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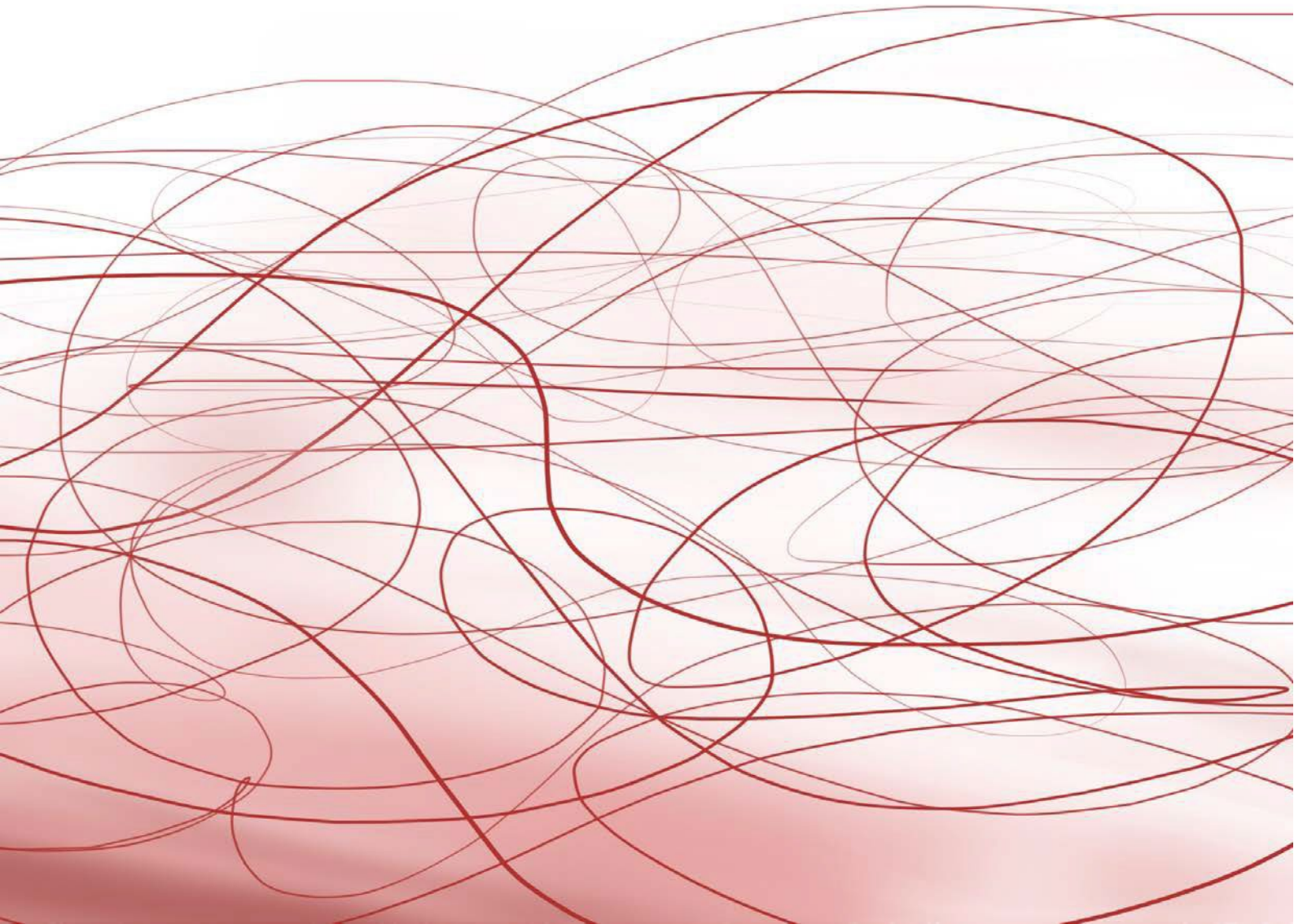

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VATICAN MUSEUMS' ACCESSIBILITY PRACTICES FOR BLIND AND PARTIALLY SIGHTED (BPS) VISITORS: A CASE STUDY

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***Abstract*:** The Vatican Museums (also referred to as "VM") are the repositories of one of the world's most remarkable and varied art collections. The relative responsibilities and challenges are plenty: the many visitors pose a significant threat to the conservation of artworks, but communicating and safeguarding the works of art is even more challenging when opening the museum collections to a Blind and Partially Sighted (referred in the article as BPS) audience. The Vatican Museums' accessibility practices, some of which aimed at providing support to the experience of visually impaired visitors, have been developed via foresight, international vision, strong partnerships, and efficient resource allocation.

The present article describes the strategies adopted by the Vatican Museums involving accessibility for BPS audiences. It examines the extent of existing measures and how they align with the "best practices" necessary to grant access to facilities and valuable information. The analysis has been carried out through first-hand observations performed during the internship period the author spent at the Vatican Museums. Finally, the article examines the educational techniques involving some of the items included in the haptic itinerary offered by the Vatican Museum, with references to applied neuroscientific research in relation to tactile perception and Museum Sciences.

Keywords: museum education, museum studies, accessibility, Vatican Museums, BPS, empirical aesthetics.

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Introduction

Getting in touch with culture can be considered a fundamental experience for a person's development and subsequent integration into society. However, visual impairment often appears to be an insurmountable obstacle when accessing culture and art because of the inherent visual approach linked to sharing and communicating content in museums. Classen & Howes (2006) highlight how touch and proprioception were once appropriate means for experiencing a work of art, particularly when museums were reserved for a social elite. However, ever since museums opened to the general public there has been an increasing abstention from aesthetic perceptual modalities other than sight (Classen, 2012; Candlin, 2008).

The prejudice of inaccessibility to cultural heritage for Blind and Partially Sighted (henceforth referred to as BPS) people is shared by many. Yet, the efforts undertaken to understand visual impairment have fortunately provided essential contributions to reflect on how best to communicate art and culture to this specific population. The present study proposes that objectives and specific measures have to be considered in order to improve the accessibility of museum structures; not limited to physical access, it’s important to establish effective museum typhlodidactics (i.e. education aimed at BPS visitors), potentially employing the insights offered by empirical aesthetics to understand the specific perceptual and learning needs of BPS people.

Research objectives

This article is presented as a case study. Its purpose is to illustrate the practices for BPS-specific accessibility and education employed by the Vatican Museums. The analysis aims to show how, through networking and focusing efforts and resources, it is possible to open a museum to everyone, shaping effective educational programs. At the same time, it is important to keep these strategies up-to-date and in line with the latest research and best practices.

The review of the accessibility methodologies employed by the Vatican Museums took place via first-hand observation, with consideration to the current "best practices" (Pressman & Schulz, 2021; Tiberti, 2020; Paschetta, 2003; on website

accessibility, Bahram, 2021) and typhlodidactics studies (Secchi, 2004; Grassini, 2015; Grassini, Socrati & Trasatti, 2018; Piscitelli et al., 2010). Finally, a few neurophysiological studies are referenced to support the relevance of understanding the mechanisms underlying the perception of BPS people (Chatterjee, 2008; Levent & Pascual-Leone, 2014). However, this research perspective would benefit from further investigation.

Structure of the article

The first part of the article briefly analyses visual impairment: its features, its proportional impact on the world population, and an estimate of its growth. Here are also described the types of barriers (structural, psychological, and social) that must be considered when designing accessibility strategies for BPS people. Finally, the role of the modern museum in cultural heritage communication is briefly assessed. The focus will be on the Vatican Museums, outlining their mission and network of relationships with professionals, institutions, and associations.

The second part lists a series of measures adopted by the Vatican Museums to make facilities and information accessible vertically, i.e. from planning the visit until after leaving the museum. The analysis will highlight strengths, challenges and some of the author's suggestions.

The third part showcases four items included in the itinerary for BPS visitors offered by the Vatican Museums. The items listed in this article have been hereby selected for their uniqueness and high pedagogical value (Isabella Salandri, personal communication). However, they comprise only a fraction of the items in the educational itinerary. In this section there are also some suggestions regarding the integration of neural correlates to the haptic perception that can be acknowledged when designing an educational museum itinerary for BPS people.

Section 1: General Assessment

For BPS people, as for the general public, visiting a museum under the appropriate conditions has the potential to be an enriching moment on many

fronts. BPS visitors can learn about culturally relevant artefacts, interact with other people, and avoid isolation. No less important is the opportunity to engage in pleasant experiences with the collections in a multisensory way, which could lead to a better understanding of the artworks. This has been linked to increased self-esteem and confidence in one's abilities (Small, Darcy & Packer, 2012). In the following sections, we will briefly disclose the characteristics of visual impairment, and the approach of the Vatican Museums to accessibility.

Visual Impairment: Statistics and Barriers

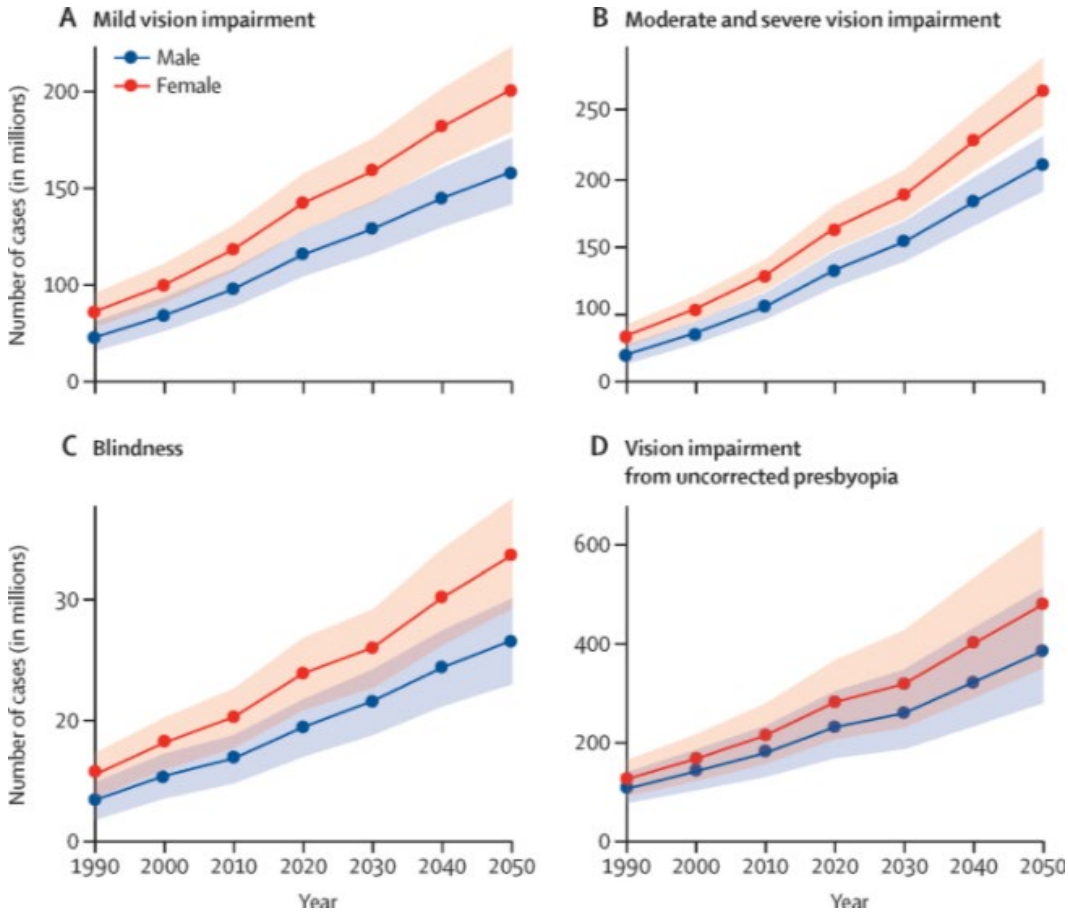
Statistical Analysis

The various degrees of visual impairment are classified in the International Classification of Diseases 11 (Fricke et al., 2018), dividing BPS people in two groups: “distance” and “near”. The different degrees of visual impairment, measured in visual acuity (referred to as v.a.), are: **mild** (v.a. worse than 6/12 to 6/18), **moderate** (v.a. worse than 6/18 to 6/60), **severe** (v.a. worse than 6/60 to 3/60), and **blindness** (v.a. worse than 3/60). Near vision impairment comprises individuals whose v.a. is worse than N6 or M.08 at 40cm. According to the World Health Organization (2021), a person’s experience of visual impairment relates to several different factors (e.g. whether the person has undergone rehabilitation or problematic access to buildings, transport, or information).

In order to understand the population-related impact of blindness in quantitative terms, as part of the World Health Organization's “VISION 2020: The Right to Sight” initiative, the Lancet Global Health has conducted a meta-analysis of statistical surveys (Bourne et al., 2021). The surveys, produced between 1980 and 2018, investigated the incidence of visual impairment worldwide, predicting the future impact of blindness on the world's population. The results of the study showed that, by 2020, approximately 43.3 million people were blind, 295 million had moderate and severe visual impairment, and 258 million had mild visual impairment. Globally, between 1990 and 2020, visual impairment due to old age (over 50) decreased by 28.5%. In contrast, severe and moderate visual impairments increased by 91.7%, while the number of people with blindness increased by 50.6%. The meta-analysis estimates that there will be 61 million blind people in 2050, while 474 million will have severe, moderate, or mild forms

of visual impairment (Figure 1). Considering the increase in the visually impaired population projected by this study, the present article suggests that enhancing accessibility in general, including museums and cultural facilities, may be a worthwhile investment.

Figure 1. Prediction of the number of people affected by mild vision impairment (A), moderate and severe vision impairment (B), blindness (C), and vision impairment from uncorrected presbyopia (D), all ages by sex, 1990-2050. Source: Bourne et al. (2020)



Barriers faced by Visually Impaired People

According to the "social" model of disability (Oliver & Barnes, 2010; Bolt, 2005), individuals have physical disadvantages due to various psychophysical reasons, but only for society this is identified as disability. In this sense, disability is not a functional limitation, but a consequence of external barriers that preclude full access to society. Some of the main challenges that BPS people face when participating in social activities are related to the physical features of the

environment. Specifically, architectural barriers can cause locomotion difficulties during exploration (Agostiano, Baracco, Caprara, Pane & Virdia, 2009). Limited familiarity with an unknown area is also likely to cause anxiety and insecurity, especially if a location is visited without a companion (Richards, Pritchard & Morgan, 2010).

The studies above suggest that, for BPS people, barriers can take many different forms, ranging from physical and psychological to social limitations. Those involved with accessibility should broaden their knowledge and skillset: be aware of both physical and psychological challenges, research the specific needs of people with disabilities, study accessibility measures in an ecologically valid context, and ensure a high level of training for staff and service providers.

Vatican Museums' commitment to accessibility

General Features

According to the latest Statute of the International Council of Museums (ICOM), adopted during the Extraordinary General Assembly held in Prague on the 24th of August, 2022, "*A museum is […] Open to the public,* ***accessible and inclusive****, […]. They operate and communicate […] with the* ***participation of communities****, offering varied experiences for* ***education****,* ***enjoyment****,* ***reflection and knowledge sharing****.*" (ICOM, 2023, emphasis added). Currently, then, the value of a museum is expected to depend not only on the scientific and historical relevance of the exhibits, but also on factors such as accessibility and enjoyment of the content, and how this content is delivered.

The Vatican Museums have a long and rich history, inextricably linked to the social and political events that have taken place in the world. The '*Museums of the Pope*' are addressed in plural because of the complexity and variety of their structures and collections. They embrace the task of "*making known, preserving and sharing that extraordinary legacy of culture, history, and beauty that the Roman Pontiffs have collected and safeguarded for centuries*" (Jatta, 2022). As is the case with the modern museum according to the ICOM definition (2023), the Vatican Museums embody, among other beliefs, the responsibilities of preserving

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and exhibiting culturally relevant artefacts. However, the mission of the museum is also to welcome and connect people through its collections.

Removing barriers

The Vatican Museums admit a considerable amount of visitors every year: in 2019, before the Coronavirus pandemic, the estimate reached almost 7 million people (Marroni, 2020). Consequently, to open the VM effectively, two major issues must be considered: conservation and fruition. The objective must be not only to passively open the museum collections to visitors, but to establish active welcoming strategies by meeting the needs of different target groups. In this sense, efforts in opening the collections are not only directed in favour of the general public, but also to specific prospective audiences. This necessarily calls for the close collaboration of multiple experts hailing from different fields: from restoration and conservation laboratories, to history and architecture departments, including administrative offices. Combining different professional backgrounds contributes to making the Vatican Museums' educational programs accessible so that the principles of conservation harmonize with museum education.

Modifications in the architecture and the collections have occurred in different moments during the centuries, reflecting diverse cultural backgrounds. The Museo Gregoriano Profano, one of the “Classics” Departments in the Vatican Museums, is of great interest for this analysis. The collection of marble sculptures themed around Graeco-Roman mythology and history was made accessible to visually impaired people in the 1990s.

External collaborations

A long-lasting rapport exists between Vatican Museums’ Department of Education and Accessibility and several associations that locally engage with the BPS community, including the *Federazione Nazionale delle Istituzioni Pro Ciechi di Roma*, and the *Associazione Museum*. The latter has been involved since the 1990s in conducting tours for the visually impaired in the Museo Gregoriano Profano and in the Sistine Chapel (Tiberti, 2020: p.205).

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Of major relevance is the partnership with the *Istituto dei Ciechi Francesco Cavazza* in Bologna, which also hosts the remarkable *Museo Tattile Anteros*. On several occasions, the Institute has produced educational supports for visually impaired visitors in the Vatican Museums. This includes the creation of 3D tactile reproductions of two major paintings, specifically Caravaggio's *Deposition*, and Raphael's *Transfiguration*. In 2011, the Chief Accessibility Officer of the Vatican Museums, Ms. Isabella Salandri, implemented innovative multisensory educational itineraries that feature these tactile supports.

Section 2: Access to Facilities and Information

Analysis of barrier removal solutions in the Vatican Museums

We will present here the different methodologies employed by the Vatican Museums aimed at enhancing the accessibility of facilities and information for BPS people "vertically" (i.e. from beginning to end, starting from gathering information on the web, up to the conclusion of the visit). In some cases, the solutions listed are accessible "horizontally" (i.e. across several disability categories: visual, auditory, mobility, and mental disabilities).

These strategies for accessibility are being regularly revised and updated, and each point is analysed below:

Official Website

The Vatican Museums' website (Vatican Museums, 2023) includes several specific information for visitors with disabilities, delivered in Italian and English. The contents are accurate and offer proper assistance to those wishing to obtain helpful directions for accessing the facility and planning a visit.

However, website browsing is obstructed by unwise graphic design, which also lacks accessibility adjustments. In order to improve the website, it may prove beneficial to review its design. A few suggestions include: enlarging the texts, making the colour contrasts more pleasant and less sharp, and grouping the information more straightforwardly. Following the example of other museums, such as the Rijksmuseum in Amsterdam (Rijksmuseum, 2023), a section

highlighting the best times of the day to plan a visit might be included. Also, it would be ideal to address museum areas with loud noises, excessive stimuli, or crowded rooms.

E-mail address

In addition to the information on the official website, it is possible to contact the back office by phone or e-mail, by writing to *education.musei@scv.va*. The back office is responsible for clarifying doubts visitors may have about educational visits and accessibility, and organising complex tours such as customised visits, or groups with a large number of visitors with disabilities.

Having a dedicated e-mail address can be of great benefit for the inclusion of the visually impaired person, as personal contact and planning are initiated. It is important to denote that this assistance to visitors with disabilities is offered directly by the Chief Accessibility Officer, who can therefore carefully organise visits for users with different needs.

Visitors' Entrance

Visitors with disabilities of any kind can access the Vatican Museums via the reserved entrance in Viale Vaticano, without making an online reservation unless they choose to take a guided tour. Skipping the line, they are referred to the Special Permits Desk in the lobby of the Vatican Museums. This desk is dedicated to assisting people with disabilities and other special or general needs.

If a guided tour has been scheduled with the Office for Services and Public Relations (*Ufficio Servizi e Relazioni con il Pubblico*, also known as USRP, translation added), visitors with disabilities will be welcomed by the Educational Operator. The course of action for the entrance is made easier by streamlining procedures, benefiting from the large waiting hall.

Tours and Educators

The educational guided tours, offered free of charge in a limited amount by the Direction of the Vatican Museums to BPS visitors who make such request, are organised and carried out, in most cases, by the person in charge of accessibility, Ms. Isabella Salandri. Following the numerous requests for accessible educational

tours, a staff of specialised museum educators has been personally trained by Ms. Salandri.

This service is fully paid for by the Vatican Museums, offering a limited number of free guided tours for people with disabilities. Although it may not be viable for most museums with fewer financial resources, it is recommended nonetheless that tours for BPS visitors be made available for any museum, in accordance with its profile and collections. Recruiting education specialists and making their prices affordable for BPS visitors is also recommended. This would be helpful in order to accommodate frequent financial constraints, a common problem for disabled people (Frick & Foster 2003).

Tactile Path Indicators and Maps

The entrance hall of the Museums has been equipped with tactile pavings, i.e. a system of textured ground surface indicators, designed by the museum's technicians and produced together with local associations involved with accessibility. The Vatican Gardens are also provided with a tactile map provided to the visitor by the museum guide during the tour (the Gardens cannot be visited without an authorized Vatican Museums' guide); a tactile map illustrating the entire Vatican City State is also available.

The Vatican Museums' areas are often historically significant, and the surfaces are subject to conservation concerns. In the current state, it is therefore impossible to implement tactile paving in the areas where most collections are displayed, due to the risk of floor damage. In general, though, tactile orientation aids can greatly help BPS people (Jain, 2014), as the visitor can create their own mental space, thus increasing their ability to move around, also supported by human guidance. The implementation of alternative solutions, digital or else, could be beneficial.

Breaking Down Architectural Barriers

Strategically placed throughout the Vatican Museums are lifts, ramps, moving platforms, and escalators. This enables total accessibility to almost all areas of the Museums for visitors in wheelchairs or with walking difficulties. The oldest lift dates back to Pope Pius XI Ratti and is located at the original 20th-century

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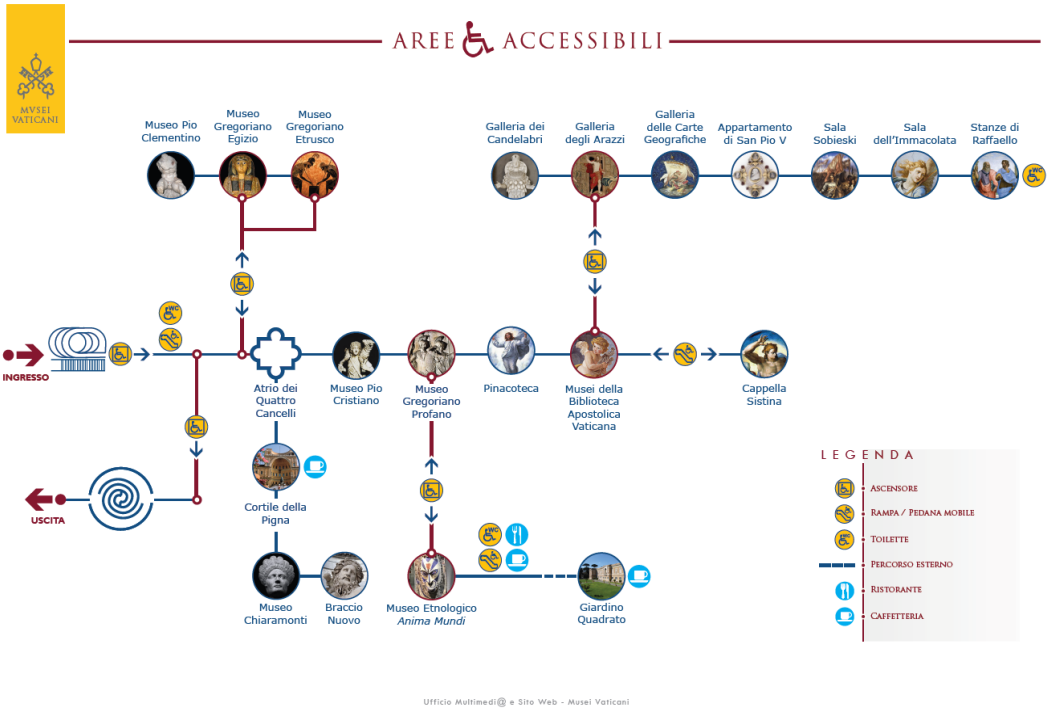
entrance to the Vatican Museums. In 2021, the newest lift was installed, leading from the Cortile delle Corazze to the Museo Pio-Clementino, Museo Gregoriano Egizio and Museo Gregoriano Etrusco levels. On the website of the Vatican Museums, a virtual map displaying the accessibility of the different areas (Figure 2) can be downloaded, and a hard copy is available at the ticket office on-site.

Figure 2. Map of Vatican Museums' accessible areas. The positioning of lifts and ramps is represented in a stylized way. The path connecting the various areas can also be identified. Source: Vatican Museums' official website. Retrieved March 31, 2022.



Lighting

The lighting in the VM is subject to several conservation concerns. The entrance and most of the rooms included in general itineraries are well lit. However, the luminosity, especially in areas where paintings and frescoes are exhibited, must be kept within specific parameters to ensure proper conservation. Lighting in other more challenging areas, especially the Tapestry Gallery, must be kept to a minimum to allow for adequate conservation of the artworks. If a companion is not available, BPS visitors can carefully hold to the handrails in the gallery and arrive in the next section.

Fast priority pathways

As tactile exploration requires much time, following quick routes to access more distant yet relevant areas becomes necessary. The Vatican Museums are in part composed of long galleries. A fast route can be used to reach some areas of great interest that are difficult to access, such as the Sistine Chapel. For example, to use the special route to the Sistine Chapel, Educational Operators who lead people with disabilities are allowed to walk through the Lower Galleries, which is normally the outflow area for visitors exiting the Sistine Chapel. Thus, in addition to avoiding an extremely long route, it is possible to circumvent the numerous steps and stairs of the regular itinerary.

Vatican Gardens

Since 2015, the Vatican Museums allows special access to BPS people who wish to visit the Vatican Gardens. This tour is free of charge and can be booked via e-mail, if available. The tour, led by a specialised guide, features art-historical, naturalistic, and anecdotal explanations. The visit is complemented by the multimodal natural ambiences, including sensations such as seasonal smells and auditory stimuli. In addition, the Educational Operator is equipped with a tactile handbook, i.e. an educational support consisting of large-format cards, produced in collaboration with the Federazione Nazionale delle Istituzioni Pro-Ciechi and Mr. Paolo Luzzi, Director of the Giardino dei Semplici in Florence. The book is written both in Braille and in enlarged letters (black lettering on a white background to create a strong chromatic contrast). The texts also include bas-relief drawings or layouts, with very simple and stylised outlines, and vivid colours specifically for the visually impaired with residual sight.

Section 3: Fruition of the artworks and guided tour

Origin and Features of the itinerary

The Vatican Museums launched their BPS accessibility program in the 1990s, when it was possible to explore some specially selected original marble sculptures haptically. In 2011, the educational offer for BPS people was improved with an innovative multi-sensory itinerary in the Vatican Pinacoteca, including bas-relief

reproductions of some relevant paintings. The itinerary has incorporated the Anima Mundi Ethnological Museum, including casts of the god Tu and Quetzalcoatl's statues, and the Pio-Cristiano Museum (Touching Art initiative). Since 2015, a multisensory itinerary has been open in the Vatican Gardens, which also made use of a tactile book with thermoformed tables and bas-reliefs, as well as text in Braille and black with enlarged characters.

The tour offered by the Vatican Museums to BPS visitors is intended to meet their cognitive and learning needs. Educational methodologies inspired by Montessori and Munari's sensory pedagogy (Munari, 1985; Montessori, 1935) are also employed. Additionally, Operators refer to Panofsky's (1961) tripartite method (pre-iconographic, iconographic, and iconological level) which dissects an image through the stratification of cognitive levels.

The typhlodidactic methodologies have been explored in theory and practice by Loretta Secchi (2004), curator of the *Anteros Tactile Museum of Ancient and Modern Painting* at the Istituto dei Ciechi Francesco Cavazza, in Bologna. Her work focused on the learning specificities of BPS people interacting with art and culture. A deep understanding of visually impaired perception can be extremely useful when developing an educational program. In this respect, an empirical aesthetics approach can provide valuable insights on the reactions of BPS people to different stimuli, informing the establishment of appropriate environments and educative techniques. It is hereby proposed that research in this field is potentially relevant if properly performed. The main objective continues to be respecting the BPS and their personal specificities, and experimenting both in a clinical environment and in ecologically valid ones such as museums.

Objectives of the analysis

The typhlodidactic strategies employed differ for each selected artwork, and every piece has been chosen according to its pedagogical value. Currently, the tactile copies are positioned adjacent to the original artwork. They are also placed in calmer areas and, thus, more enjoyable for BPS people sensitive to noises. Since a large number of people visits the Vatican Museums, it is advisable that the tour take place in spaces where crowds are unlikely to form and where the noise resulting from large gatherings does not disturb the haptic visits.

The following table lists some of the most relevant items in the Vatican Museums' tactile multisensory itinerary (Table 1).

Table 1. A list of some items in the tactile multisensory itinerary of the Vatican Museums, the name of the item, its location inside the Vatican Museums/Vatican City State, and the material or attributes important for the communication of the item to the visually impaired audiences.

N.	Name	Location	Material and attributes
1	Athena and Marsyas	M. Gregoriano Profano	Marble and gypsum
2	Deposition	Pinacoteca Vaticana	3-D perspective bas-relief
3	Sistine Chapel	Sistine Chapel	Architecture and images
4	Vatican Gardens	Vatican Gardens	Multisensory pathway

These items are thought to fully achieve the conjunction of pedagogical and aesthetic apparatus. The study was performed via direct observation of the educational activities carried out by specialised Educational Operators, and by first-hand application during BPS guided tours. The aim of the analysis is to highlight the key features of educational typhlodidactics methodologies used in the tactile itinerary of the Vatican Museums.

Item n.1: ATHENA AND MARSYAS (marble and gypsum sculptures)

The group of sculptures, Athena and Marsyas, shows the moment when the goddess, after throwing the 'aulòs' flute to the ground, surprises Marsyas, who is just about to pick it up. The sculpture of Athena (a 19th-century gypsum copy) is remarkably different from Marsyas' (an original 1st-century Roman sculpture in Pentelic marble): while the goddess is austere, the satyr is instead frozen in a very dynamic pose. Touching an original sculpture, if properly performed, can cause an emotional reaction in visitors, thus enriching the experience with emotional significance (Bacci & Pavani, 2014). It is imperative that, prior to touching original marble sculptures, hands are sanitized or, preferably,

thoroughly washed. The reason for this is to prevent bacterial growth and salt crystallization on the artwork, which harms marble (Doehne & Price, 2011).

Item.1 - Phase 1

Firstly, the Operator briefly recounts the myth. During the narration, a short audio extract of the sound of the aulòs flute, central to the story, is usually played. This facilitates imagining the context of the myth by using the auditory and emotional sensory pathways, which may fit well together in storytelling.

The following step is to convey the composition of the sculptures through words, to start building the image in the visitor's mind. Geometric coordinates should also be provided to guide the mental reconstruction of the composition (Secchi, 2004: p.90). During this phase, it is thought that proprioception can be stimulated (i.e. the bodily sensation originated by direct stimuli to muscles and tendons). The BPS visitor's body is first positioned in a stern pose imitating that of Athena; right afterward, the procedure is repeated to emulate Marsyas' complex and dynamic pose. This is done so that it is the body of the visitor itself that provides proprioceptive feedback on the position of the sculpture, allowing the user to understand it more quickly and on a deeper level.

Item.1 - Phase 2

The following phase is carried out through active tactile exploration performed by the user. It is essential that the Operator guides the exploration, at least initially, by applying their hands over the visitor's and facilitating the perceptual analysis. The criteria for the methods to be adopted during this visit are many and elaborate, stemming from extensive typhlological studies (Secchi, 2004). The first thing to be done during the tactile exploration is to achieve an all-round reconstruction of the whole figure. For the purposes of this exhibition, hand-to-hand contact can be of great interest, creating a link between the guide and the user. In fact, the contact between the hands can be invested by emotional significance thanks to the afferent C-Tactile (C-T) fibres on the back of the hand (Vallbo, Olausson, Wessberg & Norrsell, 1993; Ackerley, 2022; Watkins et al., 2021). Affective tactile fibres are located where the operator's hands are applied, and it is here proposed that this gives an emotional framework for the visit, especially if acquaintance has been initiated prior to the start of the visit.

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The BPS user relies on the guide who, with the right timing, accompanies the tactile exploration using words, which must never contradict what is being touched.

One of the peculiarities of the Athena and Marsyas sculpture group is the difference in materials: while Athena's gypsum is smooth and maintains a tepid temperature, Marsyas' marble sculpture reveals to the touch its cold, rough but well-worked texture. The different thermal sensations contribute to developing the narration, especially the marble. Exploiting the differences between the materials, perceived through slow tactile exploration (Deibert, Kraut & Kremen, 1999), could reveal interesting brain interactions in an ecologically valid study.

Item n.2: DEPOSITION (3D perspective bas-relief)

The Deposition, an early 17th-century painting by Caravaggio, is not only of great relevance for art history, but it is also exceptionally well suited to being translated into 3D perspective bas-relief for a BPS public: this may be due to the simple geometries of Caravaggio’s compositions, or to some of the figures seemingly breaking out of the canvas. The 3D translation of paintings requires a great deal of attention to detail, but also a necessary simplification of information that, haptically, would hinder rather than facilitating the shaping of a mental image (Secchi, 2004). A careful work of analysis during the production of this piece has been carried out by the Istituto dei Ciechi Francesco Cavazza (Figure 3).

