

Accessibility Evaluation Of Five Moroccan E-government Portals

Mohammed Rida Ouaziz^{1,*†}, Laila Cheikhi^{1†}, Ali Idri^{1†} and Alain Abran^{2†}

¹Software Project Management Team, ENSIAS, Mohammed V University in Rabat, Morocco

²Department of Software Engineering Information Technology, École de Technologie Supérieure, Montréal, Canada

Abstract

In the present era, e-government portals are viewed as an effective means of providing online services to citizens. It is imperative for everyone to guarantee equitable access to these services, irrespective of their abilities or limitations. Hence, accessibility is vital for those with disabilities and advantageous for everyone. Web Content Accessibility Guidelines (WCAG) provide a comprehensive set of guidelines, in terms of success criteria, that are widely utilized in various tools to assess the accessibility of websites or portals. By following these guidelines, developers can ensure that their websites are accessible to everyone. This paper reports on a study of the accessibility evaluation of five Moroccan e-government portals using the AChecker tool with respect to WCAG. The aim was to prepare recommendations to improve the overall user experience across Moroccan e-government portals. The evaluation results analysis showed that the portals have some common as well as different failed success criteria with different numbers of errors per WCAG principle and conformance level. In particular, all the portals exhibited varying degrees of adherence to the four principles, and most of the portals struggled to meet levels A and AA, and none of them achieve perfect conformance across all levels. To address this issue, a set of recommendations is provided for each portal to enhance accessibility. The lessons learned from this study can contribute to more inclusive e-government portals and provide insights for governments and designers to prioritize accessibility enhancements.

Keywords

Accessibility, e-government portals, evaluation tools, WCAG, disabilities, impairments

1. Introduction

Accessibility encompasses the design of products, services, environments, and digital content to accommodate the diverse needs and abilities of people [1]. In the context of the web, high accessibility ensures that digital content and features can be perceived, understood, navigated, and interacted with by everyone; therefore, no one is excluded from using the web effectively [2]. E-government portals are becoming increasingly crucial in today's digital era, transforming government engagement with citizens by providing efficient, transparent, and accountable platforms. They offer a wide range of services such as applying for permits, paying taxes, and accessing government documents. The 24/7 availability of these portals eliminates the need for physical visits, saving time and resources for both governments and citizens.

Accessibility in the e-government portals takes on significant importance as it should ensure equal access to government services and information for all individuals, regardless of their abilities or disabilities. Therefore developers should design and build inclusive e-government websites in order to ensure that individuals with various abilities, backgrounds, and requirements can actively participate in and derive full benefits from the information, services, and features offered by their digital platforms [3]. E-government portals with high accessibility have the capacity to narrow the digital divide and foster inclusivity within society by removing obstacles that could impede individuals with disabilities from accessing and utilizing online services. Indeed, accessibility in e-government portals should enable persons with permanent disabilities (or impairments) such as auditory, cognitive, learning, neurological,

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*Corresponding author.

†These authors contributed equally.

✉ mohammedrida_ouaziz@um5.ac.ma (M. R. Ouaziz); laila.cheikhi@um5.ac.ma (L. Cheikhi); ali.idri1@um5.ac.ma (A. Idri1); alain.abran@etsmtl.ca (A. Abran)



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speech, visual, and physical disabilities, to fully access online services [4], as well as persons with temporary impairments, situational limitations, and an aging population [5].

By incorporating accessible design principles and adhering to established guidelines provided by the Web Content Accessibility Guidelines (WCAG) standard [6], governments can guarantee online access to all people for online information and services and can benefit from the advantages of digital governance.

In this context, the accessibility evaluation of e-government portals is mainly performed using WCAG-based tools, which provide a quick and easy way to test a large number of websites for accessibility conformance [7]. This evaluation is essential to detect and address accessibility barriers, ensure that the portals are user-friendly for people with disabilities, and highlight potential improvements. Many accessibility evaluation tools have been developed (e.g., AChecker¹, WAVE², CynthiaSays³) and used for accessibility evaluations in the literature:

- Study [8] evaluated six home pages of Saudi Arabian universities using SiteImprove and WAVE. The evaluation showed that the homepage of Taibah University was more accessible than the other universities' home pages. Results also showed that SiteImprove outperformed WAVE in detecting web accessibility issues.
- Study [9] evaluated Croatia's most visited desktop and mobile websites using AChecker tool. The study found that only two of the 14 analyzed Croatian news portals have fully accessible designs. It also highlighted the impact of different web browsers which may affect accessibility.
- Study [10] evaluated Pakistan's central government websites, including all ministries and divisions, using Total Validator and Functional Accessibility Evaluator tools. The findings revealed that most websites were not developed according to the WCAG standards, making it difficult or impossible for visually disabled persons to access government information.
- Study [11] evaluated the accessibility of three Moroccan e-government websites using the AccessiWeb tool. The results indicated the presence of several accessibility issues across all three websites, affecting the three WCAG levels (A, AA, and AAA) criteria. The findings showed that none of the websites met the minimum level of accessibility, necessitating corrections to next levels issues to improve web content's perceivability, operability, understandability, and robustness for users with disabilities.
- Study [12] evaluated the impact of mobile learning on the inclusion of students with disabilities at Mohamed V University in Rabat. The findings showed that mobile learning significantly enhanced educational inclusion, motivation, and potential realization for students with disabilities. The study highlighted the crucial value of mobile devices in promoting accessible and inclusive education, suggesting the need for a thorough analysis of their contributions to students with reduced mobility.
- Study [13] investigated the potential of using smartphones and tablets as alternative learning tools for assistive technology (AT) devices in under-developed and developing countries like Morocco. They compared seven free Google Play medical apps with seven traditional AT devices in terms of functionality and affordability. The findings suggested that mobile learning through these devices can provide accessible and cost-effective solutions for students with disabilities, addressing issues such as hearing and visual impairments, autism, and speech articulation disorders.

