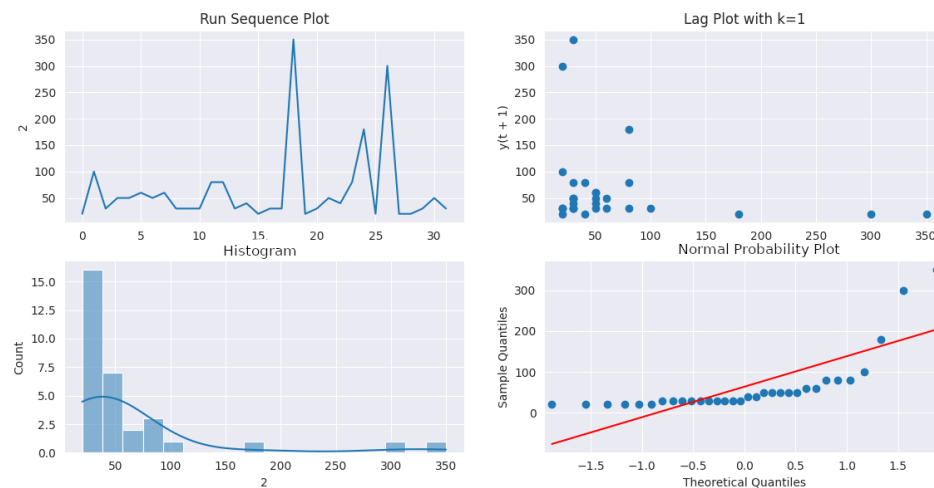


Figure 4: The 4 plots for Readability data



Consequently, in Figure 4, the 4-plot depicts a process with a fixed location, fixed variation, and randomness. The normal probability plot indicates that the data is linear, but the histogram is not bell-shaped and displays a right-skew histogram. As a result, the data can be regarded as normal. Nor are there any outliers. The 4-plot depicts a process that is random, has a fixed location, has fixed variation, and appears to have a fixed approximation. The data is linear, as indicated by the normal probability plot, even though the histogram is not bell-shaped and displays a right-skew histogram.

5. Evaluation Result

This section discusses threshold evaluation, evaluation of metrics, and the result of our proposed model.

5.1. Threshold Evaluation

This subsection experimented to find the threshold value for the efficiency of the website. For this purpose, the top 32 e-commerce websites are gathered from (Similarweb, 2024). SimilarWeb provides the website's ranking based on a combined measure of unique visitors and pageviews. Our study analysed 32 websites across three critical performance metrics: accessibility error scores, readability scores, and overall efficiency ratings. These measurements provide insights into how technical compliance (accessibility), content clarity (readability), and user experience (efficiency) intersect in website design. Figure 5 presents the raw experimental data showing each website's performance across these metrics. We then calculated average scores for all websites, with these aggregated results visualised in Figure 6. This two-stage presentation allows readers to examine both individual cases and overall trends.

The analysis revealed an average efficiency score of 63.89 across all websites. The average accessibility error score stood at 298.87, while the average readability score was 49.22. These figures establish baseline performance levels that help contextualise individual website assessments. Examining the relationship between these metrics shows a clear pattern: websites demonstrating higher efficiency typically combine lower accessibility error scores with higher readability scores. This suggests that technical accessibility improvements and content clarity enhancements work synergistically to boost overall website performance.

These findings indicate that website optimisation should address both technical and content aspects simultaneously. Reducing accessibility barriers while improving content readability appears to be an effective strategy for achieving better overall website efficiency. Hence, the method selects 63.89 as the threshold value. If the website's efficiency is above the threshold, then it is regarded as an inefficient website; otherwise, it is an efficient website.

Figure 5: Performance of 32 websites

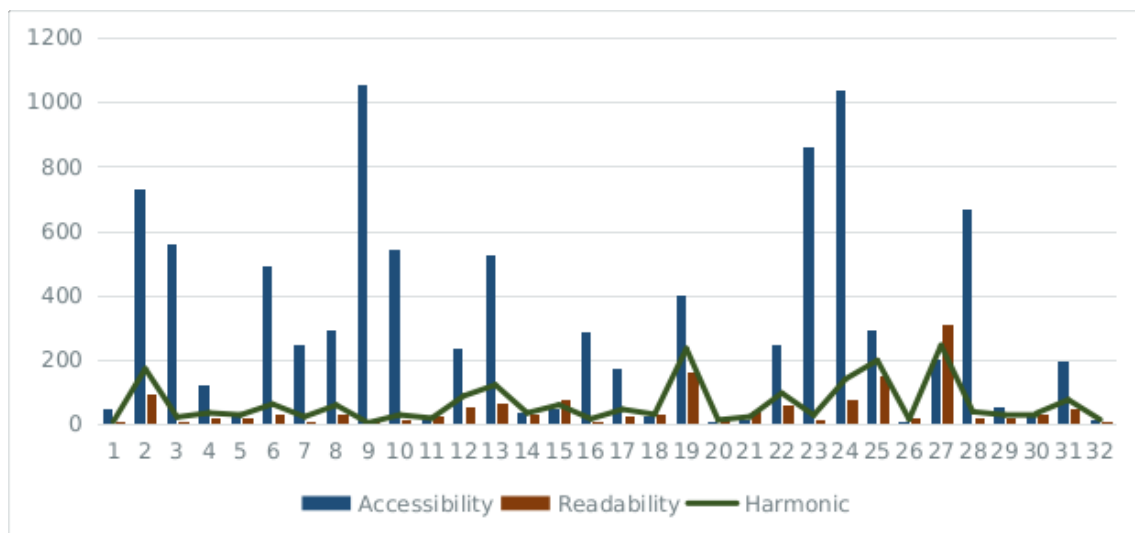
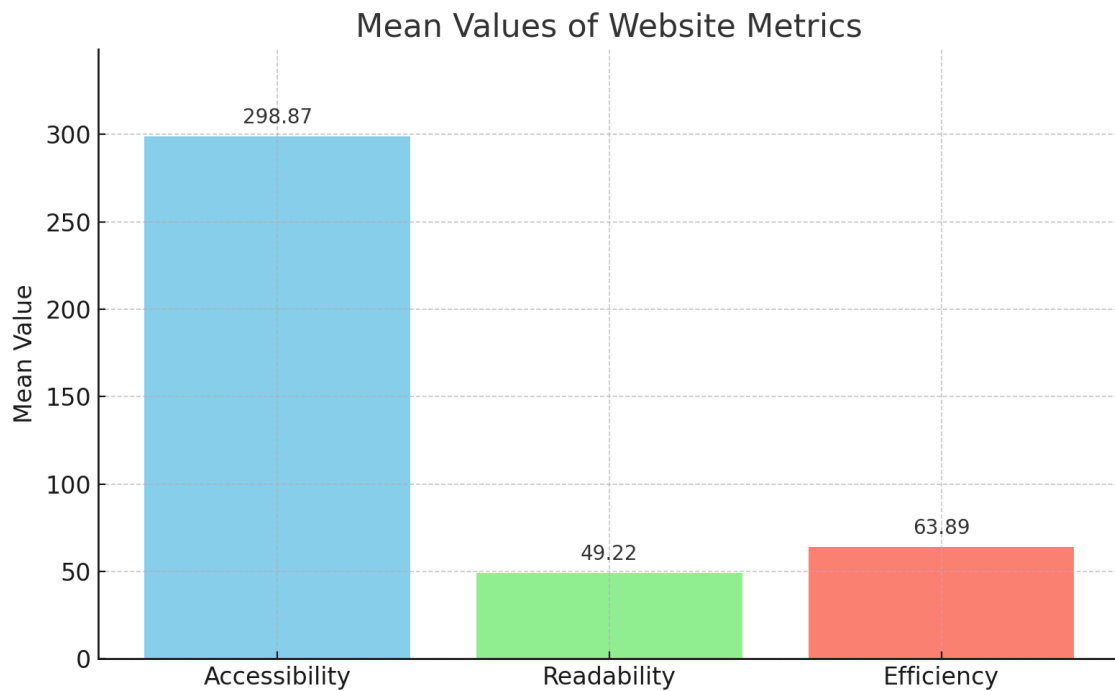


Figure 6: Average value of accessibility, readability, and efficiency score.



