An Analysis of Web Content Accessibility of Municipality Websites for People with Disabilities in Norway

Web Accessibility of Norwegian Municipality Websites

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ABSTRACT

Web accessibility is of crucial importance for people with disabilities to access online information and services in an effective manner. However, the lack of compliance with accessibility guidelines results in inequality in and exclusion from digital society. In this paper, we describe the problems of web accessibility identified in 356 municipality websites in Norway. The analysis has been carried out on the basis of the WCAG with two major evaluation tools: WAVE and TAW. Results show that none of the municipality websites meet an acceptable level of compliance. The websites violate an average of 40 checkpoints, of which many are Level A criteria that represent the minimum level of satisfaction of checkpoints. The most common violations are very low contrast, non-text content, empty button, missing form label, link purpose, info and relationships, and name, role, value criteria. Additionally, there is a weak negative correlation between the population of municipalities and the number of success criteria they violate.

CCS CONCEPTS

• **Human-centered computing** → Accessibility; Accessibility design and evaluation methods.

KEYWORDS

Web accessibility, Online evaluation, Municipality websites, Accessibility compliance, WCAG

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1 INTRODUCTION

Web is essential part of everyday life to disseminate information to interested parties, and the number of websites has been increasing at an accelerated pace for years. According to the Internet Live Stats [22], there are currently more than 2 billion websites in the world. These websites must guarantee satisfactory access for every individual so that they can perceive, understand, navigate, and interact with the web interface easily. However, the results of almost all previous studies have shown that the evaluated websites have considerable accessibility issues, thereby causing serious problems for some users.

The accessible web plays an increasingly important role in the delivery of information and services to everyone, especially for people with disabilities who constitute nearly 15% of the world's population [55]. People living with visual, auditory, physical, speech, cognitive or neurological disabilities can only access websites in an effective manner when the websites are designed to comply with accessibility guidelines. Albeit universal access to web content has gained outstanding importance over the last few years [21, 38, 47], web accessibility practices have often been neglected in the web development process [16, 19]. This results in the existence of inaccessible websites that deprives people of taking full advantage of web services, thereby impeding inclusion and equity in the digital society [20].

Web accessibility refers to the inclusive practice of making web content accessible to everyone, regardless of their abilities and disabilities [5, 54]. W3C, as the driving force behind web accessibility, provides accessibility guidelines that help practitioners understand how to construct accessible websites and test their conformance level [14, 33]. Web Content Accessibility Guidelines (WCAG) of W3C is widely recognized as a key measure of evaluating the accessibility of websites and determining violated checkpoints. WCAG 2.1 is the current version of the guidelines which includes 78 success criteria distributed across three conformance levels (A, AA, and AA) under four principles namely perceivable, operable, understandable, and robust [54]. Level A addresses minimum success criteria to be accessible, Level AA represents recommended level of compliance, and Level AAA includes optional requirements that show the highest level of accessibility conformance. As it is not always possible to fulfill all Level AAA success criteria, W3C encourages public and private organizations to meet Level A and AA checkpoints to present as many inclusive websites as possible.

To this end, many countries have developed their own legislation based on WCAG to ensure accessible web by making it legally mandatory for public and/or private organizations [50]. For instance, the commitment to promoting accessible websites started a

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long time ago in Norway. The country has enacted laws for websites from both the public and private sectors since 2013. All organizations pursuing public tasks, e.g., providing information about healthcare, education, and political rights, are obliged to adapt their websites and online services to the WCAG 2.1 conformance level AA. The Norwegian Digitalization Agency [43] is responsible for ensuring that public services are better and more accessible for effective digitalization, which has become an indispensable part of the digital society over the years. Yet, despite the increasing interest in web accessibility in recent years in Norway, websites providing public services still violate accessibility guidelines and hold inaccessible features [15, 17, 32, 44].

All municipalities have their own web portals to deliver information and services in Norway. As an important source of information and public services for their citizens, municipality websites should be constructed in an accessible way to meet an acceptable level of compliance. They require that everyone irrespective of their disabilities access online services without undue effort [27, 46]. Taken together, our aim is to figure out to what extent Norwegian municipalities have adapted their websites to the accessibility guidelines, and how they ensure digital participation for their citizens. Besides, we discuss potential obstacles against the development of websites that are compliant with accessibility guidelines.

2 RELATED WORK

Web accessibility of public services has been studied for more than 20 years. Studies focusing on the accessibility of websites have analyzed many different public organizations to understand their compliance with accessibility guidelines. Yet, there is a relatively small body of literature that is concerned with the accessibility of municipality websites. The majority of these studies that have used online evaluation tools to determine accessibility violations have found that, in general, municipality websites have serious problems in terms of accessibility, and it is necessary to put more emphasis on constructing municipality websites to be more accessible for people with disabilities.

For instance, Evans-Cowley [12] evaluated the accessibility conformance of 100 largest municipality websites in the United States using a coding sheet and Bobby software. The results showed that overall compliance with accessibility was low. Many of the evaluated websites contained accessibility problems that were easy to repair such as a lack of alt text alternative for all non-text content, or missing form labels in form fields. Another study by Akgul and Vatansever [4] found similar results that the accessibility conformance level of websites was low and the lack of alternative text for non-text content was the main violation. Form controls without labels and empty links were other common problems that the evaluated websites contained. The authors evaluated 30 municipality websites in Turkey using TAW tool against WCAG 2.0. Pribeanu et al. [34] firstly targeted three municipality websites in Romania to test their accessibility and found that none of the websites met the minimum conformance level with WCAG 2.0. In 2019, Pribeanu [33] carried out another test performing a large-scale evaluation with 186 Romanian municipalities. Results corroborated the findings of the previous study that the websites showed a low level of compliance with WCAG 2.0 guidelines. Of the evaluated websites, only one met the requirements. The most frequent error types were the lack of alternative text for non-text content and advisory information for links.