Furthermore, a 2021 review study on digital accessibility [14] reported that few studies were performed by Moroccan researchers in this context, in particular about e-government [11] and education [12], [13]. This motivated us to focus in this study on e-government Moroccan portals, a context in which accessibility evaluation is scarce.

This study reports on an evaluation study of five Moroccan portals using the AChecker accessibility tool and analyzes the results according to a set of criteria related to WCAG principles, conformance

¹<https://achecks.org/AChecker/>

²<https://wave.webaim.org/>

³<https://www.tpgi.com/cynthiasays-com-accessibility-website-scan-announcement/>



Figure 1: Summary of WCAG 2.0

levels, accessibility problems, as well as hypertext markup language (HTML), and cascading style sheet (CSS) validation. The aim was to prepare recommendations to improve the overall user experience across Moroccan e-government platforms. The contribution of this study is insights into the accessibility status of the evaluated e-government portals, facilitating the identification of areas for enhancement and ensuring a more inclusive online environment for all users.

The subsequent sections of this paper are organized as follows: Section 2 offers an overview of the WCAG, and Section 3 introduces the AChecker accessibility tool. The methodology and results of this study are outlined in Sections 4 and 5, respectively. Section 6 encompasses the discussion, recommendations, and limitations, followed by the conclusions in section 7.

2. WCAG: An Overview

The Web Content Accessibility Guidelines (WCAG) established by the World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI) are a set of technical standards designed to ensure the accessibility of web content to people with disabilities [6].

WCAG content has evolved over the years; the first version (WCAG 1.0) was launched in 1999, followed by WCAG 2.0 in 2008, WCAG 2.1, and WCAG 2.2 in 2018 and 2022, respectively. Each version has undergone enhancements, striving to address a wide range of accessibility challenges for disabled individuals. These guidelines recognize the changing nature of accessibility needs, aiming not only to cater to specific disabilities, but also to enhance overall accessibility for users across different devices. The WCAG 2.0 version, approved as an International Organization for Standardization (ISO) 40500 standard [15], was used to evaluate the accessibility of some Moroccan e-government portals. This guideline comprises four principles, 12 guidelines, and 61 success criteria classified into three conformance levels [6], as described in the following paragraphs (see Figures 1 and 2 for a summarized and detailed view of this guideline).

The WCAG 2.0 guidelines aim to enhance the accessibility of content to users with diverse disabilities [6]. Each guideline includes a set of success criteria (SC) for specific objectives that the portal should satisfy. These criteria are formulated as statements that can be evaluated as true or false when testing specific web content [16].

Furthermore, an SC can be assessed into three conformance levels depending on the extent to which accessibility guidelines are met (see Figure 2). These levels are useful to developers when designing and building portals [10].

- Level A refers to the guidelines that the website must adhere to ensure that all information is accessible to users, including those with disabilities.
- Level AA refers to the guidelines that the website should follow to address significant accessibility barriers and enhance the accessibility of information on a website.

	Perceivable Information must be perceived by users.	Operable Interface must be operated by users.	Understandable Information and interface must be understood by users.	Robust Content can be interpreted reliably by user agents, including assistive technologies.
Guidelines	1.1 Text Alternatives 1.2 Time-based Media 1.3 Adaptable 1.4 Distinguishable	2.1 Keyboard Accessible 2.2 Enough Time 2.3 Seizures 2.4 Navigable	3.1 Readable 3.2 Predictable 3.3 Input Assistance	4.1 Compatible
Level A	1.1.1 Non-text Content 1.2.1 Audio and Video-only 1.2.2 Captions (prerecorded) 1.2.3 Audio description 1.3.1 Info and Relationships 1.3.2 Meaningful sequence 1.3.3 Sensory Characteristics 1.4.1 Use of color 1.4.2 Audio Control	2.1.1 Keyboard 2.1.2 No Keyboard Trap 2.2.1 Timing Adjustable 2.2.2 Pause, Stop, Hide 2.3.1 Three Flashes or Below Threshold 2.4.1 Bypass Blocks 2.4.2 Page Titled 2.4.3 Focus Order 2.4.4 Link purpose (In Context)	3.1.1 Language of Page 3.2.1 On Focus 3.2.2 On Input 3.3.1 Error Identification 3.3.2 Labels or instructions	4.1.1 Parsing 4.1.2 Name, Role, Value
Level AA	1.2.4 Captions (Live) 1.2.5 Audio Description 1.4.3 Contrast (Minimum) 1.4.4 Resize text 1.4.5 Images of Text	2.4.5 Multiple Ways 2.4.6 Headings and Labels 2.4.7 Focus Visible	3.1.2 Language of Parts 3.2.3 Consistent Navigation 3.2.4 Consistent Identification 3.3.3 Error Suggestion 3.3.4 Error Prevention (Legal, Financial, Data)	
Level AAA	1.2.6 Sign Language (prerecorded) 1.2.7 Extended Audio Description 1.2.8 Media Alternative 1.2.9 Audio-only (Live) 1.4.6 Contrast (Enhanced) 1.4.7 Low or No Background Audio 1.4.8 Visual Presentation 1.4.9 Images of Text (No Exception)	2.1.3 Keyboard (No Exception) 2.2.3 No Timing 2.2.4 Interruptions 2.2.5 Re-authenticating 2.3.2 Three Flashes 2.4.8 Location 2.4.9 Link Purpose (Link Only) 2.4.10 Section Headings	3.1.3 Unusual Words 3.1.4 Abbreviations 3.1.5 Reading Level 3.1.6 Pronunciation 3.2.5 Change on Request 3.3.5 Help 3.3.6 Error Prevention (All)	

Figure 2: Detailed view of WCAG 2.0

- Level AAA offers guidelines that could improve the usability of websites for individuals with disabilities, making their browsing experience more comfortable.