5.2. Evaluation of Metric

This section discusses the accuracy metrics, which are used to compute the performance of the method. Assume EP denotes the number of websites that are less than the threshold value, and IP denotes the number of websites that are above the threshold value.

Accuracy (efficient): The accuracy of the efficient websites of the proposed efficiency method is shown in equation (10).

$$Accuracy(efficient) = \frac{EP}{EP+IP} \quad (10)$$

Accuracy (Inefficient): The accuracy of the inefficient websites of the proposed efficiency method is shown in equation (11).

$$Accuracy(Inefficient) = \frac{IP}{EP+IP} \quad (11)$$

5.3. Result

The section discusses the result of the proposed method. For this purpose, the 60 e-commerce sites were chosen from publicly accessible directories such as (Similarweb, 2024) to ensure that the platforms we examined in our study represented important real-world usage patterns and a range of accessibility and readability feature implementations. Table 1 shows that the dataset captures 52.52% of global e-commerce traffic, covering major industries like retail (Amazon, Walmart), marketplaces (eBay, MercadoLibre), and speciality commerce (Etsy, Ticketmaster), as well as key regions including North America, South America, Europe, and Asia. The platforms listed are among the top performers in their respective countries, with massive monthly visits and unique visitor counts.

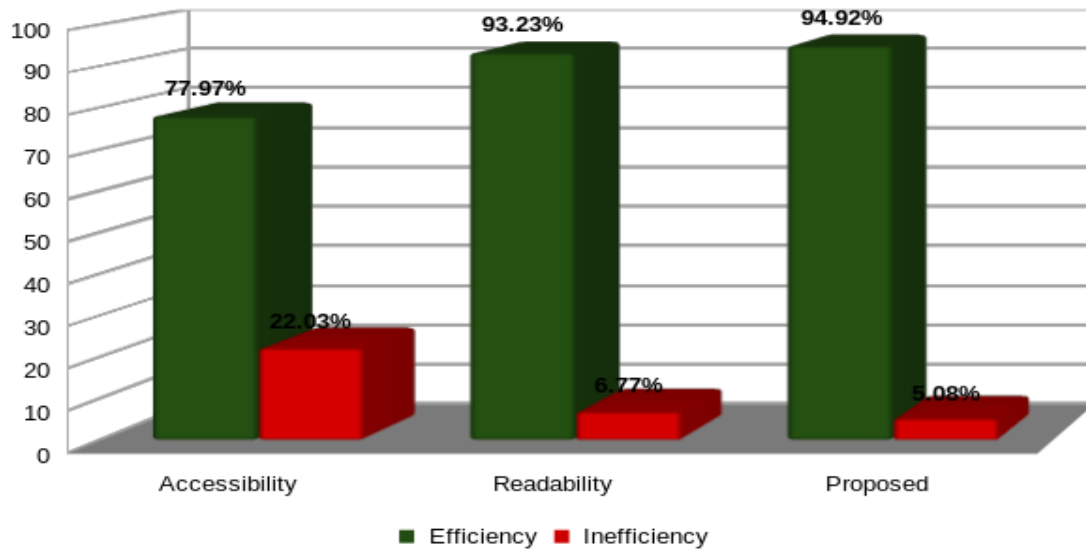
Table 1: Top 60 E-commerce websites

Sl No	Domains	Country	Traffic Share	MoM traffic change	Country rank	Monthly visits	Unique visitors
1	amazon.com	United States	9.25%	4.89%	#8	2.530B	493.6M
2	temu.com	China	4.82%	14.70%	#26	1.317B	383.1M
3	aliexpress.com	China	2.31%	0.24%	#51	630.6M	226.8M
4	ebay.com	United States	2.22%	5.73%	#42	606.8M	157.5M
5	amazon.co.jp	Japan	1.95%	4.55%	#47	532.6M	79.70M
6	ozon.ru	Russia	1.69%	5.22%	#44	462.6M	106.0M
7	walmart.com	United States	1.64%	5.04%	#65	448.7M	160.6M
8	rakuten.co.jp	Japan	1.59%	1.99%	#62	434.0M	63.23M
9	amazon.in	India	1.49%	8.06%	#58	408.1M	153.8M
10	amazon.de	Germany	1.46%	1.42%	#59	399.0M	71.18M
11	etsy.com	United States	1.41%	3.95%	#74	384.4M	152.8M
12	amazon.co.uk	United Kingdom	1.29%	2.62%	#78	351.5M	73.56M
13	wildberries.ru	Russia	1.26%	7.82%	#63	343.5M	54.33M
14	avito.ru	Russia	1.11%	1.55%	#80	303.5M	39.74M
15	coupang.com	South Korea	1.03%	4.96%	#102	282.0M	72.96M
16	mercadolivre.com.br	Brazil	0.86%	5.10%	#105	235.5M	56.43M
17	amazon.it	Italy	0.71%	1.94%	#126	195.2M	42.78M
18	taobao.com	China	0.71%	4.23%	#118	192.9M	37.82M
19	ebay.co.uk	United Kingdom	0.70%	2.47%	#138	190.9M	37.52M
20	amazon.fr	France	0.68%	5.63%	#129	184.7M	48.05M
21	amazon.ca	Canada	0.66%	8.54%	#122	180.8M	39.70M
22	amazon.com.br	Brazil	0.65%	5.91%	#158	177.1M	77.12M
23	flipkart.com	India	0.64%	9.42%	#153	174.8M	66.80M
24	allegro.pl	Poland	0.63%	1.15%	#142	173.4M	27.76M
25	target.com	United States	0.63%	1.70%	#189	171.8M	77.75M
26	rakuten.com	United States	0.57%	5.91%	#321	156.5M	62.56M
27	market.yandex.ru	Russia	0.52%	12.18%	#171	143.5M	36.73M
28	shopee.com.br	Brazil	0.51%	7.70%	#197	138.7M	49.08M
29	craigslist.org	United States	0.51%	5.88%	#109	138.3M	25.34M
30	mercari.com	Japan	0.50%	7.21%	#186	137.0M	39.80M
31	shopee.vn	Vietnam	0.50%	4.61%	#228	135.7M	44.17M
32	shop.app	United States	0.49%	9.53%	#313	134.8M	78.90M
33	shopee.co.id	Indonesia	0.46%	7.79%	#206	125.9M	34.34M
34	leboncoin.fr	France	0.45%	1.82%	#222	121.8M	19.54M