Figure 3. The three-dimensional perspective bas-relief of Caravaggio's "Deposition" is positioned by the side of the original artwork. The bas-relief is placed on a stand that can support the weight applied by the person performing the haptic exploration. The bas-relief has a high elevation, favouring a reconstruction of the shapes in the user's mind.

Item.2 - Phase 1

The user is first eased into the context of Caravaggio's artwork, including a description of the pyramidal composition and the articulated positioning of the mourning participants. This is followed by a rich oral description of postures, expressions, and details. During the first description, if considered appropriate by the Operator according to the type of audience, it is possible to make the user touch some fabrics of the kind worn by characters in the painting, as well as a fragment of painted canvas manufactured by the Laboratorio di Restauro Dipinti (Paintings Restoration Lab) of the Vatican Museums. Characteristic smells and sounds can also be made available to the user.

It is also important, at this point, to give spatial coordinates, indicating the size of the painting and the position of certain pictorial elements that seem to emerge from the surface of the canvas, typical of Caravaggio's style. In this phase, the objective is to reconstruct in the user's mind the composition that, once abstract, will become tangible. An in-depth study is necessary to understand whether exploiting the parallels between the neural substrates common to touch and sight

(Amedi, Jacobson, Hendler, Malach & Zohary, 2002; James et al., 2002), would help to create a mental image of the painting perceived haptically.

Item.2 - Phase 2

The tactile exploration of the Deposition requires a relatively long time, due to the numerous details (wrinkles, drapery, facial features, and so forth) perceivable through fine touch. The Operator's presence is necessary to slow down the visitor's often curious and dynamic approach. A relationship of trust has to be established through emotional contact and narrative skills so that the BPS person can rely on the guide and successfully unravel the complex details of the 3D bas-relief.

The role of memory is essential at this stage. Since there are many figures in complex poses, it is necessary to trace the outlines of the characters several times during the analysis to consolidate the memory of their position and, consequently, the way they interact with other figures. Since tactile information stimuli are continuously provided, it is necessary to ensure that the position of the characters has been assimilated by the user, retracing their outlines if necessary.

Item n.3: SISTINE CHAPEL (architecture and images)

The Sistine Chapel plays a vital role in the experience of many Vatican Museums visitors. Reaching this unique, large environment and having the privilege of perceiving this overwhelming example of human greatness and ambition, is for some people the pinnacle of their visit. In communicating the Sistine Chapel to a visually impaired audience, the most effective tool is emotion which, if combined with good storytelling, passion, and creativity, can compensate for the large amount of information precluded to touch.

Item.3 - Phase 1

Being a place of worship, it is not possible to explain inside the Sistine Chapel. Its description is given to all visitors in areas equipped with analogical and virtual panels. Usually, in the ordinary guided tours for the general public, This happens

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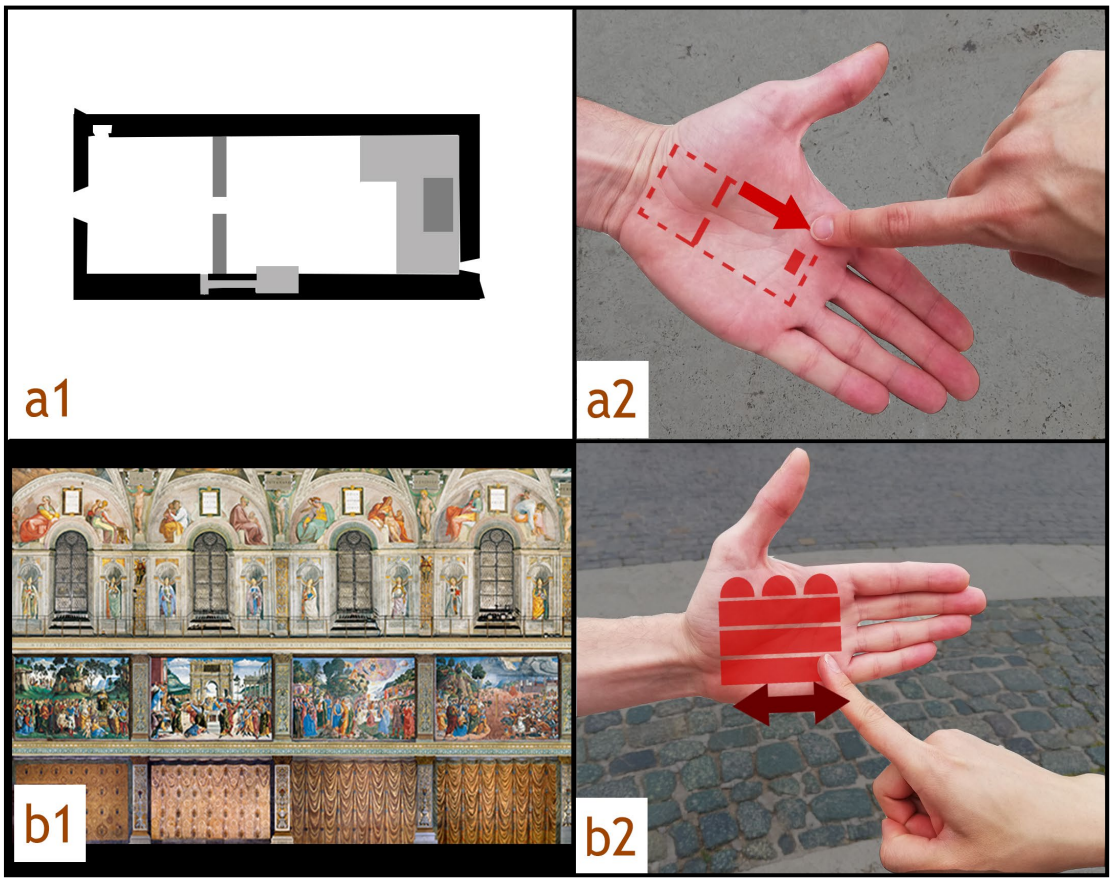
at the beginning of the visit, before carrying on to the different areas inside; the visitors then reach the Sistine Chapel on their own.

In the case of BPS visitors, the tour to the Sistine Chapel must be guided by complex descriptions that also make use of proprioception and interoception (i.e. the perception of the physiological condition within the body) to understand the proportion of the spaces, the artistic and physical efforts of the artist (thus exploiting the visitor's empathy) and the positioning of some of the most relevant figures.

The Sistine Chapel features an immense amount of images, and it is implausible to include them all in the description. It is suggested to proceed thematically, explaining the figurative program and providing historical and theological context. It is then appropriate to make the visitor understand the architectural space. In this phase, the Operator can use proprioception and an orderly description of both real and painted architecture: BPS visitors can understand the layout of the Sistine Chapel with the Operator outlining it on the palm of their hand (Figure 4, a). After hearing out the experts' opinions and through personal experimentation, a similar methodology was applied to the parietal fresco figurative program (Figure 4, b) and Michelangelo's Ceiling. However, this the efficacy of this experimental methodology still requires further investigation. Using this methodology, the Operator can also emphasize specific positioning or showcase the layout of the figures. This is a cheap and useful method that can be applied to almost any layout, as long as adequately guided and explained. Finally, prominent artworks created by Michelangelo are described via a rich narration and proprioception to understand the powerful poses of Michelangelo's monumental figures.

Figure 4. The architectonic layout of the Sistine Chapel (a1) can be outlined on the palm of the visitor's hand, positioned parallel to the ground (a2). The structure of the figurative program (b1, in this instance a section of the north wall. Source: Vatican Museums' official website. Retrieved April 30th, 2022.) can also be outlined on the hand, positioned perpendicular to the ground (b2).



Item.3 - Phase 2

Inside the Sistine Chapel, as an exception for visitors with disabilities, Educational Operators for BPS visitors are allowed to carry out simple explanations, although always respecting the sacredness of the place. It is thus possible to help the user position themselves in the space, building their own mental spatial map making use of the coordinates provided by the Operator. The latter, via tactile-plantar guidance and proprioception, guides the mental and physical elaboration of the environment. In the Sistine Chapel, if considered appropriate by the Custodian Staff, it is possible to touch the Cosmatesque floor, the High Altar, and the original sixteenth-century doorway leading to the Sala Regia.

Item n.4: VATICAN GARDENS (multisensory pathway)

Many visitors to the Vatican Museums disclose an interest in the Vatican Gardens, which cover 23 km^2 and cover more than half of the surface of the Vatican State. The Gardens are open to the public prior reservation and can be included in a tour itinerary. In addition to the "Gardens without Barriers" type of guided tour, specifically for people with reduced mobility, it is also possible to organise free guided tours of the Gardens for BPS people. The visit to this cultural site is an excellent example of how to exploit a multisensory resource already available in the museum complex.

Item.4 - Phase 1

The visit to the Vatican Gardens allows visitors to stroll here surrounded by nature's season-specific stimuli. The visit is therefore naturally enriched by the splashing of water in the numerous fountains, the chirping of birds, the rustling of leaves, the scent of aromatic plants, the smell of rain, and so forth. All of this is accompanied by interoceptive stimuli, as the visit is articulated along a walk through the Gardens. The multimodal stimuli are therefore an integral part of the route and are consolidated in the memory as they accompany the user throughout the visit. A walk through nature, art, and history also improves the mood of the visitors, who are hoped to return to the Vatican Museums with renewed interest.

Item.4 - Phase 2

A tactile book can also be used to complement the multisensory itinerary and the words of the Operator, who recounts anecdotes and describes the works of art encountered. The book is composed of thermoformed tables and perspective bas-reliefs, featuring texts in Braille and in black with enlarged characters; it is produced in collaboration with the Federazione Nazionale delle Istituzioni Pro-Ciechi, and Dr. Paolo Luzzi, Director of the Giardino dei Semplici in Florence. The book contains brief historical notes and several prospects and layouts of the buildings encountered in the Gardens. The bas-reliefs are accompanied by rich descriptions and the chance, where possible, to perceive details of the original structure haptically. The bas-reliefs have proven to be useful to BPS visitors: the supports help BPS create a mental image of what is described and of what they

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perceive haptically. Consequently, the inability to touch large buildings in their entirety is compensated.

Results

The measures to favour BPS accessibility in the Vatican Museums show variety and attention to detail. This case study analysis reveals reduced attention to the deployment of more technological measures for accessibility in favour of an analogical approach. However, one finds a significant reliance on the role of educational professionals and human contact, in line with typhlology studies (Secchi, 2004; Grassini, 2015). The interactive collaboration between experts, associations, and institutions has also proved to be an effective strategy for creating highly comprehensible typhlodidactic methodologies. Lastly, a frequent restoration of artworks and modernization of spaces inside the Vatican Museums can be seen. Thanks to the work of restorers and architects, and to the financial support of the *Patrons of the Arts in the Vatican Museums*, it was possible to eliminate most architectural barriers and make the VM more accessible.

These efforts, aimed at opening the museum and its collections to BPS visitors have endorsed the inclusion of the Vatican Museums in the international network of accessible museums (Isabella Salandri, personal communication). The accessibility objectives in the VM seem to be preserving and protecting artefacts and environments, providing access to areas and information, and developing specific educational projects.

As can be observed from the article, accessibility in the VM is fostered by considering the following guidelines:

- opening of the museum to all possible audiences;
- guaranteeing the competency of the employees who are directly or indirectly involved with accessibility;
- favouring interaction between different specialists within the museum;
- developing a solid network with accessibility-related institutions (such as other museums, associations, Patrons);
- continuously updating strategies to keep up-to-date on best practices;

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- designing a varied, well-codified, and creative educational program that enriches the user's experience.

Conclusions

What can be inferred from the analysis of the Vatican Museums' accessibility strategies is that, by directing efforts appropriately, it is possible to open a major museum, mostly considered visually-centred, to BPS people, providing also efficient accessible museum education. However, it is important to keep one's strategies up-to-date and in line with the latest research and best practices. The incorporation of these guidelines as a whole could be instrumental in the development of appropriate museum accessibility.

Museums need to open their collections to BPS users, who are not prevented from enjoying works of art that most people consider only recognizable through sight. Seeing the results achieved by the Vatican Museums, it can be concluded that the implementation of museum accessibility practices addressed to BPS people is an achievable goal, though liable to continuous updating. In the context of accessibility to a BPS public it is also helpful to offer various options and approaches to meet their methods of learning and information acquisition.

As a result of this analysis, it is hereby proposed that research focusing on museum education for BPS people -as well as on museum accessibility- should therefore be conducted in the field, in so-called "ecologically valid" settings. This may include research using neurophysiological and psychological tools and methodologies aimed at understanding the unique perception of BPS visitors. Therefore the suggestion is that the museum must play the role of a laboratory, be open to research and be attentive to the latest studies on accessibility. The hope is that, by adhering to these recommendations, a wider range of museums will be more and more accessible to the BPS community in the future.

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ACCESSIBILITY OF STUDENTS WITH PHYSICAL DISABILITY TO PUBLIC SERVICE VEHICLES IN THE WESTERN PART OF KENYA.

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***Abstract*:** Bus termini are an essential component of urban transport facilities which define the beginning or end of the line for the transportation system. In the study area, students with physical disability frequently used bus termini to access educational institutions which were far removed from their residences. Various bus termini were linked by fourteen seater vehicles or buses. During such trips, the students encountered numerous design barriers due to the inappropriate layout of the public service vehicles. This study established that the following design barriers existed in public service vehicles: high entry steps, lack of grab bars at the entrance, narrow doors and narrow spaces between seats. While navigating these design barriers, the students encountered the following attitudinal barriers: inferiority, pity, hero worship, spread effect and backlash. This study concluded that students with physical disability experienced hampered mobility due to the design barriers highlighted above. In addition to this, other users of the vehicles compounded the problem by exhibiting attitudinal barriers. Therefore, this study recommends enforcing standards in the design of public service vehicles which enhance access for all. Further, there is a need for the members of the public to embrace people with disabilities and stop the ongoing attitudinal barriers.

Keywords: Public transport, design barriers, attitudinal barriers

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Introduction

In 1994, the United Nations (UN) launched 22 rules for achieving equality for people with disabilities and identified eight areas of participation that should be recognised by governments when legislating to integrate people with disabilities into society. These areas were accessibility, education, employment, income maintenance, family life, culture, recreation and religion (United Nations, 1994). Five years later, the UN recognised that the process of translating the Rules into actual policy and practice was a 'major challenge' and, in response to this, called for empirical research to be carried out into the social, economic and participatory issues affecting the lives of disabled people and their families (United Nations, 1999).

The driving force behind the UN's stand on the importance of empirical research was the need to propose approaches which could be used in translating rights into action (United Nations, 1999). Further to this call for empirical research, the UN Convention called on participating governments to ban discriminatory practices and instead promote equal access to education and healthcare, promoting equal participation in public life and personal mobility (United Nations, 2019). This convention requires state parties to take appropriate measures to ensure that disabled persons have access to the physical environment, transportation and other facilities open to the public since all human rights are universal, indivisible, interdependent and interrelated, (United Nations, 2006). In 2007, Kenya became one of the first states to sign the International Convention on the Rights of Persons with Disabilities (United Nations, 2019). By this act, the Government was stating its commitment to promote and protect the rights of persons with disability. More importantly, the country was stating its willingness to promote access of disabled people to facilities open to the public.

The existence of an enabling legal framework promoting the rights of disabled persons does not necessarily mean that issues of accessibility are translated down to society. Coulson (2003) confirms that people with disabilities living on low incomes often 'fall between the gaps'. This study intends to focus on students with physical disability since they are a marginalised group within disabled people.

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Since 2003 when the Government launched Free Primary Education, gross enrolment rate (GER) had increased to 104 per cent in 2018 (Kenya Institute for Public Analysis, 2020). Enrolment increased across all categories of students, despite physical ability. Consequently, the volume of youths with disability attending school increased in 2003 due to the advent of free primary and secondary education in Kenya (Tooley, Dixon and Stanfield, 2003).

In order to access special schools, learners with Physical disabilities (LwPD) have to make use of termini since special schools are far removed from their residence. Kenya has twelve special schools of which eight are primary schools while four are secondary schools (Handicap International 2010).

High entry steps in vehicles have been identified as a barrier to access (Venter *et al.*, 2003). To mitigate this problem, low-floor buses should be utilised since they reduce the height difference between the kerb and bus floor. Research has also established that although low-floor buses are generally seen as a means of improving accessibility for passengers with disabilities, all passengers benefit from low-floor bus services (Bus Priority Team, 2006).

In Kenya, the Draft Kenya Standard, Road Vehicles Passenger Vehicle Body Construction Specification (2018) specifies that the lowest step for entering into a vehicle shall not exceed a height of 460 mm from the ground.

Within the study area, the two main modes of transportation are the bus and minivan. The main modes have been illustrated in the plates below:

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Figure 1. Image of a Bus used for public transportation

Figure 1 shows an image of an example of a Bus used in the western part of Kenya Kwoba and Mettke (2020) explain further that the public transport system is dominated by privately-owned public service vehicles which include buses and minibuses (known as matatus). Bus capacities range from 32 to 57 seaters.

Figure 2. Image of minivan (Matatu)

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Minivans are a common mode of public transport used in Western Kenya. Kwoba and Mettke (2020) explain further that matatu capacities range from 14 to 25 seaters.

This study, therefore, examined the design of the common modes of public service vehicles and the extent to which students with physical disabilities interacted with them in a typical trip to school. Accessible entrances are beneficial to a wide number of the populace, including children, the elderly, and persons with physical disability. Therefore, this study sought to evaluate the entrances of public service vehicles which used bus termini in the western part of Kenya.

In a typical trip to school, LwPD have to use termini since these termini define the beginning or end of the trip to school. A bus terminus can be a minor or major stop. A minor terminus is a simple bus stop, while a major terminus acts as a transfer station from one vehicle to another. It becomes clear, therefore, that to access special schools which are few and also far removed from the residences of the learners have to use bus termini and public service vehicles. Depending on the residence of a given student, a school trip may entail using more than one terminus and more than one type of vehicle. This study evaluated the design of buses, fourteen seater, and seven seater vehicles- so as to ascertain the design barriers in these vehicles. The study also sought to determine whether the learners experienced attitudinal barriers as they navigated over the design barriers.

Other examples of attitudinal barriers are spread effect, when other people assume that an individual's disability negatively affects other senses, abilities or personality traits; while stereotypes are formed when non-disabled members of the society form positive or negative generalisations about people with disabilities. Lastly, backlash is manifested when people believe individuals with disabilities are given unfair advantage; while fear occurs when non-disabled people are afraid that they will "do or say the wrong thing" around someone with a disability (World Bank, 2007).

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Methodology of Work

The study area was located in the western part of Kenya. Bus termini under consideration included: Bungoma, Kisumu, Kakamega and Kendu Bay. Bungoma terminus is situated next to the Bungoma Municipal market. This terminus acted as an intersection point for students learning at Nalondo Primary, Joy Valley Kamatuni and Nalondo Secondary School. It also acted as the origin point for LwPD, who learn in special schools located in other Counties, yet resided in Bungoma. Kisumu bus terminus is located in Kisumu which is a port city in the western part of Kenya. It is the third largest city in Kenya, the principal city of western Kenya and the headquarters of Kisumu County. This terminus acted either as an endpoint for students learning at Joyland primary and Secondary schools or as an origin for students who learnt either in Kendu Bay, Kakamega or Bungoma.

Kakamega terminus is located in western Kenya and 52 km from Kisumu terminus. This terminus acted either as an end point for students who studied at Daisy school or as an intersection point for students on their way to special schools in Bungoma or Kisumu. Lastly, Kendu Bay terminus is located on the shore of Lake Victoria along Katito Homa-Bay road. This terminus is located in Kendu Bay, a bay and a town in Kenya. Kisumu terminus is located 40 kilometres north of Kendu Bay. This terminus served either as an endpoint for students learning at Nyaburi or as an origin for students who learnt at Bungoma, Kisumu or Kakamega. These bus termini served up to 1,525 LwPD at the beginning and end of every school term. 315 respondents took part in this study.

The students had to evaluate the vehicle they used before terminating their school trip at a major bus terminus. The major bus termini in the study area were: Kisumu, Kakamega, Kendu Bay, or Bungoma. The vehicle types used in these bus termini included: seven seaters, fourteen seaters or buses. Respondents were required to document the specific design barriers experienced in the vehicle before terminating the school trip. Further, the respondents pointed out specific attitudinal barriers exhibited by commuters who did not have a disability.

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Discussion of Findings

Socio demographic Profile

Assistive Devices Used by Respondents.

A total of 315 respondents took part in the study, of which 34% made use of Bungoma terminus, while 25.4% of the respondents made use of the Kisumu terminus. Respondents who utilised Kendu Bay terminus were 27%; while 13.7% used Kakamega terminus. Respondents in the study area used assistive devices to substitute- to some extent- the missing or disabled limb. These devices also helped the students to be independent since they enhanced movement from one place to another. The assistive devices used within the study area have been presented in Table 1.

Table 1. Type of Assistive Device Used in Study Area

	Bungoma	Kisumu	Kendu Bay	Kakamega	Total
None	2.2%	14.3%	16.5%	7.9%	**41.0%**
Wheelchair	27.3%	4.4%	1.6%	0.6%	**34.0%**
Walking Stick	0.0%	1.0%	0.6%	0.0%	**1.6%**
Walker	0.3%	0.0%	0.0%	0.0%	**0.3%**
Crutches	2.9%	5.4%	5.4%	3.2%	**16.8%**
Tricycle	0.0%	0.3%	0.0%	0.0%	**0.3%**
Special Boots	1.3%	0.0%	2.9%	1.9%	**6.0%**
Total	**34.0%**	**25.4%**	**27.0%**	**13.7%**	**100%**

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A presentation of the assistive devices used across the study area reveals that the level of disability among respondents varied- such that the highest percentage of respondents did not use any assistive device (41%). These respondents had neurological disorders, which significantly reduced their dexterity and stamina. From these results, it can be deduced that the schools based in Kisumu had the highest percentage (14.3%) of students with neurological disorders, while Bungoma accounted for the least number of students with neurological disorders (2.2%).

Respondents who used wheelchairs in the study area accounted for 34% of the total respondents. These results establish that the highest percentage of students with the most significant degree of disability were based in Bungoma; while Kakamega had the least number of these students (0.6%). Respondents who used walking sticks had a slight disability on the lower limbs. Respondents who used walking sticks terminated their trip at Kisumu or Kendu Bay. None of the respondents who terminated their trip in Bungoma or Kakamega used walking sticks.

The results show that the highest percentage of crutch users were based in Kisumu and Kendu Bay (5.4%, respectively); while the lowest percentage of crutch users were based in Bungoma. Respondents who used special boots had slight lower limb disability when compared to crutch users. These respondents accounted for 6.0% of the total percentage of respondents. In Bungoma, special boot users accounted for 1.3%, while in Kendu Bay, they were 2.9%. Amongst respondents who terminated their trip in Kisumu terminus, none used special boots; while the highest percentage of special boot users terminated their trip in Kendu Bay.

Age of Respondents

Respondents in the study area were between the ages of 11 years to 19 years as has been illustrated in Table 2.

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Table 2. Age of Respondents per Town Cross tabulation.

	Bungoma	Kisumu	Kendu Bay	Kakamega	Total
11 years	3.8%	0.0%	1.0%	1.6%	**6.3%**
12 years	6.7%	1.0%	2.2%	1.6%	**11.4%**
13 years	2.5%	2.9%	10.8%	6.3%	**22.5%**
14 years	6.0%	6.3%	5.1%	3.5%	**21.0%**
15 years	7.3%	6.0%	3.2%	0.6%	**17.1%**
16 years	4.4%	3.2%	3.2%	0.0%	**10.8%**
17 years	1.3%	4.1%	1.0%	0.0%	**6.3%**
18 years	0.6%	2.2%	00.0%	0.0%	**2.9%**
19 years	1.3%	0.3%	0.0%	0.0%	**1.6%**
Total	**34.0%**	**26.0%**	**26.3%**	**13.7%**	**100%**

Within the study area, the bulk of respondents were aged 13 years (22.5%, followed by the fourteen year olds (21%). The lowest percentage of respondents were 19 years and they accounted for 1.6% of the respondents. The disparity of ages across the study area can be attributed to the fact that respondents were drawn from both primary and secondary schools. In the primary section, respondents were drawn from class six to eight, while in secondary, respondents were drawn from form one to four.

Barriers in Vehicles

High Entry Steps in Vehicle

Table 3 presents a breakdown on the occurrence of high entry steps in vehicles.

Table 3. High Entry Steps per Type of Assistive Device Used Cross tabulation

	None	Wheelchair	Walking Stick	Walker	Crutches	Tricycle	Special Boots	Total
No Barrier	6.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	**7.6%**
Minivan	6.3%	5.1%	0.6%	0.0%	0.9%	0.0%	0.0%	**13.0%**
Bus	28.6%	27.3%	1.0%	0.3%	15.9%	0.3%	6.0%	**79.4%**
Total	**41.0%**	**34.0%**	**1.6%**	**0.3%**	**16.8%**	**0.3%**	**6.0%**	**100%**

Amongst the vehicles, the bus seemed to be a more popular means of transport when compared to the seven seater and fourteen seater. However, the entry steps in buses proved to be a barrier to most of the respondents since it accounted for slightly more than three-quarters of the responses (79.4%). High occurrence of this barrier were reported by respondents who did not use any assistive device (28.6%), wheelchair users (27.3%), crutch users (16.8%), and special boot users (6%). These results reveal that the respondents in the study area experienced much difficulty in boarding vehicles plying the routes in the study area due to the presence of high entry steps. Respondents noted that during some instances, the crew of the vehicles would assist them in alighting and boarding the vehicles.

The height of the minivan steps was 300 mm across the study area, while that of the steps of the buses were 460 mm of the ground. None of the buses had a retractable first step. Although the specified dimensions are within the proposed standards by the Kenya Bureau of Standards (2018). The researcher

noted that the step entrances in the study area do not promote ease of use of vehicle entrances.

In areas where it is not feasible to have low-floor buses, a retractable first step at a bus entrance (or a movable stool) should be provided to assist semi-ambulatory passengers, while an accessible footboard of 230mm should be provided to facilitate boarding of vehicles by non-ambulatory passengers. To prevent tripping hazards, non-skid materials should be used for step and floor surfaces (Singh, Nagdavane and Srivastva 2007).

Bhise, Bhise and Dhanuka (2022) advocate for providing low heights of first step in vehicles to enhance ease of access by people with disabilities.

Lack of Grab Bars at Entrances

Another hindrance posed by the design of vehicles was the lack of sufficient grab bars at entrances, as has been illustrated in Table 4.

Table 4. Lack of Sufficient Grab Bars at Entrances per Type of Assistive Device Used Cross tabulation

	None	Wheelchair	Walking Stick	Walker	Crutches	Tricycle	Special Boots	Total
No Barrier	4.4%	6.7%	0.6%	0.3%	1.0%	0.0%	0.0%	**12.1%**
Minivan	13.3%	22.8%	0.6%	0.0%	8.2%	0.3%	2.3%	**48.6%**
Bus	23.2%	4.4%	0.3%	0.0%	7.6%	0.0%	3.8%	**39.4%**
Total	**41.0%**	**34.0%**	**1.6%**	**0.3%**	**16.8%**	**0.3%**	**6.0%**	**100%**

Lack of sufficient grab bars was highlighted by almost half of the respondents who used the minivan, while slightly more than a third of bus users (39.4%) highlighted this problem. Wheelchair users in the minivan category reported the highest percentage compared to other assistive devices (22.2%). In the bus

category, respondents with neurological disorders reported the highest occurrence of lack of grab rails at vehicle entrance (23.2%).

Respondents revealed further that when they were allocated the front seat in the minivan, embarking the vehicle entailed a delicate balance of making use of the seat and the grab bar positioned in the dashboard next to the co-driver. During other instances, when allocated a seat behind the driver, the respondents would use the seat as a means of support to hoist themselves up. However, the bus did not have this feature, which explains why it reported the highest percentage on this barrier. Wheelchair and tricycle users also pointed out further that due to the absence of grab bars at the entrance of buses, they had to bear the indignity of being carried into the bus when they had to board. Further, these results reveal that grab bars benefit all the LwPD regardless of the assistive device used.

Bhise, Bhise and Dhanuka (2022) advocate for the provision of railing near the steps of buses to enable pwD to board easily.

Narrow Doors

Another barrier to access was presented by narrow door openings, as has been illustrated in Table 5.

Table 5. Narrow Door Opening per Type of Assistive Device Used Cross tabulation

	None	Wheelchair	Walking Stick	Walker	Crutches	Tricycle	Special Boots	Total
No Barrier	2.2%	3.8%	0.0%	0.0%	0.3%	0.0%	0.0%	**6.3%**
Minivan	18.1%	21.9%	0.6%	0.3%	7.3%	0.3%	1.2%	**49.9%**
Bus	20.6%	8.3%	1.0%	0.0%	9.2%	0.0%	4.8%	**43.8%**
Total	**41.0%**	**34.0%**	**1.6%**	**0.3%**	**16.8%**	**0.3%**	**6.0%**	**100.0%**

Amongst users of the minivan, respondents who used the wheelchair experienced the most significant difficulty (21.9%), followed by respondents with neurological disorders (18.1%). In the bus category, respondents who had neurological disorders reported the highest percentage (20.6%), followed by crutch users (9.2%), wheelchair users (8.3%) and special boot users (4.8%).

The width of the doorways of buses ranged between 650 mm and 700 mm, while that for the 14 seater minivan was 600 mm. The doorway of buses was clear of any obstacles, while that of the minivan had seat fixed within the doorway space. Getting into the minivan thereby required contortion of the body in order to squeeze between the little space left. The responses from the study area show that a significant percentage of respondents experienced difficulty manoeuvring over the doorways. Given the fact that some assistive devices are bulky and require a significant amount of space. In addition to this, LwPD need additional space to manoeuvre through the doorways of vehicles adequately.

Presence of narrow door openings in vehicles is a design barrier which hinders access by people with disability. (Venter, Savill, Rickert et al., 2002; Bhise, Bhise and Dhanuka, 2022). It is important to note at this juncture that accessible vehicle entrances benefit a wide category of people including people with young children, people with pushchairs, ambulant disabled people, people with impaired vision, wheelchair users, passengers with shopping or luggage and elderly people (Bus Priority Team, 2006).

Narrow Seat Spacing

The issue of seat spacing in vehicles is presented in Table 6.

Table 6. Narrow Space between Seats per Type of Assistive Device Used Cross tabulation

	None	Wheelchair	Walking Stick	Walker	Crutches	Tricycle	Special Boots	Total
No Barrier	2.9%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	**5.7%**

	None	Wheelchair	Walking Stick	Walker	Crutches	Tricycle	Special Boots	Total
Minivan	34.2%	38.3%	1.6%	0.0%	16.5%	0.3%	0.6 %	**88.9%**
Bus	2.9%	2.9%	0.0%	0.3%	0.3%	0.0%	0.0%	**6.3%**
Total	**41%**	**34.0%**	**1.6%**	**.3%**	**16.8%**	**.3%**	**6.0%**	**100%**

Narrow seat spaces in minivans presented a problem to the following categories of LwPD: 34.2% of respondents who did not use any assistive device, 38.3% of wheelchair users, 1.6% of walking stick users, 16.5% of crutch users and 0.6% of special boot users. Respondents who had a problem with the seat spacing in buses was such that 2.9% did not use any assistive device, 2.9% used wheel chairs, 0.3% used walkers, while 0.3% used crutches.

Narrow space between seats was evident in the gangway and also in the knee clearance between seats. The gangway measurement for the bus was 450 mm, while that of the minivan varied between 300 mm and 350 mm. Within the study area, the knee clearance for the minivan ranged between

Due to the inappropriate design of the built environment, the participation of PwD is limited. They also spend more money on private means of transportation –(Bhise, Bhise and Dhanuka, 2022).

Sources of Attitudinal Barriers

While navigating over the design barriers highlighted above, respondents noted that they were recipients of attitudinal barriers from commuters, hawkers, drivers and conductors as is evidenced in Table 7.

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Table 7. Sources of Inferiority

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Bungoma	0.9%	18.3%	16.4%	2.8%	15.1%	4.1%	0.3%	18.9%
Kisumu	0.9%	14.5%	12.6%	2.8%	11.7%	3.8%	0.3%	15.1%
Kendu Bay	5.0%	15.1%	20.2%	0.0%	5.4%	14.8%	0.9%	19.2%
Kakamega	2.2%	7.3%	9.5%	0.0%	2.2%	7.3%	0.3%	9.1%
Total	**9%**	**55.2%**	**58.7%**	**5.6%**	**34.4%**	**30%**	**1.8%**	**62.3%**

Across the study area, respondents pointed out that travellers reported the highest percentage of inferiority (62.3%) when compared to conductors (55.2%), hawkers (5.6%) or drivers (30%). Within the study area, 55.2% of the respondents confirmed that inferiority emanated from conductors, of which 18.3% were from Bungoma, 14.5% were from Kisumu, 15.1% were from Kendu Bay, while 7.3% were from Kakamega. Bungoma reported the highest percentage of inferiority from conductors (18.3%).

Inferiority occurs when non-disabled members of society believe that the presence of impairments renders disabled persons ineffective (World Bank, 2007). As highlighted, evidence of this insensitivity and rudeness was present in the study area. When making verbal their thought, the researcher got a view of their view of disability. Within the study area, some non-disabled users interpreted the presence of disability as a sign of disfavour from the gods, referring to the parents of these learners as having done something wrong to warrant having a disabled child. Sources of pity have been presented in Table 8.