In addition, WCAG 2.0 proposes a set of four principles, referred to as “POUR,” that the website should satisfy (Figure 1). Each principle includes a set of guidelines and their corresponding SC [?]:

- Perceivable (P): “Users should be able to perceive information and user interface components, ensuring that the presented information is not hidden from any of their senses.”
- Operable (O): “Users should be able to operate user interface components and navigate through the interface, ensuring that the interface does not demand interactions beyond the user’s capability”.
- Understandable (U): “Users should be able to comprehend both the information and the functioning of the user interface, ensuring that the content and operation are within their understanding capabilities.”
- Robust (R): “Content should be reliable and adaptable to various user agents, including assistive technologies, ensuring continued accessibility as technologies evolve.”

Moreover, to conform to WCAG 2.0, a webpage must adhere to the following set of requirements [6]:

- “One of the following levels of conformance is met in full”.
- “Conformance (and conformance level) is for full webpage (s) only, and cannot be achieved if part of a webpage is excluded”.
- “When a Webpage is one of a series of webpages presenting a process (i.e., a sequence of steps that need to be completed to accomplish an activity), all webpages in the process conform to the specified level or better. (Conformance is not possible at a particular level if any page in the process does not conform to that level or better.)”.
- “Only accessibility-supported ways of using technologies are relied upon to satisfy the success criteria. Any information or functionality that is provided in a way that is not accessible and supported is also available in a way that is accessibility supported”.
- “If technologies are used in a way that is not accessibility supported, or if they are used in a non-conforming way, then they do not block the ability of users to access the rest of the page”.

Therefore, the WCAG 2.0 level compliance for a website is defined as follows [6]:

- Level A: “the minimum level of conformance when the webpage satisfies all the Level A success criteria” [?]. This corresponded to a total of 25 SC met.
- Level AA: when “the webpage satisfies all the Level A and Level AA success criteria” [?]. This corresponds to 38 SC to be met (13 (AA) + 25 (A)).
- Level AAA: when “the webpage satisfies all the Level A, level AA, and Level AAA success criteria” [?]. This corresponds to a total of 61 SC to be met (23 (AAA) + 13(AA) + 25(A)).

3. AChecker Accessibility Tool

Many tools have been developed for accessibility evaluation; they differ in terms of features, but all of them implement WCAG in different versions. The specificity of a tool refers to how many kinds of issues it can find and explain; that is, a tool that can detect and describe a wide range of issues is considered more powerful because it can offer specific advice and suggestions to web developers and make it more valuable to use [17].

The AChecker tool was chosen in this study based on a systematic review in [18] on automatic tools used to evaluate university websites, which reported that it had been the most used for evaluation purposes from 2011 to 2020. It has a wide range of customization options, covers most accessibility guidelines [19], is frequently used in accessibility testing [20], and can check WCAG conformance and principles.

In addition, AChecker goes beyond accessibility evaluation by offering HTML and CSS validation checks [21]. Its validation process entails checking webpage scripts against syntax rules and standard specifications. Within this context, validating the HTML is important for evaluating web accessibility [22]. Assistive technologies rely on these established standards when interacting with both the HTML and CSS [23]. This AChecker web accessibility tool uses Jigsaw, a W3C tool used for checking a website's code to determine its adherence to formatting standards such as n HTML and CSS guidelines [24]. AChecker is a free web-based tool designed to evaluate websites for conformance with WCAG 2.0. Notably, it stands out for its informative approach to error reporting; for each identified error, the tool provides a comprehensive explanation of the issue and its impact on users and offers multiple potential solutions to address it. This tool identifies three types of accessibility problems, as provided in [25].

- “Known problems: These are problems that have been identified with certainty as accessibility barriers. Webpages must be modified to address these problems”.
- “Likely problems: These are problems that have been identified as probable barriers but require a human to make a decision. The webpage likely needs to be modified to address these problems”.
- “Potential problems: These are problems that AChecker cannot identify, which requires a human decision.”

4. Evaluation Methodology And Execution

The motivation behind this study is to evaluate the accessibility of the five Moroccan e-government portals. The evaluation methodology used included three steps: 1) selection of the sample of Moroccan e-government portals, 2) performing the accessibility evaluation, and 3) analyzing the evaluation results.

4.1. Step 1 - Selection of the sample of e-portals

To select the five Moroccan e-government portals, several factors were considered to ensure relevance and representativeness, with the focus on evaluating accessibility as in [6], such as diversity of services, user traffic and popularity.

Moroccan portals were selected based on their importance in providing essential services to citizens and residents. Indeed, those portals are from different governmental entities (recorded with “. gov.ma”),

including from different sectors, thus offering diverse e-government services in Morocco to develop recommendations for enhancing user interaction with similar e-government services. Details regarding the websites' functionalities and services may not be disclosed for confidentiality reasons.

Furthermore, the selected portals are among the most visited in Morocco. High user traffic indicates that these portals are essential to a large number of citizens. By focusing on portals with substantial daily interactions, our study addresses accessibility issues that impact many users. Notably, these websites number of visitors range from 10.000 to 7.2 million visits per year according to SimilarWeb⁴. This highlights their importance and frequent use. Evaluating these sites ensures that our findings and recommendations will be relevant and benefit a significant portion of the population.

Besides, the selected portals are popular and provide services efficiently, making them preferred choices for users. Indeed, these websites are among the most visited websites in Morocco according to SimilarWeb. By selecting them, we aim to assess and enhance the accessibility of platforms that are already widely trusted and utilized. Improvements made to these sites can therefore lead to a more inclusive and user-friendly experience for a broader audience.

It should be noted that Moroccan websites are multilingual including (Arabic, French, English, and Amazigh). All website versions had the same design and content, and the Arabic version was chosen for the evaluation. For confidentiality purposes, these portals are referred to as Portals A, B, C, D, and E.