Sl No	Domains	Country	Traffic Share	MoM traffic change	Country rank	Monthly visits	Unique visitors
35	shopping.yahoo.co.jp	Japan	0.44%	4.38%	#316	119.5M	45.83M
36	ebay.de	Germany	0.44%	0.77%	#254	119.2M	25.65M
37	kleinanzeigen.de	Germany	0.42%	1.26%	#237	116.2M	31.94M
38	sahibinden.com	Turkey	0.40%	1.62%	#159	110.7M	19.07M
39	amazon.es	Spain	0.40%	2.49%	#236	110.3M	27.48M
40	dmm.com	Japan	0.39%	8.33%	#354	107.2M	23.88M
41	ticketmaster.com	United States	0.39%	11.78%	#343	105.6M	58.95M
42	trendyol.com	Turkey	0.39%	0.94%	#273	105.6M	28.09M
43	shopee.co.th	Thailand	0.39%	3.09%	#287	105.3M	30.31M
44	mercadolibre.com.ar	Argentina	0.37%	9.39%	#216	100.4M	18.33M
45	mercadolibre.com.mx	Mexico	0.34%	10.38%	#277	93.11M	25.97M
46	shopping.naver.com	South Korea	0.34%	0.12%	#357	92.53M	14.07M
47	costco.com	United States	0.33%	10.18%	#341	91.51M	38.84M
48	amazon.com.mx	Mexico	0.33%	12.38%	#293	89.84M	36.16M
49	olx.com.br	Brazil	0.32%	1.62%	#346	88.30M	24.08M
50	wayfair.com	United States	0.32%	4.89%	#344	87.61M	37.49M
51	jd.com	China	0.31%	11.87%	#297	85.68M	22.98M
52	olx.pl	Poland	0.31%	2.29%	#314	83.64M	13.43M
53	alibaba.com	China	0.27%	0.88%	#413	73.62M	33.56M
54	kakaku.com	Japan	0.26%	4.46%	#527	72.47M	22.58M
55	dns-shop.ru	Russia	0.26%	13.14%	#448	72.13M	22.07M
56	bol.com	Netherlands	0.25%	4.72%	#445	68.25M	18.32M
57	slickdeals.net	United States	0.24%	3.41%	#724	66.44M	7.543M
58	tmall.com	China	0.24%	9.87%	#318	66.13M	16.38M
59	aliexpress.ru	Russia	0.24%	3.13%	#427	66.11M	18.60M
60	hepsiburada.com	Turkey	0.23%	0.49%	#519	63.94M	19.96M

Once the data were collected, the method evaluated the efficiency of the website using the accuracy parameter shown in section 5.2. The result of the investigation shows that 94.92% are efficient and the remaining 5.08% are inefficient for persons with disabilities. From the investigation, it is found that many websites are efficient for persons with visual impairments. It is good news that many websites are following the guidelines of accessibility and readability. However, there are still 5.08% of websites that fail to design their websites for persons with visual impairments. Moreover, the proposed method is compared with the accessibility and readability methods shown in Figure 7.

Figure 7: Evaluate the efficiency and inefficiency of websites



The figure shows that the efficient rate of the accessible method was evaluated at 77.97% and the inefficient rate at 22.03%. Moreover, the efficiency rate of the readable method was evaluated at 93.23%, and the inefficiency rate was 6.77%. However, our proposed method shows that 94.92% are efficient and 5.08% are inefficient. From the analysis, it can be revealed that while a significant number of top-ranked e-commerce sites originate from highly developed countries, their commercial success does not correlate with compliance with accessibility and readability standards.

6. Discussion

This paper proposed a novel method, “AMEEW”, to evaluate the efficiency of websites. The method successfully explored the e-commerce websites, and the result of the experiment shows that the method evaluated 94.92% as efficient websites and 5.08% are inefficient websites. Although this paper approached the novel method, there are some issues regarding implementing the method. Therefore, this section discusses these important issues and explains how the proposed method overcame this issue, as discussed below:

- One issue is that some of the websites provided identical scores for both the accessibility error score and the readability score. Hence, the method selected anyone’s score as efficient without further investigation.
- Another issue concerns the accessibility score. As some websites provide full accessibility. Hence, their accessibility score is zero (0). Therefore, the method overcame this issue by regarding the website as an efficient website without further examining the readability of the website, because the proposed method evaluated zero if one of the scores is zero.
- One more possible issue perhaps occurred, but in our evaluation, the method did not confront it; that is, the readability score is zero (0). The readability score of zero indicated that the website did not provide any text of the websites and outlined the website only images or some other technologies, which will be difficult for persons with disabilities because the persons with disabilities handle the website using the screen reader, and the screen reader only reads the text, and it is unable to read the image. As a result, the method of regarding the website as an inefficient website.

- The accessibility error and readability error cannot be together at zero because the accessibility error and readability are inversely proportional to each other. If the accessibility error is zero, it means it is a readable website; otherwise, if the website is not readable, then the website is not an accessible website, which prompts the expansion of the accessibility error score.
- The four assumption tests in our study have different but complementary purposes. Initially, the randomisation test (lag plot) confirmed whether or not error occurrences displayed systematic dependencies or followed an independent pattern. Non-random errors could reveal biases or technical problems in our data gathering process that needed to be fixed before analysis. Second, the run sequence plot, or fixed location test, determined whether the errors' central tendency held steady over measurements. This stability indicates constant performance over time for readability and website analytics, which is essential for accurately forecasting future behaviour. A crucial prerequisite for many statistical techniques, the fixed variation test (which also used a run sequence plot) made sure that the variation in error rates didn't change significantly across data. The normal probability plot and histogram distribution tests were used to confirm that we were using parametric statistical techniques. The normal probability plot's linearity suggested that, for analytical purposes, the data might be regarded as roughly normal, despite the histogram's noticeable right-skew. The data can be transformed using the Box-Cox transformation to address the data's non-normal distribution, as indicated by the histogram upon analysis.

7. Conclusion

This paper analysed the accessibility errors and readability scores of the top e-commerce websites and proposed a novel method, “AMEEW” to explore the efficiency of the websites using the accessibility error score and readability score. Initially, the model analysed 32 websites and calculated their efficiency scores using the proposed equation. The threshold was then determined by averaging these scores. Websites with efficiency scores above the threshold were classified as inefficient; otherwise, they were considered efficient. Finally, the method collected 60 current e-commerce websites from online sources and evaluated the efficiency scores of the websites. Moreover, this paper proposed two evaluation metrics to calculate the accuracy of both efficient and inefficient percentages. The result of the investigation shows that the method evaluated 94.92% of websites as efficient websites, and the other 5.08% are inefficient websites. Our analysis reveals that while a significant number of top-ranked e-commerce sites originate from highly developed countries, their commercial success does not correlate with compliance with accessibility and readability standards. This paper is an initial version of the accessibility and readability of the website.

In the future, the method will be enhanced and analysed by the other sectors of the websites for persons with disabilities.

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Experience of remote customer service accessibility for adults with acquired speech disorders in the UK

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Abstract: Businesses and institutions have been increasing their reliance on telephone services over face-to-face interactions, and on automatic speech recognition over human operators. These trends risk disadvantaging people with speech conditions, whose speech is not easily understood. This qualitative study used semi-structured interviews to explore the experiences with customer services of people with acquired speech conditions. Thirteen people from the United Kingdom shared both positive and negative experiences of customer service accessibility, in relation to the use of technology, institutional practices, and interpersonal communication. Some of the main areas of challenge related to the lack of variety in communication channels, and barriers created within the existing ones due to time pressure and high communication demands on the customer, automatic speech recognition not meeting the needs of this population, and a lack of awareness of speech conditions among call centre staff, leading to negative assumptions. Participants shared key recommendations and positive experiences to have their needs met, including opportunity for multichannel communication, reducing time pressure on the customer, checking understanding, and companies keeping record of their communication needs.