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Table 8. Sources of Pity

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Bungoma	2.5%	21.5%	22.4%	1.6%	15.1%	4.1%	0.3%	18.9%
Kisumu	1.9%	17.0%	17.4%	1.6%	11.7%	3.8%	0.3%	15.1%
Kendu Bay	8.2%	17.7%	24.9%	0.9%	5.4%	14.8%	0.9%	19.2%
Kakamega	4.4%	8.5%	12.6%	0.3%	2.2%	7.3%	0.3%	9.1%
Total	**17.0%**	**64.7%**	**77.3%**	**4.4%**	**34.4%**	**30%**	**1.8%**	**62.3%**

Across the study area, respondents pointed out that conductors reported the highest percentage of pity (64.7%) when compared to hawkers (4.4%), drivers (30%) or travellers (62.3%). Within the study area, 64.7% of the respondents confirmed that pity emanated from conductors, of which 21.5% were from Bungoma, 17% were from Kisumu, 17.7% were from Kendu Bay, while 8.5% were from Kakamega. Kendu Bay reported the highest percentage of pity from conductors (17.7%).

Table 9 presents the sources of hero worship.

Table 9. Sources of Hero Worship

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Bungoma	0.9%	22.1%	21.5%	1.6%	17.7%	5.4%	0.3%	22.7%
Kisumu	0.3%	18.0%	16.4%	1.9%	12.9%	5.4%	0.3%	18.0%

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Kendu Bay	7.3%	13.9%	21.1%	0.0%	6.3%	14.8%	0.0%	21.1%
Kakamega	4.1%	5.7%	9.8%	0.0%	1.9%	7.9%	0.6%	9.1%
Total	**12.6%**	**59.7%**	**68.8%**	**3.5%**	**38.8%**	**33.5%**	**1.2%**	**70.9%**

Across the study area, respondents pointed out that travellers reported the highest percentage of hero worship (70.9%) when compared to hawkers (3.5%), drivers (33.5%) or conductors (59.7%). Within the study area, 59.7% of the respondents confirmed that hero worship emanated from conductors, of which 22.1% were from Bungoma, 18% were from Kisumu, 13.9% were from Kendu Bay, while 5.7% were from Kakamega. Bungoma reported the highest percentage of hero worship from conductors (22.1%). Respondents who noted that hero worship emanated from hawkers were 3.5%, of which 1.6% were from Bungoma, while 1.9% were from Kisumu. Kisumu reported the highest percentage of hero worship from hawkers (1.9%).

Hero worship occurs when non-disabled members of society consider someone with a disability who lives independently to be brave or "special" for overcoming a disability (Advancing Workforce Diversity, n.d.).

Another barrier experienced in the study area was spread effect. Results on this barrier have been presented in the sections following (Table 10).

Table 10. Sources of Spread Effect

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Bungoma	0.9%	11.4%	12%	0.3%	0.3%	12%	8.8%	3.5%
Kisumu	0.9%	8.5%	9.1%	0.3%	0.3%	9.1%	6.3%	3.2%

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Kendu Bay	7.6%	16.1%	23.3%	0.3%	0.6%	23%	7.9%	15.8%
Kakamega	4.4%	8.5%	12.6%	0.3%	0.6%	12.3%	2.2%	10.7%
Total	**13.8%**	**44.5%**	**57%**	**1.2%**	**1.8%**	**56.4%**	**25.2%**	**33.2%**

Across the study area, respondents pointed out that drivers reported the highest percentage of spread effect (56.4%) when compared to conductors (44.5%), hawkers (1.2%), or travellers (33.2%). Within the study area, 44.5% of the respondents confirmed that spread effect emanated from conductors, of which 11.4% were from Bungoma, 8.5% were from Kisumu, 16.1% were from Kendu Bay, while 8.5% were from Kakamega. Kendu Bay reported the highest percentage of spread effect from conductors (16.1%).

Spread effect as an attitudinal barrier occurs during instances when other people assume that an individual's disability negatively affects other senses, abilities or personality traits (Advancing Workforce Diversity, n.d.). Table 11 presents the sources of backlash in the study area.

Table 11. Sources of Backlash

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Bungoma	0.3%	14.2%	12.9%	1.6%	11.4%	3.2%	0.3%	14.2%
Kisumu	0.6%	12.0%	11.0%	1.6%	9.8%	2.8%	0.3%	12.3%
Kendu Bay	8.2%	13.6%	21.8%	0.0%	6.0%	15.8%	0.9%	20.8%
Kakamega	4.4%	5.7%	10.1%	0.0%	1.6%	8.5%	0.3%	9.8%

Terminus	Conductor No	Conductor Yes	Hawkers No	Hawkers Yes	Driver No	Driver Yes	Travellers No	Travellers Yes
Total	**13.5%**	**45.5%**	**55.8%**	**3.2%**	**28.8%**	**30.3%**	**1.8%**	**57.1%**

Across the study area, respondents pointed out that travellers reported the highest percentage of backlash (57.1%) when compared to conductors (45.5%), hawkers (3.2%) or drivers (30.3%). Within the study area, 45.5% of the respondents confirmed that backlash emanated from conductors, of which 14.2% were from Bungoma, 12% were from Kisumu, 13.6% were from Kendu Bay, while 5.7% were from Kakamega. Kisumu reported the highest percentage of backlash from conductors (11.7%). Respondents who noted that backlash emanated from hawkers were 3.2% of which 1.6% were from Bungoma, while 1.6% were from Kisumu.

Respondents who noted that backlash emanated from drivers were 30.3% of which 3.2% were from Bungoma, 2.8% were from Kisumu, 15.8% were from Kendu Bay, while 8.5% were from Kakamega. Kendu Bay reported the highest percentage of backlash from drivers (15.8%). Respondents who confirmed that backlash emanated from travellers were 57.1% of which 14.2% were from Bungoma, 12.3% were from Kisumu, 20.8% were from Kendu Bay, while 9.8% were from Kakamega. Kendu Bay reported the highest percentage of backlash from travellers (20.8%). Backlash exists when people believe individuals with disabilities are given an unfair advantage (Advancing Workforce Diversity, n.d.).

Across the study area, various attitudinal barriers existed. Freer (2021) brings to fore the fact that Students' with disabilities continue to face attitudinal barriers. Ambati (2017) suggests that there is a need for changes to be made, not only in the physical environment but also in the attitudes of people interacting with people with disabilities. This particular research was done in an educational set up, but the recommendations are valid as far as the design of public spaces is concerned. Goodall, Mjoen, Witso et al. (2022) have confirmed that many students with disabilities have experienced some form of stigma. The researchers also advocate for more awareness and understanding towards disability.

Conclusion

The presence of design and attitudinal barriers continues to perpetuate ongoing discrimination against PwD. Reversing the ongoing discrimination will stem from needed redesign of public service vehicles so as to ensure that they enhance access. In addition to this, there is the need to educate the public so as to help deal with the attitudinal barriers present in the study area.

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MONITORING WEBSITE ACCESSIBILITY: EVALUATING CURRENT APPROACHES AND A PROPOSAL FOR IMPROVEMENTS

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***Abstract*:** The introduction of WCAG 2.0 and the European Web Accessibility Directive marked significant milestones in the realm of web accessibility evaluation. However, even with the passage of considerable time, persistent challenges continue to impact the assessment of web accessibility. In this article, we aim to address these ongoing hurdles and provide comprehensive suggestions for accessibility assurance to achieve efficiency, consistency, and transparency in the processes of preparing accessibility statements, monitoring, and self-assessment. The proposed solutions include a centralised system for preparing accessibility statements, a centralised government template for feedback mechanisms, simplified self-assessment based on nine general criteria, and in-depth monitoring by experts and individuals with disabilities. Centralising all accessibility statements would facilitate monitoring updates and accessibility achievements, enabling mass verification by the bodies in charge of monitoring the Web Accessibility Directive and the public. The centralised government template for feedback mechanisms

provides benefits such as automatic form completion and shared responsibility for addressing reported inaccessible content. Simplified, centralised, and automated monitoring allows for efficient tracking of accessibility status and verification of updates using an automated software environment. Links to results can be shared with public sector bodies and inspectors, enhancing transparency and comparison. In-depth monitoring requires complete analysis and recommendations for improvements, in which experts and individuals with disabilities are involved. Proper education and training of website administrators are crucial for ensuring quality and meeting accessibility criteria. By implementing these proposals, the goal of inclusive access to information and services can be achieved for all users.

Keywords: Accessibility, World Wide Web, Web Content Accessibility Guidelines, Web Accessibility Directive, Accessibility monitoring, Accessibility statement, Feedback mechanism.

Introduction

Increased involvement of people with various forms of disabilities has, in recent years, become an important factor in the analysis, development, and evaluation of websites, mobile applications, digital products, and various services (Campoverde-Molina et al., 2023). According to the official statistical data, about a quarter of the EU population experienced long-standing activity limitations due to health problems in 2021, which can be interpreted as those people having some sort of long-lasting impairments. 6,6% of Slovenes aged 15 years or over reported severe long-term limitations and 14,8% some long-term limitations, together coming to around 21%. Numbers were the highest in Latvia, where around 37% reported some sort of long-term limitations, and the lowest in Malta, with 17% (Eurostat, 2023). The number is set to increase, due to EU population ageing, and therefore being at increased risk of developing chronic conditions (Council of the European Union, 2022).

Therefore, digital inclusion or accessibility of Information and Communication Technologies has become crucial. Digital accessibility not only being desired, but also being a right (European Commission, 2023b), was legislated with the

introduction of Directive (EU) 2016/2102, also called The Web Accessibility Directive (European Commission, 2016). The Directive obliges public sector bodies' websites and apps to be accessible, however, there are still difficulties in evaluating accessibility.

Evaluation can be performed by automated or manual evaluation tools, which cannot identify all accessibility problems (Kollotzek et al., 2021; Rajh & Debevc, 2022). In-depth monitoring as a precise manual method, however, requires a significant amount of time and expertise from the evaluator. Moreover, there is also a lack of evidence on appropriate methodologies that would allow sufficient development and evaluation of websites, mobile applications, products, and services. The Web Accessibility Directive allows a lot of freedom in terms of monitoring and reporting, lacking a unified monitoring and reporting. However, it is important to point out that many EU Member States expressed their wish for a unified approach (Rajh & Debevc, 2022).

According to the Web Accessibility Directive (European Commission, 2016), the preparation of the accessibility statement and the implementation of the feedback mechanism must be carried out by public sector bodies, while simplified and in-depth monitoring should be conducted by the assigned bodies in charge of monitoring the Web Accessibility Directive, potentially in collaboration with public sector bodies.

In this article, we highlight the current state of evaluation approaches in accordance with the given European and national accessibility laws, and provide suggestions for an appropriate methodology:

- for the preparation and presentation of an accessibility statement,
- for the implementation of a feedback mechanism,
- for evaluation and reporting for simplified and in-depth monitoring.

Existing research on website accessibility monitoring has focused mostly on comparisons or usage of automated tools only, leaving a noticeable gap in understanding of the requirements of the Directive (EU) 2016/2102, where even the bodies in charge of monitoring the compliance with the Web

Accessibility Directive strive for clear and comprehensive methodology approaches.

The first monitoring period finished in December 2021, when the Member States published their reports, providing insights into their processes and potential uncertainties. The current ongoing monitoring period will finish in December 2024. In addition to viewing the reports and other web contents where the Member States describe their processes, we had multiple talks with the Slovenian monitoring body, to get first-hand insights into their work.

Based on the current good practices of Member States, an assessment of the challenges they encounter, and an overview of the existing evaluation tools, we have formulated comprehensive recommendations. These recommendations aim to guide various stakeholders in achieving compliance with the Web Accessibility Directive effectively while facilitating enhanced accessibility for all users.

Background

Legislations and guidelines

Directive (EU) 2016/2102

The European Parliament and the Council of the European Union have adopted Directive (EU) 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the accessibility of websites and mobile applications of public sector bodies (also called the Web Accessibility Directive). In addition to technical requirements, the Directive also stipulates that public sector bodies have to provide an "accessibility statement" for their websites, which has to include information on accessibility, as well as information on submitting requests and complaints. The Directive obliges all Member States to transpose it into their national laws. In the case of Slovenia, this was accomplished through the Slovenian Act on the accessibility of websites and mobile applications (ZDSMA) (Republika Slovenija, 2021).

Fundamentally, the Directive requires that each website and mobile application has to include an **accessibility statement** and **feedback mechanism**, while also the accessibility of websites and mobile applications of public sector bodies has to be monitored and reported regularly.

Due to these requirements, simplified and in-depth monitoring (to a lesser extent) must be carried out at the national level of each European country and reported to the European Commission. Under Directive (EU) 2016/2102, there are also some exceptions, such as websites of non-governmental organisations that are not essential for the public and others.

Monitoring methodology

The European Commission has determined, in an Implementing Decision, the monitoring methodology for the Directive on Web Accessibility (European Commission, 2018a). According to this Implementing Decision, conformance of websites and mobile applications with the accessibility requirements of the Directive is monitored using the following two methodologies (European Commission, 2018a; Kollotzek, 2021, Republika Slovenija, 2021):

- **Simplified monitoring method**: Basic vulnerabilities and their severity are recorded, and a protocol is created, with descriptions of issues and heuristic solutions based on standard specifications.
- **In-depth monitoring method**: In addition to basic monitoring, a detailed analysis of the root cause for each issue, a description of its impact on user groups, and specific proposals are provided for issue resolution.

The monitoring methodology also describes the sampling approach for websites and mobile applications, and what Member States should include in their monitoring reports. These requirements are as follows:

- A detailed description of the monitoring process.
- Mapping in the form of a Correlation Table, demonstrating how the monitoring methods used relate to the requirements in the Standards and Technical Specifications of the Directive, including any significant method changes.

- Monitoring results for each monitoring period, including measurement data.
- Description of the mechanisms established by Member States for consulting relevant stakeholders on website and mobile application accessibility.
- Procedures for publishing any accessibility policy developments related to websites and mobile applications.
- Information on training and awareness-raising activities.

A feedback mechanism for reporting content accessibility needs

Directive (EU) 2016/2102 requires that public sector bodies include a feedback mechanism for sending feedback in the form of electronic messages, or by entering data into a specially prepared web or application form. The feedback mechanism is included within the accessibility statement on their website or application.

The feedback mechanism should enable users to contact the public sector body directly to report accessibility issues and request alternative formats for inaccessible content. The feedback mechanism is beneficial for users as well as public sector bodies, as it allows them to obtain valuable information to address issues on their website or application.

Directive (EU) 2016/2102 stipulates that, in response to a "legitimate and reasonable" request, a public sector body has to provide a response "in an appropriate and accessible manner within a reasonable time frame." However, if an accessibility statement is not available, the user has to establish contact with the website owner through other means, which the public sector body has to provide specifically.

The World Wide Web Consortium (W3C) provided a document to help users report website accessibility problems (W3C, 2017), in which it is stated that users should send the following information to the public sector body:

- The URL where the problem occurred.
- A description of the problem.
- The device being used.

- The operating system being used (e.g., Windows, MacOS, Linux...).
- The missing settings (e.g., font size).
- The assistive technologies being used (e.g., screen reader, magnifier, FM system...).
- If possible, a screenshot of the problem.

While the above list is a recommendation, it may be demanding for many users, and, thus, it calls for simplified and automated methods for submitting complaints or requests.

Web Content Accessibility Guidelines

The Web Content Accessibility Guidelines (WCAG) are globally recognised recommendations for enabling the accessibility of web content, published by the World Wide Web Consortium (W3C). The previous version, 2.1, which is referenced by the European Standard EN 301 549 that supports the European Directive 2016/2102, was published on 5 June 2018. As the latest EN 301 549 (version 3.2.1) references WCAG 2.1, the newest WCAG version, 2.2, published on 5 October 2023 (W3C, 2023), will become relevant when ETSI prepares standard updates and when the European Commission adopts the new version of the standard.

WCAG has a hierarchical structure, starting with principles, followed by guidelines, and then success criteria (W3C, 2018). Each success criterion belongs to one of three levels of conformance: A (the lowest level) with 30 success criteria, AA (the middle level) with 20 success criteria, and AAA (the highest level) with the remaining 28 success criteria. It is important to note that conformance on Level AA includes both Level A and Level AA success criteria.

EN 301 549

European Standard EN 301 549 (ETSI, 2021; European Commission, 2021), establishes requirements for the accessibility of Information and Communication Technologies (ICT). It has been "harmonised" with Directive (EU) 2016/2102. In practice, this means that, if the EN 301 549 is considered and applied appropriately, it is deemed to fulfil the technical requirements of Directive (EU) 2016/2102 sufficiently.

The EN 301 549 covers all areas of ICT, and the ninth chapter of the EN 301 549 (version 3.2.1) focuses on requirements for websites. In this part, the EN 301 549 relies heavily on WCAG 2.1 Level AA guidelines for web content. Annex A to the EN 301 549 provides a detailed description of the relationships between the Standard and the requirements of Directive (EU) 2016/2102. Specifically, Table A.1 provides a list of all requirements for web content from all chapters of the EN 301 549, including the Level AA WCAG 2.1 requirements from the ninth chapter.

The EN 301 549 requirements are divided into four basic principles: Perceivable, Operable, Understandable, and Robust (POUR), stemming from WCAG (Altinier et al., 2022). The Standard includes a total of **137 requirements** specifically for web pages (ETSI, 2020; European Commission, 2023; European Commission, 2023a), which encompass 50 Level AA WCAG 2.1 criteria.

Slovenian Act on the accessibility of websites and mobile applications

To claim that a Slovene public sector body' website is fully accessible, we have to demonstrate conformance with all the requirements stated in the Slovenian Act on the accessibility of websites and mobile applications (ZDSMA) (Republika Slovenija, 2021), which include the requirements of the EN 301 549.

The process of evaluating websites, mobile applications, products, and services

Examples of European good practices in monitoring

The accessibility statement provides information about accessibility and measures to improve accessibility. These statements have to be monitored by bodies in charge of monitoring the Web Accessibility Directive. Countries have taken different approaches to meet these requirements.

Examples that could be highlighted include the Norwegian, Dutch, Danish and Irish models, which represent good practices for meeting these requirements:

- **The Norwegian model** requires centralised submission of accessibility statements and relevant accessibility assessments. The statements are linked from the public sector body websites (UUtylsinet, 2023). Public access to the centralised register is not available. With this centralization, the inspection has a complete overview without manual verification, making it possible to identify which public sector bodies still need to submit statements, which ones need to update them, which ones have unresolved issues and what WCAG issues are reported. The inspection also maintains a list of all public sector bodies, including the websites and mobile applications they own. Furthermore, accessibility statements for third-party products, which are sometimes part of public sector websites or mobile applications and where the public sector bodies are only subscribers are also required (e.g., chat services and similar tools). Centralising and standardizing the accessibility statements facilitates full oversight by the inspection authorities significantly and increases transparency for the interested public. Accessibility statements are still self-assessments which could be biased.
- **The Dutch model** focuses on publicly disclosing the accessibility status of websites and mobile applications through an interactive web portal called the Digital Accessibility Dashboard (DigiToegankelijk, 2023). This portal provides information about the accessibility of websites and mobile applications of public sector bodies. The Digital Accessibility Dashboard, developed in collaboration between the Dutch government and the accessibility sector, contains information on over 4,000 websites and mobile applications. The websites and applications are assessed based on various accessibility aspects, such as usability for individuals with different types of disabilities, visual presentation, and accessibility across different devices. The assessment results are disclosed publicly and presented in the form of graphs and Tables, allowing users to assess the accessibility status of a website or application quickly. Additionally, the Digital Accessibility Dashboard provides tools and resources for improving the accessibility of websites and applications, along with instructions on how to use these tools. The Dutch model has been successful in promoting the improvement of

website and application accessibility by facilitating easier access to accessibility information. Furthermore, the Digital Accessibility Dashboard has streamlined the work of the inspection authorities, enabling them to monitor and track the accessibility status of websites and applications better.

- **In Denmark**, for simplified monitoring of website accessibility, they use an open-source automated tool, "QualWeb" (Danish Agency for Digital Government, 2023). Additionally, all simple verifications of public sector bodies are published on a shared platform, accessible to the general public. Similar to Norway, Denmark has developed a centralised system for accessibility statements.
- **In Ireland**, within the framework of the NDA organisation, they use a fully automated open-source tool called "Axe Core" for automatic checking of all specified public sector bodies' websites. The automated tool is run on a weekly basis. Each public sector body has its own link, where they can view the results. From this perspective, Ireland implements a similarly simplified monitoring approach as Denmark.

Implementation of monitoring in Slovenia

In compliance with the sampling size methodology by the European Commission (European Commission, 2018a), Slovenia has to conduct 117 inspections for simplified website monitoring and 16 inspections for in-depth monitoring (calculation based on population size on 17th July 2023) from approximately 3,000 public sector bodies (European Commission, 2022; Republika Slovenija, 2021). Regarding mobile applications, 8 inspections are required, with a smaller sample size in the early monitoring years. Each Member State also has to consult with organisations representing persons with disabilities when selecting the sample.

The first monitoring period in Slovenia

In the first inspection of the year 2021, the Slovenian inspection authority conducted 116 inspections. For simplified monitoring, they used three tools: **Wave, Axe DevTools,** and **Accessibility Insight for Web**, which were used frequently in other monitoring processes (Bhagat & Joshi, 2019). Due to

various limitations, they focused on identifying violations of a maximum of three WCAG success criteria, no matter which ones, in the initial inspection.

During the first monitoring period, using the simplified method, out of the 116 public sector bodies' websites inspected, errors were not found in only 5 of them. In 8 websites only one error was found, in 9 websites two errors were found, and in 94 websites three errors were found. Thus, the inspection identified a total of 308 irregularities in the 116 inspections conducted. By December 1, 2021, 47 bodies had resolved all the errors, 44 bodies had resolved only some of the errors, and 17 bodies had not resolved any errors. Based on the received inspection reports and identified irregularities, the public sector bodies resolved 194 errors. In three bodies with nine errors, their websites were taken down. To address the remaining 105 identified errors, the inspection authority had to continue with the inspection procedures and issue 61 orders to rectify the identified irregularities and deficiencies.

The second monitoring period in Slovenia

In the second monitoring period (2022-2024), the Slovenian Inspectorate for Information Society conducted inspections using both the simplified and in-depth methods. With the simplified method, they examined 118 public sector bodies' websites in 2022, while, with the in-depth method, the required 16 public sector bodies were inspected for each reporting period, totalling 32 sector bodies, to compensate for the absence of in-depth monitoring during the first monitoring period.

In the same year on the same sample, no errors on the websites or in the accessibility statement were found in 6 bodies. Similarly, 18 bodies did not have any website errors, but they neither had a correct accessibility statement nor had one at all. In the inspection process it was determined that 3 bodies were not subject to the Electronic Communications Act, so their missing accessibility statements were not included in the statistical overview. Errors were identified in 109 bodies, with 11 bodies having only one error, 9 bodies having two errors, and 68 bodies having three errors. Thus, the Inspectorate identified a total of 233 irregularities in the 115 inspections conducted. In 2021, during 116 simplified website inspections, 304 errors were identified,

indicating an improvement in website accessibility (European Commission, 2022; Republika Slovenija, 2021).

In 2023, the Inspectorate also began conducting in-depth inspections of mobile applications and issued a call for conformance with the law to all public sector bodies (the call was sent to nearly 3,000 bodies).

What are the difficulties in monitoring and reporting?

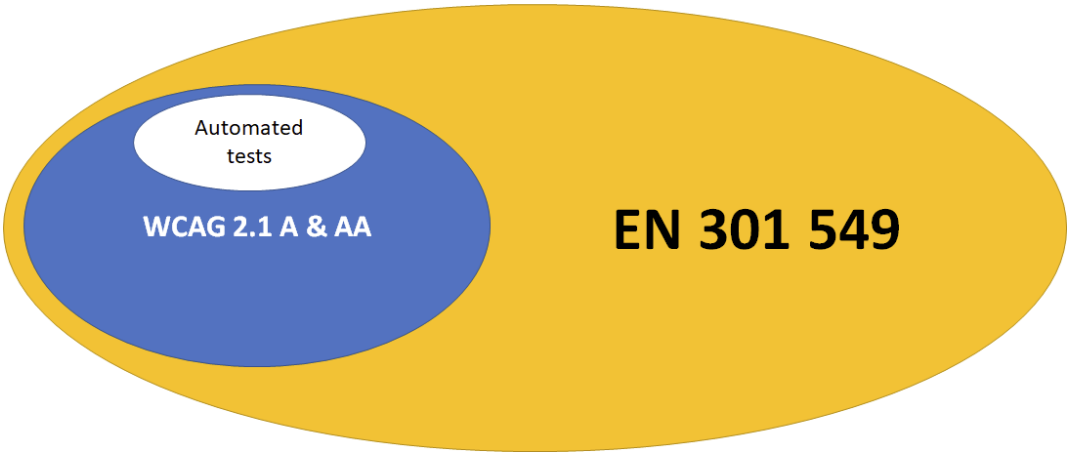
Regarding **accessibility statements,** significant difficulties were encountered in verifying who has such a statement on their website or mobile application and in checking the content of the statements. Some statements were merely copied from other public sector bodies and lacked the necessary provisions. While many public sector bodies already fulfil the statements independently, most of them indicate that the Statement is based on self-assessment. However, problems arise, as most organisations lack the necessary expertise to conduct self-assessments. This raises concerns about the effectiveness of support and independent fulfilment of the statements.

Regarding the use of **automated tools**, the Slovenian Inspectorate expected the European Commission to establish appropriate reference tools for simplified and in-depth website monitoring, ensuring comparable final results. Each tool detects different errors and varying numbers of errors, yielding varying error counts. Consequently, it is imperative to **validate all obtained results meticulously and independently.** Moreover, exercising caution is essential when categorising and defining the identified errors.

The **number of criteria** specified in the Standard also poses a significant challenge. The EN 301 549 includes 137 accessibility requirements for websites and 162 for mobile applications, encompassing 50 WCAG criteria. However, automated tools can only find issues in code, which covers practically around 30% of the WCAG criteria (Figure 1). It is also crucial to understand that automated tools only find obvious errors but cannot approve conformance. Other success criteria need to be verified purely manually. As a result, all stakeholders report that significant time and trained personnel are needed to comply with all the requirements. Currently, the Slovenian Inspectorate uses

its own list of identified errors to test the performance criteria for websites and mobile application inspections, expanding the list of errors continuously.

Figure 1. Criterion coverage using automated tests according to the European Standard EN 301 549. Source: Bogdan Cerovac.



The next issue concerns the preparation of **adequate accessibility reports**. In reports from the first reporting period, it became evident that practically every country had chosen its own concept of monitoring and reporting. Due to the diversity of results and the varied use of indicators, it is impossible to compare the results among European Union countries.

During its inspections, the Slovenian Inspectorate also observed that, due to the scope of provisions used to determine conformance to the Slovenian Disability and Accessibility Act, there has been a noticeable **reduction in web content** and a **lack of readiness** to plan and develop mobile applications in Slovenia.

Suggestions for improving the assessment methodology

Given the challenges and lack of adequately trained professionals, the following measures need to be addressed:

- **Centralized preparation of accessibility statements**: A systematised template, powered by a centralised database, should be established to ensure consistency of the statements, enhance transparency, and facilitate more effective reporting to the European Commission.

- **Centralized national template for feedback mechanism**: A recognisable, unified, and efficient contact point should be provided for end users, along with automated mechanisms to verify response deadlines and improve monitoring and reporting to the European Commission.
- **Self-assessment and reporting based on simplified monitoring**: This approach would assist public sector bodies in being more effective, while ensuring data quality for supervisory authorities.
- **In-depth monitoring and reporting by experts**: Experts should be involved in monitoring to alleviate the burden on Member States' bodies in charge of monitoring the Web Accessibility Directive. This approach should also include individuals with disabilities, to contribute to high-quality results and provide specific and professional recommendations for improvements to the public sector bodies.

Centralised preparation of accessibility statements

The Directive (EU) 2016/2102 established requirements for the accessibility of websites and mobile applications in the public sector, with the most important requirement being the accessibility statement. To ensure consistency, transparency, and more effective reporting by public sector bodies, the European Commission developed a systematised template for accessibility statements (European Commission, 2018).

However, since public sector bodies face difficulties in preparing accessibility statements, the following possible scenarios should be considered for a well-prepared statement:

- Accessibility statements with self-assessment should require evidence that the person who conducted the self-assessment possesses the necessary professional knowledge.
- Accessibility statements should include evidence that they were prepared by external experts, thereby transferring the responsibility for statement accuracy to these external experts.

Due to the lack of professionals, it is advised for public sector bodies to seek external opinions on accessibility to obtain reliable and detailed statements.

This does not necessarily require an immediate comprehensive assessment of the website. External assessors can determine relatively quickly whether the website is at least approximately accessible or not. Expert external opinions would contribute significantly to more detailed and realistic statements.

All statements should be entered into a centralised system for the preparation and creation of accessibility statements. This means that public sector bodies would complete their statements on a central website and obtain a properly prepared accessibility statement and a URL link to be placed on their main web page. With a centralised solution, bodies in charge of monitoring could easily verify the updates to statements and monitor the accessibility status of each public sector body according to the criteria. This solution would enable better tracking and control of accessibility statements. The centralised platform would also facilitate quick verification of statements against the Web Accessibility Directive requirements.

Although the centralisation of statements does not guarantee an improvement in quality, it is important that all public sector bodies have regular opportunities for structured and mandatory education, as required by Directive (EU) 2016/2102.

Until centralised solutions for accessibility statements are developed and incorporated into legislation, we recommend promoting (or even requiring) the use of existing tools to generate accessibility statements consistently. One example is the W3C WAI Accessibility Statement Generator (W3C, 2021).

Centralised national template for feedback mechanism

The implementation of a centralised national template for a feedback mechanism, as required by Directive (EU) 2016/2102, would necessitate coordinated actions at the State level. To achieve this goal, it would be necessary to establish the appropriate infrastructure and organisational framework.

The centralised template for the feedback mechanism would provide the option for automatic completion of certain required fields, such as the institution's name and address, URL, operating system, and browser type. It

would then include the necessary software solutions to fulfil the other aspects of the feedback mechanism. An example of such a feedback system was also proposed in the European project UPowerWAD (UPowerWAD, 2021).

A unified feedback form would serve to report inaccessible content. The responsibility for processing information from the feedback mechanism would be transferred to the website administrator or another independent organisation responsible for the website. In this case, the administrator would need to possess a high level of expertise in identifying errors and a profound knowledge of accessibility.

Bodies in charge of monitoring could also use the feedback mechanism to monitor common issues and enhance their knowledge and assessment skills further regarding appropriately fulfilled criteria. An increase in received reports for a particular public sector body may signal the need for additional oversight.

Self-assessment and reporting based on simplified monitoring

Directive (EU) 2016/2012 requires the implementation of simplified monitoring, providing the option for a public sector body to conduct self-assessments and submit reports upon request by the body in charge of monitoring. In this regard, a centralised self-assessment template can be helpful, allowing an overview of the status and changes according to the criteria of the Accessibility Standard for each public sector body. This would enable inspectors to review individual criteria and track changes more easily, contributing to improved transparency, not only for the body in charge of monitoring, but also for the general public as well.

In the simplified monitoring process, public sector bodies can complete the centralised self-assessment template themselves if they possess internal knowledge or with the assistance of external experts. Such a template also contributes to consistency in the evaluation process among different public sector bodies and facilitates more effective reporting to the European Commission.

The Report should include information about identified barriers, actions taken to address them, and any plans for future improvements. The Report should be detailed, comprehensive, and communicate the public sector body commitment to web accessibility clearly.

Furthermore, the Accessibility Report should be publicly accessible, ensuring transparency, and providing users with information about the accessibility of their digital services. This allows not only the body in charge of monitoring, but also individuals, including those with special needs, to understand the level of accessibility provided and to make informed decisions about service usage.

In the case of simplified monitoring, which relies primarily on testing with automated tools and, to a lesser extent on manual testing, it is not necessary to follow the WCAG guidelines directly. Instead, the focus is on the following **nine user accessibility needs**, which are then mapped to success criteria within WCAG (Fischer, 2019; European Commission, 2018b):

- Use without vision.
- Use with limited vision.
- Use without color perception.
- Use without hearing.
- Use with limited hearing.
- Use without vocal ability.
- Use with limited manipulation or strength.
- Need to reduce the risk of seizures caused by flashing content.
- Use with limited cognition.

For simplified monitoring, not all WCAG success criteria are required. Instead, a limited and narrow set of success criteria is determined that can be identified by automated tools. These success criteria are then mapped to the nine users' accessibility needs. Part of these success criteria can be identified through programmatically automated systems that include automatic tests for website verification. A public sector body could verify the results produced by these programmatically automated systems independently using the assigned URL links. Additionally, at least once or twice a year, a manual evaluation

template would be provided as part of the centralised template. This template would also cover the assessment of mobile applications.

In the centralised self-assessment template, reliance can also be placed on the rules of Accessibility Conformance Testing (ACT) (Abou-Zahra, 2018; W3C, 2020a; W3C, 2020b), developed by companies and organisations under the W3C consortium. Although officially published by the W3C, the ACT rules ensure credible verification of the WCAG 2.1 success criteria. The goals of participating communities include reducing diverse interpretations of WCAG, making test procedures comparable, and developing a library of widely accepted rules. ACT rules also guide the development of automated and semi-automated testing tools that public sector bodies and regulatory bodies can use for more efficient and successful monitoring.

Moreover, the centralised template could facilitate the maintenance of a unified record and statistics based on key indicators, enabling easier comparisons among public sector bodies and countries within the EU.