4.2. Step 2 - The Evaluation Erocess and Tools

The AChecker tool was selected to evaluate the adherence of the chosen portals to the WCAG 2.0 standards mentioned in Section 2, and for its robust feature set, as outlined in Section 3.

The evaluation itself took place with the e-government portal versions available on December 3, 2023, at 20:37 hours, utilizing Firefox 124.0.2 (64-bit) on Windows 11, with each portal's homepage being analyzed.

The evaluation process checks the website's HTML and CSS codes against the established accessibility and coding standards. For instance:

- HTML content elements, such as images, links, headings, and form controls were evaluated to ensure compliance with the WCAG criteria.
- The syntax and structure of the HTML markup were evaluated to ensure the proper nesting of elements and appropriate attribute usage.
- CSS styles were evaluated for compliance with CSS specifications, including rules for layout, typography, and color.

The evaluation results were documented in five main parts, including known problems, likely problems, and, when selected, HTML and CSS validation issues. In the evaluation report, failed SC were listed alongside their corresponding guidelines, SC name, level of conformance, principle, check name, and instructions on how to rectify the issue to achieve compliance with the specific SC.

4.3. Step 3 - The Analysis of Evaluation Results

The evaluation results were analyzed based on to four criteria:

1. WCAG principles to identify the extent to which portals meet the "POUR" principles.
2. Conformance levels to see if the portals adhere to WCAG 2.0 standards.
3. Accessibility problems that the portals encounter and need resolution.
4. HTML and CSS validation issues to be addressed to conform to the guidelines.

The analysis was performed using qualitative and quantitative methods to develop insights into the portals' conformance with WCAG 2.0, standards, and recurrent accessibility issues.

⁴<https://www.similarweb.com/>

5. Evaluation Results Analysis

This section presents the overall results of the evaluation followed by the WCAG principles, conformance levels, accessibility problems, and validation issues reported by the AChecker tool.

5.1. Overall results

The AChecker accessibility evaluation results of WCAG failed success criteria (SC) (designated by tool as “Known problems”) are reported for portal A to E in terms of the number of errors. It also reports the total number of errors per portal, per failed SC, per WCAG principle, and conformance level, and at the bottom, the number of failed SC. From Table 1, it can be observed that portals have different occurrences of each failed SC (i.e., number of errors) per principle and level. A more detailed analysis is presented next based on WCAG principles, conformance levels, accessibility problems, HTML, and CSS validation.

Table 1
WCAG 2.0 failed SC per principle and Number of Errors

WCAG 2.0 failed SC per principle	Number of errors				
	Portal A	Portal B	Portal C	Portal D	Portal E
1.1.1 non-text content (A)	30	17	13	23	15
1.3.1 Info and Relationships (A)	9	0	0	0	2
1.4.4 Resize text (AA)	4	10	19	8	91
1.4.6 Contrast (Enhanced) (AAA)	4	0	13	2	0
Total SC failed - Perceptible	47	27	45	33	108
2.4.4 Link Purpose (In Context) (A)	27	12	3	42	10
2.4.6 Headings and Labels (AA)	1	2	2	2	3
Total SC failed - Operable	28	14	5	44	13
3.1.1 Language of Page (A)	0	0	2	0	0
3.3.2 Labels or Instructions (A)	5	0	0	1	1
Total SC failed - Understandable	5	None	2	1	1
4.1.1 Parsing (A)	1	0	0	0	1
Total SC failed - Robust	1	None	None	None	1
Total of errors	81	41	52	78	123
Level A errors	72	29	18	66	29
Level AA errors	5	12	21	10	94
Level AAA errors	4	0	13	2	0
Number of failed SC	8	4	6	6	7

5.2. WCAG principles

This subsection presents an analysis of the WCAG principles (Perceptible, Operable, Understandable, and Robust) (see Figure 3).

- Perceptibility:
 - Portal E is the least perceptible with the highest number of errors, followed by Portals A, C, and D, which face perceptibility challenges primarily related to “non-text content”, “resize text”, and the “contrast”.
 - Portal B is the most perceptible with the lowest number of errors, and encounters difficulties in only two SC.
- Operability:
 - Portal C demonstrates strong operability with a low number of errors, making user interface components and navigation accessible.

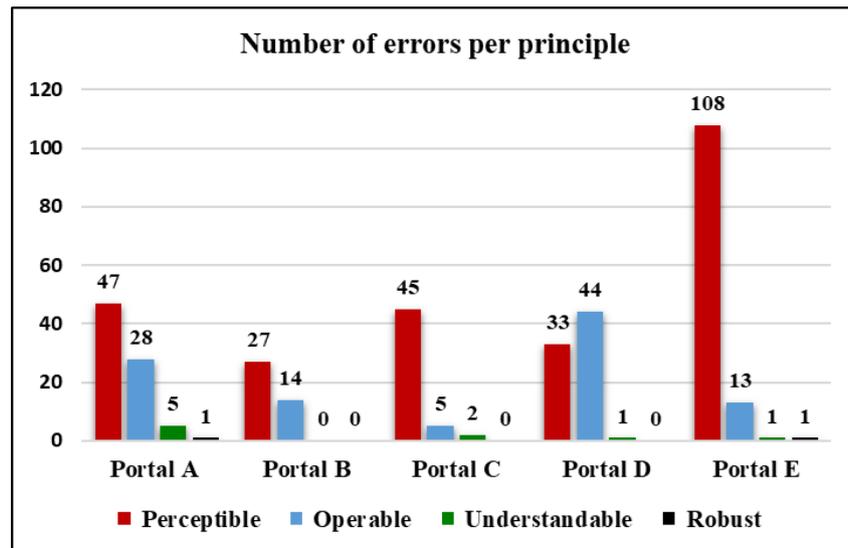


Figure 3: Distribution of errors per WCAG principles

- Portals B and E which face some operability issues, particularly in “link purposes”, then Portals A and D with the highest number of errors, which exhibits notable operability emphasizing the need for substantial improvements.
- Understandability:
 - Portals A, D, and C exhibit lower levels of understandability due to several errors related to “labels or instructions”, highlighting the necessity of a comprehensible digital environment.
 - Portal B stands out as the most understandable: it shows no errors in this principle and presents information effectively for the user.
- Robust:
 - All portals show good adherence to the robust principle, with only one error identified in portals A and E. This suggests that the portals have implemented coding practices and content presentation approaches that align well with the different browsers and assistive technologies.