Sabev et al. [37] tested the accessibility of 100 public administration websites in Bulgaria. The authors conducted both manual and automated evaluations to determine the accessibility problems of the websites. WAVE and aXE were the tools that data derived from automated evaluation. The authors found that a very small portion of the evaluated websites passed the accessibility test. Lack of suitable alternative text, missing or incorrect use of headings, lack of a link to skip to the main content, and insufficient color contrast were the main problems detected in the evaluation. In their study, Król and Zdonek [28] included 182 local government websites in Poland. Evaluation outcomes against WCAG were derived from WAVE tool. None of the municipality websites was accessible, although web accessibility has become popular in recent years in the country, as reported in the study. Very few of the websites passed the accessibility test with minor problems, whereas the rest of the websites violated many success criteria and thereby were inaccessible.

Shi [39] carried out an exploratory study to provide an overview of the accessibility of local government websites including province, county, and municipalities in China. In total, 324 government websites were tested using Bobby software. All evaluated websites contained at least one or more violations of WCAG. The author concluded that this causes challenges in accessing local government services without undue effort as all evaluated websites failed to meet WCAG guidelines. Another study by Iseri et al. [23] indicated that 67 Cyprus Island municipal websites had some form of accessibility problems against WCAG 2.0. Online tools, namely European Internet Inclusion Initiative Page Checker and AChecker were used in the assessment.

In some of the studies, municipality websites from different countries were comparatively analyzed in terms of their compliance with accessibility guidelines. For instance, Inal and Ismailova [21] explored the relationship between the human development index of countries and their web accessibility performance. They included 41 countries with different development levels according to the 2016 Global Human Development Report of the United Nations. The municipality websites of their capital cities were tested using the AChecker evaluation tool. The authors found a linear relationship between the human development level of countries and their web accessibility conformance. The municipality websites from the countries with a lower development index contained more errors than those with a higher development index. In another study by Rodríguez et al. [35], the municipality websites of capital cities from 31 countries were evaluated using a proposed framework consisting of 152 metrics. None of the municipality websites met all metrics such as friendliness, navigability, usability, accessibility, information, truthfulness, and functionality.

Whereas some countries promote solely WCAG to encourage public and private organizations to make their websites accessible, others develop their own guidelines by adopting such existing ones. For instance, a study carried out by Kous et al. [27] described accessibility issues in 189 Slovenian municipality websites using the AChecker tool. The results showed that none of the evaluated websites were fully compliant with the accessibility guidelines in

2017. However, after the adoption of the web content requirements of Standard EN 301 549, developed based on WCAG, 33% of the websites met all accessibility success criteria at the end of 2018. In their study, Freire et al. [14] presented a metric to evaluate and observe Brazilian municipality websites against accessibility requirements. The authors detected several violations in the evaluated websites which indicated that there were challenges and barriers that hinder access to the municipality websites effectively by people with disabilities. Therefore, it was suggested that the government should put more effort into making public services more accessible.

Even though countries (e.g., Germany, France, Denmark, Sweden, Canada) have started to develop their own legislation based on web content accessibility guidelines over the years, it is a fact that there are many websites delivering information and services for the public that hold inaccessible features in countries where regulatory frameworks have been implemented for web accessibility for years - thus fall outside the scope of the UN Convention on the Rights of Persons with Disabilities [8]. For instance, web accessibility has been a legal obligation for public services in Norway since 2013. By adopting the website accessibility laws and regulations, the aim was to create an inclusive society to give equal access to online services to as many people as possible [36]. Yet, there still exist Norwegian public websites that violate success criteria and fail to meet the recommended conformance level. For instance, very few public websites met the accessibility requirements in 2006 in the country [32]. Providing alternative text to non-text content was the main problem that several websites contained at the time. Olsen et al. [31] evaluated the accessibility of Norwegian municipality websites using Unified Web Evaluation Methodology mainly based on the WCAG. The authors found the evaluated websites to be far from being completely accessible. Invalid or deprecated HTML and/or CSS was the main problem that results in the incompatibility with assistive technologies such as screen readers. Links with the same title for different targets, lack of alternative texts for non-text content, and form elements without labels were other common problems detected in the evaluation.

In 2018, a total of 278 Norwegian websites including banking, media, transportation, health, education, municipal administration, culture, and organization were tested against WCAG 2.0 conformance level [44]. In the evaluation, 16 of the 35 mandatory success criteria in the WCAG were applied including navigation, keyboard operation, code of content, use of forms, and alternative text format for non-text content. The content and functionality of the websites were mainly tested with manual test procedures. In addition, SiteImprove Accessibility Checker, Color Contrast Analyzer, and W3C HTML Validator were used for automated evaluation of some tests. In general, the results of the evaluation indicated that none of the evaluated websites passed the accessibility test. Similar to the previous studies, lack of alternative text was the main issue that most websites violated. Of the evaluated websites, twenty-nine were municipality websites, which were found to be relatively good in both navigation and keyboard control, yet they violated success criteria in relation to the use of form.

Taken together, these studies support the notion that many websites from different countries providing public services hold inaccessible features. Although some research has been carried out on the accessibility conformance level of websites in Norway, there is still very little scientific understanding of to what extent public organizations pay attention to the compliance with accessibility guidelines in their websites at the country level. Our aim is, therefore, to focus on municipalities as they are an important source of information and public services for their citizens. To this end, we analyzed all municipality websites using online evaluation tools and discussed potential obstacles against the development of websites that are compliant with accessibility guidelines.