A good practice example of simplified monitoring was conducted by the Norwegian body in charge of the monitoring as a pilot project within the European project WAI-Tools (Uutylsinet, 2020; W3C, 2020c). The simplified monitoring methodology within the WAI-Tools project provides organisations with a structured and practical approach to evaluating the accessibility of their websites.

In simplified monitoring it is also important to consider the significance of a website and ensure an appropriate level of reviews accordingly. Setting excessively high requirements for a local community that publishes one post per year would be impractical, while higher requirements should be established for social welfare centres, healthcare facilities, or elderly care homes. For the former, high-quality self-assessments made with the help of the centralised template would be sufficient, but, for the latter, strict reliance on self-assessments should be avoided, especially if they cannot demonstrate the necessary expertise.

In-depth monitoring

The method of in-depth monitoring, as required by Directive (EU) 2016/2102 (European Commission, 2018), involves a detailed examination of **all the requirements and criteria** described in the Standards and Technical Specifications in the Directive.

In most European countries, in-depth monitoring is typically carried out by external experts who are engaged for this purpose. These experts can also utilise templates such as WCAG-EM (Acosta-Vargas et al., 2016). The WCAG-EM template provides guidance on using evaluation methodologies and solutions for specific situations related to WCAG 2.1 (50 success criteria). With the help of the WCAG-EM template, a summary report for management is prepared, where individual areas are described in a clear and accessible manner, highlighting any issues. This summary is then supplemented with a technical report that describes the results based on the individual success criteria listed in the EN 301 549 (137 success criteria). Each result has to include a heading or location where a non-conformance was found. If the non-conformance is recurring, it is noted as a global non-conformance that needs to be addressed. Each individual success criterion is assessed using the following five options:

- Passed.
- Failed.
- Cannot tell.
- Not present.
- Not checked.

During the evaluation process, the authors of the article found it appropriate to introduce an additional assessment category for "**passed, but with possible improvements**". This category is already being used for monitoring in Norway and Sweden and is reserved for proposing enhancements to otherwise relatively good solutions.

Automated tools and their effectiveness

Conformance in in-depth monitoring cannot be determined solely using automated evaluation tools; a significant degree of human manual analysis is required. Furthermore, current automated evaluation tools only enable checking for obvious errors evident in the code and cannot assess overall conformance.

There are also tools available on the market known as Intelligent Guided Tests that assist users in conducting manual tests, even for inexperienced evaluators. Examples of these tools are **AXE devTools, Accessibility Insights for Web, Siteimprove,** and **TPGi ARC** (Manca et al., 2023).

Another type of tools utilises machine learning and combines computer vision and supervised machine learning techniques (Evinced, 2023; axe DevTools pro, 2023). Tools of this generation are becoming increasingly advanced in detecting elements of user interfaces, their possible states, and assessing accessibility simultaneously.

Intelligent guided tests and machine learning-based approaches offer improvements by providing guided assessments and utilising advanced techniques. The development of the ACT rules (ACT-Tools) by the W3C consortium has the potential to automate certain evaluations and monitor accessibility trends (Abou-Zahra, 2018; W3C, 2020a; W3C, 2020b).

Conclusion

We have presented comprehensive proposals for improving accessibility assurance according to the requirements of the Web Accessibility Directive. Considering a general lack of appropriately skilled personnel, we emphasised the importance of centralised solutions to enhance efficiency, consistency, and transparency in the processes of preparing accessibility statements, monitoring, providing, and receiving feedback, and self-assessment. The proposed solutions are as follows:

- A centralised solution for preparing accessibility statements.
- A centralised government template for a feedback mechanism.

- Simplified monitoring and reporting in the form of self-assessment using nine general criteria.
- In-depth monitoring and reporting by experts and individuals with disabilities.

The incorporation of all accessibility statements into a centralised system would facilitate the monitoring of statement updates and accessibility achievements. Bodies in charge of monitoring and the wider public would be able to conduct mass verification of statement updates and monitor the state of accessibility achievements according to the criteria set for each public sector body.

The centralised government template for the feedback mechanism would bring additional benefits, such as automatic form completion, making it easier to report inaccessible content. Website administrators would be responsible for addressing information received through the feedback mechanism. Additionally, a higher number of reports from a particular public sector body would assist in additional verification.

The Directive (EU) 2016/2102' requirements also include simplified and in-depth monitoring for ensuring website accessibility. The proposed simplified, centralised, and automated monitoring allows for efficient tracking of accessibility status, verification of statement updates, and fulfilment of success criteria by utilising an automated software environment that checks the basic success criteria related to all nine user points of concern periodically. Links to the results, which could be made available to the public, would be sent to public sector bodies and bodies in charge of monitoring, enabling them to conduct reviews based on individual criteria and track changes, thereby enhancing transparency and accountability. As an additional measure, the A3 metric could be introduced for easier and faster comparison of reports.

In-depth monitoring, involving experts with specialised knowledge and experience, as well as individuals with disabilities, would enable a thorough analysis of website accessibility. These experts would relieve supervisory bodies, provide quality results, and offer specific and professional recommendations for improvement to the public sector bodies. The

integration of both simplified and in-depth monitoring would contribute to raising the quality of website accessibility and understanding the needs of users with disabilities better.

Properly trained website administrators are crucial for ensuring quality and conducting assessments in accordance with the accessibility success criteria. Training should also include ongoing education, to enable them to successfully meet most accessibility criteria while recognising that they may not be able to fulfil all of them.

Implementing the proposed solutions and ensuring the availability of appropriately skilled professionals would lead to significant progress in the field of Accessibility, benefiting all website users. This contributes to greater inclusivity and enables equitable access to information and services for all users.

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Conflict of Interest

The authors have no conflicts of interest in connection with this study.

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READILY AVAILABLE BUT HOW ACCESSIBLE? AN ANALYSIS OF THE WEB ACCESSIBILITY OF HEALTHCARE-RELATED RESOURCES

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***Abstract*:** With advances in technology, more health information is readily available to the public. Individuals with disabilities rely on online healthcare-related resources to access educational information and promote informed decision-making in their care. The Web Content Accessibility Guidelines (WCAG) were created to provide universal web practices which complement the needs of all individuals, such as those with low vision or screen readers users. However, many websites and the resources within them (e.g., PDFs) do not prioritise WCAG, leaving individuals with disabilities at a disadvantage in terms of their autonomy and health literacy. The objective of this study is to investigate and describe the common web accessibility errors present on international occupational therapy and pediatric websites and the resources within them. This mixed methods study evaluates compliance to WCAG success criteria using automatic web accessibility evaluation tools, specifically WAVE and AChecker, and manual checks to capture the human element. Descriptive statistics were used to examine the frequency of errors across several success criteria within the sample websites and PDFs. A subsequent thematic analysis was used to further examine how and why these errors violate the WCAG success criteria. Through automatic evaluation tools, many websites and resources did not comply with numerous WCAG 2.0 success criteria. Through

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manual checks of the web pages and resources within them, 5 themes were identified: inaccessible images, challenges accessing additional resources, poor structural formatting, lack of tagging in PDFs, and minimal colour contrast. The results of this study can inform web developers and contributors (e.g., Occupational Therapists) on how to successfully produce accessible websites and PDFs to provide equal access to health information. In conclusion, this study adds to the current understanding that many public-facing websites and the resources within them (e.g., PDFs) are not accessible, including healthcare-related websites meant to support informed decision-making among individuals with disabilities.

Keywords: Web Accessibility, Disability, Health-Related Resources, WCAG 2.0, Health Information, Usability, Web Development, Accessibility Errors, Universal Design

Introduction

As technology advances, more scientific information is made available to the public via the Internet. It is important that reliable information on healthcare-related websites is accessible to everyone, including those with disabilities. Individuals with disabilities rely on websites to access information that can help them understand their health and disability, engage in informed decision-making, take an active role in their healthcare, and experience increased independence and better health outcomes (Cook et al., 2005; Chinn & Homeyard, 2017; Zeng & Paranto, 2004, as cited in Mason et al., 2021). Occupational therapists (OTs) working with pediatric clients with disabilities and their families share websites to support their clients, hoping they experience these positive outcomes. These websites provide a collection of OT and pediatric health-care related information that potentially informs clients and families of the role and scope of OT, settings in which OTs work, the type of interventions OTs offer, and OT and pediatric health-related publications.

In recent years, web inaccessibility has become a prevalent issue, especially with the number of individuals with disabilities increasing across the world

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(Wagner, 2021). Governments have recognized the need for web content accessibility, and a variety of countries in North America, Europe, and Asia, as well as Australia, have addressed web accessibility by imposing laws and policies and amending non-discrimination laws within human rights acts to ensure inclusivity (Mueller et al., 2018). These laws and policies are based on the Web Content Accessibility Guidelines (WCAG).

The WCAG was created by the World Wide Web Consortium (W3C) in collaboration with individuals and organizations internationally to provide universal guidance on how to make web content more accessible to individuals with disabilities (Henry, 2019). The WCAG, which has had four releases, WCAG 1.0, 2.0, 2.1, and 2.2, is one of the most recognized web accessibility standards around the world (Henry, 2019). The fifth release, WCAG 3.0, is under development (W3C, 2023a). The WCAG contains several layers of guidance for promoting accessibility. The first layer includes four principles which outline that web content should be (1) perceivable, (2) operable, (3) understandable, and (4) robust (Alajarmeh, 2021). For each principle, there are guidelines (thirteen in total) with three different conformance levels: Level A (easiest level to achieve), AA, and AAA (most difficult level to achieve). For a website to be considered accessible, conformance with Level AA should be met (UsableNet, 2021). Each guideline has a set of testable success criteria. Some examples of success criteria indicated by WCAG include non-text content, contrast (minimum), and info and relationships (W3C, 2018). The last layer includes techniques that help meet success criteria. The W3C encourages web developers to employ all layers of guidance to accommodate a wide range of users.

Literature Review

After reviewing existing literature, it is evident that most of the information, including healthcare information, offered through the internet is not accessible based on WCAG. A recent study assessing the web accessibility of popular health websites around the globe found that 91.3% of the sampled home pages had accessibility failures, with the most common errors being low contrast, empty links, missing alternative text, empty buttons, and missing form labels (Mason et al., 2021). Another example of a study that examined

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top-ranked hospital homepages worldwide found issues related to the perceivable, robust, operable, and understandable WCAG principles (Acosta-Vargas et al., 2020). These researchers measured the level of accessibility using online automatic evaluation tools including WAVE and TAW, and then used manual evaluations to validate these scores (Acosta-Vargas et al., 2020). One commonly reported error involved images not being designed with the correct alternative text, therefore not supporting the function of screen readers (Acosta-Vargas et al., 2020). In addition, healthcare-related websites in Europe had many errors detected, mostly with alternative text (Sik-Lanyi & Orbán-Mihálykó, 2019). Further emphasizing the breadth of accessibility errors that occur, a study in Korea reported that blind and second-level sight-impaired individuals who evaluated government and public agency healthcare websites found that these websites had problems across all four principles of accessibility (Yi, 2020). These findings support the need for web accessibility awareness amongst web developers worldwide to promote inclusive health-related websites and reduce the barriers to individuals with disabilities.

Schmutz and colleagues created three versions of a municipal website based on three levels of accessibility by the WCAG 2.0 and tested the websites with two populations (people with visual impairments and people with no disabilities). The website with the lowest level of conformance to WCAG indicated prolonged task completion times, reduced completion of tasks in those with visual impairments, and poor perceived usability and aesthetics (Schmutz et al., 2017). The study also found that both non-disabled users and users with visual impairments benefited when using websites that have higher conformance to WCAG as they all experienced increased performance and more positive user ratings. This study demonstrated that websites that correspond to a high level of accessibility are more inclusive and user-friendly for everyone, and are compatible with multiple assistive devices, including screen readers, screen magnifiers, and braille boards. There is a clear demand for accessible websites to accommodate the needs of individuals with disabilities, which inadvertently supports non-disabled individuals.

The resources found on websites also need to be considered. A pilot study suggested that people face challenges viewing resources within databases, such as journal articles (Nganji, 2015). Most publishers use the portable

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document format (PDF) when publishing journal articles; however, if the PDF file is inaccessible, then persons with disabilities will be denied access to its contents (Nganji, 2015). Using key WCAG 2.0 criteria, such as tagging among a sample of journal articles, this study found that only 4.5% of the selected articles were tagged. Thus, most documents were not compatible with text-to-speech software, such as Adobe Acrobat XI Pro Read out Loud (Nganji, 2015). This study demonstrated that although journal articles within databases can be identified, the content within them may not be compatible with accessibility devices.

These studies demonstrate a lack of accessibility of websites, including healthcare-related websites, and PDFs, as they do not adhere to WCAG success criteria, leaving individuals with disabilities at a disadvantage because they cannot access this educational web content. However, research has not been published evaluating the accessibility of occupational therapy and pediatric healthcare-related websites. Assessing and understanding the accessibility of these websites and the resources within them could promote inclusion and greater accessibility.

Research Purpose and Questions

To continue the observations from the pilot study and build on the existing research, further investigation was needed to analyze other forms of web content, such as occupational therapy and pediatric healthcare-related websites. It is important to address this research gap because these websites are a primary supplier of resources and evidence for OTs and their clients. Since OTs often work with persons with disabilities, websites must be accessible to help inform individuals with disabilities while making health-related decisions (Mackenzie et al., 2017). The purpose of this study is to investigate and describe the common web accessibility errors present on international occupational therapy and pediatric websites and the resources within them (e.g., PDFs), based on WCAG success criteria. In this mixed methods study, the following questions will be addressed: 1) How often do international occupational therapy websites and pediatric health-related websites and PDFs violate the accessibility criteria outlined by WCAG? and (2) How and why are essential web accessibility criteria of WCAG violated?

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Methods

A sequential explanatory mixed methods research design was selected to address the proposed research questions. A mixed methods approach was chosen because research shows that automatic evaluation tools are not always accurate and may not address all aspects of web accessibility, and therefore, should be complemented by the perspectives and judgements of manual checkers (W3C, 2021; Nganji, 2015; Acosta-Vargas et al., 2020).

Study Sample

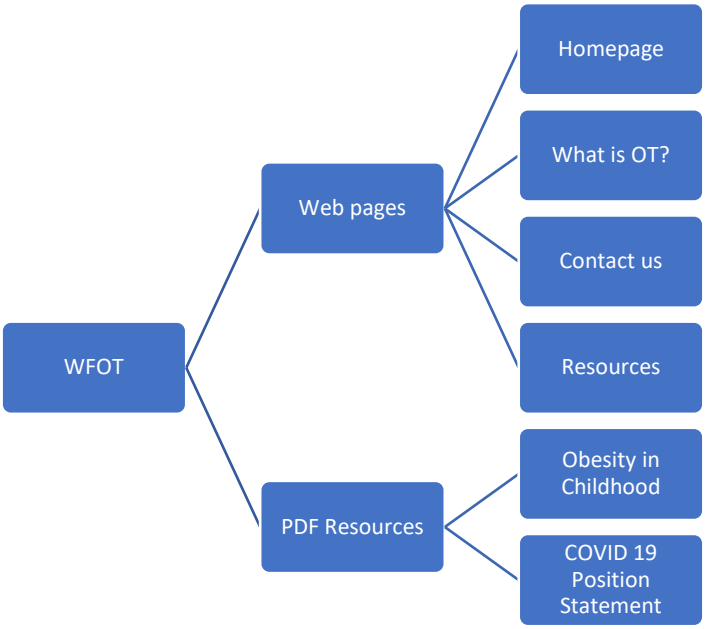
Through convenience sampling, a comprehensive list of occupational and pediatric healthcare-related websites was compiled by the team.

The following were the inclusion criteria:

- Occupational therapy and/or pediatric healthcare-related content
- Developed by Canadian, African, or international organizations
- Published in English
- Healthcare-related resources (in PDF format) provided within the website

Since online resources are available to people worldwide and the research team members are located in Canada and Cameroon, the sample was intended to allow for the exploration of web accessibility of international websites. Through random selection, 7 websites were selected from this list for in-depth analysis. Within these websites, the authors determined high-traffic web pages that users visit to gather healthcare-related information. These categories were homepage, contact us, resources, about us, and what we do, as shown in the example in Figure 1.

Figure 1: Example of web pages and PDF resources from a website in the sample (e.g. WFOT)



Ultimately, a sample of 28 web pages were selected for the quantitative and qualitative components of the study. During data collection, one web page server was no longer available thus there was limited data from this web page. In addition, it is important to investigate the accessibility of the resources provided on these web pages because many individuals rely on these resources for additional information to support their decision-making. Thus, the first 12 resources (e.g. position statements, brochures, annual reports, educational handouts) encountered when navigating the sample of web pages were selected to be included in the study sample.

For the qualitative component, the authors were used as research tools to provide subjective descriptions of the web content of the sample. The authors are experts or emerging professionals in web accessibility and are able to ensure detailed and accurate judgements in supplement to the automatic evaluation tools as suggested by Alajarmeh (2021).

Selection of Automatic Evaluation Tools

Web accessibility errors were determined using online automatic evaluation tools. Relying on one automatic web accessibility evaluation tool is not recommended. Thus two tools were used in conjunction to take advantage of

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the benefits of each (e.g., tool accuracy and the number of success criteria evaluated) (Vigo et al., 2013). This process increased the soundness, the internal validity, and the construct validity of the results (Vigo et al., 2013).

The automatic evaluation tools used in this study were WAVE (WebAIM, 2023) and AChecker (AChecker.com, 2018). Both tools evaluated web accessibility using WCAG 2.0 success criteria. At the time of the study, there were no automatic evaluation tools developed based on WCAG 2.1, thus, these tools were the most relevant. WAVE was selected because errors, alerts, and features are outlined in a summary and a detailed description of each violation. AChecker was selected because the tool evaluates each line and provides known, likely, and potential errors.

Data Collection from Web pages

The quantitative component was aimed to determine the number of errors in success criteria detected on each web page using WAVE and AChecker. Based on the accessibility reports derived for each web page at a cross-section, all errors were collected and organized into a Microsoft Excel spreadsheet that outlined the number of total violations based on success criteria at conformance levels A and AA.

The qualitative component involved further investigation into common web accessibility errors identified by the quantitative data. Manual evaluations were guided by WCAG success criteria and team discussions capturing various user perspectives. This basic qualitative descriptive approach allowed for an in-depth understanding of the user experiences regarding the level of accessibility. Written descriptions were systematically recorded in Microsoft Word documents for all web pages analyzed. This data was leveraged to validate whether the web accessibility errors labelled as likely or potential, were accurate, and to identify how the errors occurred, as these errors require human investigation. All qualitative data was recorded in organized tables on Microsoft Word. Reflexive journals, memos, and audit trails were maintained throughout the study to establish strong rigourData Collection from PDF Resources

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To evaluate the web accessibility of the sample of resources, the PDF Accessibility Checker tool within Adobe Acrobat XI Pro was utilized to generate accessibility reports. All success criteria were not assessed due to limited resources. Thus there was a focus on 7 success criteria, as shown in Appendix 1. Based on the design of this software, the reports indicated whether the PDF passed or failed in specific success criteria. Afterwards, each failure was investigated manually for subjective experiences and observations, such as colour contrast, alternative text, page titles, and reading order.

Data Analysis

To confirm whether a web page is accessible, the data from the automatic evaluation tools must be further evaluated by knowledgeable humans (WebAIM, 2023; W3C, 2021), therefore we used both quantitative and qualitative analysis to obtain a full picture of the web page accessibility. The quantitative data was analyzed through descriptive statistics to examine the level of compliance and the frequency of errors across several success criteria within the sample websites and PDFs. A subsequent coding of the researchers' perspectives was completed to further examine how and why these errors violated WCAG 2.0 success criteria, using Braun & Clarke's thematic analysis process (2006). Multiple investigators were involved in finding common web accessibility error themes as a form of triangulation.

This qualitative data was compared to the quantitative data to determine the agreement between the researcher's perspectives and the results from the automatic evaluation tools. By integrating findings from the quantitative and qualitative components, recommendations to improve web accessibility while developing web content and PDF resources were developed and proposed.

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Results

Quantitative Results

Table 1. Average Number of Errors Based on Type of Web page (depending on automatic evaluation tool used)

Type of Website	WAVE Average Number of Errors	WAVE Range or Error Frequency	AChecker Average Number of Errors	AChecker Range of Error Frequency
Homepage	51.00	8 - 105	37.00	6 - 115
What is OT? Or About Us	26.29	5 - 66	41.29	11 - 101
Contact Us or Find an OT	33.67	3 - 85	31.33	11 - 101
Resources, Events or Downloads	34.50	19 - 68	26.75	3 - 69
What do we do? Or Our Work	38.00	2 - 85	20.00	14 - 27

The overall number of errors based on types of web pages was examined using the two automatic evaluation tools. Using WAVE, homepages had 51 errors on average, resulting in the greatest number of errors compared to the other types of web pages, as shown in Table 1. According to AChecker, the “What is OT?”/”About Us” web pages had the greatest number of errors, specifically 41.29 errors on average. The range of the number of errors varied among the types of web pages. For example, using WAVE, some homepages had 8 errors, while others had 105 errors in total. These differences demonstrated the high variation in the web accessibility of the study sample.

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Figure 2: Level of Compliance of Web page Sample to WCAG 2.0 Success Criteria Using WAVE

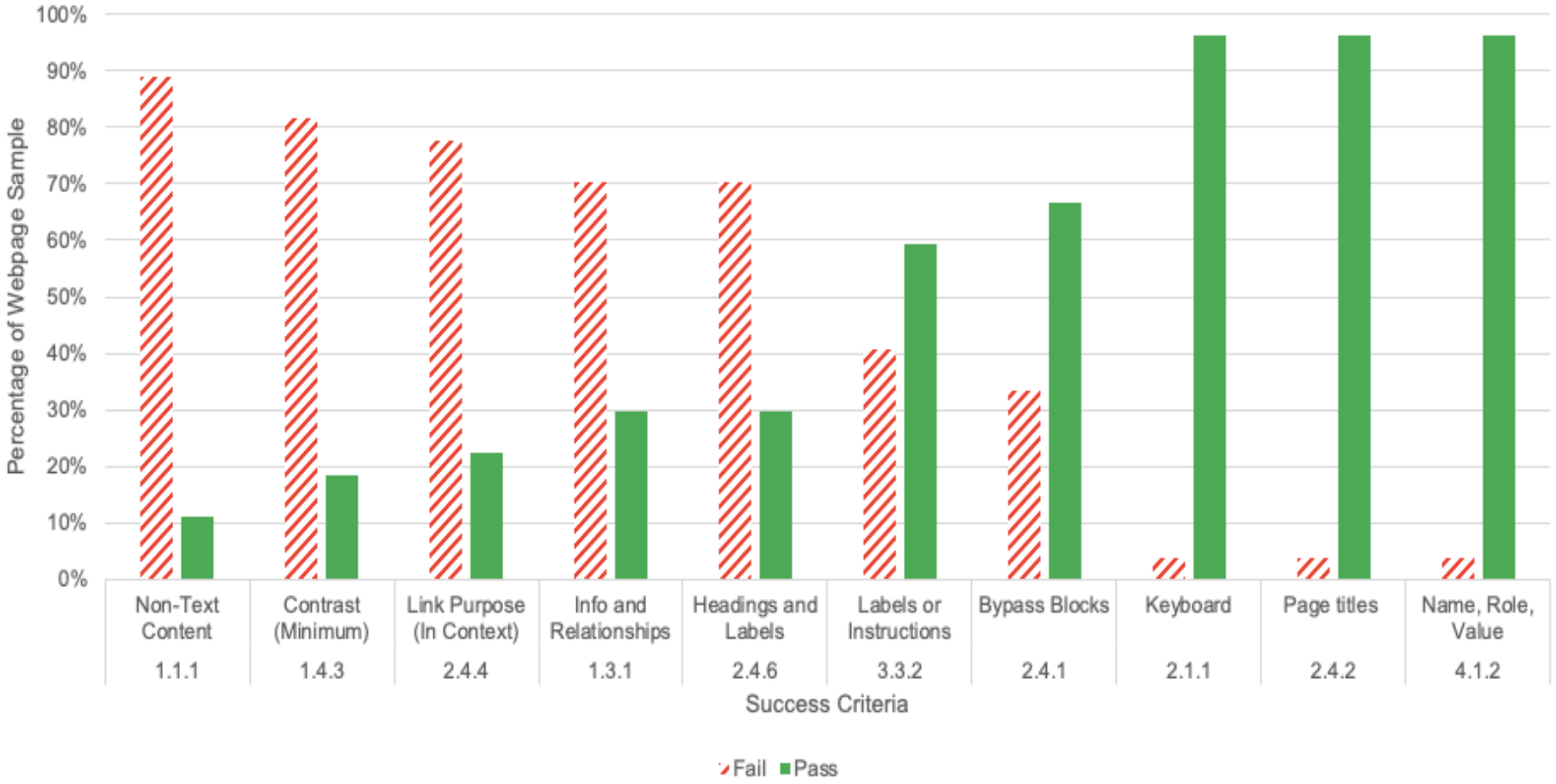

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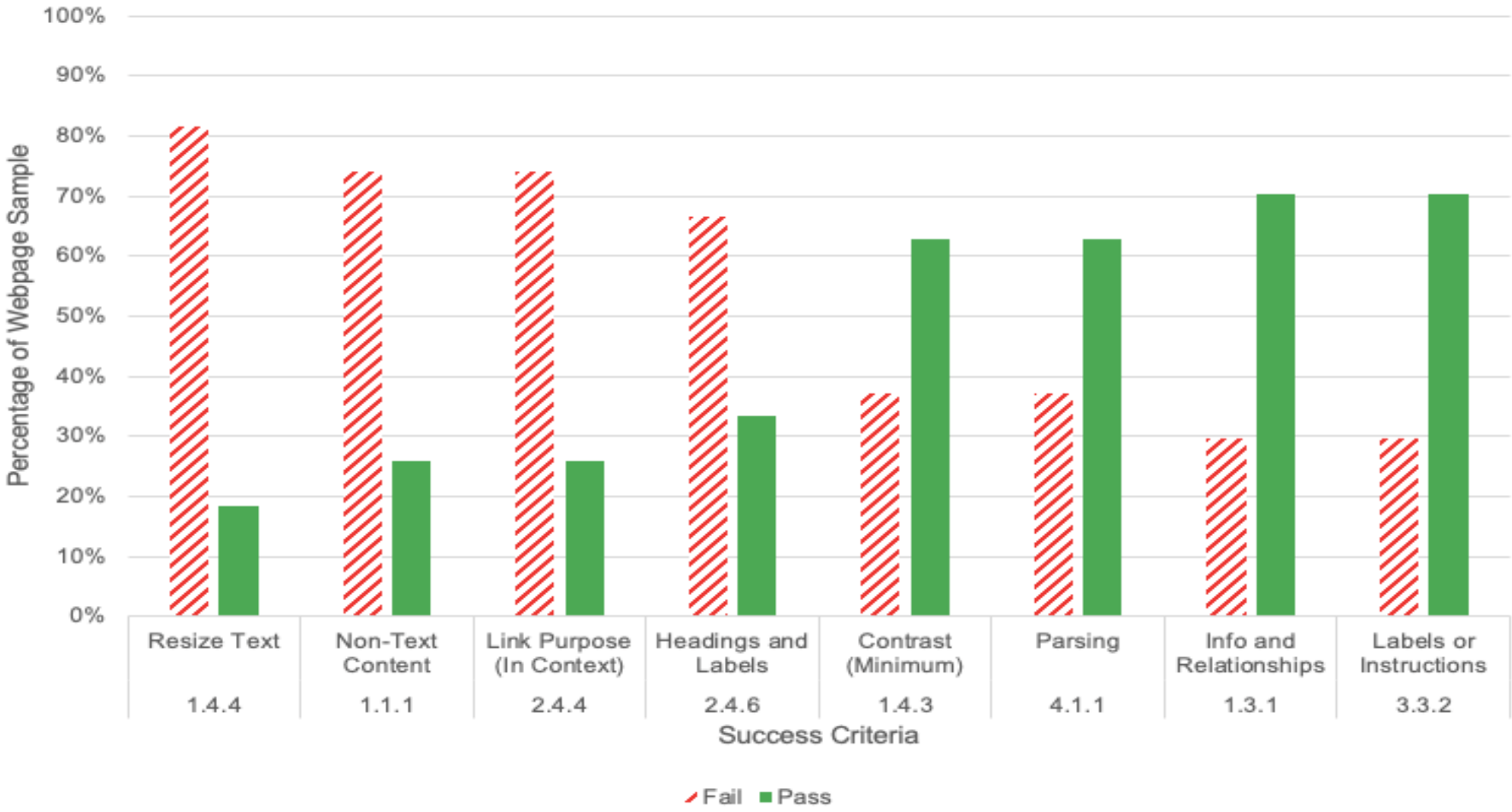
Figure 3: Level of Compliance of Web page Sample to WCAG 2.0 Success Criteria Using AChecker



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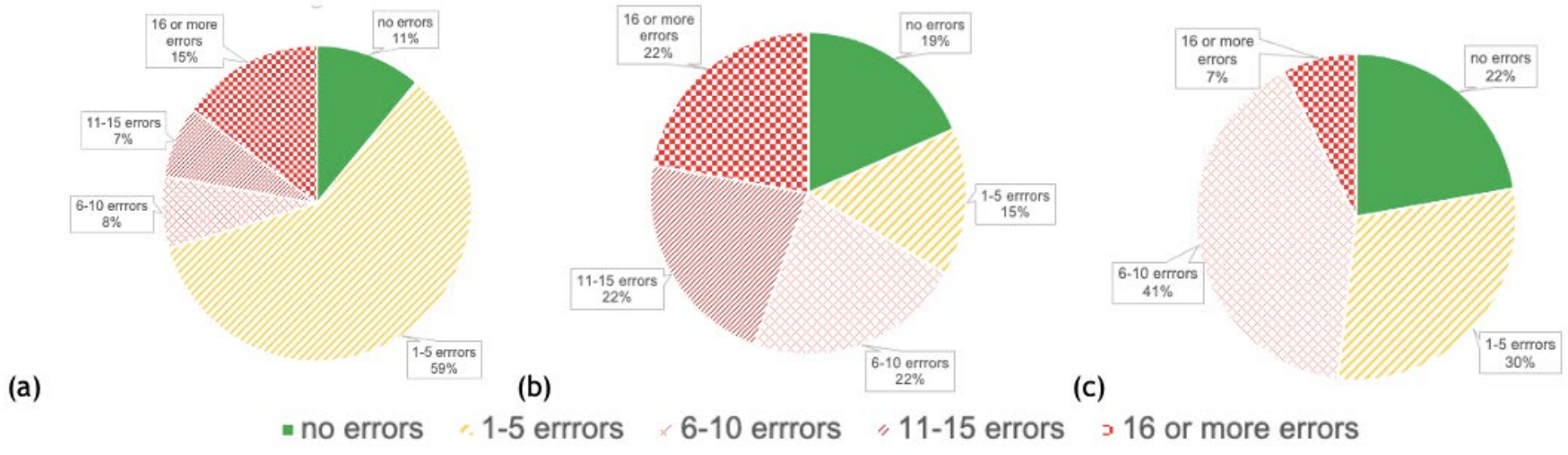
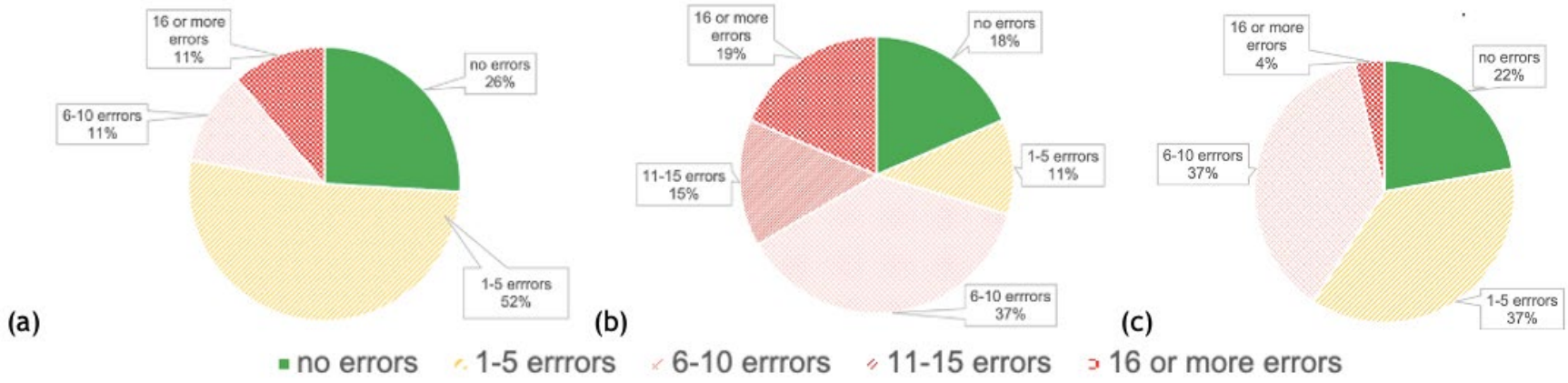
After examining the total number of errors, the level of compliance with specific WCAG 2.0 success criteria was investigated using the two automatic evaluation tools across a sample of 27 web pages. Using WAVE, the top three violated success criteria starting with the most violated were 1.1.1 Non-Text Content, 1.4.3 Contrast (minimum), and 2.4.4 Link Purpose (in context), as shown in Figure 2. Using AChecker, the top three violated success criteria starting with the most violated were 1.4.4 Resize Text, 1.1.1 Non-Text Content, and 2.4.4 Link Purpose (in context), as shown in Figure 3. Success criteria 1.1.1 and 2.4.4 were among the most violated success criteria for both WAVE and AChecker, while 1.4.3 and 1.4.4 being among the most violated success criteria was unique to each checker.