Keywords: acquired speech disorders, Parkinson's disease, Ataxia, Multiple System Atrophy, customer service, telephony, automatic speech recognition, accessibility

1. Introduction

At any one time up to 20% of the UK population are likely to have increased speech, language and communication needs (SLCN) during their lifetime, while 1-2% of the UK population are likely to have a severe speech, language and communication disability (Law, et al., 2007). The majority of studies investigating the experiences and quality of life of people with SLCN focus on groups of people with a specific diagnosis (Baylor, Burns, Eadie, Britton, & Yorkson, 2011), making it harder to generalise findings and mount large-scale campaigns for increased accessibility. In their unique cross-diagnosis study on the experiences of communicative participation of adults, Baylor et al. (2011) identified that adults with SLCN face functional and emotional interferences with communication, as well as variability in the sources of interference. The authors argue that there

is a need for interventions that focus on the ability of people to participate effectively in daily activities and that these interventions need to be informed by the experiences of people across diagnoses.

Telephone conversations were identified as one of the most challenging forms of communication for a wide variety of people with SLCN, including hearing impairment, aphasia, voice disorders, dysarthria, spasmodic dysphonia and stuttering (Baylor, Yorkston, & Eadie, 2005; Baylor, Burns, Eadie, Britton, & Yorkson, 2011; James, Brumfitt, & Cudd, 1999; Smith, Gray, Verdolini, & Lemke, 1995; Verdolini & Titze, 1994). Reported barriers include the sole reliance on speech for communication (no non-verbal communication available), increased time pressure, inability to assess the reactions of the interlocutor (which for some is a positive), and fear of being misunderstood and creating a bad first impression (James, Brumfitt, & Cudd, 1999). A key finding of Baylor et al. (2011) is that the phone was seen as a barrier to communication for most participants, not only due to challenges with intelligibility but also due to loss of nuance – with interlocutors making incorrect assumptions about the message based on the voice quality of the speaker with a speech disorder.

Whilst it is difficult to reduce some of these barriers due to the nature of the communication mode, it is important to consider that communication is not the sole responsibility of the speaker with SLCN. Successful communication is an interactive process where listeners have agency too and can enhance the success of the interaction by supporting the speaker with SLCN to get their message across. To maximise the effectiveness of such support, training opportunities have been developed such as Communication Access UK, which is a free short course that aims to provide training and accreditation to individuals, institutions and businesses for supporting individuals with SLCN (Royal College of Speech and Language Therapists [RCSLT], n.d.). It is led by the Royal College of Speech and Language Therapists (RCSLT), in collaboration with charities representing people with lived experience of SLCN and carers. A cornerstone of the programme is the TALK prompt: Time, Ask what helps, Listen, Keep trying (Communication Access UK Inclusive Communication for All A Prospectus for Early Adopters, n.d.), applied in different settings, such as telephone or written communication. The Listen component includes focused attention, checking understanding on both sides (Let's TALK about communication on the phone, n.d.).

The component of giving focused attention to the speech is consistent with research which has shown that familiarisation with speech is a natural skill which occurs rapidly and automatically in listeners (Kleinschmidt & Jaeger, 2015). Some types of speech, such as disordered speech (e.g., voice disorders, dysarthria etc.), are harder to understand for inexperienced listeners than typical speech, but a recent review by Borrie and Lansford (2021) has shown that systematic familiarisation with disordered speech through exposure and focused attention can improve understanding. A more recent study has shown that enhancing listener understanding of the speech condition and setting up an expectation of success, further enhances results of listener training (Borrie, Tetzloff, Barrett, & Lansford, 2024). These studies focus on listener adaptation to speech (the way the words and sentences sound), rather than to language (the choice of words and their order). One limitation of the evidence base is that listener adaptation abilities have not been tested in telephone conditions.

Since the publication of Baylor et al. (2011), the impact of accessibility challenges in telephony are likely to have increased. The last decades have seen an increased reliance on telephone-based customer services over face-to-face interactions, and an increased volume and complexity of calls (Berg, Buesing, Hurst, Lai, & Mukhopadhyay, 2022). During the COVID-19 pandemic many in-person clinical appointments were permanently replaced with telephone and online triage and

consultations (National Health Service [NHS] England, 2019; NHS England, 2020; Sivarajasingam, 2021). The trends for the customer care sector are to move towards self-service and digital-first, and this has already been reported for the high street, banking and healthcare sector in the UK (Dickie & Farr, 2024; NHS England, 2024; Panjwani & Booth, 2024; Simpson & Codd, 2024). While this transition is happening, many organisations still rely on over-stretched, under-valued and undertrained contact centre agents who are also harder to recruit and retain. As a response, the market of Automatic Speech Recognition technologies has been increasing exponentially and is projected to continue its growth (Fortune Business Insights, 2023), while still being unequipped to meet the needs of people with speech disorders (Lin, Dang, Wang, Li, & Ding, 2023) (but see ongoing work on Project Euphonia (Google Research, n.d.)). These realities create a risk of losing contact with groups of customers and require a renewed investigation into the experiences of people who are likely to encounter challenges in this rapidly changing environment of customer service.

Past research has identified that telephone communication causes a significant challenge for people with speech and language conditions (Baylor, Yorkston, & Eadie, 2005; Baylor, Burns, Eadie, Britton, & Yorkson, 2011; Smith, Gray, Verdolini, & Lemke, 1995) but there is a paucity of recent academic studies investigating the consumer experiences of people with disabilities. The majority of research has focused on people with visual impairments (Taylor, Balandin, & Murfitt, 2019). The present study aims to revisit the question of participation and accessibility for adults with speech conditions when accessing services in a modern context to evaluate whether improvements or new challenges have been created. The study focuses on acquired speech conditions to narrow the research focus, based on the assumption that speakers with developmental speech conditions (e.g., stammering) are more likely to have a different relationship with their condition informed by life-long experiences (Carter, Yaruss, & Beilby, 2017) than a speaker who has experienced a change in functioning in adulthood and who therefore may be at greater risk of not participating (Dickson, Barbour, Brady, Clark, & Paton, 2008). This study explores the experiences, priorities, and communication strategies of adults with acquired speech conditions contacting services in a post-pandemic context.

2. Methods

2.1. Participants

The study proposal and all participant materials received ethical approval by the University of Strathclyde ethics committee. All participants had been provided with a Participant Information Sheet and signed a Consent form before entering the study. Both documents were available in electronic or paper format and followed guidance from the UK National Research Ethics Services. Particular care was taken to inform participants about the secure handling of their voice recordings to maintain confidentiality.

Participant inclusion criteria were: over 18 years of age, with acquired speech difficulties (affecting their voice and/or pronunciation), who can carry out a verbal conversation, who have called a company, customer service, or a hotline on the phone at least once in the past year. Participants were recruited in the United Kingdom. Researchers did not assess speech disorders, participation was based on self-reports. As the study was advertised to be conducted in English, the exclusion criteria were: not being able to speak English, and not having sufficient hearing to interact with the researchers. Difficulties with cognition and language were not specifically listed as exclusion criteria, as some level of cognitive and language decline may accompany some

conditions associated with speech difficulties (Baylor, Burns, Eadie, Britton, & Yorkson, 2011). It was deemed unsuitable to use cognition and language exclusion criteria while depending on participant insight and self-report.

A purposive sample of participants was recruited via social media (Twitter, now X), professional networks, and third-sector organisations established for people who commonly experience acquired speech difficulties, i.e. Ataxia UK, Parkinson's UK, and the MSA Trust. Whilst stroke and traumatic brain injury survivors also frequently experience speech impairment, this population was not approached due to the high likelihood of concomitant language and cognitive problems.

Thirteen participants participated, four female and nine male, aged between 29-78 (see Table 1). Two participants did not disclose their age. The mean age was 61 (SD = 17). In an online questionnaire they reported having Parkinson's disease (PD), progressive ataxia, Multiple System Atrophy (MSA), dystonia, and one participant did not disclose their condition. Participant 1 was the only speaker of English as a second language. The data of a fourteenth participant, Participant 2, was not analysed due to an incomplete consent form.