3 METHODS

The study evaluates the accessibility of 356 municipality websites in Norway. In the evaluation process, the websites were tested automatically in terms of their accessibility and WCAG compliance. Norway consists of 11 first-level administrative counties ("fylke") and 356 second-level municipalities ("kommune") including the capital of Oslo, which is considered both a county and a municipality. The list of municipalities and their population were obtained from the website of Statistics Norway [40] and all tests were performed in February of 2022. Two popular accessibility evaluation tools, called WAVE [52] and TAW [42], have been used to evaluate the websites. The following research questions guided the study:

- How many of the municipality websites are accessible to people with disabilities?
- What are the most common violations of web accessibility checkpoints on municipality websites?
- Which checkpoints provided in WCAG are violated on each website that needs to be fixed?
- What is the relationship between the population of the municipalities and their web accessibility performance?

W3C proposed a methodological approach to evaluate the conformance level of web applications and mobile websites against WCAG compliance. This approach, called Website Accessibility Conformance Evaluation Methodology (WCAG-EM), details guidelines and procedures for evaluators under the following five steps: (1) define the scope of the evaluation, (2) explore the website, (3) select a representative sample, (4) evaluate the selected sample, and (5) report the evaluation findings [51]. In the evaluation process, we followed the WCAG-EM approach to check the current state of accessibility of municipality websites in a systematic manner.

3.1 Scope of the evaluation

WCAG-EM suggests selecting a representative sample when it is impracticable to test all pages of a website [51]. We, therefore, confined our evaluation to the homepages of the municipality websites. This is a widespread practice supported by several researchers [2, 56] to evaluate the accessibility of a website using online evaluation tools [24, 29]. Homepages are considered to be of utmost importance in accordance with compliance with accessibility guidelines [1, 30]. Accessibility errors detected in the homepage and other pages of a website generally resemble each other [49], which results in the fact that visitors are likely to encounter problems accessing other pages from an inaccessible homepage on the website [1]. Besides, public websites are usually built using a web content management system (CMS) to host and deliver content as they allow multiple contributors to create, edit and publish easily. Any issues where accessibility guidelines have been violated relating to page layout,

structure, menu design, and content flow would likely continue through the rest of such websites. Therefore, to what extent accessibility guidelines are paid attention to on a homepage is likely to give an insight into the overall accessibility of the website.

3.2 Web accessibility evaluation tools

There are different evaluation methods, such as manual evaluation and online evaluation, in the evaluation of web accessibility. Manual evaluation is considered the most correct way of detecting accessibility errors in a website [47]. However, evaluation might be affected by personal judgments and open to making mistakes during the process [6] and it requires more time and effort to perform [5, 34], especially when conducting a large-scale evaluation. Online evaluation, on the other hand, is a valuable method for evaluating the accessibility performance of a website based on accessibility guidelines, determining problems, and providing useful feedback for the identified issues [10, 24, 56]. Online tools have been used to carry out accessibility evaluation successfully for many years. Reports produced by online tools are helpful for practitioners to check the status of accessibility of their websites and figure out how to fix identified problems [3]. An accessibility test with both online and manual evaluation methods provides higher coverage of detected issues, however, only tool-based evaluation still is a reliable measure to understand the level of accessibility compliance of a website [47].

W3C provides a list of web accessibility evaluation tools including software programs and online services to help practitioners test their web content in accordance with WCAG conformance levels [53]. We applied the following inclusion criteria to select the tools for the evaluation: available in the English language, running on a web browser online, available with a free license (non-commercial), displaying results on the same page without having to download, and high coverage of accessibility issues based on previous research [25, 48]. Besides, in studies that applied more than one online tool for accessibility evaluation [26, 41], each tool generated different types of results in terms of accessibility errors, alerts, and warnings when evaluating the same website. Therefore, it is highly recommended the use of multiple tools in accessibility evaluation to maximize coverage and completeness and thereby obtain more reliable data [25, 48]. Based on these considerations, we selected two popular accessibility evaluation tools, i.e., WAVE and TAW, for the evaluation in the study. WAVE and TAW also complement each other in that WAVE presents the errors and alerts with icons embedded in the evaluated website, while TAW categorizes violated checkpoints into WCAG principles on a list. A brief description of the tools is as follows:

TAW (Test de Accessilibilidad Web) Tool: TAW was developed by Spanish Fundación CTIC. The tool has been widely used in numerous accessibility studies over the years [4, 5, 26]. Aiming to help practitioners in making their websites more accessible and inclusive for people with disabilities, TAW provides a very useful evaluation report by displaying proposals on how to remedy accessibility problems. The report also provides a very clear picture of the violated checkpoints, divided into four principles: perceivable, operable, understandable, and robust. Besides, the tool groups accessibility issues under three categories: problems (corrections are needed), warnings (an expert review is necessary), and not reviewed (fully manual review is necessary).

WAVE (Web Accessibility Evaluation) Tool: WAVE is another popular online evaluation tool developed by the WebAIM community. WAVE has been successfully used in several web accessibility studies since it was launched in 2001 [28, 29, 37, 56]. The tool reported accessibility violations being detected on the left side of the screen in a summary panel including errors, contrast errors, alerts, features, structural elements, and ARIA (accessible rich internet applications). On the right side, WAVE shows the evaluated webpage with injected icons that report identified problems graphically with red (accessibility problems that need to be fixed), yellow (highlight other elements that need to be checked), and green (accessibility features that improve accessibility) indicators. By clicking on any of the icons, the tool provides very detailed explanations of violated checkpoints with improvements and recommendations that can be used to fix errors and alerts.