Figure 4: Frequency of Errors in Specific Success Criteria using WAVE



Success criteria presented: (a)Non-text Content, (b) Colour Contrast, (c) Link Purpose

Figure 5: Frequency of Errors in Specific Success Criteria using AChecker



Success criteria presented: (a)Non-text Content, (b)Resize Text, (c) Link Purpose

To further investigate the top violated success criteria, the frequencies of errors are presented in Figures 4 and 5. According to both WAVE and AChecker, more than half of the web pages had between 1 to 5 non-text content errors. WAVE identified that 22% of the sample had 16 or more colour contrast errors. Both WAVE and AChecker identified that more than 70% of the sample had between 1 to 10 link purpose errors. AChecker, 37% of the sample had between 6 to 10 resize text errors.

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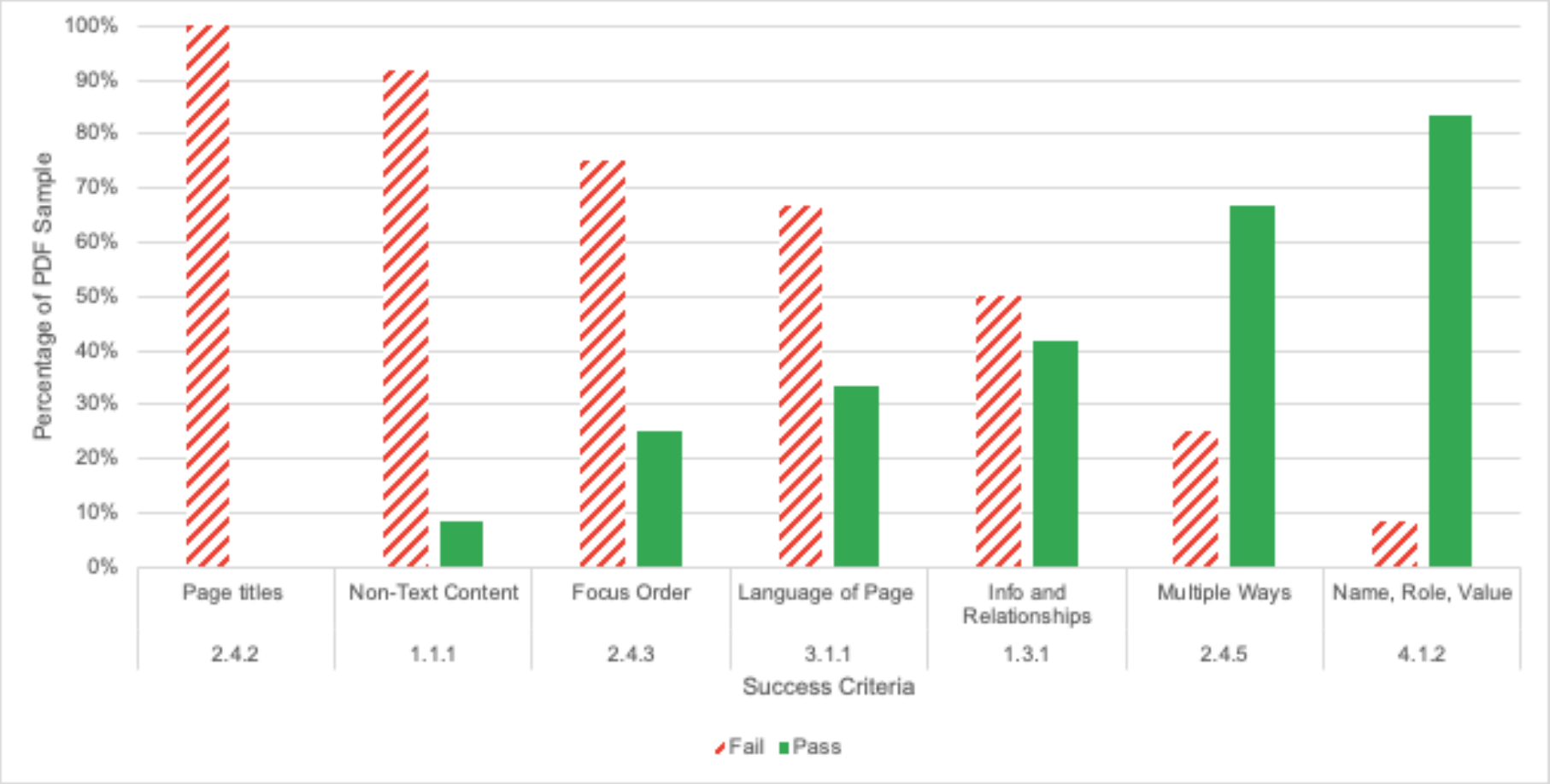
Figure 6: Level of Compliance of PDF Resource Sample to WCAG 2.0 Success Criteria Using Adobe Acrobat XI Pro



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The level of compliance with WCAG 2.0 success criteria was investigated using Adobe Acrobat XI Pro across a sample of 12 PDFs. The top three violated success criteria starting with the most violated were 2.4.2 Page Titles, 1.1.1 Non-Text Content, and 2.4.3 Focus Order. Success criteria 2.4.2 was violated by 100% of the sample, while 1.1.1 was violated by over 90% of the sample and 2.4.3 was violated by over 70% of the sample.

Web page Qualitative Results

Using the process described in the methods section for manual checks of the sample of web pages, 3 themes emerged:

Theme 1: Inaccessible Images

Images presented on web pages often did not have appropriate alternative methods of perceiving images that meet individuals' needs, such as when using a screen reader.

Subtheme 1.1: Missing Alternative Text

On some web pages, images were missing alternative text to describe what was occurring in the image. These images included regular and linked images (e.g., previews of linked articles) or images acting as buttons (e.g., website logos or social media icons). Some web pages had carousels, a series of images that are presented one at a time with a set time spent on each one. None of the carousels encountered had alternative text such as an overlaying description or link to a long description. Some images in the carousel had important information (e.g., event details) while others were decorative. Some images did not have alternative text but had a caption nearby that was either not descriptive enough or the image was decorative.

Subtheme 1.2: Inappropriate Alternative Text

In addition, some images had alternative text, but the alternative text was inappropriate. For example, some images had alternative text that was not relevant to the image or did not describe what was happening in the image (e.g., the image file name was provided as alternative text). Other images had alternative text that was not descriptive enough to describe what was

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occurring in the image or had null alternative text when there should have been a description. Some images had shadows to add a visual effect, yet the shadow was coded as an image and provided alternative text.

Subtheme 1.3: Redundant Alternative Text

Some images had alternative text that was not necessary. For example, some images had alternative text that provided more information than what was presented within the image. Other images had nearby text that was the same as the alternative text provided for the image, making it repetitive. Similarly, some images had both alternative text and a caption or title; however, neither were descriptive enough. Finally, some images were unnecessary (i.e., did not add to the user's educational experience) or were decorative with unnecessary alternative text instead of null alternative text.

Subtheme 1.4: Text in Images

Some images had text within them. These images include those in carousels without alternative text as well linked images with lots of text (e.g., posters, previews of specific files, or advertisements) without alternative text or with inappropriate alternative text. Some images had alternative text or text near the image describing it, but it did not include the text in the image, only a description of what was happening in the image. Finally, some images had null alternative text despite having important and relevant text within the image.

Theme 2: Challenges Accessing Additional Resources

When additional resources were provided, the navigation to access these resources was unclear and difficult to follow.

Subtheme 2.1: Missing Link Purpose

On some web pages, linked text or images (e.g., logos redirecting to the homepage, social media icons) were missing for the purpose of the link, indicating where the link takes you and what its function is.

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Subtheme 2.2: Suspicious Links

Some web pages had suspicious links in that the links would appear as “click here” instead of providing a functional description. Some links were also used as placeholders. For example, one link led to a pseudo-email error.

Subtheme 2.3: Redundant Links

Another error encountered was redundant links such as a redundant link in an empty space on the web page, making it difficult to navigate. Other redundant links include repeated links or links that lead to the current page.

Subtheme 2.4: Links to Inaccessible PDFs

There were several web pages that had links to PDFs which were not accessible once opened.

Theme 3: Poor Structural Formatting

Web pages that lack structure limit easy navigation within the web page while using assistive devices and applications, such as screen readers.

Subtheme 3.1: Lack of Appropriate Heading Sequence

Within some web pages, all text was labelled as “body” and no heading labels were provided to specify the varying levels of headings. Other web pages had heading labels; however, they were hidden within forms, footers and headers, or heading levels were skipped, resulting in confusion while navigating the order of the web page. Within some web pages, all heading levels were provided, but were not representative of the flow of the web content or did not follow a logical sequence.

Subtheme 3.2: Lack of Appropriate Labelling

In addition to the lack of heading sequencing, other elements on the web page were not labelled appropriately. For example, form fields were not labelled with a form label or purpose. Another common example was using style elements to match list styling; thus list semantics, such as <ul> or <ol>, were not provided. Similarly, many table columns, rows, and data cells were not labelled appropriately, thus reducing the compatibility with assistive devices.

Subtheme 3.3: Lack of consistency between menu and body

Other errors encountered on web pages were the inconsistency between the menu item order and the heading sequence, and that menu items were hidden; thus the tab order was challenging to navigate and perceive.

PDF Qualitative Results

Through manual checks of the sample of 12 PDF resources, 2 themes emerged:

Theme 1: Minimal Colour Contrast

The use of colours allows for visually appealing PDF resources. However, many web pages contained content and background with limited contrast. When there is minimal colour contrast, many users will find it difficult to read the web content.

Subtheme 1.1: Challenges Heading and Body Text

Within some PDFs, the selected colours of heading text, including titles, headings, text box headings and subheadings, did not satisfy the WCAG 2.0 contrast criteria of 4.5:1 with the background colour. Similarly, some body text, including email links, dates, paragraphs, and page numbers, did not satisfy the WCAG 2.0 contrast criteria of 4.5:1 with the background colour.

Subtheme 1.2: Logo designed with poor colour contrast

Some logos of organizations were designed with poor colour contrast; thus, the image was difficult to perceive or differentiate with its background or the design elements within it.

Theme 2: Lack of PDF tagging

PDF resources have many elements within the file, however, each element was not tagged appropriately with <image>, <H1>, <P>, <Table>, or <L>. Due to the lack of tagging, it was challenging to navigate through the elements on the file using assistive devices.

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Subtheme 2.1: Illogical reading order

When using a screen reader, such as the "Read out loud" feature on Adobe Acrobat, some documents were not read in a logical order. For example, when reading some PDFs, images were skipped, or the text in images was not read. Another common error was the disruption of reading flow due to footers, tables, columns, text boxes, and empty pages. Some resources had a table of contents with no tagging; thus reading sequence between the section name and page number was not logical. Overall, the lack of tagging by the authors caused additional confusion when reading the document.

Subtheme 2.2: Lack of appropriate alternative text

Since most resources were not tagged, many images were not identified as figures, thus no alternative text was provided. Some resources compensated with descriptive captions around the image on the page. However, the image was not detected by the screen reader, thus the caption was not necessary.

Discussion

This study aimed to investigate and describe the common web accessibility errors present on international occupational therapy and pediatric websites and the resources within them (e.g., PDFs), based on WCAG success criteria. Using a mixed methods approach, two research questions were addressed: 1) How often did international occupational therapy websites and pediatric health-related websites and PDFs violate the accessibility criteria outlined by WCAG? and (2) How and why are essential web accessibility criteria of WCAG violated? The results of this research have provided valuable insight into where and why these errors occur as well as the high prevalence in which they occur, thereby severely impacting the experience of individuals with disabilities attempting to access these health-related websites.

Prevalence of Accessibility Criteria Errors

Based on the sample studied, none of the web pages and PDFs were accessible, as they contained at least 2 or more errors, with some web pages having as many as 115 errors. This speaks to the prevalence of accessibility issues and

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variation in the frequency of errors across web pages encountered by users accessing international health-related information. Among the web pages sampled, homepages had the highest prevalence of errors, which poses a unique navigation challenge, as the website is inaccessible from the first point of access. This means that individuals with disabilities will be placed at a disadvantage when determining what the website may offer, limiting their access to valuable information that is most relevant to their current needs.

Common Accessibility Criteria Errors

The results show that errors violating success criteria 1.1.1: Non-text Content were some of the most pervasive. This finding is consistent with previous studies that found missing alternative was one of the most common errors (Acosta-Vargas et al., 2020; Mason et al., 2021; Sik-Lanyi & Orbán-Mihálykó, 2019). In our study, we found that many images (including linked images and those in carousels) did not have alternative text and upon subjective investigation, it was found that even when alternative text was provided, it was often inappropriate or missing meaningful information. Among the PDF samples, we found that because many of the PDFs were not tagged, there was no alternative text for images in these specific PDFs. Alternative text is important, especially for those with visual impairments, as they are not able to perceive the image through visual senses and rely on devices such as screen readers to read the alternative text that describes what is happening in the image.

Another major issue found among web pages and PDFs was difficulty with navigation. Nganji found that most journal articles sampled were not compatible with screen readers due to the lack of tagging (2015). His finding is consistent with the current study's findings because most PDF resources were not tagged with <H1>, <H2>, <p>, <link>, or <figure> for each element. Tags are significant for accessibility because these tags provide chronological and visual structure for the assistive device to facilitate navigation for users. Similarly, it is evident that web pages also require an appropriate heading sequence. Heading structure is significant because it provides a chronological order for the web content and provides relational data of the web content. These features can assist in the comprehension of the entire web page,

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without the need for visual input. For example, screen reader users can jump between the major sections of the web page or resource to find relevant information to support their decision-making. If heading levels are skipped or illogical, it adds confusion to the screen reader user when navigating the web page or resource. Another issue that created difficulty with the navigation of web pages included violations of success criteria 2.4.4: Link Purpose as well as errors regarding redundant links. When the purpose of the link is not provided, the individual will not know where the link is sending them (e.g., returning to the homepage) when using a screen reader. Redundant links, such as a link in a footer within an empty space, can make it difficult for the individual to pass or skip that area easily when tabbing (using the tab key to navigate through the content).

Many elements of web pages violated WCAG 2.0 Success Criteria 1.4.3: Colour Contrast, based on WAVE. In addition, through manual checks of PDF, most resources had at least one element that did not satisfy the minimum colour contrast requirement of 4.5:1. In fact, some web pages had several colour contrast errors because these web pages were designed using an inaccessible colour theme. Since the selected colours were repeatedly used in the web page, thus amplifying the frequency of errors occurred. Colour contrast is vital for web accessibility because adequate colour contrast between the foreground and background is necessary for comprehension of the content for all users, especially those with low vision.

One issue that was prevalent and unique to websites was violations of success criteria 1.4.4: Resize Text. For example, some web pages had <i> (italic) and <b> (bold) text elements in an attempt to emphasize a word or phrase. However, this does not meet the success criteria because the visually rendered text was not scaled in a way that can be read by individuals with mild visual impairments without the use of an assistive device (e.g., a screen magnifier). When the individual zooms in on this kind of text, it can be difficult for the individual to read, as the content may no longer be visible on the page or has lost its function.

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Complexity of Web pages and PDFs

Complex web pages and PDFs are designed with multiple elements including menus, columns, heading sections, links to news articles or blogs and information carousels. Through subjective reports contributed by the authors, it is evident that web pages and PDFs with high complexity presented with a higher frequency of errors. For example, the homepage is the main landing page, which is responsible for displaying what information is provided within the website and guiding the user to the location of that content. Therefore, homepages are designed with complex design elements which require additional attention to ensure that these elements are designed according to WCAG principles.

Recommendations

Based on the findings, we present several recommendations:

Appropriate Alternative Text

Web developers should provide alternative text for regular images, linked images, logos, social media icons, and images in carousels that are detailed enough to describe what is happening in the image. The alternative text should also include any text that is present in the image. If the image is decorative, null alternative text (i.e., alt="") should be used to indicate this. When creating PDFs, developers should manually tag or auto-tag elements including images (e.g., <figure>) in the PDF and then provide a text alternative in the image properties. Providing alternative text allows visual information to be provided in electronic text which can be rendered visually, auditorily, tactilely, or a combination of these, making it accessible to various individuals in a form that meets their needs.

Clear Link Navigation

Web developers should use link text that is meaningful and identifies the purpose of the link so that individuals know its purpose and direction (e.g., to the homepage). Therefore, individuals can decide whether they want to follow the link. Web developers should also avoid repeating links within close proximity to avoid complexity and confusion. Additionally, developers should

avoid placing links in empty spaces on the web page or using text that states "click here" instead of providing context. All these techniques allow ease of navigation for those using assistive devices or those who are tabbing from link to link. Finally, developers should ensure that when PDFs are linked, that the PDF is accessible or that HTML content is used in addition or in place of the PDF.

Scaleable Text

Web developers should ensure that text is scaled so that it can be resized without the use of assistive devices (e.g., screen magnifier) up to 200 percent without interfering with the content or function (W3C, 2023b). This means that individuals with minor visual impairments will be able to read the information directly. Web developers can do this by using technology that supports individuals to zoom in on content, using percent for font sizes, giving users controls on the web page to change the size of the text, and using em units for font. For example, web developers can replace <i> (italic) and <b> (bold) text elements with or in the code to convey that the word/phrase needs to be emphasized.

Structured and Purposeful Labelling

Web developers should prioritize providing structure to a web page, including heading levels, lists, tables, images, forms and search bars. When using web content editor software, it is recommended to review all structural elements after publishing using automatic evaluation tools (WordPress.com Support, n.d.). When using Adobe Acrobat programs, there is a quick method to tag elements of the PDF resource automatically. This labels headings, figures and body content with the appropriate tags to ensure that the resource will be read in a logical sequence and thoroughly. Upon review, if the tags are not representative of the content of the resource, the resource author can manually label elements appropriately.

Greater Colour Contrast

When designing a colour theme for a web page or resource, it is beneficial to check all colours using a colour contrast evaluation tool. These tools specify if the contrast between the foreground and background satisfies the WCAG 2.0

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success criteria and allows for easy perceivability of the content. Another consideration related to colour contrast is designing the text, images and decorative elements of a company logo using an accessible colour theme. To improve the colour contrast of text or body content, web developers can bold, outline letters in black or increase the font size of the text. Another method to improve colour contrast is to avoid using busy backgrounds since busy backgrounds introduce more visual confusion when reading the web page or resource.

Occupational Therapy Relevance

This research matters to OTs because OTs work with individuals with various disabilities, including visual impairments, auditory impairments, cognitive decline, or motor challenges. When working with these individuals OTs want to enable occupation through holistic strategies and advocating for equity. OTs strive to support autonomy, such as prescribing assistive devices (e.g. screen readers, magnifiers) to alleviate the visual demands of exploring the internet for health-related information in order to make evidence-based decisions. Being able to identify errors because OTs should be informed of the barriers clients might face due to web inaccessibility and be able to advocate for specific changes. OTs can act as change agents in improving web accessibility of occupational therapy-related and pediatric resources, as well as a broader scope of web content.

Limitations

Our study has several limitations despite the steps taken to improve the quality of this research. For example, automatic evaluation tools used in the study do not have the capacity to check for all 38 WCAG success criteria. Thus, some types of errors may not have been detected, ultimately skewing the data as some errors reported as most prominent may not be in reality. To mitigate this issue, we included two automatic evaluation tools and manual checks in our research design so the limitations of one type of evaluation could be compensated by the other. We also could not complete screen reader compatibility tests during our qualitative data collection because we lacked human resources and time. This type of data would be beneficial; therefore,

such data collection would be a future direction for our research. In terms of positionality, we recognize that we are able-bodied individuals, and we did not include the perspective of those with lived experiences. We designed our study to focus on the number of errors and types of errors. Future studies can investigate these perspectives as demonstrated in Yi's (2020) study.

Conclusion

Occupational therapy and pediatric health-related websites are intended for use by individuals receiving medical and social therapeutic intervention, and therefore, individuals with disabilities are more likely to frequent these websites. As demonstrated in this study's findings, these websites are not designed with individuals with disabilities in mind, creating a large barrier in healthcare.

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We are grateful to the many people who are dedicated to providing resources to improve web accessibility, including those in the World Wide Web Consortium (W3C) and the W3C Web Accessibility Initiative (WAI). The WebAIM (Web Accessibility In Mind) group at the Institute for Disability Research, Policy & Practice at Utah State University has developed and administered WAVE as a free community service.

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THE RELATION OF DESIGN TOOLS TO UNIVERSAL DESIGN THEORY

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***Abstract*:** Are researchers in Universal Design (UD) using UD theory? There is a link between theory and the appropriate use and selection of tools in design research. On that basis, 256 conference papers from the Cambridge Workshop of Universal Access and Assistive Technology (2002 to 2020) are reviewed for instances of tool use and links to UD and general design theoretical content. From this, it is shown that the instance of explicit tool use can be found in a minority of articles. Those that do have articulated links between the tool of inquiry and theory are classed into four groups, a minority of which are based on UD theory. A recommendation is made for a more explicit explanation of the basis of tool use in research design in order to improve the transparency and comprehensibility of the research design.

Keywords: Universal Design, design theory, design tools, design research, Inclusive Design minimum three words.

Introduction

Tools “without theoretical substance can be sterile, representing technical sophistication in isolation” (Van Maanen et al., 2007, p.1146). In the light of this proposition, this article consists of an examination of the linkage between design theory and the use of design tools in Universal Design (UD) research. Design tools matter for the design process, being a connection between the user and the mind of the designer. Examples include drawing, mood boards, A/B testing, focus groups and cultural probes. The importance of theory is the two-way relation between it and data, connected by the instruments of

inquiry, the design tool. Ideally, these are strongly connected (Fawcett, 1978; Wacker, 1998, p.362; Swanson & Holton, 2005, p.8; Van Maanen et al. 2007, p.1145; Sileyew, 2019, p.28).

Rather than re-iterate the main points of UD, readers needing background are referred to the comprehensive overview of the definition, scope and features found in Persson et al., (2015) and also Patrick & Hollenbeck (2021). In brief, the main ambition of UD is to maximise accessibility without the need for specialised features by acquiring and structuring information about users´ needs (Ning & Dong, 2016, p.147).

Ning and Dong write that design tools are part of this gathering of data (ibid). Or, as Persad et al. (2006) write: "In the product design process, designers require systematic methods, tools and data in support of product design evaluation" (p.1). Further, design tools "capture human goals and actions and their impact on the functional parts of a given product" (Mieczakowski, et al. 2010, p.142). Using tools is not easy or necessarily straightforward and Goodman et al. (2006) write about the problems designers have with design methods (here meaning tools): "When they do use methods, the methods are not always applied appropriately or consistently and they are often applied in inappropriate situations leading to disappointing results" (p.47). With this in mind, it would be good to know on what basis design tools are used and what effect this has on the research/design outcome. It would also be good to find out if there is much evidence of researchers making clear the theory-tool relationship.

The literature on the linking of theory to tools in UD is not extensive. Some articles touch on the matter but do not deal with it as a primary focus. Dong et al. (2003) discuss the discrepancy between theory and practice in commercial settings. They conclude that the "provision of design support tools is necessary to bring inclusive design theory and practice closer together". Ruffino et al. (2006) is quite a detailed examination of the Universal Design for Play Tool. The link to theory is noted a being the tool´s basis in the seven principles of UD. The article does not discuss UD theory any further. Cremers et al. (2016) is a focused paper that links UD to their ICT design tool. They see the link as being from 1) standards and guidelines, 2)

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anchoring of design patterns in ethics and values and 3) situated design derived from case analyses. The pattern that emerges is that searches in using Google Scholar do not produce results that suggest there has been much work done on the general theory-to-tool linkage. This is true for searches using the terms Universal Design, Inclusive Design or Design for All.

This paper builds on previous work regarding tools' relation to method (Goodman-Deane et al., 2008) and the nature of tools in design (Rampino & Colombo, 2012; Dalsgaard, 2017; Herriott & Akoglu, 2019). It also relates to the instantiation of theory in UD research (Herriott, 2023). That article concluded that research into UD theory had a tendency to omit elements that were related to principles of implementation. Design tools are derived from theory, in particular principles of implementation: according to Jones & Gregor´s (2007) proposal for the structure of a design theory, such principles are "a description of processes for implementing the theory (either product or method) in specific contexts" (p.27).

What we are interested in here are the design tools that depend on the content of UD theory, which is the articulation of why and how to maximise accessibility without the need for specialised features. Since UD has commonality in general design principles, some tools used in UD may be based on what one might call "standard user-centred design". In passing we will also encounter design tools based on other theory from outside UD and its related fields.

With the desire to improve UD practice (meaning better grounds for tool use) and to improve UD theory-building in relation to principles of instantiation, these questions will be addressed:

- To what extent do researchers in UD use design tools that are dependent on UD theory?
- How do researchers in UD use existing design tools if they use them?
- What is revealed about the relationship between tools and UD theory?

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The terms Universal Design (UD), Inclusive Design (ID) and Design For All are treated as being synonymous in much design research literature (Stephanidis, 2001; Ostroff, 2009, p.3; Heylighen & Bianchin 2013, p.93; Persson et al. 2015, p.2; Zhu et al., 2020, p.2). As such, all of those terms will be encountered in citations and the general discussion of the subject in this text. The term UD will be used here without the intention to exclude ID and Design for All.

Design tools and theory

Before moving to the review of research, it is necessary to lay out a conception of what tools are. Though there is a large body of design research involving tools, research articles about tools theory are not numerous. However, the few available are adequate for the purposes of this article. First, where are tools located in the hierarchy of specificity? Rampino & Colombo (2012, p.85) explored terminology in design research. They proposed a hierarchy of research levels, from general to specific:

1) nature of the research,
2) research process,
3) codified research procedures,
4) specific instruments.

Tools are classed as specific instruments. The related term “method” may be placed in category 3 or 4. As with Herriott & Akoglu (2019), Rampino and Colombo (2012) find that the terms “method” and “tool” are used interchangeably but prefer to place them in separate classes, i.e. to assign the word “tool” and “method” different meanings. Rampino and Colombo (2012) define a “research tool, or instrument” as “a structured procedure sharply focused on a precise objective, for example, on collecting empirical data, elaborating those data, analysing them and so forth” (p.89).

Casais (2020) offers this definition of tools and so links tools to theory: “Design tools are compact vehicles of data, often with game elements, that deliver methods of working, inspire with ideas or solutions, and summarise complex information in a format that is possible to handle. Such tools have the

potential to increase eloquence in intricate matters, by streamlining concepts and theories" (p.3). Casais produced this rubric of the nature of tools:

1) summarising theoretical knowledge;
2) providing inspiration/displaying design cases;
3) understanding the user; and
4) providing methodological support. (Casais, 2020, p.5)

It is understood that these four characteristics are demonstrated to some degree in tools.

The work on tools´ nature is not unequivocal. There exist differing conceptions of tools. One is a directly instrumental view, where something happens or is discovered: design tool as an instrument of inquiry (e.g. Dalsgaard, 2019). Another is more abstract, the design tool "as an instigator and mediator in small and large social transactions" (Winton & Rodgers, 2020, p.11).

Having looked at what tools do, we must also ask what they are for. Tools do something more than inquire. Designers might be said to use them to "capture human goals and actions and their impact on the functional parts of a given product" (Mieczakowski et al., 2010, p.142). This implies tools help interpret what is found out.

Although a rigid demarcation is not feasible, some form of distinction is needed between tools and methods. Pragmatically one might define the difference between a tool and a method as being that tools are more prescriptive or constraining (think of a knife that affords just cutting). Methods are more general and would involve the choice of tool(s) and sequence of use e.g. the order and timing of steps in a process. That is how they are distinguished here with the proviso it is still a matter of interpretation and context. One could think of tool as like nouns and methods as being analogous to a verb.

One further point is to do with terminology. As well as methods being conflated with tools (e.g. the term "framework" is also used in relation to

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design inquiry and analysis, e.g. Goodman-Deane et al. (2008; p.23) and Karam & Langdon (2016; p.187). The Goodman-Deane et al. (2008) text concerns a framework for selecting methods and tools. They studied the choice of design methods (by which term they seemed to mean tools). The work determined by research what tools were used at what stages. In this instance, what is called a framework is not a directly applied means to achieve a design end. It appears to be a categorisation of existing things which themselves are instruments of inquiry. It is derivative of existing tools but a case can be made that it is a tool not a method. Karam & Langdon (2016) discuss a framework "highlighting the somatosensory system in our understanding of the design and development of computer interactions for the human body…. and this framework is intended to serve as a *tool* for broadening our understanding of the multidisciplinary aspects that influence all interactions designed for the body" (p.187, italics added). Here the word "tool" could be replaced by the word "means". The framework here is broadly a kind of mid-level theory rather than a direct way to interact with the world. It meets only the first criteria of Casais (2020, p.5).

Having clarified that point, it is possible to say that for the purposes of this study, the target of the inquiry is descriptions of sharply-constrained structured procedures (to paraphrase Rampino and Colombo, 2012) that might be named as tools or methods. In this article, the focus is on looking for descriptions of tool use and the design of tools. This is related to the nature and extent of any linkage to UD theory or design theory in general.

Zitkus et al. (2012) is representative of the difficulty of identifying tools in research texts with several terms being used at once. The term "techniques" is used to refer to "co-designing methods" (p.145) and to physical items like an age-simulator suit (p.145) and to "impairment simulator tools" meaning screen-based exclusion calculators (p.146). The critical reader might also point out the absence of Nickpour & Dong (2010) from the final selection. The paper, titled *Developing user data tools*, deals with issues related to the design of tools to support designers and is detailed and thorough. For instance, they identify challenges, limitations and opportunities during exploration, conceptualisation and evaluation stages. However, the relation to theory – a model of design – is not made explicit other than this passing reference:

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"Inclusive design is an excellent example of how such support tools become both essential and significant" (p.79).

Methodology

To source the data, a long-running series of conference papers was chosen, that of the Cambridge Workshop on Universal Access and Assistive Technology (CWUAAT). This ensured consistency of the source material and regularity of the series (no gaps or breaks). The conference is recognised for its significance in UD research. Every paper from 2002 to 2020 was read and inspected for descriptions of the use of design tools. The use of a design tool was noted and illustrative text was extracted for analysis. Additional notes were made regarding the theoretical basis of the tool use, if present.

The advantage of this method lies in its consistency of approach. The disadvantage is that analysing only the CWUAAT engineering design tradition might lead to a systematic omission of other design research methods. Counter-balancing this point is there are no clear boundaries between industrial design and engineering design methodologies. At an abstract level, the basic difficulty in this process involved deciding what constituted a theory since the nature of theory is not a settled matter (Rosenberg, 2016). There was a danger of the selection process falling prey to the "one true Scotsman" problem (see Anderson, 2017 for an explanation).

It is a deliberate decision that the terms for the tools recorded were not amalgamated into more general categories. This is to limit the chances of inconsistent interpretation/classification in addition to inconsistencies that might arise from selecting what counts as a significant instance of tool (a term already conflated with method).

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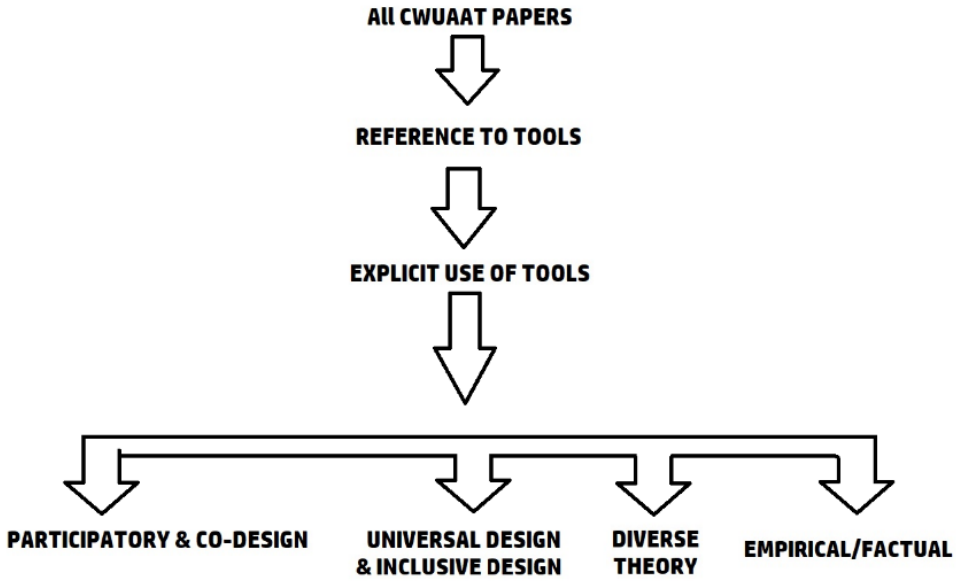
The filtering process is shown in Fig. 1 below:

Figure 1. The selection process. At the top is the entire data set. At the bottom, the final selection of papers that deal with tool use and the basis of use..



Data

Ten volumes of CWUAAT proceedings were inspected, amounting to 242 papers. 56 papers contained references to design tools and the use of tools. See Table 1, below. Something was designated a tool if it was a distinct unit in a design research process and that did not seem to be capable of subdivision into smaller named units.

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Table 1. The design tools referred to in the CWUAAT conference proceedings.