Table 1 summarised the participants' code within the study, their age, gender, and condition.

Table 1. Participant demographics. A “-” indicates that a participant did not disclose this information.

Participant code	Age	Gender	Self-reported condition
Participant 1	77	F	Cerebellar ataxia
Participant 3	55	M	-
Participant 4	53	M	Spino-cerebellar ataxia type 6
Participant 5	58	M	Spino-cerebellar ataxia
Participant 6	78	M	Ataxia
Participant 7	76	M	Dystonia
Participant 8	73	M	SCA6
Participant 9	37	M	Ataxia
Participant 10	-	M	Spastic paraplegia type 7
Participant 11	29	F	Ataxia
Participant 12	76	F	PD
Participant 13	60	F	MSA
Participant 14	-	M	PD and stammering

2.2. Data collection

Data collection occurred between March and June 2023. Participants initially completed a brief questionnaire about their age, gender, and native language. They then participated in online semi-structured interviews that were recorded through Microsoft Teams and lasted no longer than 60 minutes. The interviews followed a topic guide which covered information related to the participants' mode of contacting client services on the phone and their experiences using these services, including talking to human and automated agents.

Eleven participants were interviewed with one or two of the authors present. One participant was interviewed over the phone due to technical difficulties. One participant disclosed that verbal speech causes them severe physical and emotional exhaustion and preferred to respond to the questions in writing. The interviews lasted approximately 20 minutes.

Participants were compensated with a £10 voucher for their time.

The topic guide, consent forms, and other supplemental materials are available via an Open Science Framework (OSF) webpage dedicated to the project (Cairney, Fuzesi, Rai, & Lowit, 2025).

2.3. Data analysis

The interviews were audio recorded, and the first author deleted any identifying information from the audio. The audio was then transcribed by [Transcription Centre](#) into intelligent verbatim and checked for accuracy by the authors.

Data was analysed using the constant comparative method (Strauss & Corbin, 1994) by the first three authors. The first author coded all interviews, and the second and third authors coded half of the interviews each. After completing individual coding, the researchers met at regular intervals to discuss their codes and the grouping of codes into higher order categories and subcategories. A codebook was compiled and differences between codes were discussed and refined.

A limitation is that we were not able to contact the participants to review the interview transcripts and this manuscript as we had omitted to request permission for further contact with them at the point when they volunteered. A brochure, summarising the results (Dokovova, Rai, & Fuzesi, 2024), was shared with the participants who consented to this communication as well as Ataxia UK and Parkinson's UK who had initially shared the study advertisement and who circulated it with their newsletters. No participant reached out to comment following that.

2.4. Reflexivity statement

The three authors who carried out the interviews do not have speech, language or communication conditions, placing them as outsiders to the participant group. All authors acquired English outside of their family environment, within formal education environments, which gave them lived experience of having an accent that is not easily understood by everyone on the phone, creating a shared, albeit not insider, experience with the participants. Maria Cairney and Anja Lowit are also linguists and registered Speech and Language Therapists, with professional familiarity of the experiences, described by the participants, and allies and advocates for people with speech, language and communication needs. Harleen Rai and Peter Fuzesi have a background in Psychology and Sociology and have experience conducting research related to the lived experiences of people with disabilities, placing them as outsiders to the participant group but allies and advocates for people with disabilities.

3. Results

This section presents relevant themes which emerged from the interviews that are most relevant to the main research aim. They are summarised in the list below as overarching categories (level 1), sub-categories (level 2) and detailed codes (level 3). Due to the heterogeneity of the participant pool, supporting quotes are presented with the context of the participants' reported gender, condition and age.

1. Health
 - i. Description of condition(s)
 - ii. Progressive deterioration
 - iii. Compensatory abilities
2. Self-image

- a. Life experiences as sources of identity
 - i. Faced with disability when calling
 - ii. Emotions linked to condition and misunderstanding (upset, frustration, fed up, tears, denial)
 - iii. Traits
 - iv. “Good times” before
 - v. Comparison with other people
 - vi. Work relationships
- b. Life experiences as sources of empathy and skills
 - i. Empathy with agents
 - ii. Working on the other side of the phone
 - iii. Understanding the tactics
 - iv. Skills & life experience
- 3. Strategies
 - a. Organisational strategies
 - i. Persistence
 - ii. Choosing the best available mode of communication
 - iii. Bypassing ASR to talk to a human
 - iv. Supportive of research
 - b. Interpersonal strategies
 - i. Disclosure or not
 - ii. Self-advocacy (asking for adjustments/ double checking/ taking the lead)
 - iii. Involving support (vicarious assistance/safety net model)
 - iv. Changing own speech (Enunciating/ NATO phonetic alphabet/volume control/ slowing down/accents change)
 - v. Changing own language (shorter words, extra courtesy)
 - vi. Changing environment (memory aids, background noise control)
 - vii. No strategies (building up courage to call, going along with being misunderstood)
 - viii. Cost of strategies (colleagues chuckle)
 - c. Considerations
 - i. Fatigue impacts speech (time of day/call duration)
 - ii. Emotions impact speech
 - iii. Daily variation (in speech/ability)
 - iv. Type of information (complex/urgent/technical/complaints)
 - d. Recommendations
 - i. For institutions (provide and monitor multiple communication channels, client accounts with needs, trained & empowered agents, less scripts & more conversation)
 - ii. For agents (give time, patience, no assumptions, ask for clarifications)
 - iii. For others with speech conditions (praise positive experiences)
- 4. People
 - a. Strangers on the phone
 - i. Various experiences and skill levels
 - ii. Person determines the experience of the company
 - iii. Others’ good practice (patient, asking for clarification, repeating what they heard, giving time)

- iv. Others' poor practice (hang up, rushing, rude, not asking for clarification, "passive aggressive pause")
 - v. Assumptions from others: (drunk, old, "or a bit simple")
 - vi. Assumptions about others: (age, regional accents, immigration/outsourcing accents)
 - b. In-group support
 - i. Support from family, friends, professionals
 - ii. Lack of support
 - iii. Conflicted/rejected reliance on family support ("second class citizen", disability rights)
- 5. Institutions
 - a. Agencies
 - i. Banks/financial institutions
 - ii. Medical institutions
 - iii. Government agencies
 - iv. Charities
 - v. Education
 - vi. Service providers
 - vii. Utility companies
 - b. Procedures
 - i. Authentication
 - ii. Inadequate triage
 - c. General experiences
 - i. Differences in quality of experiences
 - ii. Disability-friendly set-up (multichannel, low communication demand, UK agents, client account with needs, direct to correct agent)
 - iii. Delay or lack of response
 - iv. Inaccessibility: limited channels of communication
 - v. Lack of person-centred support (scripts, geared towards majority)
 - vi. Barriers reaching a person
- 6. Technologies
 - a. Tools
 - i. Email
 - ii. Chatbot
 - iii. Chat/texts
 - iv. Automatic speech recognition (ASR)
 - v. Phone (landline)
 - vi. Social media
 - vii. Video calls/face to face
 - viii. Speech to text
 - ix. Website/FAQs
 - b. Preferences and familiarity
 - i. Variability in preferences
 - ii. Opting out of technology (automation, verbal)

3.1. Experiences of contacting services

3.1.1. Self-image

While all participants shared that their speech condition gets in the way of phone communication, for some this was particularly linked to their perception of themselves. A key finding is that using the telephone to call customer services is a reminder of their disability. One participant reflected on being forced to face the fact that his speech had changed noticeably only when speaking to a stranger on the phone and describes the experience as a “wake-up call”: *“It was a bit of a wake-up for me, I suppose. Because I was [...] in denial that my speech had changed or was changing.”* (Participant 5, M, ataxia, 58)