3.3 Inclusion of accessibility guidelines

Online evaluation is faster than a manual alternative to get an overall insight into the state of accessibility compliance of a large number of websites in a short amount of time [56]. However, the inclusion of accessibility guidelines depends on design elements such as text, image, button, animation, audio, video, and form on an evaluated webpage and online evaluations tools as they have different coverage of accessibility issues [25, 48]. For example, Guideline 1.2 Time-based Media (including Checkpoints 1.2.1 Audio-only and Video-only (prerecorded), 1.2.2 Captions (prerecorded), 1.2.3 Audio Description or Media Alternative (prerecorded), 1.2.4 Captions (live), 1.2.5 Audio Description (prerecorded), 1.2.6 Sign Language (prerecorded), 1.2.7 Extended Audio Description (prerecorded), 1.2.8 Media Alternative (prerecorded), and 1.2.9 Audio-only (live)) can be checked in a website when it contains a prerecorded or live audio/video. Besides, using online evaluation tools, it is not possible to analyze a logical tagging order of content which is essential for screen reader or keyboard users as detection of these violations are programmatically challenging and they require more advanced technology relating to content language and text understanding. Therefore, checkpoints on making text content readable and understandable (3.1.2 Language of Parts, 3.1.3 Unusual Words, 3.1.4 Abbreviations, 3.1.5 Reading Level, 3.1.6 Pronunciation) are not possible to identify by current evaluation tools. Although some guidelines are considered to be complied with, evaluation tools cannot show whether the requirement is met in an accurate and appropriate way. For instance, it is possible to check whether the alt-text is present by testing Checkpoint 1.1.1 Non-text Content under Guideline 1.1 Text Alternatives, however it is difficult to evaluate if an adequate and equivalent description for the non-text content is provided. Therefore, practitioners should pay attention to these issues during the web development process so that they can address most accessibility guidelines to be able to provide as inclusive design as possible.

4 RESULTS

Accessibility evaluations using WAVE and TAW tools produced a variety of results. We describe a number of errors, warnings, and

Table 1: Errors and alerts in the WCAG analysis

Error Numbers	No. of Websites	Alert Numbers	No. of Websites
0 (error-free)	16 (4%)	0 (alert-free)	0 (-)
1-29 (few errors)	317 (89%)	1-29 (few alerts)	316 (89%)
30-59 (moderate number of errors)	15 (4%)	30-59 (moderate number of alerts)	23 (6%)
60-89 (several errors)	2 (1%)	60-89 (several alerts)	9 (3%)
90 and above (many errors)	6 (2%)	90 and above (many alerts)	8 (2%)

Table 2: WAVE most common accessibility errors

	Type of Errors	No. of Occurrences	Websites	
			Number	% of Total
1	Very low contrast	1855	263	74
2	Empty button	964	95	27
3	Missing form label	505	157	44
4	Empty link	500	169	47
5	Missing alternative text	456	54	15
6	Linked image missing alternative text	170	61	17
7	Empty heading	100	70	20
8	Language missing or invalid	19	16	4
9	Empty form label	19	12	3
10	Missing or uninformative page title	12	12	3

alerts in terms of web accessibility derived from each tool in more detail in subsequent sections.

4.1 WAVE tool

Table 1 shows the summary of web accessibility errors and alerts detected by the WAVE tool. Overall results indicate that almost all municipality websites display a certain number of errors and alerts in web accessibility and are not consistent with compliance with accessibility guidelines. Only 16 websites (4%) were found to be error-free but contain many alerts that should be fixed. The majority of websites include few errors followed by a moderate number of errors, many errors, and several errors. Regarding the number of alerts, none of the websites passed the accessibility test. A total of 316 of the websites reported 1 to 29 alerts, 23 websites had 30 to 59 alerts, nine websites included 60 to 89 alerts, and eight websites had more than 90 alerts.

Table 2 shows regularly occurring errors, the number of occurrences, and the number of municipality websites holding the errors. Contrast error is the most frequent accessibility problem detected in the evaluation. It refers to the color combinations in the background and in the foreground for the evaluated websites. Most websites have an issue with "very low contrast". Relevant checkpoint is 1.4.3 Contrast (minimum) at the conformance Level AA. Of the municipality websites tested, 74% contain this type of error. The average is seven errors, with an SD of 9.76, indicating some variance between municipalities. Adequate contrast between text and background colors is necessary for all users, including especially users with visual impairment, low vision, or color problems. According to WCAG 2.1, the contrast ratio should be at least 4.5:1 for normal texts, and 3:1 for large texts as the smaller text requires more contrast than large text. The "empty button" (n=964) error means that buttons are empty or have no value text, which is the second-highest error incidence. This is a critical issue that needs to be solved; instead, the descriptive text should be added to the button so that screen reader users can understand the function of the button. Relevant checkpoints are 1.1.1 Non-text content (Level A) and 2.4.4 Link purpose (in context) (Level A).

Almost half of the municipality websites include a form control without a corresponding label ("missing form label") and a link without text ("empty link"). Relevant checkpoints are 1.1.1 Non-text content (Level A), 1.3.1 Info and relationships (Level A), 2.4.6 Headings and labels (Level AA), 3.3.2 Labels or instructions (Level A), and 2.4.4 Link purpose (in context) (Level A), respectively. All design elements should be presented with adequate descriptions because missing information on a page contributes to loss of control and confusion of the screen reader users. These problems, therefore, should be rectified by adding a descriptive title for the form element and providing text within the link. Other errors with the highest number of repetitions are "missing alternative text" (1.1.1 Non-text content (Level A)), "linked image missing alternative text" (1.1.1 Non-text content (Level A) and 2.4.4 Link purpose (in context) (Level A)), and "empty heading" (1.3.1 Info and relationships (Level A), 2.4.1 Bypass blocks (Level A), and 2.4.6 Headings and labels (Level AA)).