The accessibility of each portal across the four principles is presented in Figure 4 in terms of the percentage of SCs satisfied per principle (regardless of the number of errors per failed SC):

- Portal B is the most perceptible (in red) with 91% (two failed SC among 22 of this principle), followed by Portal C, D, and E with 87% (three failed SC) each, and Portal A with 82% (four failed SC).
- All Portals are operable (in blue), with 90% (two failed SC among 20 of this principle, each).
- Portals A, C, D, and E are the most understandable (in green) with 95% (one failed SC among 17 of this principle), while Portal B is the best with 100% conformance to this principle (no failed SC).
- Portals A and E are less robust (in black) with 50% (one failed SC among the two of this principle), while the other three portals reached 100% because no failed SC was reported.

To summarize, each of the portals showed good adherence to WCAG 2.0, with a range between 4 and 8 of failed SC among the 61 proposed by the guidelines (see Table 1). However, none of the portals fully adhered to these four principles. Therefore, addressing a specific SC within each principle is important for overall accessibility improvement across all portals.

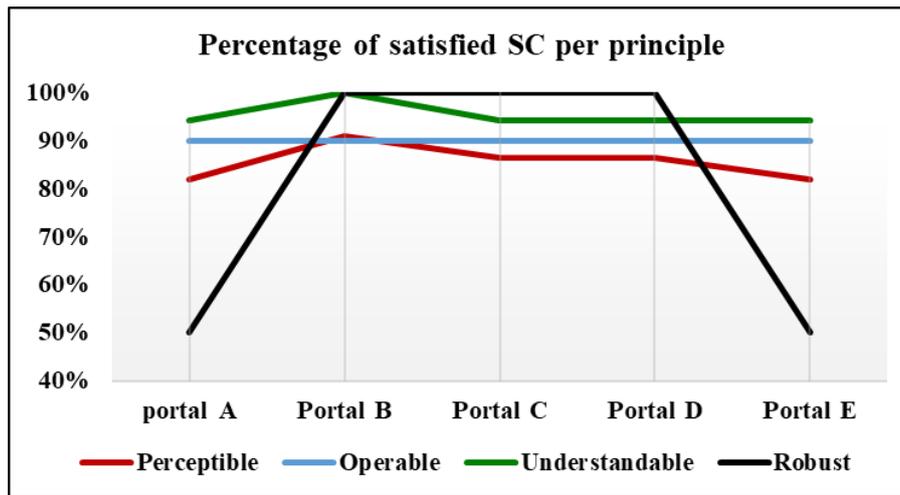


Figure 4: Percentage of satisfied SC per principle

5.3. Conformance Levels

This subsection presents an analysis of the WCAG conformance levels (A, AA, and AAA) (see Figure 5) with the total number of errors for the failed SC of the five portals. As observed:

- The number of errors in Level A (in blue) varies across most Portals A particularly in Portals A (72), D (66), and E (29). These errors represent critical accessibility barriers that directly hinder the usability of these portals for disabled users.
- Portal E presented the highest number of errors at level AA (94) (in purple). These errors, often categorized as "known problems" by AChecker, can significantly impact the user experience. The other portals also exhibit errors (ranging from 5 to 21), but with significantly lower occurrences. Understanding these errors and their impact across all portals is crucial for prioritizing improvement efforts.
- Portals A (4), C (13), and D (2) present moderate numbers of errors at the AAA level (in yellow) associated with advanced accessibility features. While not as frequent as in the A and AA levels, their presence warrants attention, particularly when they pose barriers to specific user groups. Interestingly, Portals B and E show no failed SC, suggesting that they excel at handling accessibility at this highest level. However, it is important to note that the absence of failed SC at the AAA level does not imply that a website is entirely accessible. To achieve this, the website needs to meet all SCs of the three levels.

Figure 6 provides more insights on portal conformance in terms of the percentage of satisfied SC per level, as well as the number of errors reported.

- Among the 25 SC of Level A (e.g., the minimum level of conformance)
 - Portal B satisfied 23 SC (92% conformance rate), demonstrating notable progress in enhancing accessibility.
 - Portals C and D achieved 88% conformance with each other (22 satisfied SC per portal).
 - Portals A and E achieved 80% conformance (with 20 satisfied SC per portal), highlighting the need for improvements to meet the foundational accessibility standards.
- Among the 13 SC of level AA (e.g., the mid-range level of conformance),
 - All five portals shared the same percentage of conformance at this level, with 85% each (e.g., 11 satisfied SC per portal).
 - All portals failed on two SC related to "resizing text and "headings and labels".
- Among the 23 SC of level AAA (e.g., the highest level of conformance),