Participants 11 and 13 communicated with service providers on the phone as part of their job. Participant 11’s experience was also affected by the COVID-pandemic of not having been in the office around people and referred to **traits** such as her confidence to describe the impact of isolation: *“And I just feel like with lockdown in Covid, my confidence has been down a little bit. [...] I really didn’t want anyone else to hear me or notice.”* (Participant 11, F, ataxia, 29)

While participant 11 eventually regained her confidence (*“I’m really talkative now on the phone.”*), participant 13 describes the challenge of having to face her disability from the phone interlocuter and her colleagues as a daily experience. She also refers to the **cost of using strategies** (Strategies/Interpersonal strategies) to make herself understood on the phone: *“People always say to me, ‘Sorry, what? Can you repeat that?’ And then in the end I say [redacted] which always makes my colleagues chuckle. That’s the way I have to get round it. That happens on a daily basis.”* (Participant 13, F, MSA, 60)

3.1.2. Institutions

When asked broadly about their **General experiences** of calling companies on the phone, the participants consistently reported **Differences in quality of their experiences** across providers: *“But yeah, different services that I have called, like from my own back, it’s definitely a different situation with all of them.”* (Participant 11, F, ataxia, 29).

3.1.2.1. Converging experiences

When discussing contacting institutions, there emerged two sectors where participants’ experiences tended to converge. Participants frequently reported negative experiences when contacting **medical institutions**. Although some participants recognised their negative experiences may have been because of pressures on healthcare staff, they expressed distress at the memories of contacting surgeries, summarised by one participant as: *“GP surgeries are a nightmare... They’re under a lot of pressure because there’s so much volume coming in, they’re trying to do it quickly and get you off the phone. If you can’t express yourself, you hear them getting frustrated and angry with you and you think, ‘I can’t help it, I’m a patient, I need help and you’re not helping me, you’re winding me up.’”* (Participant 14, M, Parkinson’s and stammering)

Conversely, participants contacting **banks and financial institutions** rarely reported communication challenges. There are multiple possible explanations that could be hypothesised, including resource availability, company incentives, and the characteristics of the agents. One person attributed the good experience to the education of the phone agents *“when you speak to investment companies, or, perhaps, companies where the knowledge base is, perhaps, a bit more academic, it’s a marked difference, the knowledge of the whole company, the understanding, their ability to hear what you’re saying.”* (Participant 3, M, unspecified, 55). Another explanation is the ability to avoid phone conversations. When we asked participants about their experiences with

banking specifically, they often dismissed the topic, saying: *“I usually do that online; I don’t often call them.”* (Participant 12, F, Parkinson’s, 76).

3.1.2.2. Disability-friendly communication

The code of **disability-friendly set-up** encompasses the positive practices that participants reported encountering when communicating with different institutions. As illustrated in the case of banks, this includes *multichannel and multimodal communication*, where different options for communication were available, sometimes within one conversation (*“and it asks you to say your date of birth, or you can type it in.”* Participant 11, F, ataxia, 29), thus allowing the participants to rely on their communication strengths: *“There’s a government website, gov.uk, or something. [...] And that was very straightforward in terms of the questions being fairly short, the answers could be entered using a keyboard. I had the option of talking to someone if I wanted to, but I chose not to.”* (Participant 5, M, ataxia, 53). The short questions and answers reduce both the cognitive and expressive demands on the user.

Participants also highlighted the benefit of having a customer record to include information about their communication needs, such as being connected to a person directly: *“My utility company are good because they’ve got me registered as someone having a disability so they tend to recognise my number and then put me through to a person straight away, which is really good. I massively value that, that’s really good, positive support.”* (Participant 14, M, Parkinson’s and stammering)

3.1.3. People

One of the main challenges for the participants was that while they mainly communicated with familiar people, when calling customer services, they had to encounter **strangers** (e.g., nurses, overseas agents, local agents, school administrators, theatre receptionists) **on the phone**, who would be unfamiliar with their speech. One of the most prominent themes that came up was the high variability of experiences that people had and that the quality of their **experience** was mostly **determined by** the attitude of the call **agent**: *“I find there’s no particular company, but it just depends on the person you get hold of, really.”* (Participant 13, F, Parkinson’s, 76)

Participants discussed some accent-related **assumptions about others**. They reported mutual communication challenges when they assumed they were talking to a person whose first language was not English: *“They might have trouble understanding me but equally I have trouble understanding them, so I think, you know, that sort of conversation is going to go nowhere.”* (Participant 8, M, ataxia, 73). However, this experience was not universal: *“I find that minorities in the UK, which aren’t your usual Caucasian, white, are actually better at understanding you on the phone. You’ll have Caucasian white who will have no idea what you’re saying, very rarely do I get minority who may have a strong accent themselves, questioning what I’ve just said.”* (Participant 3, M, unspecified, 55). Both positive and negative personality stereotyping was shared also when discussing regional UK accents: *“The people with the Scottish accents, they do take greater care to listen.”* (Participant 6, M, ataxia, 78) and *“just thinking about saying to them, my speech is maybe hard to understand me, but I wouldn’t want cheeky Scottish people to say anything rude.”* (Participant 11, F, ataxia, 29).

While reflecting on accents one participant pointed out that as a listener, he can tune into the other person’s speech and expressed **empathy with agents** who experience time pressure demands in their job, making it challenging to tune into the caller’s speech: *“I mean, when we talk to a new person we have to tune in a bit to their voice. [...] And I think that so often people in*

call centres, like you said [redacted], are under pressure to get the call finished quickly.” (Participant 8, M, 55)

3.1.4. Good practice, Poor practice, and Emotions linked to condition and misunderstanding

Some of the best experiences of participants were linked to being given enough time to express themselves and being asked for clarifications when they were misunderstood: *“The main things that make a difference are 1) their patience / taking time to understand and 2) their ability/wish to help to a meaningful conclusion”* (Participant 10, M, ataxia, 37). This was echoed by another participant: *“I spoke to a lady there who was, first of all, very patient, repeated what I’d said, was not at all patronising, and made me feel valued. And at the end I told her that.”* (Participant 8, M, ataxia, 73).

Unfortunately, this good practice was not always encountered and participants often reported resulting negative treatment and **poor practice** from the agent such as: *“they think that you’re drunk, you can tell by that passive-aggressive pause.”* (Participant 3, M, unspecified, 55) or being hung up on, which prolonged their unsuccessful communication experience: *“you’ve been holding for an hour and then you talk for three minutes, and they just hang up.”* (Participant 3, M, unspecified, 55). The participants also reported not being listened to, not being asked for clarification, and instead hearing the agent misunderstand them and proceed with the misunderstood information, not giving an opportunity for correction: *“just blindly go forward, rather checking back with you and saying, “I didn’t understand that, can you help me understand what you’re talking about?” They just keep going and not listen. They’ve got a mouth, no ears.”* (Participant 14, F, MSA, 60). Part of this experience often included the agent talking quickly and creating a sense of urgency: *“Right, they tend to talk quickly and demand a quick response.”* (Participant 5, M, ataxia, 58).

One of the key sub-categories that emerged was the significant **emotional impact of the condition and misunderstandings**. Some of the negative emotions that participants experienced were linked to fear and upset. They reported fear that the agent would make wrong **assumptions about them** based on their speech and upset when that happens. One of the recurring stereotypes that participants were concerned about was that they might be perceived as drunk, which many people with ataxia experience (Ataxia UK, 2020): *“I’m sure people think I’m drunk half the time.”* (Participant 13, F, MSA, 60). Some participants have experienced direct accusations: *“they have been very rude on the phone because they can’t understand what I’m saying, like, “Are you drunk?””* (Participant 11, F, ataxia, 29), which leads to negative **emotional impact**: *“And obviously that makes you feel rotten, it makes you feel really bad and stuff like that.”* (Participant 11, F, ataxia, 29).