Alerts usually cause accessibility problems, so they need to be fixed to be able to develop complete accessible websites. As seen in Table 3, alerts are prevalent among the municipality websites. Many of these are due to "redundant link" (2.4.4 Link purpose (in context) (Level A)), in which the page includes adjacent links that go to the same location. This is followed by "redundant title text", in which advisory information for the title text is the same as alternative text. These should be avoided; instead, the redundant links should be

Table 3: WAVE most common accessibility alerts

	Type of Alerts	No. of Occurrences	Websites	
			Number	% of Total
1	Redundant link	2441	298	84
2	Redundant title text	1420	143	40
3	Accesskeys	533	180	51
4	Broken same-page link	390	90	25
5	Unlabeled form control with title	376	188	53
6	Underlined text	206	30	8
7	Link to PDF document	165	59	17
8	Missing first-level heading	119	120	34
9	Skipped heading level	114	96	27
10	Device dependent event handler	114	55	15

removed and combined into one meaningful link. Any redundant texts or redundant alternative texts should be removed as they cause additional repetitions for keyboard and screen reader users. Redundant title text should be either removed to avoid repetition or modified to provide advisory information.

More than half of the municipality websites contain "accesskeys" (2.4.1 Bypass blocks (Level A)) that are used to provide shortcut keys for elements on the page. Yet, it is likely to result in conflict with other shortcut keys defined by users of assistive technologies. Therefore, accesskeys should be removed to avoid conflict. "Broken same-page links" (2.1.1 Keyboard (Level A)) have been found on many municipality websites that some pages contain links that do not work. Landing a 404-error page - after clicking a link on a page - affects not only the accessibility of the page but also its quality of usability attributes, thereby user experience. It is, therefore, important to ensure that the target for the link is valid and active. Other most common accessibility alerts include "unlabeled form control with title", "underlined text", and "link to PDF document", respectively. Relevant checkpoints are 1.1.1 Non-text content (Level A), 1.3.1 Info and relationships (Level A), 2.4.6 Headings and labels (Label AA), and 3.3.2 Labels or instructions (Level A). The presence of these errors and alerts inhibits the ability of people with disabilities to effectively understand the content and navigate the website.

4.2 TAW tool

The outcome of the accessibility evaluation conducted with the TAW tool is presented in Table 4 and Table 5. Results of the evaluation indicate the existence of barriers to accessing the evaluated websites for people with disabilities. The detected errors constitute failures in the WCAG principles: perceivable, operable, understandable, and robust. As can be observed in Table 4, warnings hold maximum violations of WCAG than problems. The robust and perceivable principles reveal the highest average of problems while the operable and perceivable principles have the highest average of warnings.

A more detailed analysis of the problems and warnings on the municipality websites shows that the robust principle is the most critical issue with an average of 15.5 problems and 38.1 warnings for each evaluated website. This principle refers specifically to web content that is comprehensible by a great variety of users with different browsers, assistive technologies, and other user agents. The percentage of robust principle (48%) constitutes nearly half of the total errors, thus circumventing the accessibility regulations from being complied with. Perceivable is the second principle in terms of problems with an average of 9.9 (SD=14.45) and the third principle in terms of warnings, with an average of 22.9 (SD=32.88) detected.

The percentage of operable principle constitutes half of the total warnings (51%). The intention of the operable principle is to ensure that people with diverse disabilities navigate websites effectively. The principle with the lowest mean, in relation to problems (M=3.3) and warnings (M=10.4), is understandable, which refers to the content presented on websites that is easy to understand and comprehend by all types of users and assistive technologies without undue effort.

Table 5 gives a summary of the municipality websites' conformance to WCAG Levels A and AA, including violated checkpoints with a different number of occurrences. The vast majority of the websites violate the success criterion "1.1.1 Non-text content" of Level A in the perceivable principle, which addresses particularly the provision of alternative text for all non-text content such as images, buttons, diagrams, charts, and animations. This issue is important especially when the non-text content conveys important information. Non-text content will not be available to screen reader users unless an adequate and equivalent description for the non-text content is provided.

The most common violation found in the operable principle refers to the checkpoint "2.4.4 Link purpose (in context)" at the conformance Level A. This violation occurs when the purpose of a link is not clear enough from its text or context. It is essential to make the links clear and easy to understand because the links with adequate descriptions help screen reader users know where they are and navigate between links to reach the information needed. The problem can be solved by making the link target concise and clear in the link text and in the context of its surrounding content.

Almost half of the websites violate the success criterion "3.3.2 Labels or instructions" of Level A in the understandable principle in relation to the requirement of labels or instructions when user input is necessary for content. The solution is to ensure that input fields have simple and clear labeling, instructions, and cues in terms of any requirements for entering data. In the robust principle, 77% of

Table 4: Descriptive statistics of problems and warnings categorized by principle

Error Type	Principles	Total Errors	%	Min	Max	Mean	Std. Dev
Problems	Perceivable	3392	35.5	0	106	9.9	14.45
	Operable	966	10.1	0	91	3.8	6.56
	Understandable	596	6.2	0	39	3.3	3.68
	Robust	4606	48.2	0	100	15.5	21.42
Warnings	Perceivable	7937	25.3	0	282	22.9	32.88
	Operable	15985	51.0	0	369	45.0	41.83
	Understandable	3366	10.7	0	30	10.4	6.90
	Robust	4037	12.9	0	600	38.10	89.92