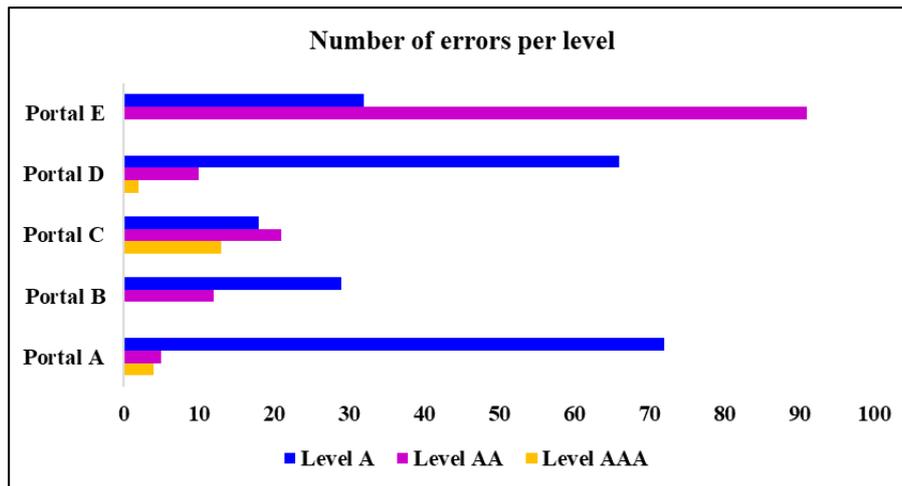


Figure 5: Distribution of errors per conformance level

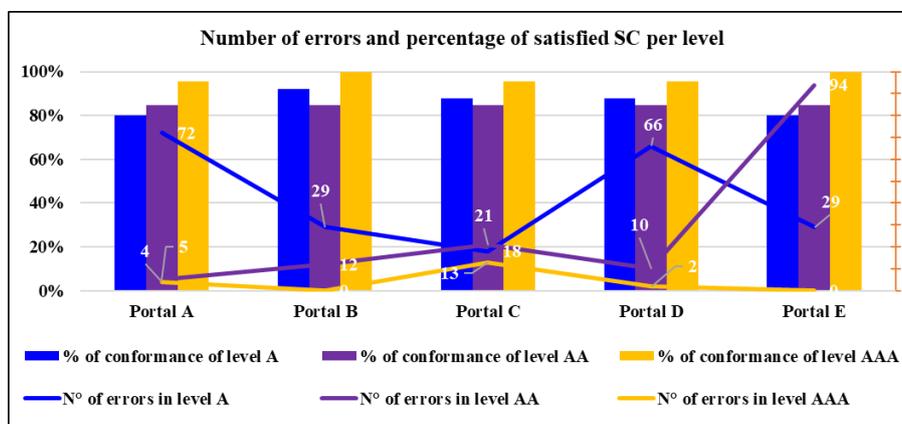


Figure 6: Percentage of satisfied SC per level

- Portal B and E stand out with 100% conformance each.
- Portals D, A, and C achieved 96% conformance at this level, with one failed SC per portal.
- However, we cannot conclude that these portals meet the AAA level; all of them have errors in levels A and AA.

To summarize, each portal shows a different level of conformance to each level, and no portal has reached the three levels of conformance. For example:

- Portal A showed 81 errors, with conformance rates of 80% (level A), 85% (level AA), and 96% (level AAA).
- Portal B had 41 errors, achieving 92% (level A), 85% (level AA), and 100% (level AAA) conformity.
- Portal C exhibited 52 errors, with conformance rates of 88% (level A), 85% (level AA), and 96% (level AAA).
- Portal D demonstrated 78 errors, achieving 88% (level A), 85% (level AA), and 96% (level AAA) conformity.
- Portal E displayed 123 errors, with conformance rates of 80% (level A), 85% (level AA), and 100% (level AAA).

The identified errors indicate the need for continuous enhancements to meet all SC of accessibility conformance levels recommended by WCAG 2.0.

5.4. Accessibility Problems and Validation Issues

Table 2 presents the number of accessibility problems as well as the HTML and CSS validations reported by AChecker across the five portals. Table 3 provides examples of the development of additional insights.

Table 2

Problems and Validations Issues per Portal

	Portal A	Portal B	Portal C	Portal D	Portal E
Accessibility problems (Likely)	239	93	23	132	257
Accessibility problems (Potential)	726	516	98	325	783
HTML Validation	0	0	0	0	0
CSS Validation	9	60	38	51	32
TOTAL	974	669	159	508	1072

As stated previously, the AChecker tool reports three types of accessibility problems (see Section 3); “known problems” related to failed success criteria have already been discussed in Section 5, while those readily identifiable by automated tools “Likely problems” and those beyond the tool’s capacity for detection “Potential problems” [25] are analyzed in this section. As it can be remarked:

- Portal E emerges with the highest count of “likely problems, ” suggesting a higher likelihood of existing accessibility issues that may impact the user experience. In contrast, Portal C had the lowest count, indicating potentially better adherence to accessibility guidelines. This variation across portals highlights the diverse landscapes of the accessibility challenges faced by each portal. The most detected problem in all five portals is related to “change on request” SC in level AAA, which highlights a specific concern related to links and anchors that open a new window, potentially missing a warning.
- Portal E once again leads with the highest count of “potential problems”, which signifies a larger set of issues that may impact accessibility in the future, requiring proactive action. Conversely, Portal C maintained its position with the lowest count, setting a positive precedent for future accessibility considerations. One of the most recurrent detected problems is related to the “use of color” SC in level A: this highlights a specific concern related to images that may contain text with poor contrast.

The CSS validation highlights potential styling issues that can impact the visual presentation of portals. Portals A, B, C, D, and E all exhibited varying counts of CSS validation issues, suggesting potential challenges in maintaining a consistent and effective visual design. This signifies the need for vigilance in ensuring that styling choices do not compromise the accessibility and usability of portals. Some CSS errors detected by the tool are related to incorrect values of padding, unknown parameters, or incorrect use of CSS styling attributes.

The absence of HTML validation errors across all portals indicates strong adherence to proper HTML syntax and rules, which confirms the effective coding practices implemented in the design and implementation of these portals, suggesting that the structural foundation of the webpages is consistent with established standards.