It was frequently reported that the **emotional impact** of these negative experiences led to worsening of their speech symptoms, leading to a vicious cycle of being misunderstood even more: *“With Parkinson’s, your body stiffens up and then [** 0:12:24], and then you get the crazy vicious cycle of getting more frustrated, more symptoms, more frustration, more symptoms. And then on occasion, I just turn the call off and say, “I can’t do it anymore.””* (Participant 14, M, Parkinson’s and stammering).

3.1.5. Technologies

When asked about their preferred mode of communication, participants ranked some of the commonly used ones, demonstrating **variability of preference** between people and circumstances: *“By email, but I use a phone if I can’t find an email address.”* (Participant 6, M,

ataxia, 78) or *“If I can’t get to a person quickly, I hang up and try the email route. Or sometimes, I use text chat and those sorts of things. But text chats are a challenge because quite often, you get bots rather than people.”* (Participant 14, M, Parkinson’s and stammering)

Despite the variabilities, **automatic speech recognition (ASR)** was consistently the hardest to manage for the participants: *“Especially that automated service when you need to say stuff, that’s terrible.”* (Participant 11, F, ataxia, 29), or *“the bot doesn’t recognise my voice.”* (Participant 8, M, ataxia, 73), or *“I find that where it’s voice recognition, I struggle.”* (Participant 14, M, Parkinson’s and stammering), or *“Oh, it’s a nightmare”* (Participant 3, M, unspecified, 55).

3.2. Strategies

3.2.1. Organisational and Technology

A consistently reported strategy for contacting service providers is that participants **seek out the best available method of communication**, which is often not available or not implemented in a manner that supports their communication needs: *“I no longer ask for video calls as I have been told on every occasion that the provider is not set up for this (this includes telephone calls with health care providers). Complex stuff is difficult to communicate easily by typing for all parties.”* (Participant 10, M, ataxia). However, a participant cautioned that in the past he would not have been able to choose the best communication method to match his strengths: *“Just a note of caution that whereas I can probably select the most appropriate option at the minute, now, I think previously I was in denial and therefore wouldn’t have sought help, thinking I didn’t need it.”* (Participant 5, M, ataxia, 78). This suggests that organisations need to be prepared to support customers with limited insight about their condition effectively and discretely.

Participants consistently reported requiring **persistence** to complete the task, which was required due to failure to be understood either by ASR or a person: *“I’m a very stubborn person, so I would persist.”* (Participant 11, F, ataxia, 76) or *“I call back several times till I find somebody that will listen.”* (Participant 6, M, ataxia, 78).

In addition, participants frequently reported **opting out of using technologies**, which were primarily the ones involving automation, such as ASR: *“I just give up and start again, to be honest, put the phone down and pray that I’ll get somebody.”* (Participant 13, F, MSA, 60) or trying different methods to get the ASR menu (**bypassing ASR**) to connect them with a person: *“But I’ve discovered that if I just make several pauses, the automated response will say, “We are not able to understand, and we’ll put you through.””* (Participant 7, M, dystonia, 76).

3.2.2. Considerations

Participants often reported having to take into consideration multiple factors, relating to their state, before placing a phone call. **Fatigue** was frequently reported to affect the participants’ speech symptoms, which, in addition to the **type of information** that needs to be communicated, were some of the factors that influenced participants’ choice of methods: *“When I’m not tired and can be clear, then I can generally get through the phone conversation, yeah? But issues arise when I’m tired. Plus the sort of phone calls I make tend to use a lot of technical information and pronunciation can be a bit of an issue for me.”* (Participant 5, M, ataxia, 58)

3.2.3. Interpersonal and People

Some of the interpersonal strategies that the participants discussed were related to **self-advocacy** and choosing to **disclose their speech condition** to the phone agent: *“When I call on the phone, I will ask if there’s an email option and point out that I have a voice condition, which makes speaking*

to a call centre difficult.” (Participant 7, M, dystonia, 76); “I’d say I’ve taken the lead to say how I want the conversation to go. It’s pretty much around allowing me to slow down and speak and get the whole element of my message out there before they reply and say anything.” (Participant 4, M, ataxia, 53). However, this strategy was not preferred by all participants, due to fear of judgement: “just thinking about saying to them, my speech is maybe hard to understand me, but I wouldn’t want cheeky Scottish people to say anything rude.” (Participant 11, F, ataxia, 29).

Some participants also encouraged the agent to ask for clarifications if they are struggling to understand: “I always start by saying that I’ve got Parkinson’s and that my speech is affected. And I say that, “If you can’t understand me, please tell me and I won’t be offended.” But people don’t always tell me.” (Participant 12, F, Parkinson’s, 76). Participants also proactively checked the agent’s understanding: “So, sometimes, I will say, if it’s important, I’ll say, because I know they’ve not heard me, I’ll say, “Can you just read back what I’ve said to make sure that we’re both on the same page here, what exactly I’m asking?” (Participant 3, M, unspecified, 55).

When all these strategies or considerations fail, the participants often **involved support** (usually family) to help with phone calls. This was coded as the *vicarious assistance*, meaning that participants asked the family member to initiate phone calls (“I ask my mum to phone here or there, but I am quite independent.” Participant 11, F, ataxia, 29; “certainly there was a time I asked my wife if she would make a call for me.” Participant 8, M, ataxia, 73); or the *safety net model*, when a supportive person was present in the room, ready to take over if needed (“I ask her to take over.” Participant 6, M, ataxia, 76). In both models participants remained in the room to relay their answers to the person helping with the call.

While a highly prevalent strategy, some participants **rejected relying on family**: “No, because that is making me a second-class citizen. I should, I believe, under the disability legislation have the right to be able to, you know, for firms to make provision for me to contact them and accommodate my disability.” Participant 7, M, dystonia, 76). Other participants had a **lack of in-group support**: “unfortunately both my parents have since passed away a long time ago. I have no brothers or sisters. So I don’t really need to depend on family for anything.” (Participant 9, M, ataxia, 37) or faced the prospect of losing it: “We are both very old, so if one of us dies, if he dies, I’m stuck.” (Participant 1, F, ataxia, 77).

3.3. Priorities (Recommendations)

3.3.1. For institutions

Participants mostly made suggestions for how companies can support callers by keeping records of client needs, to meet them as they are calling: “One thing I’d pass onto them would be wherever possible, try and flag it in the system. So the person you speak to is routed through to a person appropriate to deal with this type of query.” (Participant 4, M, ataxia, 53). This has already been described as a positive experience by another participant in 3.1.4.

Second, institutions can implement more effective triage, resulting in connecting the caller with an appropriate agent: “On the WhatsApp bot it asked me a series of questions which is like a triage, and having completed those questions I would expect to be put through to an appropriate department. Well actually, all it does is to gather information then puts me through to the next available operative. So I think they’re not using the triage possibility very well.” (Participant 08, M, ataxia, 73). This option reduces the need for the caller to explain their issue to multiple agents. For people with acquired speech difficulties this means reducing the risk of fatigue and frustration, both of which they experience as negatively affecting their speech.

Third, companies can allow the caller alternative means of communication without having to go through ASR triage (i.e., opting out of ASR): *“When it says press a number between 1 to 6, I press star quite often to try to get through that way. So, that works, sometimes. But there’s no failsafe that always works because all the different companies are set up differently.”* (Participant 14, M, Parkinson’s and stammering). This is imperative until ASR has been convincingly demonstrated to be accessible to all customers. It also shows an opportunity for standardisation of accessibility designs across institutions.