Table 5: WCAG checkpoint problems and warnings categorized by principle

Error Type	Principle	Checkpoint	No. of Occurrences	Websites	
				Number	% of Total
Problems	Perceivable	1.1.1 Non-text content	1618	323	91
		1.3.1 Info and relationships	1774	291	82
	Operable	2.4.2 Page titled	22	22	6
		2.4.4 Link purpose (in context)	944	246	69
	Understandable	3.1.1 Language of page	20	20	6
		3.3.2 Labels or instructions	576	171	48
	Robust	4.1.1 Parsing	3785	207	58
		4.1.2 Name, role, value	821	275	77
Warnings	Perceivable	1.1.1 Non-text content	3250	334	94
		1.3.1 Info and relationships	1354	257	72
		1.3.2 Meaningful sequence	989	242	68
		1.4.3 Contrast (minimum)	31	21	6
		1.4.4 Resize text	2313	221	62
	Operable	2.1.1 Keyboard	767	252	71
		2.4.1 Bypass blocks	669	287	81
		2.4.2 Page titled	332	332	93
		2.4.3 Focus order	425	146	41
		2.4.4 Link purpose (in context)	5767	248	70
		2.4.6 Headings and labels	8025	340	96
	Understandable	3.3.1 Error identification	1125	323	91
		3.3.3 Error suggestion	571	322	90
		3.3.4 Error prevention (legal, financial, data)	1670	321	90
	Robust	4.1.1 Parsing	4037	106	30

the websites contain violations against the checkpoint "4.1.2 Name, role, value" at the conformance Level A. All design elements on a webpage should have a name, role, and value attributes assigned to them so that assistive technologies can recognize the purpose of every element and gather essential information about them.

Similarly, regarding warnings, the most violated success criterion is the lack of alternative text in the perceivable principle. This is followed by the success criterion "1.3.1 Info and relationships" at the conformance Level A with 82% of the evaluated websites. The most violated checkpoints are detected in operable principle indicating that most of the municipalities fail to provide navigable websites. For instance, 96% of the websites violate the success criterion "2.4.6 Headings and labels" at the conformance Level AA, which addresses the omission of descriptive headings and labels to explain the topic and purpose that provides easier navigation on the website. Another common warning in this principle is against the checkpoint "2.4.2 Page titled" at the conformance Level A, which suggests that each page on a website should include a clear and descriptive title to let users easily understand if they are navigating on the right page.

Three checkpoints, namely "3.3.1 Error identification" of Level A, "3.3.3 Error suggestion" of Level AA, and "3.3.4 Error prevention (legal, financial, data)" of Level AA in the understandable principle, are violated by the majority of the websites, respectively. These should be avoided; instead, the municipality websites should help users avoid mistakes, identify, and describe input errors, and suggest corrections and solutions on how to fix when users make errors. In the robust principle, the success criterion "4.1.1 Parsing" of Level A is the only warning with a high number of occurrences presented by

Table 6: Accessibility errors categorized by county

Location of Municipalities	Mean	Min	Max	No. of Total Errors	Std. Dev
Viken	69	1	491	3536	89.64
Troms og Finnmark	52	6	111	2027	33.63
Agder	47	9	112	1165	38.64
Vestfold og Telemark	42	3	226	959	52.79
Trøndelag	39	7	195	1473	41.84
Innlandet	37	3	170	1658	42.77
Nordland	36	6	123	1461	33.42
Vestland	22	5	92	966	19.71
Rogaland	21	2	96	482	20.25
Oslo	18	-	-	18	-
Møre og Romsdal	17	6	66	446	11.43

30% of the evaluated websites. The websites should adopt cutting-edge technologies so that people with disabilities using assistive technologies can access all types of digital content easily.

4.3 Web accessibility map of Norway

We aggregated the data derived from WAVE and TAW tools for each county and municipality in order to have an overall view of evaluation results of accessibility in accordance with WCAG guidelines. There are 14,191 checkpoint violations with an average of 40 violations per municipality (SD=48.92). Almost half of the municipalities have an above-average number of violations, indicating that improvements are necessary to comply with the law - hence providing equal access and equal opportunities to people with disabilities.

Table 6 shows the accessibility errors detected in each county. The municipality websites in Viken present the highest average of errors (M=69), with an SD of 89.64, followed by Troms og Finnmark (M=52, SD=33.63), Agder (M=47, SD=38.64), and Vestfold og Telemark (M=42, SD=52.79). The municipality websites that have the fewest accessibility errors are Møre og Romsdal with an average of 17 (SD = 11.43), followed by Rogaland (M=21, SD=20.25), Vestland (M=22, SD=19.71), and Nordland (M=36, SD=33.42). In the evaluation, Oslo municipality displays a total number of 18 errors which is fewer than all counties, except for Møre og Romsdal. Details of the accessibility performance of each county and municipality are given in Figure 1, which depicts the aggregated results in terms of the status of accessibility of each municipality website evaluated.

A municipality with a low population does not necessarily have an accessible website. One example is Bykle kommune, which has a very low population but presents a high number of errors (n=111). This is followed by Loppa kommune, which has a very low population but garnered 105 errors. We, therefore, performed bivariate correlations to understand the relationship between the population of the municipalities and the number of success criteria they violated. A weak negative correlation (r=-0.064) was observed, which indicates that municipalities with a high population comply with more web accessibility guidelines compared to those that have a low population. In other words, municipalities with a low population violated more accessibility success criteria than bigger municipalities.