These insights allow for the identification of targeted improvements in accessibility problems, particularly in addressing specific SC and CSS validation issues across portals. Adherence to HTML standards is commendable and provides a strong foundation for accessibility.

6. Discussion, Recommendations and Limitations

This study has evaluated and reported on the accessibility of five Moroccan e-government portals (A, B, C, D, and E) in conformance with WCAG 2.0 using the AChecker tool.

Accessibility evaluation analysis was performed using the number of errors followed by the SC per portal. As previously mentioned, the number of errors does not necessarily reflect their severity, as

Table 3

Examples of problems and validation issues provided by AChecker

Accessibility Problems	Examples	Checks and Validation Errors
Accessibility problems (Known)	SC 1.1.1 Non-text Content (A) SC 1.3.1 Info and Relationships (A) SC 1.4.4 Resize text (AA)	“ Check 7: Image used as anchor is missing valid Alt text.” “ Check 168: Form missing fieldset and legend to group multiple radio buttons.” “ Check 116: b (bold) element used.”
Accessibility problems (Likely)	SC 3.2.5 Change on request (AAA) SC 1.4.6 Contrast (Enhanced) (AAA) SC 3.3.2 Labels or Instructions (A)	“ Check 18: Anchor that opens new window may be missing warning.” “ Check 306: The contrast between the color of text and its background is not sufficient to meet WCAG2.0 level AAA.” “ Check 188: Label text is empty.”
Accessibility problems (Potential)	SC 1.3.1 Info and Relationships (A) SC 1.4.1 Use of Color (A) SC 2.1.1 Keyboard (A)	“ Check 271: Dir attribute may be required to identify changes in text direction.” “ Check 251: Image may contain text with poor contrast.” “ Check 89: Script user interface may not be accessible.”
CSS Validation	Errors in padding Error in sidebar property Error in anchor	“px is not a value” “Wrong property” “Unknown value”
HTML Validation	None	None

different errors affect accessibility to varying degrees. However, it provides a general overview of the accessibility of each portal. Notably, the evaluation outcomes underscore that, while Portal E has the most severe accessibility challenges with a high number of errors, other portals may also encounter significant barriers to accessibility, albeit with different error distributions.

The next analysis in terms of the SC, regardless of the number of errors, allowed for additional insights into each portal’s conformance with the WCAG. The main findings are summarized as follows, with corresponding recommendations to enhance the accessibility of portals:

- Concerning the WCAG principles, all five portals exhibited varying degrees of adherence across the four principles. While some portals demonstrate strengths in certain areas, such as perceptibility or operability, others show notable challenges, particularly in areas related to understandable and robust principles. In particular, Portal E presents significant perceptibility issues, whereas Portal B has stronger operability features. However, none of the portals fully adhered to all the WCAG principles, highlighting the need for targeted improvements to achieve comprehensive accessibility.
- For conformance levels, the findings revealed a mixed level of conformance across portals. Most portals struggle to meet the level A conformance SC, with notable challenges identified in Portals A, D, and E. Level AA conformance also presents challenges for all portals, with Portal E exhibiting a notably high number of failed SC. Portals B and E demonstrate strong conformance to the AAA level. It is important to note that none of the portals achieved perfect conformance across all levels, which underlines the importance of continuous improvement efforts to meet the diverse needs of users with disabilities.
- Concerning accessibility problems, the findings revealed significant variations across portals. Portal E exhibited the highest number of problems, suggesting a higher likelihood and a larger set of existing and future accessibility issues. In contrast, Portal C consistently had the lowest count, indicating better adherence to accessibility standards. The most recurrently detected issues were related to specific SC, such as “change on request” and “use of color” highlighting concerns related to links, anchor behavior, and contrast in images.

- Regarding HTML validation, all portals demonstrated full adherence to proper HTML syntax and rules with no reported validation error. This reflects effective coding practices and ensures that the structural foundation of webpages is aligned with the established standards. In terms of CSS validation, varying counts of validation issues were detected across all portals, signaling potential challenges in maintaining consistent and effective visual designs. While the counts were moderate, they underlined the importance of vigilance in ensuring that styling choices do not compromise accessibility and usability. Examples of CSS validation issues include errors in padding, sidebars, sections, headers, anchors, and menu-icon styling.

In conclusion, these findings highlight the importance of enhancing accessibility across all evaluated portals to ensure a more inclusive and user-friendly online experience for all citizens. These results confirm the finding of the study [11] in the Moroccan context. This study has identified that none of the evaluated websites met the minimum WCAG 2.0 level A with significant barriers across all four principles: perceivability, operability, understandability, and robustness. For level AA, five criteria were not respected in each website, affecting the principles of perceivability, operability, and understandability. For level AAA, 11 to 13 criteria were not met across the websites, indicating substantial non-compliance with advanced accessibility standards. This emphasizes the need for enforceable accessibility standards and more comprehensive research to ensure inclusive access to digital services in Morocco.

Table 4 provides a set of recommendations for each portal. By following these recommendations, the accessibility of these five portals can be improved, and their content made more accessible to a wider range of users, which will improve the overall user experience for everyone.

Portals	Examples of recommendations
Portal A	<p>Prioritize improvements in “non-text content”, “info and relationships”, “contrast”, “text resizing”, “Headings and Labels” and “link purposes”, to establish a foundational structure for accessibility at level A. Examples of actions to undertake are presented as the following:</p> <ul style="list-style-type: none"> • Ensure each image used as an anchor has descriptive alt text identifying its purpose or function. • Provide a concise and descriptive label for each input element. • Evaluate and adjust text and background colors to ensure a contrast ratio of 7:1 for standard text and 4.5:1 for larger text. • Replace <code><i></code> elements with <code></code> or <code></code> elements to provide semantic meaning along with styling. • Ensure each <code><label></code> element contains descriptive text that identifies the associated input element. • Ensure that only <code><h1></code> or <code><h2></code> follows an <code><h1></code> header. • Ensure that headers following an <code><h3></code> are <code><h1></code>, <code><h2></code>, <code><h3></code>, or <code><h4></code>.