Fourth, organisations should provide institutional power and training to agents to solve various client demands, instead of relying on scripts: *“I would just say that if somebody invested in having more people onshore who listen to you and are well trained, less scripts, more conversation, then that would get my business. Anything that gives me more help. It’s the scripted, untrained, automated, chat bot type operation that I can’t operate with.”* (Participant 14, M, Parkinson’s and stammering).

The final area of advice relates to the use of technology. As reported in 3.1.5 there was no universally preferred modality of contacting service providers, even video calls, which can combine visual, auditory, and written modalities: *“I don’t want video phones, put it that way. Because my face gets really tight, especially at work.”* (Participant 13, F, MSA, 60). The variability in participant preferences (see below) suggests that offering several options for communication is necessary to accommodate people with different communication needs and allowing clients to opt out of technologies that present barriers (e.g., ASR).

Many participants preferred written modalities and wanted email to be more widely available and responded to promptly: *“Just email address and then to answer the emails.”* (Participant 6, M, ataxia, 78). However, alternatives like chats were not suitable, due to the imposed time pressure: *“there’s been a decline in my speech, my dexterity has declined as well. [...] And email, at least it allows me more time to compose and reflect and to make corrections. Often when I’ve done that over the web chat, I’ve been asked whether I’m still here.”* (Participant 5, M, ataxia, 58). However, another participant suggested that a WhatsApp chat service *“would be handy, I think, yes. Perhaps all customer services departments could get those put in just in case.”* (Participant 13, F, MSA, 60).

Some participants recommended multimodal communication, allowing typed responses during a conversation: *“It would have to be something you could pick up in a middle of a conversation, you wouldn’t have to... that would be quite good. Otherwise, you’ve got to put the phone down, phone up again and everything else. But if you could say, “Right, would you like to spell that out and do that,” sort of thing, it would be ideal, perfect, in fact, I think.”* (Participant 13, F, MSA, 60).

3.3.2. For agents

While participants were generally empathetic to the work constraints of agents, they suggested that agents should be trained to be proactive when they do not understand (*“If they just tell me.”* Participant 12, F, Parkinson’s, 76) and double-check understanding, which was frequently explicitly encouraged by participants and highlighted as good practice they have observed (see 3.1.3 and 3.2.3). However, one participant suggested that while he prefers double-checking, other people with speech conditions might not: *“It’s difficult that, because if they said to me, “I’m sorry, you’re a bit difficult to understand,” that would upset a lot of people.”* (Participant 8, M, ataxia, 73).

4. Discussion

This study aimed to fill in a gap in the recent research on accessibility of services by exploring the experiences, communication strategies, and priorities for adults with acquired speech conditions contacting services in a post-pandemic context. It was motivated by the limited amount of research including experiences across different health conditions and by the increased societal reliance on remote communication since the last study with a broadly similar focus by Baylor et al. (2011). The results of the study align with the findings of past research, such as Baylor et al. (2011). Both studies reveal the significant emotional and functional impact of the participants' condition on communication. There was also overlap in how participants dealt with communicative challenges: They had to consider how their symptoms might vary during the day, in addition to the purpose of the call, their environment, and expected length of the communication. There was also a similarity in seeing one's family as support to lean on, while communication with strangers was often more challenging. Noteworthy findings in our study were the sentiments of those who did not have access to family support. In addition, some participants felt that, according to UK disability legislation (Equality Act (2010), section 20), the onus was fully on the service providers to make reasonable adjustments to not put people with disabilities at a substantial disadvantage. Based on the evidence presented in this article, many services are not meeting this legal requirement.

While the emotional impact, considerations, and support might be similar to previous reports, the present study reflects the changing technological environment and different communicative demands for people with speech conditions over the last 15 years. For example, comments reported in Baylor et al. (2011) were restricted to phone conversations, whereas participants in the present study' also provided views on email, chats and chatbots, ASR, talking to local and overseas agents on the phone, and multimodal communication. Another notable difference between the two studies relates to attitudes towards the use of technology. Participants in Baylor et al. (2011) frequently reported avoiding communication as a strategy to avoid the inconveniences, difficulties, and frustrations associated with communication in certain situations. On the other hand, participants of the present study also talked about "persistence" and proactively "choosing the best available mode of communication", which sometimes meant avoiding communication channels, specifically those involving automation and time pressure.

Our participants' experiences and recommendations reveal not only the need for but also the path towards improved accessibility in customer communications. A variety of approaches to making customer communication more accessible that were praised by our participants are already recognised as good practice by existing solutions, such as the Plain English Campaign (Plain English Campaign, n.d.) or the Communication Access training (Royal College of Speech and Language Therapists [RCSLT], n.d.). UK government websites have incorporated the Plain English principles (Government Digital Service, 2024), and the associated short questions and answers were appreciated by one of our participants. These principles reduce demands on cognition, language processing, and dexterity and are therefore accessible for more people.

The Communication Access training supports increased awareness of the variable communication needs within the UK population and the use of strategies, ensuring that the person with communication needs is listened to until the message is understood and confirmed (Let's TALK about communication on the phone, n.d.). This training that can address most of the participants' challenges reported in this study around being stereotyped as "drunk", hung up on, rushed and misunderstood. The training also encourages offering alternative means of communication, as needed, which echoes our participants' frustration at having no alternative methods of

communication that fit their needs. A major obstacle to accessibility was Automatic Speech Recognition (ASR)-based triage, that participants had to go through before reaching a representative. ASR has been shown to be inadequate for the needs of people with dysarthria (Moore, Venkateswara, & Panchanathan, 2018) and while solutions might be underway (Google Research, n.d.), it is currently a barrier to communication.

The implementation of these solutions requires organisations to recognise the accessibility needs of their customers and to invest in implementing solutions. The results of this study suggest that many UK institutions are not meeting the requirements of existing policy, such as the Equality Act (2010). Activism efforts, such as the More than Words campaign (2025), need to focus on engaging institutions in improving their accessibility for people with speech-related disabilities. Some solutions outlined in this study include: Providing and monitoring multiple channels of communication that allow bypassing methods that increase communication demands (e.g., ASR or chatbots), reducing communication demands by using Plain English and by connecting people with disabilities directly with trained agents, who have institutional power to resolve client requests without needing further transfers. This might require companies to store customer data relating to disability and required adjustments.

Another long-term avenue for widening accessibility for people with speech conditions is developing research on supporting listener understanding of dysarthric speech (for a review see Borrie & Lansford, 2021). This could involve not only providing training to some customer service agents (human and automated) on effective communication strategies (Communication Access UK – Inclusive communication for all, n.d.), but also helping them understand the speech of people with different speech disorders via targeted speech exposure training. Finally, this study represents the views of a small group of participants from the UK. Further research needs to reach broader populations whose needs may not be represented here.

6. Conclusion

This study investigated the experiences of people with acquired speech conditions in the UK when contacting service providers over the phone. A key finding was that the recent developments in technology (e.g., automatic speech recognition (ASR) or chatbots) have not only failed to improve the experiences of people with speech difficulties, but instead often exacerbated their previous difficulties.

Our study thus highlights that, in the case of people with speech-related disabilities, service providers currently fall short of the requirements of the UK Equality Act (2010) and points to an urgent need for institutions to improve the accessibility of their services for these consumer groups. On a more positive note, our participants were able to make recommendations for how providers can make reasonable adjustments to support them more effectively. Further research is necessary to investigate the feasibility, acceptability and effectiveness of such measures to develop viable and effective support mechanisms.

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