5 DISCUSSION

This paper describes the problems of web accessibility identified by online evaluation tools in municipality websites in Norway. We aim to understand to what extent Norwegian municipalities have adapted their websites to the web accessibility laws and policies. Data from 356 municipalities show that all evaluated websites fail to meet accessibility compliance. The municipality websites have several barriers and critical accessibility problems that prevent people with disabilities from effectively utilizing them. The websites violate an average of 40 checkpoints, of which many are Level A success criteria that address the minimum level of satisfaction. In the following, we discuss the evaluation results and derive implications for practice and future research.

Consistent with extant literature [4, 33], perceivable and robust are the highest violated principles in the evaluated websites. These principles aim to ensure that websites are compatible with assistive technologies, different browsers, and other user agents, and the information presented on the websites is available and understandable by all users regardless of their abilities and disabilities. The municipality websites lack features to meet the recommended level of accessibility conformance and contained numerous accessibility errors. They furthermore violated accessibility guidelines that negatively affect the navigation experience of users, especially those with visual impairments. Empty button, missing form label, empty link, and empty heading are the main violations detected in the evaluation. They all revolve around providing concise and meaningful information for design elements. This is a critical issue that needs to be solved because missing information causes the loss of control and confusion of users, particularly those who require the use of a screen reader. Adequate descriptions should be added to the design elements so that users can understand the content and function of each design element.

Previous research [4, 12, 21, 27, 33, 39] has consistently shown that the most common error in websites of municipalities is the violation of the success criterion, which is related to providing a text equivalent for non-text content. Our study garners similar results that among the detected errors, the majority of the websites have at least one issue in terms of missing alternative text. The lack of alternative text causes misinterpretation for users with visual impairments, as non-text content will not be available for

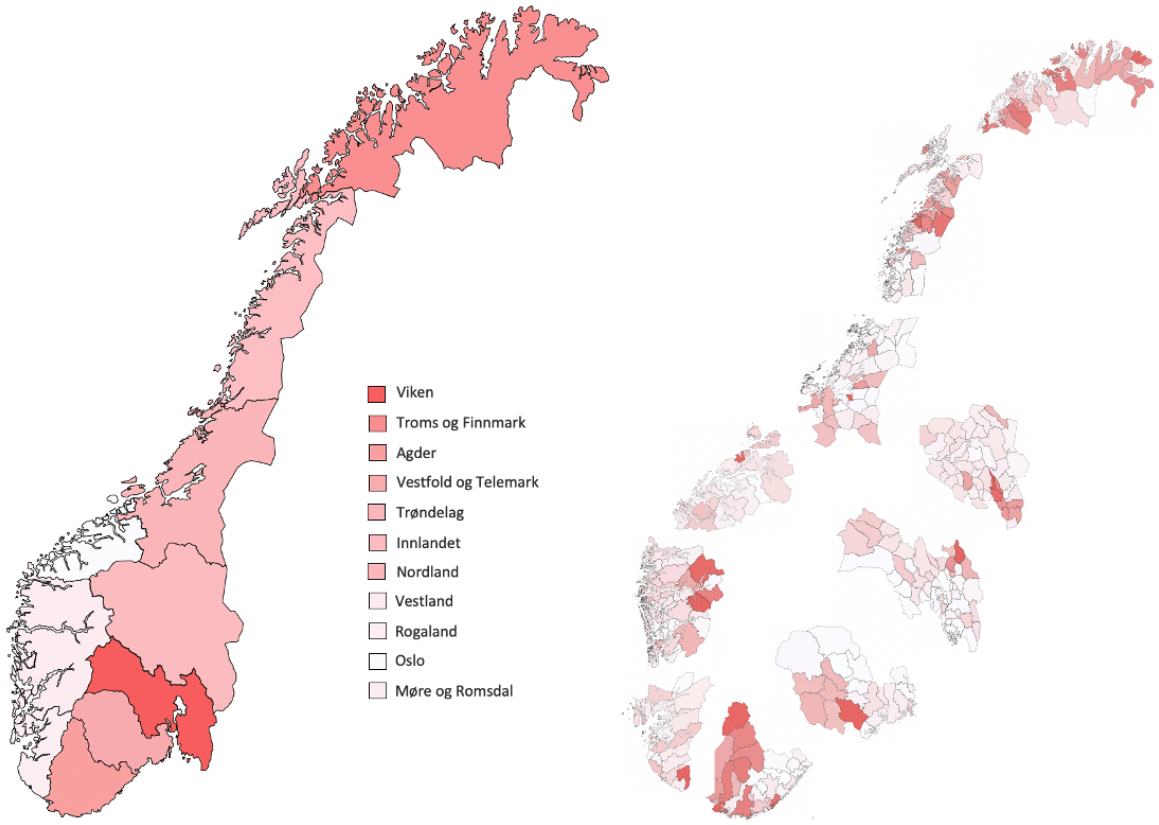

Figure 1: Status of web accessibility of each county (left) and municipality (right)

them unless a descriptive explanation is provided. What is more, very low contrast between foreground (text) color and background color is the main problem in most municipality websites. Adequate contrast is necessary, particularly for users with low vision and color deficiencies. This issue can also be challenging for everyone as it might prevent or impede an efficient reading experience. A similar pattern was observed in [37], showing that the most violated accessibility errors were insufficient color contrast in Bulgarian municipality websites.