Year	Total no. of papers in volume	No. of papers with an identifiable tool	Tools referred to
2002	28	4	1) Inclusive Design Cube, 2) Interviews, 3) Focus group, 4) User-trials, 5) user-group
2004	26	5	1) Questionnaires, 2) user-observations, 3) Focus groups, 4) Interviews, 5) Diary studies, 6) Critical user studies, 7) user-trials, 8) ethnographic studies, 9) self-observation, 10) brainstorming, 11) expert-heuristic evaluation, 12) task-analysis, 13) simulation, 14) cognitive ability scales, 15) participatory design interviews.
2006	24	7	1) focus groups, 2) user trials, 3) A CAD model of a human, 4) A tool to evaluate the capability demand relationship, 5) cultural probes, 6) UC video ethnography, 7) toilet audit tool.
2008	25	6	1) Exclusion calculator, 2) Ergonomic measurement tool, 3) Focus groups, 4) Audit, 5) user observations, 6) interviews, 7) sketching, 8) prototyping.
2010	22	2	1) User-data tools, 2) Colour contrast assessment system.
2012	23	3	1) VR for HCI, 2) Cognitive impairment interpreter, 3) Data representation about UD, 4) interviews.

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Year	Total no. of papers in volume	No. of papers with an identifiable tool	Tools referred to
2014	24	4	1) User capabilities analysis, 2) Effort analysis, 3) Kano questionnaire, 4) Checklist tool, 5) Field-base survey, 6) Focus groups, 7) Self simulation, 8) Photo
2016	27	13	1) Unspecified quantitative and qualitative tools, 2) tool for testing graphics, 3) Prototypes, 4) Anthropometrics, 5) Personas, 6) Mock-ups, 7) participant observation, 8) interviews, 9) document analysis, 10) phone interviews, 11) real-world observations, 12) focus groups, 13) diary studies, 14) Eye-tracking, 15) storyboards, 16) data collection toolkit, 17) 3D scanners, 18) photography, 19) big data analysis.
2018	24	5	1) Topological data analysis, 2) Workshop, 3) Colour contrast evaluator, 4) Photovoice, 5) Semi-structured interviews, 6) Prototyping.
2020	19	6	1) Design kits, 2) Unspecified, 3) Co-operation platform, 4) Exclusion calculator, 5) PDF accessibility checker, 6) Focus groups, 7) Interviews, 8) Ethnographic studies.

Following this, the instances of the tool use were extracted. Table 2 (below) shows the instance and the paper describing its use.

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Table 2. Occurrence of types of tools.

	Type of Tool	Instance	Reference
1	Focus Group	11	Hine et al., 2002; Gheerawo & Donahue, 2004; Cardosa et al., 2004; Goodman et al., 2004; Boyle et al., 2006; Savitch et al., 2006; Baskinger & Hanington, 2008; Andrews, 2014; Raheja & Suryawanshi, 2014; Williams et al., 2016; Liu et al. 2020;
2	Interviews (all types)	8	Hine & Evans, 2002; Gheerawo & Donahue, 2004; Cardosa et al., 2004; Allen, 2004; Hurtienne 2008; Jokisuu et al., 2012, Skjerve et al., 2016; Steenwinkel et al., 2016; Williams et al., 2016; Morris et al., 2016; Jellema et al., 2018, Nguyen et al., 2020
3	User-observation	6	Gheerawo & Donahue 2004; Cardosa et al., 2004; Hurtienne et al., 2008; Andrews, 2014; Steenwinkel et al., 2016; Williams et al., 2016
4	Personas	4	Broulé & Joiffrais, 2016; Afacan, 2016; Morris et al., 2016; Kunur et al., 2016
5	Questionnaires	3	Gheerawo & Donahue, 2004; Cardosa et al., 2004; Ma & Dong, 2016
6	Audit	3	Bichard et al., 2006, Mayagoitia et al., 2008; Froyen, 2008,
7	User trials	2	Porter & Lesley 2002, Cardosa et al. 2004; Boyle et al. 2006
8	Exclusion calculator	2	Waller et al., 2008; Goodman-Deane, 2020
9	Guidelines	2	Kwok et al., 2008., Shamshirsaz & Dong, 2014

	Type of Tool	Instance	Reference
10	Prototypes	3	Hurtienne et al, 2008; Boyd et al., 2016; Chakraborty & Nguyen, 2018
11	Ethnographic studies	3	Cardosa et al., 2004, Raheja & Suryawanshi, 2014, Nguyen et al., 2020
12	Capability demand assessor	1	Persad et al., 2006,
13	Sketching	1	Hurtienne et al, 2008
14	Visual documentation	1	Raheja & Suryawanshi, 2014
15	Image Schemas	1	Hurtienne et al. 2008
16	Diary studies	1	Gheerawo & Donahue, 2004
17	User-group forum	1	Smith et al., 2002
18	Critical user-studies	1	Gheerawo & Donahue, 2004;
19	Self-observation	1	Cardosa et al., 2004; Raheja & Suryawanshi, 2014
20	Brainstorming	1	Cardosa et al., 2004;
21	Expert/heuristic evaluation	1	Cardosa et al., 2004;
22	Task analysis	1	Cardosa et al., 2004;
23	Simulation	1	Cardosa et al., 2004;
24	Capability scales	1	Langdon et al., 2004
25	CAD model	1	MacDonald et al., 2006
26	Cultural probes	1	Dewsbury et al., 2006, Nickpour & Dong, 2010

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	Type of Tool	Instance	Reference
27	Collage	1	Andrews, 2010
28	Foam models	1	Andrews, 2010
29	Product feedback method	1	Andrews, 2010
30	Storytelling	1	Andrews, 2010
31	Video ethnography	1	Gough, 2006.
32	Inclusive Design Cube	1	Keates & Clarkson, 2002.
33	Torque-measurement tool	1	Yoxall et al., 2008.
34	User data tools	1	Nickpour et al., 2010.
35	Colour contrast assessment	1	Dalke et al., 2010.
36	Virtual Reality device	1	Ceccacci et al., 2012.
37	Medical diagnosis interpreter	1	Jokisuu et al., 2012.
38	Data provision tool for designers	1	Zitkus et al., 2012.
39	Mapping	1	Heitor et al., 2014.
40	Level of effort analysis	1	Heitor et al., 2014.
41	Kano questionnaire	1	Shamshirsaz & Dong, 2014.
42	Lead user testing	1	Andrews, 2014.

	Type of Tool	Instance	Reference
43	Design cards	1	Andrews, 2010; Broulé & Joiffrais, 2016.
44	Workshop	1	Broulé & Joiffrais, 2016; Bridge, 2018.
45	Critical artefact methodology	1	Chamberlain et al., 2016.
46	Data collection toolkit	1	Ma & Dong, 2016.
47	Graphics testing tool	1	Waller et al., 2016.
48	Anthropometrics	1	Holt et al., 2016.
49	Mock-up	1	Afacan, 2016.
50	Document analysis	1	Steenwinkel et al., 2016.
51	Diary studies	1	Williams et al., 2016.
52	Eye-tracker	1	Chakraborty et al., 2016.
53	Story boards	1	Kunur et al., 2016.
54	Topological data analysis	1	Persad et al., 2018.
55	Contrast evaluation tool	1	Danschutter & Deroisy 2018.
56	Photovoice	1	Jellema et al., 2018.
57	Design kits	1	Winton & Rodger, 2020.
58	Co-creation platform	1	Liu et al., 2020.
59	PDF accessibility too	1	Jembu-Rajkumar et al. 2020.

Finally, from this sub-sample could be created a list of papers that offered reasoning for the tool use. Four categories emerged by inspection (see Table

3 below). The 1st class differs from the second by directly drawing on participatory design (and related fields).

Table 3: Four classes of foundation for tool use in universal design/inclusive design research.

Participatory design & co-design	Universal design/ inclusive design	Other theory	Empirical factual
Allen (2004); Goodman-Deane et al. (2008); Raheja & Suryawanshi (2014); Brulé & Jouffrais (2016); Liu et al. (2020).	Langdon et al. (2004); Persad et al. (2006); Bichard et al. (2006); Waller et al. (2008); Froyen (2008); Ma & Dong (2016), Goodman-Deane et al. (2020).	Keates & Clarkson (2002); Savitch et al. (2006); Gough (2006); Dewesbury et al. (2006); Hurtienne et al (2008); Chamberlain et al. (2016); Jellema et al. (2018); Heitor et al (2014);	Goodman-Deane et al (2004); Kwok & Ng (2008); Zitkus & Langdon (2012); Shamshirsaz & Dong (2014); Waller et al. (2016); Danschutter & Deroissy (2018).

In the introduction some questions were posed and in the following sections they are answered.

The first question asked to what extent do researchers in UD use design tools that are dependent on UD theory. In quantitative terms, 25 out of 242 papers made explicit reference to the basis for the use of design tools. Seven of the 25 used inclusive design theory (and related fields) as the basis for the use of the tool or the development of the tool. Given that the entire data set is about design for accessibility one might be surprised at this result. But the question is very narrow, not about UD/ID research but the use of theory to support tool use in UD/ID. It turns out that one can conduct research in this field while drawing on other sources for theory supporting the tools of inquiry. Some of the tools articles, unsurprisingly, rely on the co-design theoretical tradition. Eight draw on fields outside and six of the 24 used proto-theoretical or, simply

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put, a factual basis for the selection and use of the tools. The good news, so to speak, is that practitioners are drawing from fields outside UD and co-design and these papers, when used in subsequent research become part of the ID/UD body of knowledge.

Most UD/ID research relies on a small number of tools. Focus groups, interviews and field observations top the list with a long tail of tools with under four instantiations. The large majority are instantiated just once. It is possible to probable that the top five tools are themselves under-reported. Familiar-tools such as prototyping and sketching only got a pair of mentions. However, it is very unlikely that the absence of researchers naming sketching is a true indication of the use of sketching. More likely is the banal fact that researchers are not making very strenuous efforts to accurately report their research process. The long tail conceivably consists of tools named in the article because the authors considered them sufficiently distinctive to be interesting.

The second question is 2) how do researchers in UD use existing design tools. Table 4, below, summarises the data. The third column “How tool was used” notes the role of the tool in the research. As well as being for data gathering and affecting change on the design (the point of a tool) the tool in the articles served as instantiations of how to change researchers´ behaviour, how to select and use tools, how to develop them and about the provision of accessible data.

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Table 4. How tools were used in research.

Context	Tools	How tool was	Author
Healthcare	Co-creation tools	Behaviour change	Liu et al. (2020)
Visual	Design cards,	Tool created for	Brulé & Jouffrais
Education	field-based observations, focus groups, visual documentation and self-simulation	Tool selection	Raheja & Suryawanshi (2014)
Assistive	Interviews	Tool selection, use	Allen (2004)
Unspecified	Design guidance	Tool creation,	Langdon et al
Digital product	Capability	Tool creation	Goodman-Deane
Packaging	Data collection	Method of use,	Ma & Dong (2016)
Toilet design	Audit	Usability	Bichard et al.
Unspecified	Exclusion guide	Usability	Waller et al.
Software	Cultural probe	Tool selection,	Dewsbury et al.,
Visual design	Image schemas	Tool selection,	Hurtienne et al.
Social design	Critical artefacts	Tool selection,	Chamberlain et
Hospital design	Photovoice	Tool selection,	Jellema et al.
Social design	Focus group	Tool use, tool	Savitch et al.
HCI	Conceptual	Tool design	Keates &

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Context	Tools	How tool was	Author
Packaging	Video	Tool development	Gough (2006)
Building design	Spatial analysis	Tool development,	Heitor et al.
Mobile ´phone	Focus group	Tool selection,	Goodman et al.
Building design	Guidelines	Tool design	Kwok & Ng
Social design	Quality table	Tool design	Shamshirsaz &
Product design	Data presentation	Data provision, use	Zitkus et al.
Product design	Data presentation	Data provision, use	Waller et al.
Building design	Data presentation	Data provision, use	Danschutter &

Under the separate categories we find that category 1 articles (based on participatory design/co-design theory), there were tools for behaviour change, tool creation, tool selection and intensity of use. Under category 2, work based on UD/ID theory related to tool design and form-giving, methods of tool use and tool adaptation. Category 3 (other theory), the articles reported work on tool selection and use, mode of use, form-giving output, tool development. The last category (4), papers using data or proto-theory, reported insights on tool selection, tool use, tool design and data presentation. There is not enough data to see if there are any correlations between the theory type and the tool or the context of use.

Analysis

Dealing with question first (3) what is revealed about the relationship between tools and UD theory, I will look particularly at which theory provided the support for the tool use (see Table 3, above).

Participatory design and co-design provides the basis in five papers. The most elaborated is Liu et al. (2020) concerning co-creation in healthcare engineering. The tool is a platform aimed to promote co-creation and the basis for the use and elaboration of the tool is in Sanders & Stappers (2008). The effect on the process was to change the methods of researchers who came primarily from an engineering design background; thus the theory about user-involvement translates into changes of behaviour in terms of the specific selection of tools and the resultant output – an expected outcome. Brulé & Jouffrais (2016) discusses the design and testing of a tool for designers working with visual impairment. For this, co-design is offered as the theoretical basis. The paper describes the steps from initial discussions with stakeholders. The process had three phases: general inquiry, design-card creation and then workshops. Personas are used to get around the tricky matter of dealing with many child subjects. In their paper on universal access in educational environments, Raheja & Suryawanshi (2014) use a participatory approach. That translated into using a range of tools that would detect user experiences: field-based observations, focus groups, visual documentation and self-simulation. This "showcases a methodology for inclusive planning and design for implementation on campus-built environments" (p.173). Allen (2004) deals with product semantics in assistive device design. The work is based on the framework of designer-facilitated participatory design and the tool of inquiry is the interview. Like Goodman-Deane et al.´s (2008) article on tool selection, the connection to theory is implicit.

The second group is general level UD theory and its cognates. This theory is used to support tool use in a group of papers about building design, packaging, product design and product interfaces. This theory is that which makes up the main corpus of UD thinking on how and why to go about design for inclusivity: the work of the Cambridge Engineering Design Centre, publications by London Royal College of Art/Helen Hamlyn Centre and design standards. It is theory from inside the UD research community. Examples: Langdon et al. (2004) makes explicit the theory-to-tool link, based on "a simple cognitive user model" (p.60) and the Cambridge Inclusive Design model. Those lead to the design of design-guidance measures. Persad et al. (2006) also make use of previous EDC work (in this case it is Keates & Clarkson, 2002) in their

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capability-demand relationship tool. Specifically, the product interface features are targeted following on from the cognitive user-model. Goodman-Deane (2020) examines how to quantify exclusion for digital products, drawing from the theory outlined in Persad et al. (2006). These ideas shape the form of the tool which analyses product tasks individually for capability assessment. Ma & Dong (2016)´s investigation of packaging openability applies Clarkson (2010) to adapt a research process for ergonomics study in an Asian social context. It produced a data-gathering methodology that found out what the users could and could not do (p.122). The two other papers in this set, Bichard et al., (2006) Waller et al., (2008) leave the theory implicit. The former refers to BS899 to construct their toilet design audit tool. The latter produces a useful and usable exclusion guide but leaves the underlying UD principles under-explained.

The third group is based on a heterogenous body of theory from outside the co-design and UD fields. Four items draw on an articulated theory of tool use: 1) Dewsbury et al., (2006) refer to Gaver´s (1999) cultural probe theory; 2) Hurtienne et al. (2008) exploit the concept of image schemas in a design process using existing design tools; 3) Chamberlain et al. (2016) use critical artefact theory while 4) Jellema et al. (2018) refer to the photovoice literature (Wang & Burris, 1997) which prompts decisions on tool selection and use. Jellema (2018) and also Dewsbury et al. (2006) are clear on which theory they draw on but focus most on the case and context in which it is used. That leaves three works with explicit and clear links from theory to implementation. HCI theory supports Keates & Clarkson's (2002) concept of the Inclusive Design Cube; medical theory on dementia supports Savitch et al. (2006); Jordan and Miller´s product pleasure work is used by Gough (2006) for a paper on tool development while space syntax theory underpins Heitor et al.´s (2014) research on architecture and accessibility. Standing out for particular attention is Gough (2006) which is one of very few in this study to explicitly set out to describe the development of creative design tools. Gough developed user-centred, video-ethnographic research techniques to enable in-house design groups to conduct work with key consumers (Gough, 2006): "the tool formalises key insights from the research and provided an intuitive visual interface for evaluation and comparison" (p.211). Gough (ibid.) derived this

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from video recordings that showed a) which elements of the packaging helped and b) which did not. The way the tool was derived coordinated its structure with the product pleasure concepts, that is, to target which elements of the products reconciled (or not) the interaction with the packaging. In a similar vein, Chamberlain et al. (2016) builds on earlier work to develop a design research tool. This is critical artefact theory which is used to focus on the needs of groups of individuals who are under-represented in the UD/ID research arena, including individuals from diverse ethnic communities …" (p.100). The work uses objects and artefacts as a means to stimulate and structure thinking and so allow the complexities of people´s life to be understood. The resultant theory is made material as "an exhibition in a box" (p.104). The subject's home becomes a research field. As with Gough (2006) there is a direct and tangible line from theory towards a physically manifest design research tool which is desirable. Heitor et al. (2014) translate concepts of space syntax analysis (the work of Hillier & Hanson, 1984) which is a set of theories and techniques for the analysis of spatial layouts. By mapping these concepts to the tool the researchers could represent, quantify and compare spatial systems. Again, abstract concepts were transformed into specific means to capture elements of the physical environment and the likely way users could be either helped or hindered. As with Gough (2006) and Chamberlain et al. (2016) the tool was deployed in a case study. Keates & Clarkson (2002) devote their effort to translating HCI work in model human processors. The result is a tool (they use the term "method") for dividing the population according to their ability to perform functions. The tool then allows the designer to identify "which level of capability to address" (p.16). For a designer the tangible output is to "highlight the aspect of the product which needs to be improved" (p.17). What is missing is how to map the design geometry to the range of capability, which could be provided in the form of a rubric.

Returning to Hurtienne et al. (2008), one may understand this work as putting a pre-existing theory (human cognition) into an existing design method using known design tools (user observation, interviews, sketching and prototyping). This means the theory altered the way in which standard tools were used rather than leading to a new tool or a revision. The direct link to the theory

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came at two points, the generation of design proposal and in the result, the extent to which the design was in accord with Johnson´s (1987) image schema concept.

The last category is that of tool-orientated design research based on what one might call proto-theoretical foundations or, simply, factual evidence. For a study on mobile ´phones, Goodman et al., (2004) the decision to use focus group relied on factual knowledge of older users´ needs. Kwok & Ng (2008) provides a tool in the form of guidelines for designing a good living environment using empirical research. Shamshirsaz & Dong (2014) followed a similar path, leading to a quality table tool for a form of service design for care homes. Zitkus et al., (2012), Waller et al., (2016) and Danschutter & Deroisy (2018) are concerned with how to supply designers withknowledge of inclusion. The papers deal with accessible data-provision. It is derived from observations of designers´ difficulties in using tabulated statistical data. The first two are addressed to product designers; the last one is for building designers. All three discuss the creation of a design tool with elements traceable to the foundational concepts.

In summary, the relation between UD theory (and other theory) is detectable in a small set of the papers examined and the reported relationship is one-way. Without a forensic re-reading of the texts for subtle signs, no authors unambiguously offer clear feedback to UD design theory. Where authors do explain the forward influence from theory to design tool we see a positive relationship: the theory leads to a hypothesis that suggests the use of one tool over others.

Conclusion and discussion

The three questions posed by this paper lead to the following discoveries. One, that researchers in UD do not make very much explicit use of UD theory in their choice and use of design tools. Given that researchers might be expected to have a strong interest in theory/data relations, this is something of a surprise. Further work is needed to question researchers about their attitude to the theory-tools relationship. This echoes an earlier call by Stolterman & Pierce (2012) in an article looking at HCI designers choice of tools. That article

offered little evidence to believe theory was a strong consideration for HCI designers and it may not be a strong consideration for UD designers.

A priori, and based on practising designers' very restricted use of design research (see Mieczakowski et al., 2010 and Fisher and Taffe, 2022, for example) one might expect an even less promising situation in commercial settings. Perhaps those working with UD could be more fastidious about the basis of their tools use. Further work is needed.

The second question indicates that those researchers in UD inclined to use design tools in relation to theory mostly seem interested in tool selection, tool adaptation and tool design rather than having feedback to modify theory.

What is revealed about UD theory (and theory in general) and tool use is that the relationship is one-way. UD researchers are not feeding back findings explicitly into revised theory. When one uses a design tool one makes discoveries not only about the user but also about the tool and by extension the theory it is based on. There is a gap in design research for explorations of UD that exploits the leverage a tool has on theory; if the theory is sound and suggests plausible hypotheses then the tool ought to be a means to work with the theory. In reverse, the tool can be a mechanism to explore the theory as much as it is a means of inquiry into the user and the design situation. Every use of a tool tests the theory it is based on. The findings of the tool use reveal something about the theory such as its validity, scope and completeness.

The literature examined here only hints at the problem with tools. Mieczakowski et al., (2010) show designers don´t really use tools; and that designers´ cognitive models are themselves and people they know: "…they do not have the capacity to represent and match how different users interpret and use a given product with how designers intend that product to be understood and used" (p.142). The inquiry also raised the question of how tools are conceptualized and taught for those students interested in (or explicitly studying) Universal Design and this is a direction planned for further work.

The survey here did not look beyond the range of the papers submitted to the CWUAAT series. An interesting examination might be to see what the more

art-based design research theory-tool relationship might reveal. There is a lot of other design research available, research founded much less on the kinds of natural-science-inspired work represented by the CWUAAT series. But even artistic design research must have some basis in design theory. It might be profitable to examine what kind of tools are used and whether in that arena there is less, more or the same kind of linkage shown in this study. This work suggests that UD researchers could take some more time and expend more effort to ensure that the theory-tool-data link is made explicit in order to develop theory and to make the process of the design research more transparent.

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HOW EXPENSIVE IS IT TO BUILD A VISITABLE HOME? A CASE REPORT

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***Abstract*:** Loneliness and social isolation of older people or those with mobility impairments may result from the physical environment not being in correspondence to their degree of mobility. Winter conditions combined with the presence of steps at the entrance to homes are among the obstacles that prevent them from participating in social or community activities necessary for their well-being. The concept of visitability is proposed in order to allow seniors or individuals with mobility impairments to visit their loved ones. The three criteria for achieving the basic visitability of a residence are: 1) an entrance without a step at the front, back or side of the home (located on a path accessible from the street); 2) wide doors on the main floor (minimum 813 mm (32") opening); and 3) an adapted bathroom on the main floor. The objective of this study is to validate whether visitability can be an economically viable solution, through a comparative cost analysis, to enable older people or people with mobility impairments to visit their loved ones. The results of this case study demonstrate that the marginal costs of applying visitability criteria to new construction can be zero or negligible. These results indicate that the approach to visitability, both basic visitability and so-called improved visitability, should be taken into account more systematically by

builders and developers in order to promote the social participation of older people or those with motor disabilities.

Keywords: Visitability; Cost; Building; Older People; Motor Disability; Social Participation.

Introduction

Having a social life and participating in community life are important elements in maintaining quality of life and well-being for all (Holmes & Joseph, 2011; World Health Organization, 2002). This includes, among other things, visiting family and friends, which may seem trivial for some people, but can be difficult for others, such as older persons or those with mobility impairments. While great progress has been made in creating accessible public spaces in Canada, and even elsewhere in the world, this trend does not generally concern the accessibility of private homes (Government of Quebec, 2012). The difficulty, or even impossibility, of people to access or leave their loved ones' homes is a hindrance to their participation in social and community life. In fact, they may prefer to stay in their home rather than leave because of the challenges of visiting the home of a loved one. These barriers to mobility in the built environment mean that they are forced to live in isolation (Edelbrock et al., 2001; Gardner, Brooke, Ozanne & Kendig, 1999). Social isolation has also been associated with other consequences for quality of life, such as depression and suicide (Gutzmann, 2000; Silveira & Allebeck, 2001). In order to remedy the lack of accessibility of homes, a concept has been put forward for some 40 years, namely that of "visitability". Visitability can be defined as the ability of an environment to be visited by the vast majority of the population, based on simple, sustainable, inclusive and affordable criteria (visitablehousingcanada.com, PARA et al., 2006). The aim of visitability is not to make changes to a home in order to satisfy the specific needs of its users. Rather, visitability aims to provide a basic level of accessibility in all new home construction and all new neighbourhood developments, not just for older people or those with motor disabilities, but for the entire population -

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Eleanor Smith and her group Concrete Change introduced the concept of visitability to the United States in the mid-1980s. However, the concept was introduced in Europe shortly before. For example, in Sweden, standards ensuring a basic level of accessibility have existed since 1976 (PARA et al., 2006). In 1992, the City of Atlanta (Georgia, USA) was the first city to enact the imposition of basic visitability features in the construction of single-family homes and duplexes using subsidies from the city. In June 2006, 44 states and local municipalities in the United States implemented a visitability program (National Council on Independent Living, 2020). In Canada, a more unified approach to the design of cities and communities is needed to make them more sustainable and inclusive. For example, the Canadian Centre on Disability Studies in Winnipeg, Manitoba, conducted the project Understanding the Status of Visitability in Canada (visitablehousingcanada.com) from August 2006 to 2007, recognizing the need for research to address the issue of visitability (Canada Mortgage and Housing Corporation, 2007). The goal of this project was to develop an understanding of visitability in Canada. The results showed that, while great progress has been made in creating accessible public spaces in Canada, there is a shortage of private homes with minimal accessibility (Government of Quebec, 2012).

A home qualifies as accessible if it meets the criteria set out in Progressive Accessibility Re-form Associates (PARA), including an entrance without steps at the front, back or side of the home (located on a path accessible from the street), wide doors on the main floor (minimum 813 mm (32") door opening), and an adapted bathroom on the main floor (PARA et al., 2007). These three criteria are necessary to achieve basic visitability, thus ensuring that everyone, regardless of their level of mobility, is able to visit someone else's home, use the bathroom, and enter and leave the home without difficulty. Since "visiting" implies a visit lasting from a few minutes to a temporary stay (Maisel, 2006), a notion complementary to basic visitability is put forward in this paper as “enhanced visitability”. Enhanced visitability includes all of the criteria of basic visitability, in addition to making certain improvements that allow for greater safety, functionality, comfort and flexibility at relatively low space and cost (PARA et al., 2006). In addition to benefiting older visitors or those with mobility impairments for longer visits, improved visitability allows

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the residents of the home to stay longer and grow older. In other words, a home with improved visitability can be adapted more easily to the new mobility needs of its occupants as a normal process of ageing. On the other hand, as it has been argued before in the literature, one of the barriers to implementing visitability may be the associated costs (Maisel, 2006; Truesdale et al., 2002).

Objective

The aim of this study is to explore and explain comprehensively whether visitability can be an economically viable solution to enable older people or those with motor disabilities to visit their loved ones. It will thus be possible to establish if the implementation of the three visitability criteria is cost-effective in a context of increased accessibility of new single-family homes in order to facilitate visits by a majority of the population.

Context of the study

Winter, in Quebec (Canada), makes home entrances the most restrictive areas for adults with motor difficulties (Morales & Rousseau, 2010). In some large urban centres, snow precipitation average is over 3m (9.84') per year (Environment Canada, 2017). These weather conditions have a direct impact on the configuration of residences along with home entrances with snow and ice. Indeed, basements in private homes are very common in Quebec. Due to the cold weather, the foundations must go below the frozen ground layer with reinforced concrete walls to resist the forces caused by frozen ground; otherwise the structure may suffer major damage during the winter period (Régie du bâtiment du Québec, 1995). Meeting these structural constraints therefore requires costly excavation operations (Morales et al., 2014). In order to limit costs, it is often preferable to stop excavation at the minimum depth below the frozen layer of earth. Although this depth varies from region to region depending on the average minimum temperatures recorded, the level of the frozen ground is lower than the average height of a person standing. For example, to create habitable basements, the level of the entire house is often raised above street level, leading to the construction of several ground-level entrances with steps (Ward et al., 2014). The presence of steps at the

entrance to homes is one of the barriers that prevent older people or those with mobility impairments from visiting their loved ones.

Methodology

The study of the economic impact of the adoption of visitability measures for new buildings was carried out using a quantitative approach based on a case study (Mazumdar & Geis 2001; Yin, 2013). A comparative cost analysis was developed in the form of a case study. In order to do this, an architectural project of a rather “representative” modern-single-family home in Quebec, whose does not a priori meet the three basic visitability criteria, was identified. The architectural project is a unit located in a townhouse residential development, the plans for which were provided by a local estate developer. Each house in the building complex has a basement, a garage, a bedroom and a bathroom. On the ground floor, there is a living room, dining room, kitchen and a powder room. Two bedrooms and a bathroom are located upstairs. The cost estimate is based on a single unit.

A cost study of the plans associated with the application of the basic and improved visitability criteria was carried out. The costs are sometimes positive (+), so the modifications increase the cost of the basic construction, or they can be negative (-), so the modifications reduce the cost of construction. For the basic visitability, modifications were made to the entrance, the interior circulation and the bathroom. To do this, the steps of the main entrance were removed, for the development of a visitable main entrance. Different options were analysed in order to identify which modifications could be made along with their associated cost (see Figures 1, 2, 4 and 5). In addition, all doors on the main floor were modified to obtain a minimum opening of 813 mm (32") (see Figures 7 and 8, element Ci-1). Also, the surface area of the bathroom was increased to obtain a turning area of 1500 mm (5') (see Figures 9 and 10, element Sb-1). Moreover, a cost evaluation of the improved visitability criteria was carried out in addition to the basic criteria (See Figures 3 and 6). Modifications based on improved visitability include, among other things, relocating the counters to allow a 1,500 mm (5') turning area in the kitchen (see Figures 12 and 13, element Cu-1), raising the height of the controls,

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electrical outlets and faucets to make them accessible to an elderly population or one with mobility difficulties (see Figure 3, element E1-9; Figure 6, element E2-7 and Figure 8, elements Ci-2 and Ci-3) and adding an accessible room on the ground floor (see Figures 14 to 16). The cost estimate includes materials and labour on an item-by-item basis. The overall estimate was quantified by a professional estimator on the basis of costs recognized in the province of Quebec (Canada) in 2016.

Results

Main entrance

As previously mentioned, the entrance is the most problematic area of the home due to the presence of steps (Morales & Rousseau, 2010). Five options were considered to make it visitable. The first two are to lower the level of the ground floor to the pavement level to eliminate the use of steps and allow an unobstructed entrance (see Figures 2 and 5). This involves eliminating the garage space in the basement (see Figure 2, elements E1-1, E1-2, E1-3 and E1-4). Parking is therefore located at garden level. The window, already present on the initial basement plans, is retained with the addition of a curbstone (see Figure 2, Element E1-5). The front and rear stairs, already present in the initial plans, are removed (see Figure 2, item E1-6). The second option involves lowering the ground floor level while retaining the garage space (see Figure 5, elements E2-1 and E2-2). As in the first option, the window is retained with the addition of a curbstone and the exterior stairs are removed (see Figure 5, elements E2-3 and E2-4 respectively). This second option makes it possible to retain most of the original elements that add value to the house.