Portal B	<p>Direct efforts towards resolving issues in “non-text content”, “info and relationships”, “contrast”, “text resizing”, “Headings and Labels” and “link purposes”, such as:</p> <ul style="list-style-type: none"> • Make sure to add an <code>alt</code> attribute to <code></code> elements. • Replace Bold elements <code></code> with <code></code> or <code></code>. • Ensure to add <code><fieldset></code> and <code><legend></code> elements to the form for each group of radio buttons. • Ensure each anchor (<code><a></code>) element contains descriptive text or a title attribute. • If an image is used within the anchor, add descriptive alt text to the image.
Portal C and D	<p>Prioritize addressing errors related to “language of page”, “contrast”, and “text resizing” as top priorities to establish a solid foundation for accessibility at level A by taking into consideration these examples of actions:</p> <ul style="list-style-type: none"> • For HTML documents, add the <code>lang</code> attribute with a valid ISO-639-1 two-letter language code to the opening <code><html></code> element. • For XHTML documents, add both the <code>lang</code> and <code>xml:lang</code> attributes with a valid ISO-639-1 two-letter language code to the opening <code><html></code> element. • Evaluate and adjust text and background colors to ensure a contrast ratio of 7:1 for standard text and 4.5:1 for larger text. • Make sure to remove the <code></code> element used in the document.
Portal E	<p>Enhance operability by focusing on issues in “link purposes”, “headings”, and other operable elements to improve operability at level A conformance, such as:</p> <ul style="list-style-type: none"> • Ensure each anchor (<code><a></code>) element contains descriptive text or a title attribute. • Ensure that only <code><h1></code> or <code><h2></code> follows an <code><h1></code> header. • Ensure that headers following an <code><h3></code> are <code><h1></code>, <code><h2></code>, <code><h3></code>, or <code><h4></code>. <p>Special consideration to perceivable principle as the portal faces the highest number of problems in “text resizing” due to the excess use of italic text. Examples of actions to be taken are:</p> <ul style="list-style-type: none"> • Replace <code><i></code> elements with <code></code> or <code></code> elements to provide semantic meaning along with styling. <p>Other actions to be taken concerning “labels or instructions” and “parsing”, such as:</p> <ul style="list-style-type: none"> • Adding text to the <code><label></code> element. • Making sure that the <code>id</code> attribute is unique in the document.

As for any study, these findings are limited by inherent limitations of the evaluation methodology used, including

- **Sample size:** The study was limited by the small number of websites that were evaluated.

Although the chosen Moroccan websites offer valuable insights, the findings may not be fully representative of all Moroccan e-government portals. Although the sample of portals is small, the findings revealed that accessibility needs remedies because the evaluated portals encounter many problems that should be addressed to reach higher levels of conformance.

- **Evaluation approach:** The evaluation relied primarily on an automated testing tool to identify accessibility errors. Although this tool is useful, it may not capture all accessibility issues, leading to potential gaps in the evaluation. Therefore, for a more extensive evaluation, it is suitable to use multiple tools to benefit from their strengths and mitigate their weaknesses.
- **Lack of user testing:** This study did not include direct user feedback or testing, which could provide valuable insights into the actual user experience and challenges faced by individuals with disabilities when navigating websites. Therefore, complementing automated testing with user and accessibility expert evaluations, user testing, and expert reviews is recommended for a more comprehensive evaluation of website accessibility [26].
- **Static analysis:** The evaluation was based on a snapshot of the websites at a specific point in time. Changes to websites after the evaluation period could affect the accuracy and relevance of the findings. The evaluated portals can benefit from the WCAG recommendations, and additional evaluation studies in the near future should be conducted to observe the progress of these portals in terms of accessibility achievements.

7. Conclusion

In this study, the accessibility of five Moroccan e-government portals was evaluated with respect to WCAG 2.0, using the AChecker tool. The results were analyzed according to WCAG principles, levels of conformance, accessibility problems, HTML, and CSS validation. The main findings are summarized as follows.

- None of the portals fully met all the WCAG principles, emphasizing the necessity for focused enhancements to ensure comprehensive accessibility. Indeed, the insights summarized per the WCAG principle revealed distinctive challenges and performance across portals. While certain portals excel in specific areas, such as perceptibility or operability, others face significant challenges, particularly in terms of understandability and robustness. Portal E struggles with perceptibility issues, whereas Portal B exhibits stronger operability features.
- All portals failed to meet the WCAG conformance levels, indicating a lack of accessibility as a quality factor for the website. There are common accessibility challenges at level A across all portals, emphasizing fundamental accessibility issues, especially for people with disabilities. Level AA conformance revealed operability challenges, emphasizing the need for advanced accessibility measures. The AAA conformance level indicated varying degrees of challenges, emphasizing the commitment to providing an optimal user experience.
- Accessibility problems were identified in all portals, with Portal E having the highest count. HTML validation across all portals was flawless, indicating a strong adherence to proper HTML syntax. However, varying numbers of CSS validations present potential challenges in maintaining a consistent and effective visual design.

Although accessibility is an important aspect of any website, especially e-government portals, few efforts have been performed in this context. A set of recommendations was provided to help improving accessibility not only of the five e-portals in this study, but also for other e-portals for an improved positive user experience for a diverse range of citizens. Future work is needed to evaluate the same portals using two other tools, and then provide the results to the e-government portals to tackle accessibility issues identified and reevaluate iteratively until they reach a high degree of adherence to the WCAG 2.0 standard. Furthermore, evaluating additional e-government websites using other tools, complemented by manual evaluations would help identify and address a broader range of accessibility issues across various platforms and therefore ensure comprehensive accessibility results.

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