Nevertheless, the results are promising since the majority of the accessibility errors detected in the evaluation can be easily fixed. The municipality websites mostly violate Level A success criteria which indicates that the reason for failing to meet the minimum accessibility level doesn't seem to be necessarily difficulty in implementing the accessibility practices in the development process. Besides, the number of occurrences of errors is quite high on the websites, which means that error types repeat themselves. Education and training on web accessibility are important for practitioners to gain necessary theoretical and practical knowledge [13, 18]. Poor web accessibility might result from a lack of knowledge and confidence that leads to perpetuated ignorance and negative attitudes toward the implementation of accessibility practices. Rising awareness might reduce the frequency of occurrences and help practitioners be cautious of violating the accessibility guidelines. By simply adding accessibility features, recurring accessibility errors can be easily eliminated. Therefore, it is essential to invest in developing a professional body with a high level of awareness, understanding, and knowledge in municipalities in terms of web accessibility.

Education and training are essential for practitioners to be able to obtain necessary knowledge on accessibility domain because practitioners usually lack knowledge of the needs of people with disabilities regarding using assistive technologies and how to collect data from people with disabilities to test product [9, 19]. Integrating accessibility practices in the HCI and computer science curriculum in an effective and efficient way could be a practical solution for educators. Open-community platforms for sharing knowledge, experience, and materials with regard to accessibility could be helpful for practitioners to scaffold their own learning and implementation process and increase their motivation toward accessibility domain.

We observed that some municipalities use the same web template with minor changes and adjustments. In some templates, the greatest number of accessibility errors have been detected whereas others contain very few violations. The municipality websites using the same template contain similar accessibility errors, yet their occurrences are different on each website. We propose that a common web template that complies with accessibility guidelines would provide consistency across all municipalities and eliminate most of the accessibility issues resulting from technology, operation, and

maintenance. Although any issues relating to page layout, structure, menu design and content flow might be easily managed by using a common web template that complies with accessibility guidelines, lack of personal knowledge and awareness results in inaccessible website. For instance, alt-text accessibility is created by a person who uploads non-text content to website. Therefore, it is important to note that any accessibility violations relating to personal knowledge and awareness should be eliminated.

The organizational size of municipalities is a significant factor when it comes to the adoption and implementation of guidelines and standards [11]. In line with this argument, our study found that there is a correlation between the population of the municipalities and their web accessibility performance. The municipalities with a high population violate fewer accessibility checkpoints than those with a low population. A limited budget might be a factor that results in inaccessible websites [12], such that in municipalities with a better web accessibility performance, stakeholders have a special budget that is allocated to accessibility practices [46].

Week accessibility policy results in a lack of awareness and poorly accessible websites [19, 33]. Furthermore, the main motivation for adopting accessibility practices in the web development process is policies and laws enforced by governments [21, 46]. Practitioners consider accessibility requirements more seriously when they are aware of legislation in terms of web accessibility in their countries [7]. It is, therefore, the first step to ensuring an accessible website for people with disabilities [12, 33]. Web accessibility has been legally mandatory for public services for many years however, evaluation results of previous research have consistently shown that accessibility remains a concern in public websites in Norway [17, 44]. This indicates a need for a more systematic and extensive approach to reduce the number of errors in public websites and make them reach the recommended conformance level. For instance, awareness and knowledge on national laws and regulations regarding accessibility should be improved as law is the main driver of adopting accessibility practices [20].

Taken together, the lack of compliance with accessibility guidelines indicates the existence of multiple barriers that hinder access. In this study, most detected errors seriously inhibit the ability of screen reader users to easily access and navigate the information displayed on the municipality websites. Especially users with visual impairments would not be able to navigate through the websites due to the violations. Given the low accessibility of websites, the Norwegian municipalities need to comply with the national laws and regulations, make an effort in ensuring a high degree of web accessibility - thus provide equal opportunities to each citizen to receive the same quality of information as everyone in the society.

6 CONCLUSION

This study explores the current state of accessibility of Norwegian municipality websites for people with disabilities. The evaluation was carried out in accordance with the WCAG compliance. We found that none of the municipality websites pass the accessibility test. Many errors, warnings, and alerts were detected, and robust and perceivable principles emerged as the most critical. Among the violations that are important to be highlighted included very low contrast, non-text content, empty button, missing form label, link purpose, info and relationships, and name, role, value criteria. The majority of these violations are related to features that negatively affect keyboard or screen reader users to access and navigate the websites in a normal manner. The municipalities with a higher population show better web accessibility performance.

These results show the high degree of challenges that people with disabilities are exposed to as a consequence of the lack of accessibility of the municipality websites. In order to enable the shift to sustainable, inclusive and equitable solutions for the many individuals using the websites for various reasons - e.g., to access vital information about health care services, more systematic and extensive efforts must be put on e.g., awareness-raising, management of web accessibility implementation (i.e., design and coding), technical training, and law enforcement. In the context of municipality websites, our opinion is that a common web template that complies with accessibility guidelines would not only provide consistency across all municipalities, but also eliminate most of the accessibility issues resulting from technology, operation, and maintenance. We hope this study adds to the body of knowledge on the accessibility of municipality websites in Norway and ultimately also inspires global action - in line with the UN's focus on "leaving no one behind" [45]. Albeit tool-based accessibility evaluation is still a reliable indicator of web accessibility, future research should pay more attention to implementing multiple evaluation methods to get a thorough overview of web accessibility in the country - hence ensure better municipal services "usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." [8].

7 LIMITATIONS

In this study, two commonly used online evaluation tools, WAVE and TAW, were employed for accessibility evaluation. The main limitation of the study is that only tool-based evaluation was performed to understand the current state of accessibility of municipality websites in Norway. There are further accessibility issues that are not detected by online evaluation tools and would therefore require a manual evaluation. We suggest combining the use of online evaluation tools with manual evaluation to cover as many accessibility issues as possible. This will provide consistency and obtain reliable data from evaluation results, thereby giving better insight into the state of web accessibility of an evaluated website.

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