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Figure 1

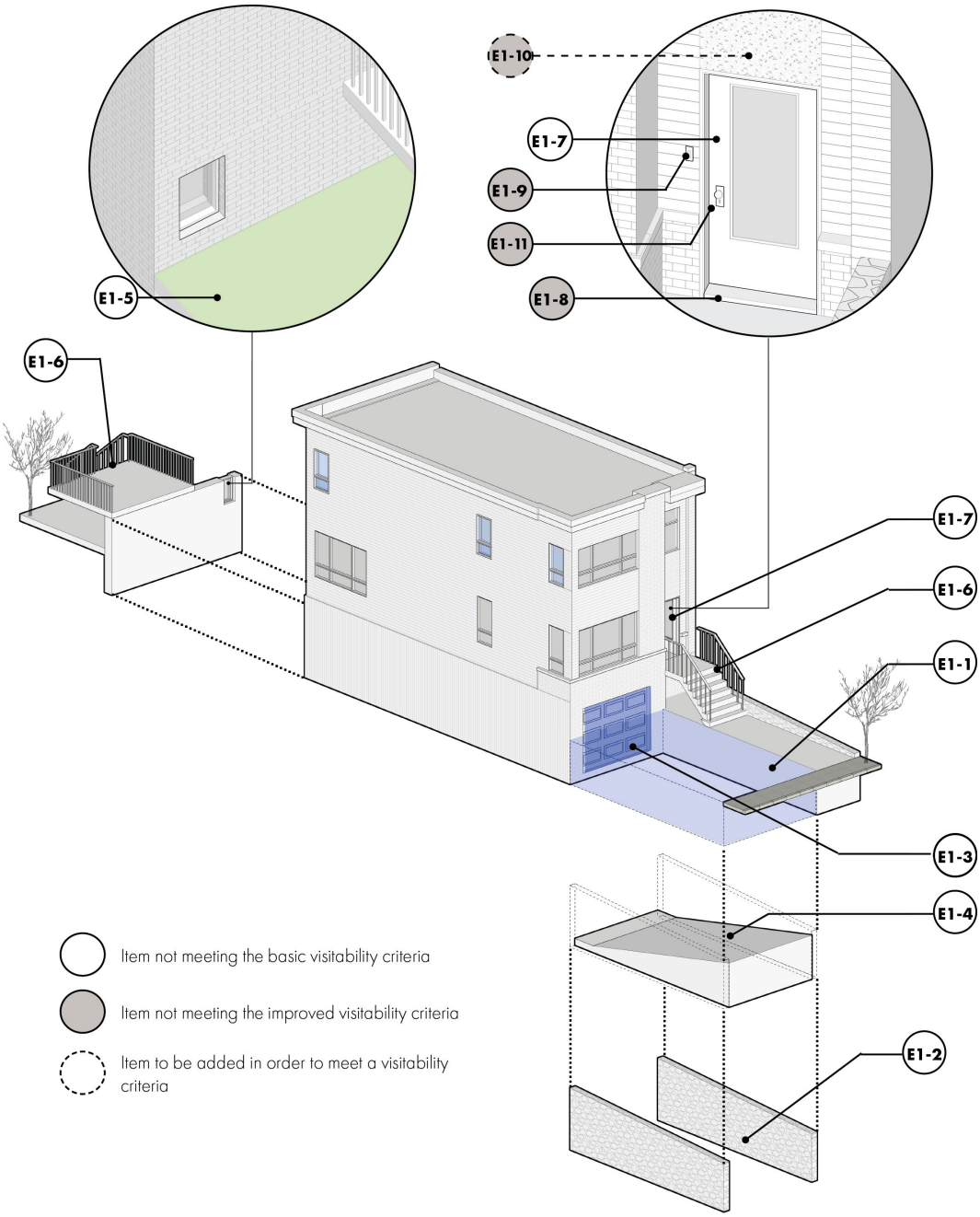

Figure 1. Entrance : Initial plan

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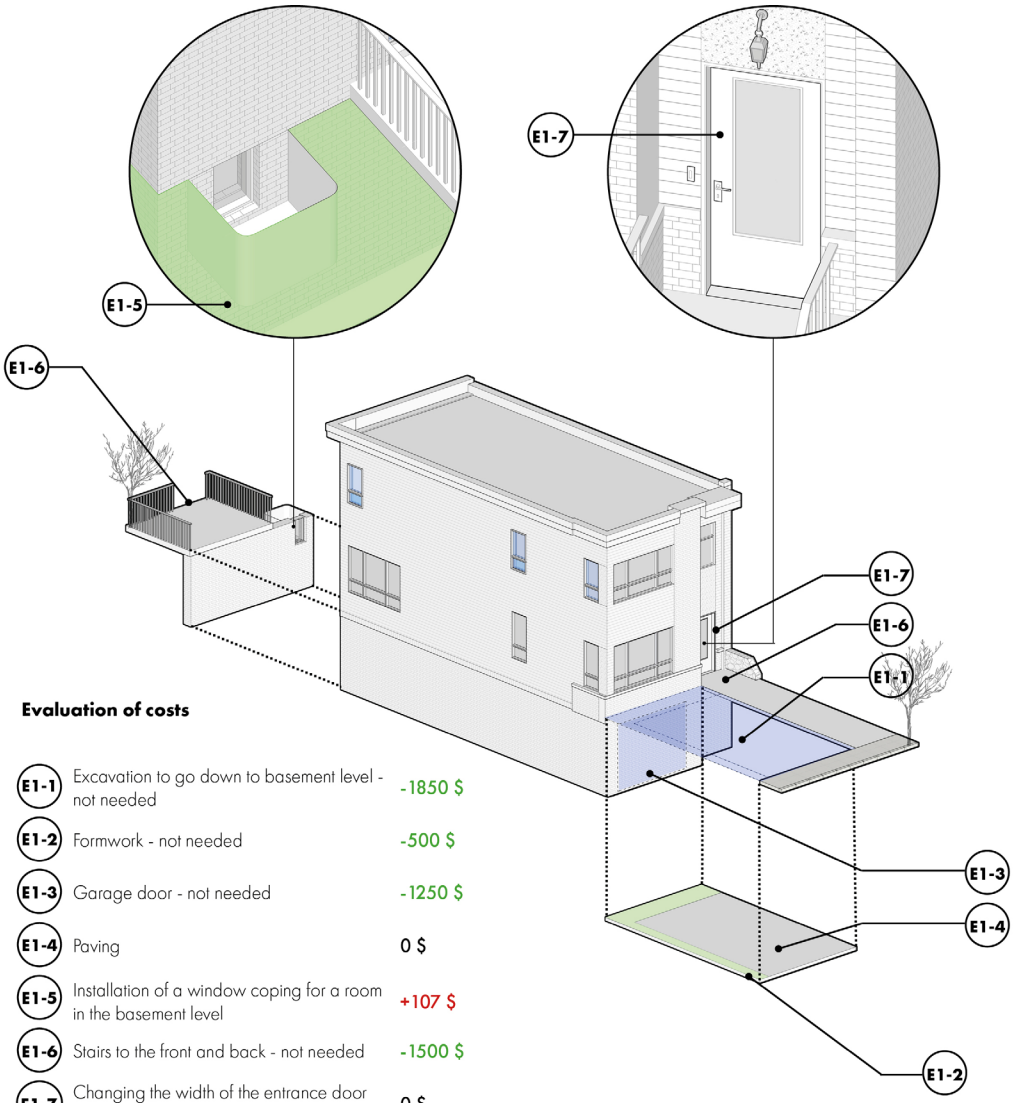
Figure 2



Evaluation of costs

E1-1	Excavation to go down to basement level - not needed	-1850 $
E1-2	Formwork - not needed	-500 $
E1-3	Garage door - not needed	-1250 $
E1-4	Paving	0 $
E1-5	Installation of a window coping for a room in the basement level	+107 $
E1-6	Stairs to the front and back - not needed	-1500 $
E1-7	Changing the width of the entrance door from 864 mm (34'') to 914 mm (36'')	0 $
	Savings	**-4993 $**

Figure 2. Modified plan according to the basic visitability criteria: Option 1

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Figure 4

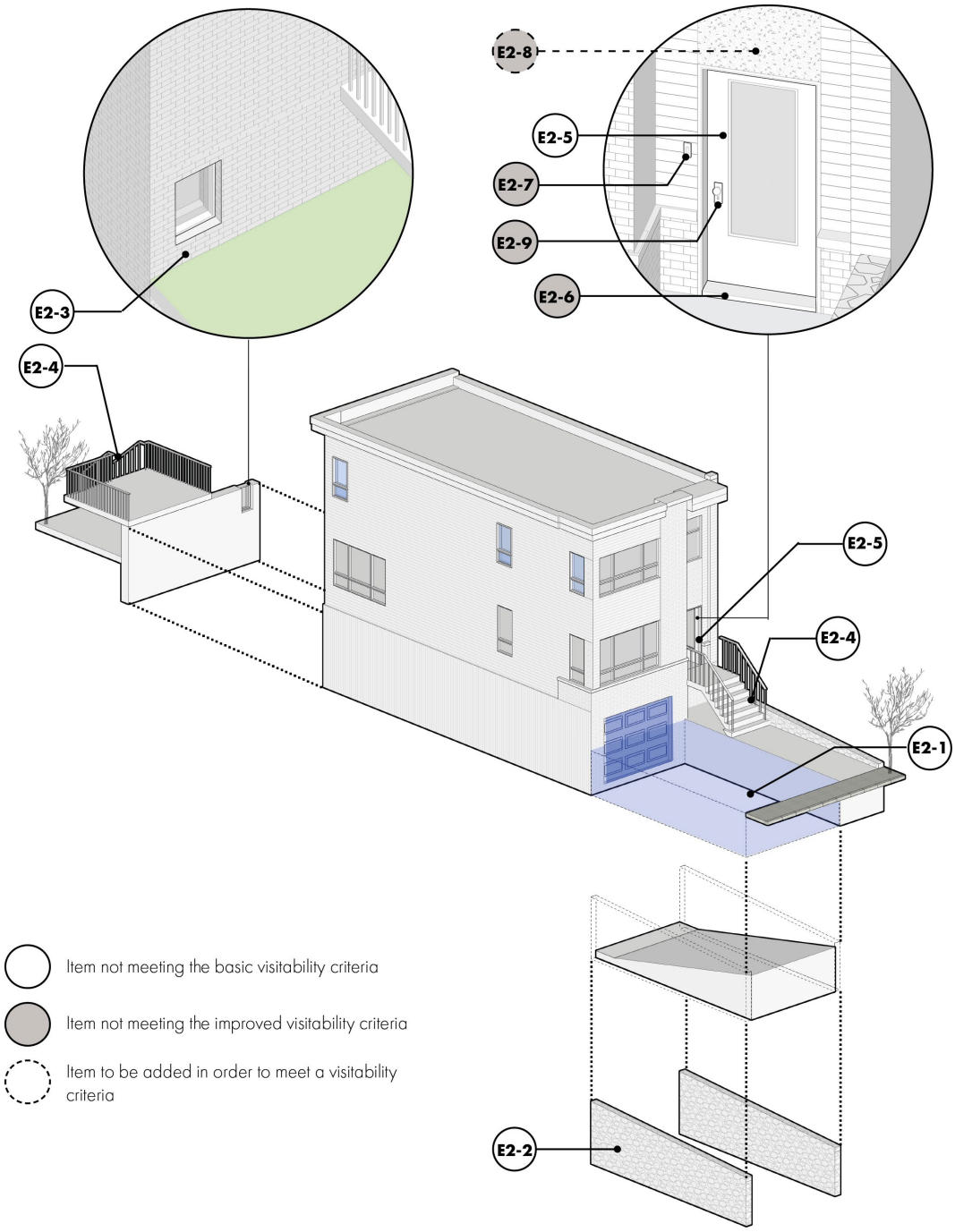

Figure 4. Entrance: initial plan

Figure 5

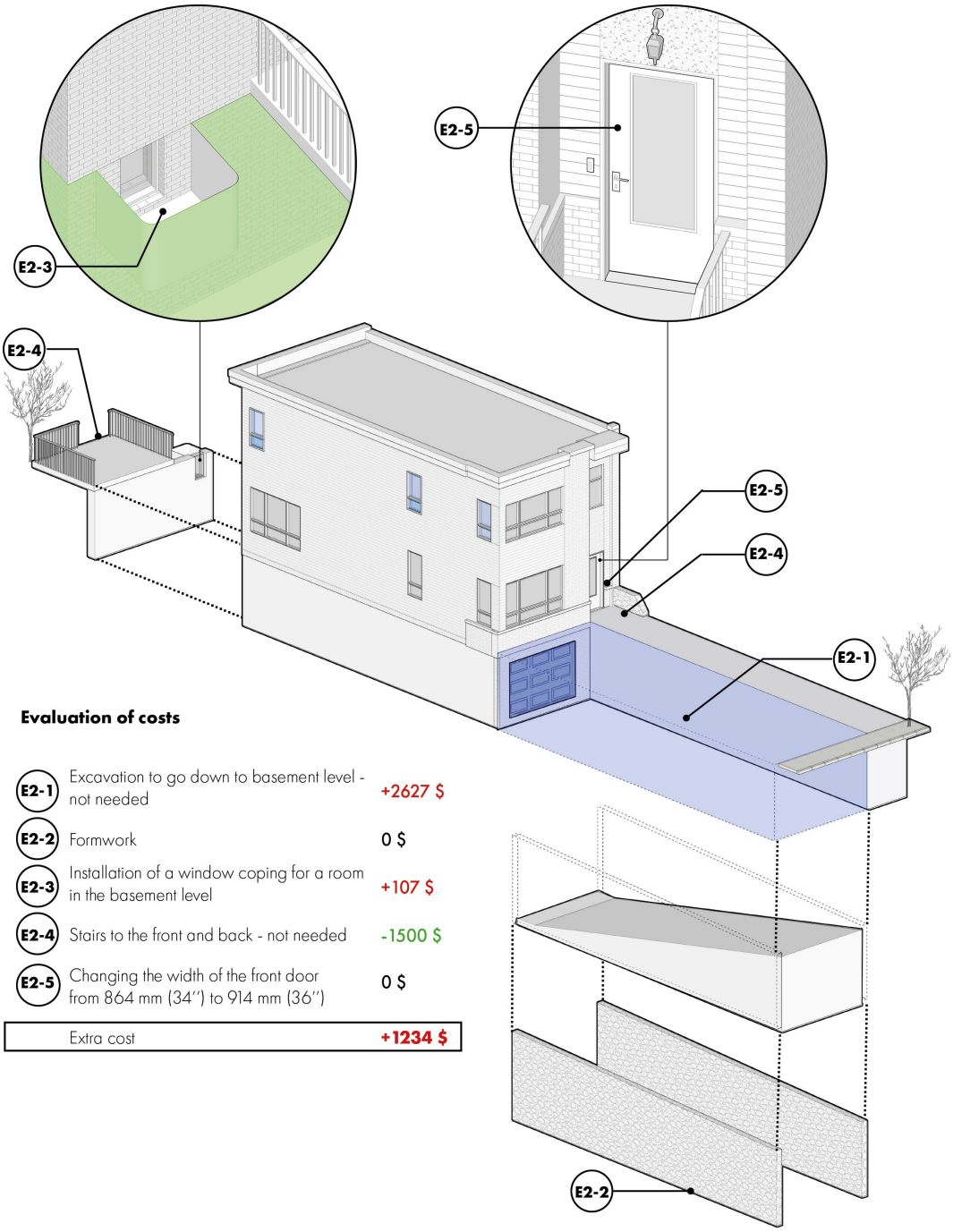

Figure 5. Modified plan according to the basic visitability criteria: Option 2

In addition, for both options, the improved visitability criteria were added such as: 1) the entrance door has been modified to be replaced by a 915 mm (36") door with no threshold (see figure 3, elements E1-7 and E1-8 as well as figure 6, elements E2-5 and E2-6), 2) the controls, such as the doorbell, have been adjusted so that they are no higher than 48" (see figure 3), The door handles have been replaced with a "lever handle" (see figure 3, element E1-

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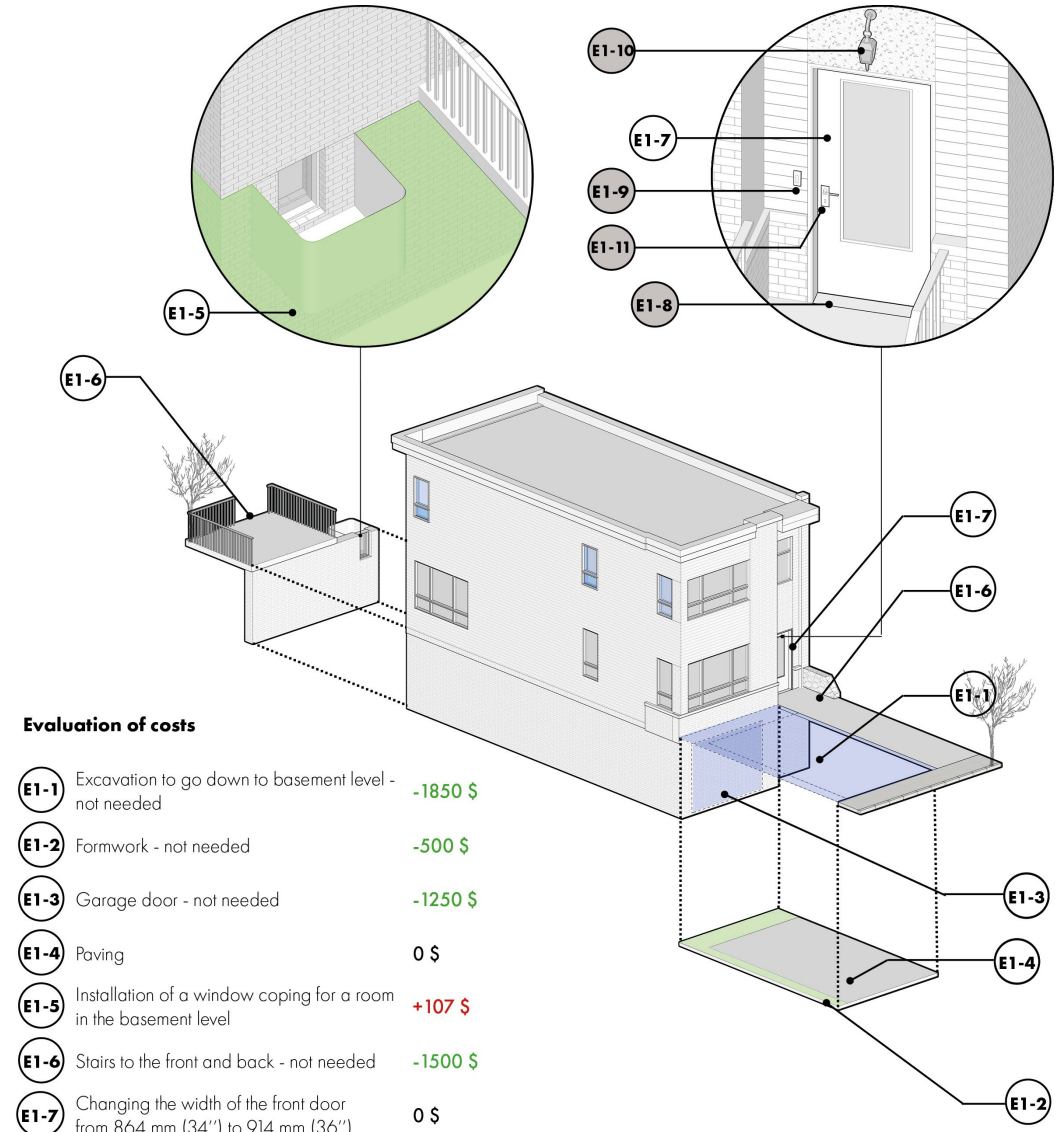
11 and figure 6, element E2-9), and 4) lighting has been added to the entrance (see figure 3, element E1-10 and figure 6, element E2-8).

Figure 3



Evaluation of costs

E1-1	Excavation to go down to basement level - not needed	-1850 $
E1-2	Formwork - not needed	-500 $
E1-3	Garage door - not needed	-1250 $
E1-4	Paving	0 $
E1-5	Installation of a window coping for a room in the basement level	+107 $
E1-6	Stairs to the front and back - not needed	-1500 $
E1-7	Changing the width of the front door from 864 mm (34") to 914 mm (36")	0 $
E1-8	Altering the door still	+115 $
E1-9	Installation of a doorbell at a maximum height of 1219 mm (48") from the floor	0 $
E1-10	Adding a light at the entrance	+1750 $
E1-11	Changing of the door handle for a lever-type door handle	+30 $
	Savings	+3098 $

Proposition 1: visitabilité améliorée

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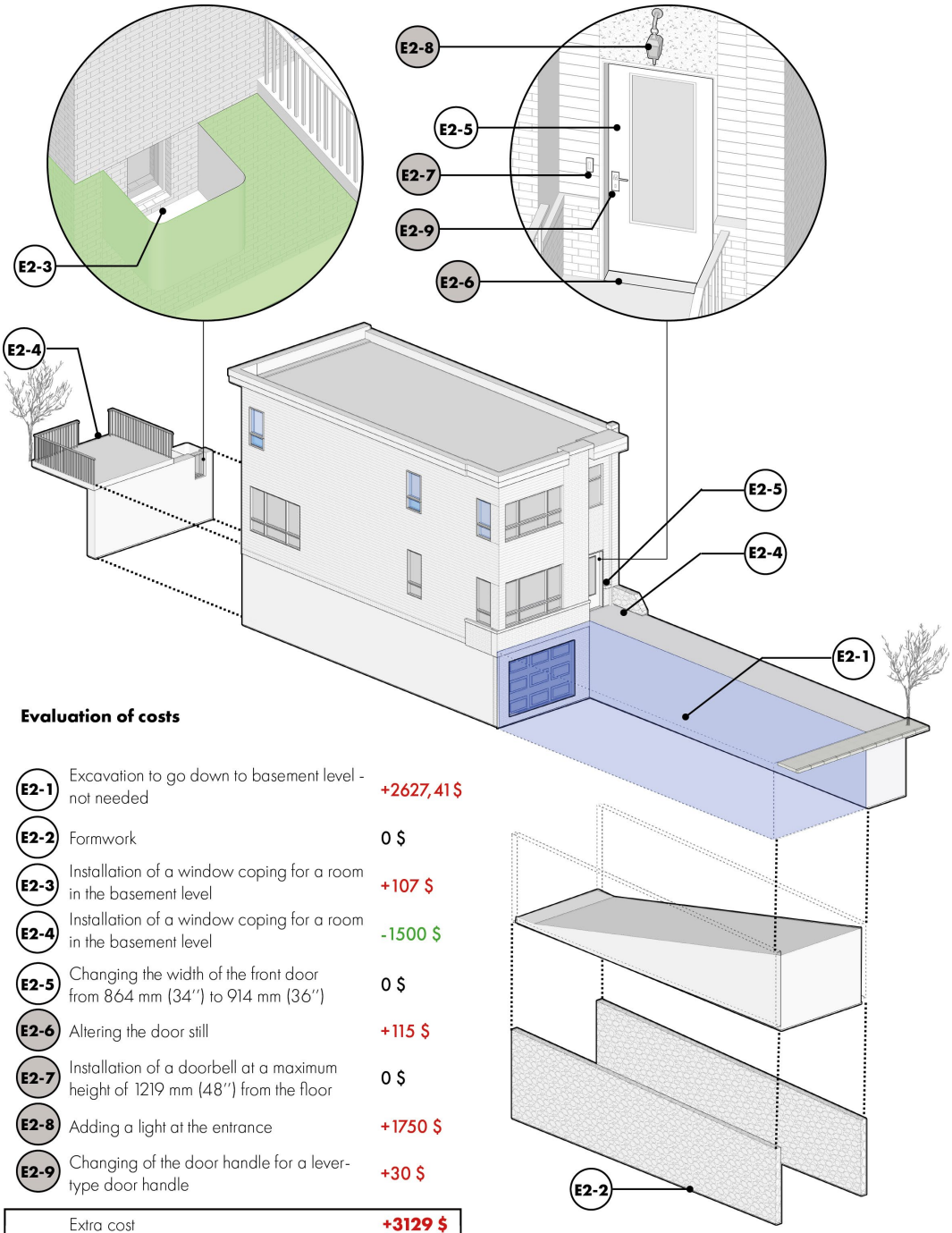
Figure 6



Evaluation of costs

E2-1	Excavation to go down to basement level - not needed	+2627,41 $
E2-2	Formwork	0 $
E2-3	Installation of a window coping for a room in the basement level	+107 $
E2-4	Installation of a window coping for a room in the basement level	-1500 $
E2-5	Changing the width of the front door from 864 mm (34") to 914 mm (36")	0 $
E2-6	Altering the door still	+115 $
E2-7	Installation of a doorbell at a maximum height of 1219 mm (48") from the floor	0 $
E2-8	Adding a light at the entrance	+1750 $
E2-9	Changing of the door handle for a lever-type door handle	+30 $
	Extra cost	**+3129 $**

Figure 6. Modified plan according to the improved visitability criteria: Option 2

For the other three options, the financial impact of adding a concrete ramp (option 3), a wooden ramp (option 4) and a lifting platform with and without shelter (option 5) should be assessed. The costs of Options 1 and 2 are therefore compared to the costs of adding a concrete and wooden ramp and a lifting platform with the plans unchanged.

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In summary, Option 1 results in a cost reduction of -$4,990 for the basic visitability and -$3,100 for the improved visitability. Option 2 results in an additional cost of +$1,230 or +$3,130 respectively for the basic and improved visitability. For the last three options: by adding a concrete ramp, the additional cost is +$6,850, for a wooden ramp, it is +$10,000, and the addition of a lifting platform at the entrance to the home was also evaluated. This would cost between +$10,000 and +$12,000 for the platform itself and would cost approximately +$3,500 more for the addition of a shelter to protect it.

Interior circulation

The interior circulation in the initial plans already includes visitable elements such as a good width of the corridors and the rooms are open-plan. In order to make the basic visitable circulation, the 762 mm (30") wide bathroom door is simply replaced by an 813 mm (32") door (see Figure 8). To make the horizontal circulation more visitable, in addition to changing the bathroom door, the electrical outlets must be installed at a minimum height of 457 mm (18") and the controls must be installed at a maximum height of 1220 mm (48") (see figure 8, elements Ci-2 and Ci-3 respectively). Also, an electrical receptacle must be added above the entrance door so that the door opening can be made automatic if necessary (see Figure 8, element Ci-4). In summary, a saving of -$5 would be possible considering the basic visitability and an additional cost of +$95 would be expected for the improved visitability.

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Figure 7

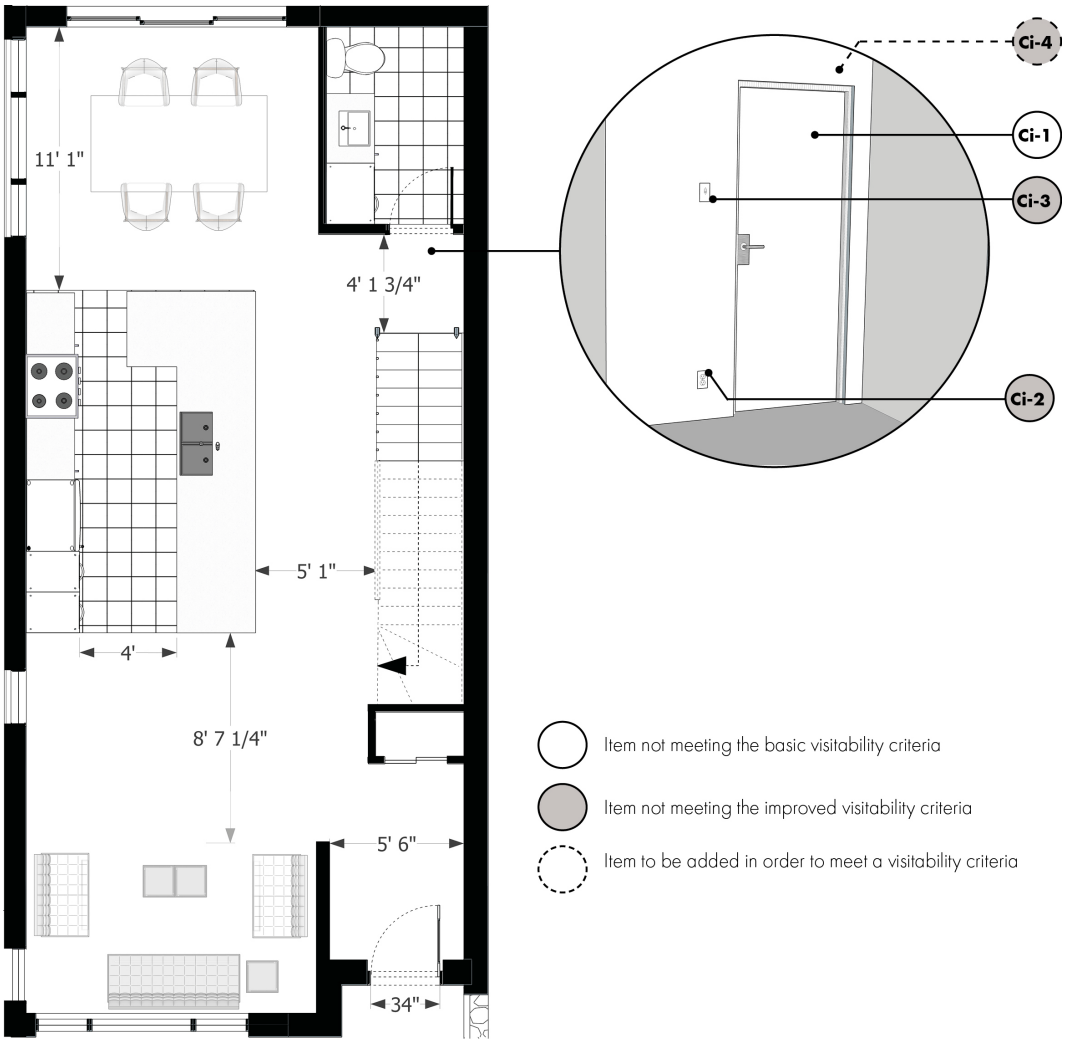

Figure 7. Interior circulation : initial plan

Figure 8

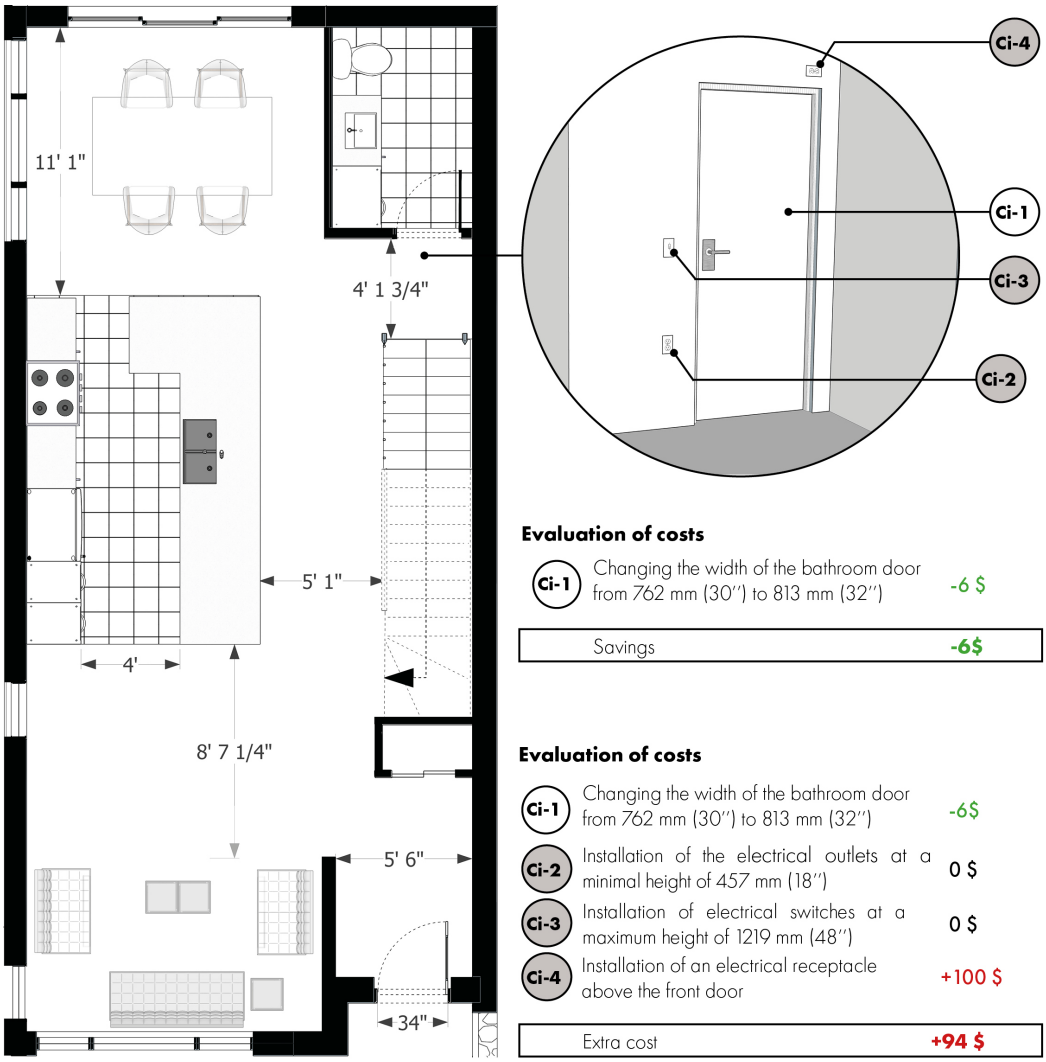

Figure 8. Modified plan according to the basic visitability criteria

Bathroom

The bathroom shown in the developer's plans only meets the criterion that the bathroom must have at least one toilet and one sink. The proposed modifications to meet the basic visitability criteria now offer a bathroom with a 1,500 mm (5') turning area in front of the toilet. To achieve this, the wall adjacent to the dining room was moved 610 mm (2') (see figure 10). This involves reducing the width of the patio door in the dining room in order to rebalance the space (see figure 10, element Sb-2). To meet the criteria for improved visitability, additional wooden plaques are added to reinforce the walls for the installation of grab bars (see Figure 11, element Sb-3). A grab

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bar is also added as well as a lever-operated valve (see Figure 11, elements Sb-4 and Sb-5 respectively). A non-slip floor covering must also be installed (see Figure 11, element Sb-6). A cost reduction of $1,450 and $1,145 would be considered based on basic visitability and improved visitability, respectively.

Figure 9

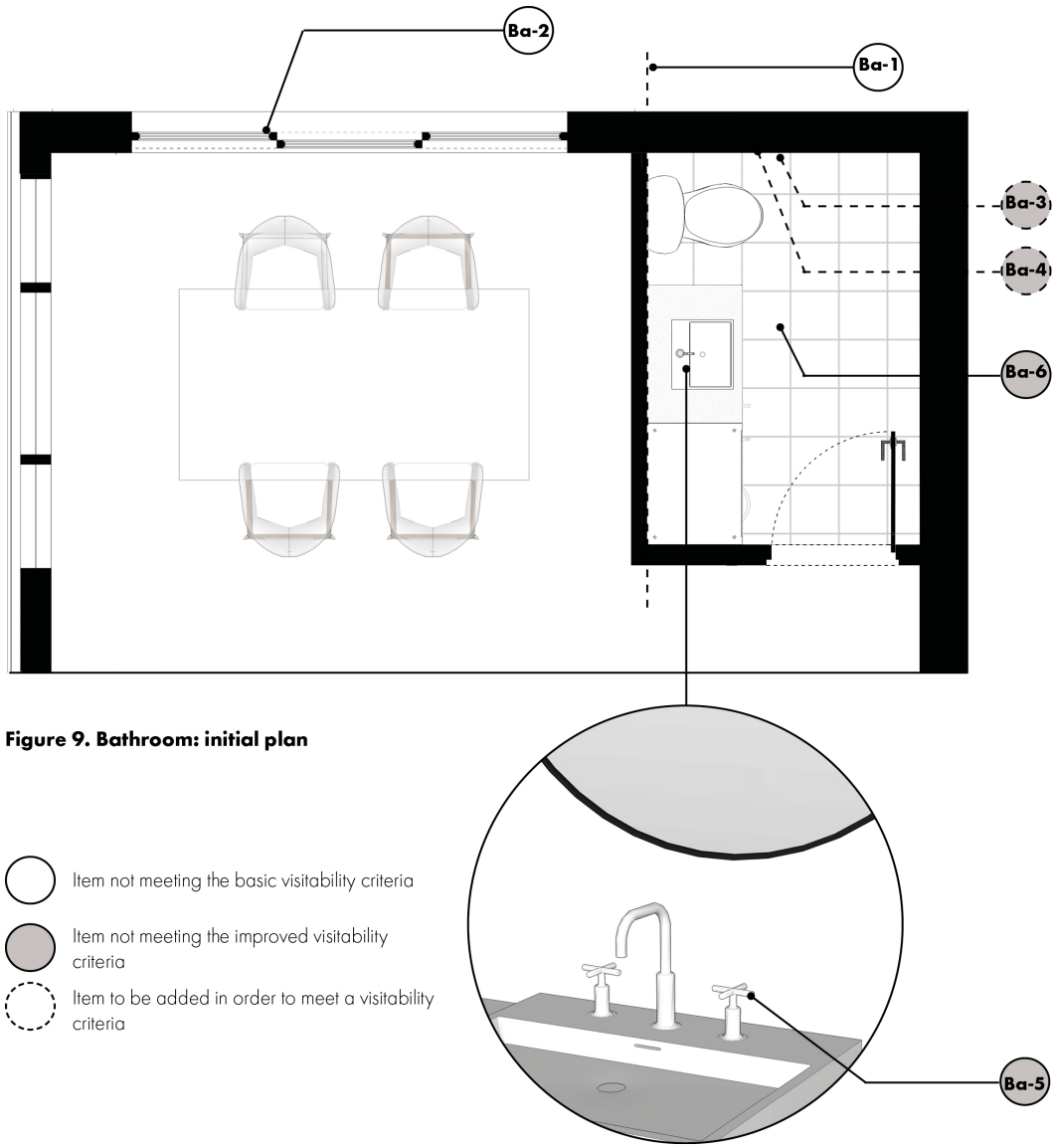

Figure 9. Bathroom: initial plan

Figure 10

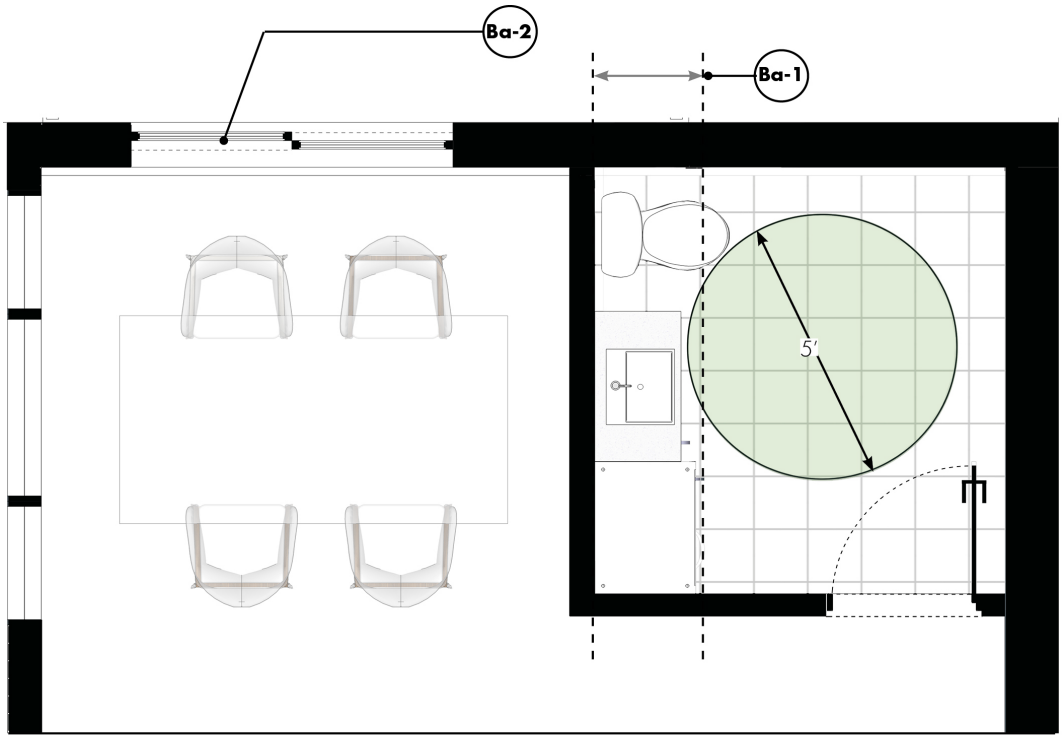

Figure 10. Modified plan according to the basic visitability criteria

Evaluation of costs

Ba-1	Expansion of the bathroom area	+50 $
Ba-2	Reduction of the width of the patio door from triple to double panes	-1500 $
	Savings	**-1450 $**

Figure 11

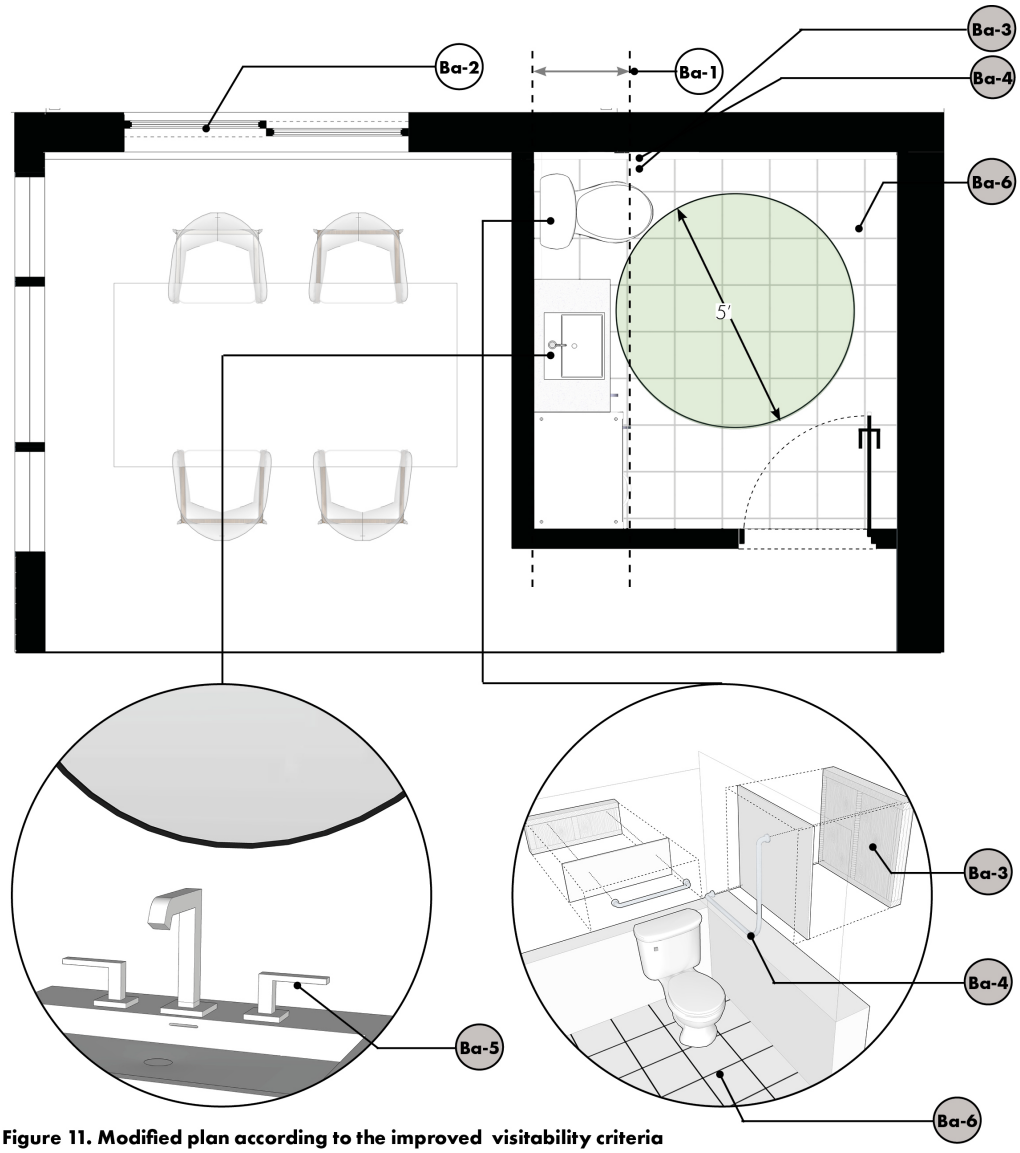

Figure 11. Modified plan according to the improved visitability criteria

Evaluation of costs

Ba-1	Expansion of the bathroom area	+50 $	Ba-4	Addition of grab bars	+55 $
Ba-2	Reduction of the width of the patio door from triple to double panes	-1500 $	Ba-5	Installation of lever-type taps	0$
Ba-3	Addition of solid batten panels	+250 $	Ba-6	Installation of non-slip floor covering	0$
				Savings	-1145$

Kitchen

The kitchen presented in the developer's plans offers adequate circulation thanks to its lab-type configuration. Since there are no basic visitability criteria for the kitchen, the modifications made to the plan are based on the enhanced visitability criteria. The space between the two counters is

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therefore widened by 305 mm (1') by relocating the island, allowing for an adequate turning area of 1,500 mm (5'). The cost of relocating the island and installing a lever-type faucet is not significant (see Figure 13).

Figure 12

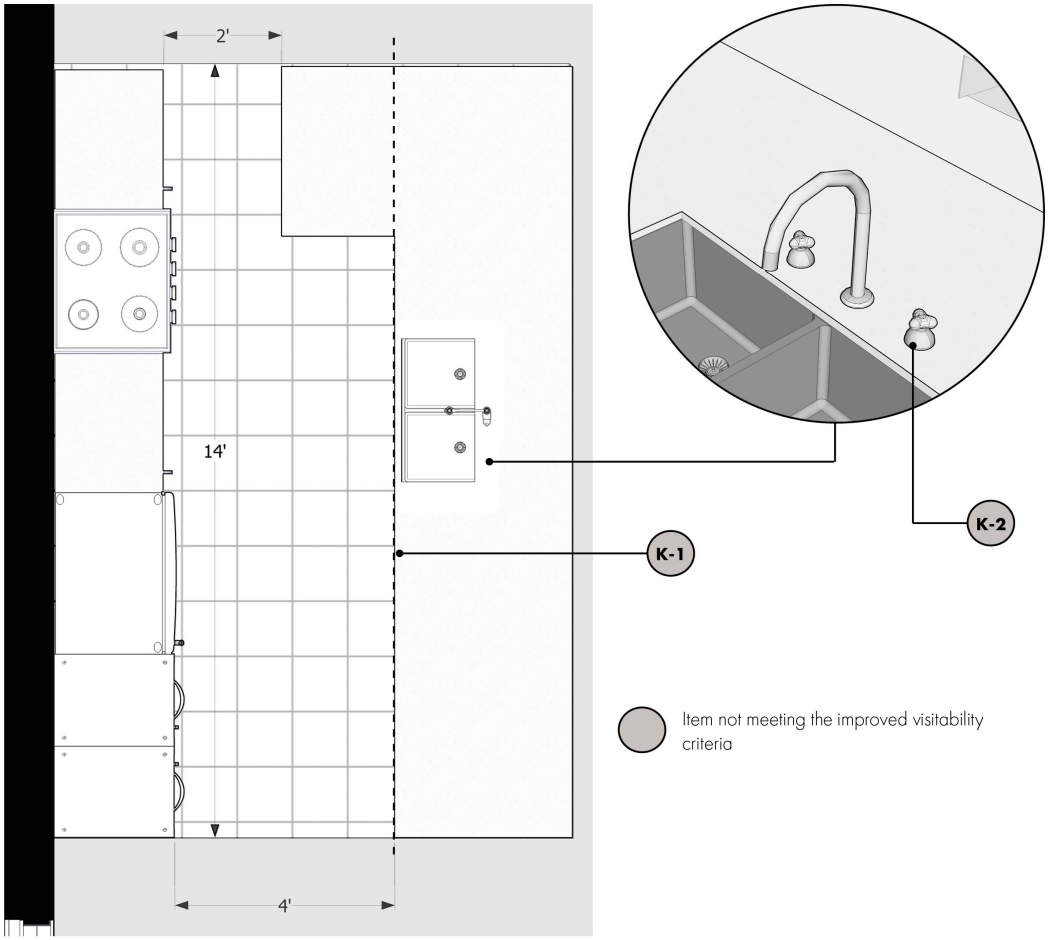


Figure 12. Kitchen: initial plan

Figure 13

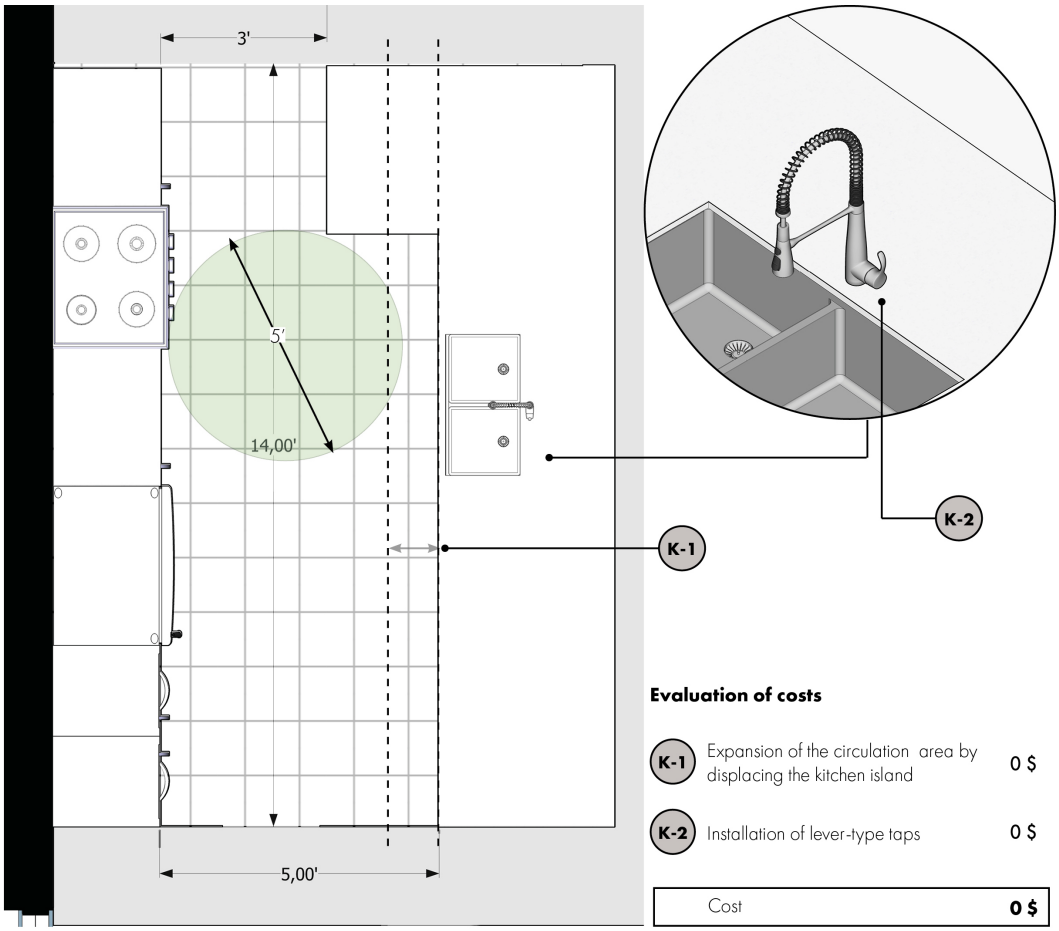


Figure 13. Modified plan according to the improved visitability criteria

Bedroom

The basic visitability criteria do not apply to the bedroom. However, in order to take the criteria for improved visitability further, a bedroom has been added on the ground floor. Since space is limited in its current configuration, it is suggested to increase the main floor area in order to include the bedroom. The bedroom was added at the back of the house next to the bathroom (see Figures 15 and 16). It measures 3,050 mm by 3,960 mm (10'x13') and can accommodate a double bed and small furniture. In order to incorporate it into the house, the patio space is reduced and the patio door is moved. The economic impact of a room that rests on additional space in the basement (see Figure 15) or is erected on piles (see Figure 16) is +$15,590.

Figure 14

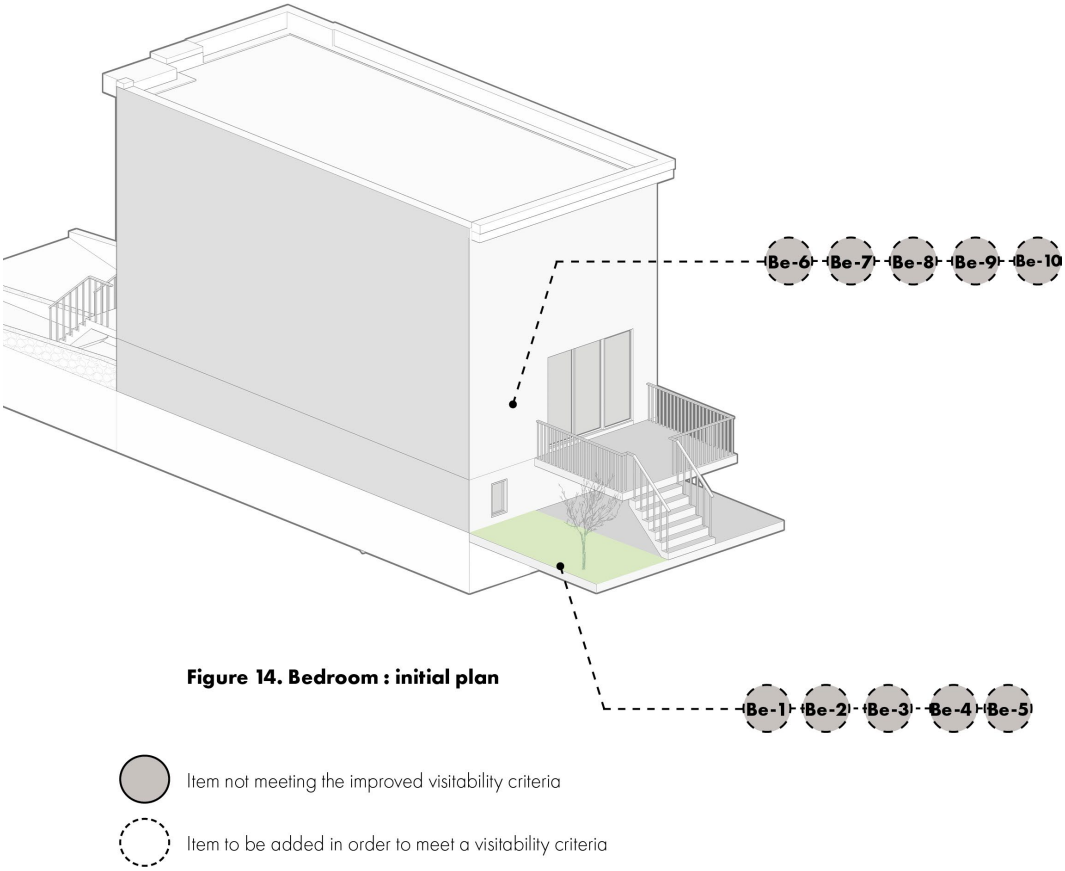
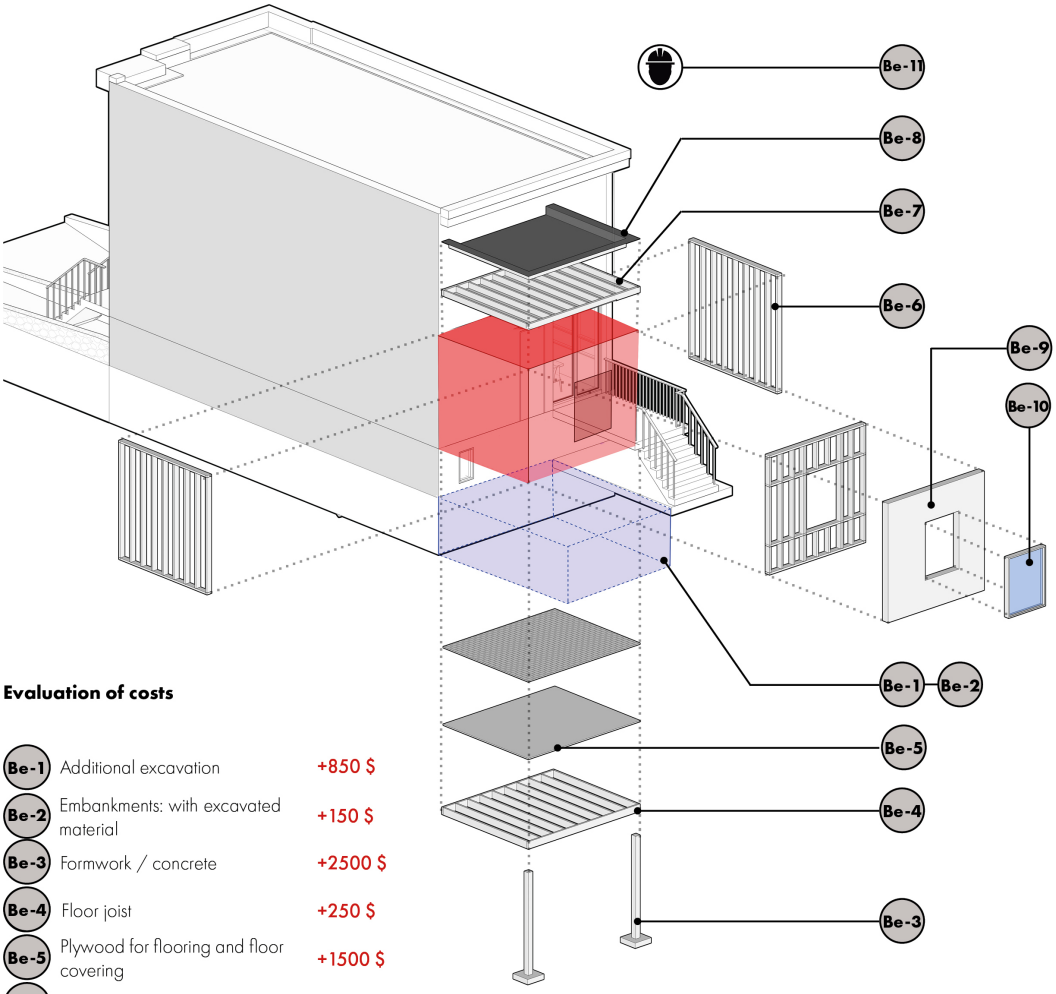


Figure 14. Bedroom : initial plan

Figure 15

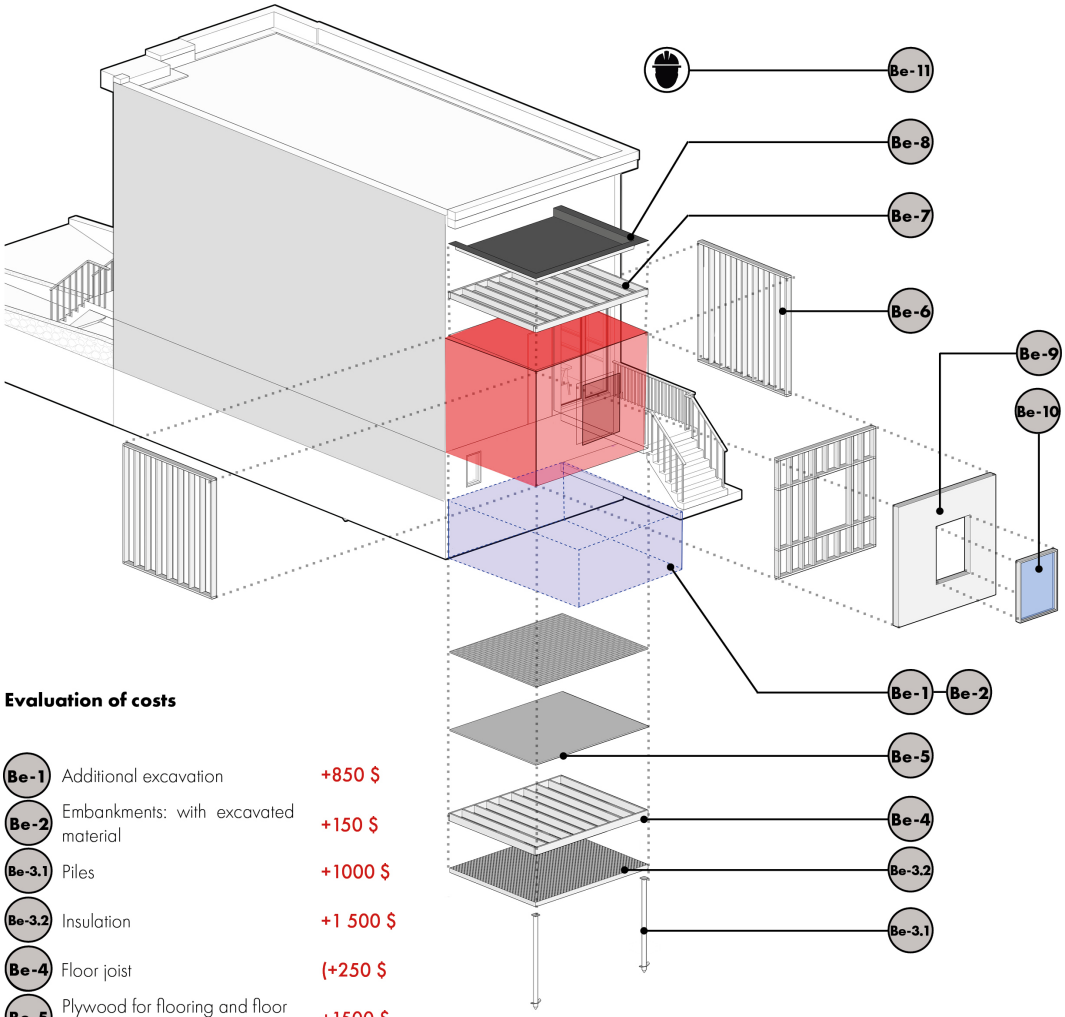


Evaluation of costs

Be-1	Additional excavation	+850 $
Be-2	Embankments: with excavated material	+150 $
Be-3	Formwork / concrete	+2500 $
Be-4	Floor joist	+250 $
Be-5	Plywood for flooring and floor covering	+1500 $
Be-6	Wall	+2000 $
Be-7	Roof	+1200 $
Be-8	Roof shingle	+500 $
Be-9	Siding	+2640 $
Be-10	Window	+500 $
Be-11	Additional labor	+3500 $
	Extra cost	**+15 590 $**

Figure 15. Modified plan according to the improved visitability criteria: Option 1

Figure 16



Evaluation of costs

Be-1	Additional excavation	+850 $
Be-2	Embankments: with excavated material	+150 $
Be-3.1	Piles	+1000 $
Be-3.2	Insulation	+1 500 $
Be-4	Floor joist	(+250 $
Be-5	Plywood for flooring and floor covering	+1500 $
Be-6	Wall	+2000 $
Be-7	Roof	+1200 $
Be-8	Roof shingle	+500 $
Be-9	Siding	+2640 $
Be-10	Window	+500 $
Be-11	Additional labor	+3500 $
	Extra cost	**+15 590 $**

Figure 16. Modified plan according to the improved visitability criteria: Option 2

Discussion

Among the visitability criteria, the modifications that increased the cost of construction are related to the installation of a barrier-free entrance and the additional bedroom on the ground floor, while the modifications made to the interior of the house, such as horizontal circulation, bathroom and kitchen,

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the extra costs (or savings generated) are negligible compared to the cost of the house.

Moreover, installing a ramp or a lifting platform in the homes of seniors or those with mobility impairments, these solutions do not allow them to access the homes of their loved ones. Indeed, these accessibility solutions generate construction or installation costs, are less aesthetic and have a negative connotation by focusing attention on motor difficulties. Moreover, unlike a step-free entrance, an access ramp or a lifting platform diminishes the value of a home for a buyer who does not suffer from a motor impairment.

Lowering the level of the ground floor of the home to allow the main and rear entrances without steps had the effect of reducing access to natural light from the living space in the basement. The basement windows that were placed above the garden level have access to natural light, after the plans were modified, only through a curbstone. The reduction in natural light is also noted in the dining room, where the width of the patio door and the patio had to be reduced to make way for a bedroom on the ground floor, in the case of improved visitability.

The changes to the interior configuration of the ground floor of the home bring improvements without incurring costs. This is particularly the case for the bathroom and the kitchen. As a result of the application of visitability criteria, these rooms have become more spacious and even more user-friendly, since they allow for easier circulation even in wheelchairs. In addition to providing added value, modifying the bathroom, kitchen and horizontal circulation generated a credit of $1,455 for the basic visitability criteria, and a credit of $1,050 for the improved visitability. It remains to be specified that these gains depend on the choice of materials. Within the framework of this study, the materials provided for in the initial plan were replaced by equivalent non-slip materials in terms of cost.

The modification of the plans did not only have a positive impact on the configuration of the single-family home. Indeed, in order to widen certain spaces and allow adequate turning radii, others had to be narrowed. This is precisely the case of the dining room and the corridor adjacent to the bathroom and kitchen respectively. The addition of the bedroom on the

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ground floor had a similar effect by reducing the luminosity of the bathroom and even the dining room due to the width of the patio and patio door, which had to be narrowed. However, providing a room is intended to accommodate visitors who stay for more than one night, but this remains the element that generated the most extra costs, +$15,590. Since visitability is a first step towards universal accessibility since it reduces the burden of work to be undertaken when needed, this visitable home therefore offers significant gains for ageing or future occupants in terms of accessibility.

Indeed, one of the main barriers in the home environment is the presence of stairs, which is a dangerous place as people age and a predominant barrier for people with mobility impairments (Canadian Centre on Disability Studies, 2013; Stark, 2001). The entrance must therefore generally be adapted first, followed by the bathroom (Johnson & Chen, 2009), being two rooms that are modified with visitability criteria. In addition, by adding the improved visitability criteria, certain elements such as installing a grab bar in the bathroom limit the costs for environmental adaptations since they are already present, along with the main spaces on the same floor to limit the use of stairs.

Adopting these criteria at the design stage of a house suggests better integration of design elements and reduces costs associated with future renovations, mainly because some of the basic features of accessibility are already in place. It could also be said, without being too bold, that visitability features in a house might reduce the risk of step-induced injuries, increase opportunities for interaction with others and contribute to a vibrant community (Maisel, 2006).

Step-induced injuries are particularly important in places such as Canada where winter conditions can be a major accessibility problem (Morales, 2014). For example, fall-related injuries due to ice or snow have been estimated to cost $ 2.8 billion a year to the Canadian healthcare system (Miller et al., 2009). Unfortunately, this situation goes hand by hand with social isolation as individuals with motor disabilities and seniors might prefer to stay home rather than go out, because of the accessibility challenges and slippery surfaces, which will certainly be encountered (Morales, 2014). Social isolation, in turn, has been associated with other negative consequences such as depression (Gutzmann, 2000; Silveira & Allebeck, 2001) and even suicide (Conwell, 1997).

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Considering that the need for accessibility is all the more pressing since 90% of new single-family homes will have to accommodate an inhabitant or visitor with reduced mobility during their lifetime (Smith et al., 2008; Smith, Rayer, Smith, Wang & Zeng, 2012), the implementation of a program requiring the three basic visitability criteria for new constructions would therefore be beneficial for both the population and the government without generating additional costs. In the same vein, Concrete Change (2012), an international network promoting visitability, suggests that providing basic access to a house can cost between $10 and $260, when considered and integrated at the beginning of the project. The present study is therefore in line with the conclusions of Concrete Change (2012): indeed, depending on the design option chosen, modifications allowing for visitability can even lead to a reduction in costs. These results also support those obtained by PARA et al. (2007). Finally, another observation is that certain modifications to the plans do not generate any costs, such as the modification of the height of controls and electrical outlets and should be considered in new constructions in order to be accessible to the entire population.

Given that few studies have focused on the economic analysis of the application of visitability criteria, this is innovative work. Only some elements of discussion could be supported by the literature, but this shows that further research could validate the results obtained.

Conclusion

In view of the results obtained, if visitability criteria were adopted during the design phase, a visitable (basic) home with a step-less entrance does not seem to cost more to build. In fact, the marginal costs are zero or negligible. Option 1 allows a credit of -$4,990 and -$3,100 for basic and enhanced visitability respectively. However, this was done at the expense of the garage space, which is a major addition to the home. Option 2, which provides for keeping the garage space in the basement, generated additional costs of +$1,230 and +$3,130 for basic and improved visitability respectively, in addition to the need to extend the access ramp to the underground parking lot to respect a maximum slope of 15% (which would be required by Quebec City, for

example). Although these two options entail costs, they are less expensive than the construction of access ramps or the installation of a lifting platform (most expensive option, with costs ranging from +$10,000 to +$15,000).

There are many limitations of this study. For example, as the evaluation presented is a case study, it remains important to note that the results presented here cannot be generalised to any construction. Since the changes are made after the plans have been designed, the magnitude of the marginal costs depends greatly on the nature of the building and the changes made to it. Since the visitability criteria considered for this study were taken from PARA (PARA et al., 2007), it should be noted that the criterion of a path accessible from the pavement to the entrance door, which is one of the basic visitability criteria, was omitted from this study.

Moreover, this study focused on the economic aspect of visitability, so the point of view of older people or people with motor disabilities was not taken into account.

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