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ORIGINAL RESEARCH

Effect of human development level of countries on the web accessibility and quality in use of their municipality websites

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Abstract
This study aimed to explore the relationship between human development index (HDI) of countries and level of web accessibility and quality in use of their municipality websites. A list of 146 countries was obtained from the 2016 Global Human Development Report of the United Nations. Of these countries, 49 had a very high HDI, 42 had a high HDI, 33 had a medium HDI, and 22 had a low HDI. For the analysis of web accessibility and quality in use, the official municipality websites of capital cities of each country were found. These websites were tested using automated evaluation tools. The results showed that the global rank of municipality websites, their rank within the country of location, and percentage of incoming traffic within the country of location varied depending on their HDI. Furthermore, the number of websites that passed all WCAG 2.0 success criteria was very low. The analysis on whether the number of accessibility errors in the evaluated websites changed according to the country's HDI showed that for conformance level A, representing the "must satisfy" checkpoints, the difference was significant. The municipality websites had fewer errors in countries with a higher HDI.

Keywords Web accessibility · Accessibility evaluation · Human development index · Automated evaluation tools · Web performance · Municipality websites

1 Introduction

According to the World Health Organization, over a billion people in the world have some form of disability, and this number corresponds to approximately 15% of the world's overall population (WHO 2017). On the basis of the United Nation reports, it is declared that people with disabilities have considerable problems regarding education, working, health, and housing (Baowaly and Bhuiyan 2012). They also have difficulties in accessing online web services and need to utilize assistive technologies. In this context, web accessibility aims to provide universal access to all kinds of online information on the web by everyone in the society (Abanumy et al. 2005). It specifically concentrates on people with disabilities and their needs in terms of using necessary assistive technologies to access online services effectively (Kurt 2011).

Despite the growing number of people with disabilities trying to access online services, they often do not have an equal chance to continuously and permanently utilize these services as people with no disabilities (Lujan-Mora et al. 2014). In fact, providing high accessible websites is the most critical issue that countries, from underdeveloped to highly developed, are expected to consider (Ismailova and Inal 2017). These websites should also be very inclusive for all citizens independent from their disability, technology use, capability, and educational background. Some developed countries, such as the USA, Canada and Australia, have strict regulations and policies about web accessibility so that people with disabilities can access online government services without any difficulty (Maisak and Brown 2014). However, the results of almost all previous studies have shown that the evaluated government websites have considerable accessibility errors (e.g., Kuzma 2010; Kopackova et al. 2010; Akgul and Vatansever 2016), and most do not even meet the minimum level of conformance (e.g., Abanumy et al. 2005; Lujan-Mora et al. 2014; Adepoju et al. 2016; Karaim and Inal 2017). This indicates

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the necessity of undertaking more work toward addressing accessibility issues of public websites to minimize the barriers that prevent people with disabilities from having an equal access to online services.

At this point, a critical question is whether the development level of a country has an effect on the level of accessibility and quality in use of the government websites of that country. Previous studies have highlighted the importance of development indicators of countries in revealing the development levels of their e-government (e.g., Makoza 2013); nevertheless, there is almost no study in the literature that focused on the relationship between the development levels of countries and the level of e-government accessibility and quality in use on a global scale. Since HDI is calculated based on dimensions such as health, knowledge and living standard (UNDP 2015), with measuring the level of access to knowledge and resources, as well as gaps and inequalities within countries, it can define the web development understanding as well. On the other hand, accessibility standards such as WCAG 2.0 ensure the access to web content to all people regardless of their health conditions (W3C 2006). In addition, website quality is also an essential component of web usage to maintain the traffic. Website quality is a wide measure that can consist of many criteria (Jati and Dominic 2009). The quality in use and performance of websites are mostly considered based on technical parameters such as load speed of a website, the number of broken links and connection errors, which have an impact on the user attraction and maintenance of the traffic. Yet, these characteristics are crucial criteria for improving Web services (Ouadah et al. 2018).

Therefore, in this study, we evaluated the web accessibility and quality in use of the municipality websites of capital cities of 146 countries in relation to the development levels of those countries. As an indicator measuring the degree of human development level of countries, the human development index (HDI) of the United Nations Development Programme was used (McGillivray 1991; Sagara and Najamb 1998; Hou et al. 2015). The HDI was chosen since, unlike GDP and GNP (which mostly measure the living standard based on national income), in evaluation of HDI, the dimensions such as health and knowledge are also measured. On the other hand, many researches show that health conditions can affect the interaction of people with websites (Alonso-Virgos et al. 2018). HDI ranks the countries from highly developed to underdeveloped on the basis of three factors; health, education, and standard of living (Wu et al. 2014).

The research questions of the study were formulated as follows:

- Does the rank of municipality websites (global and domestic ranks) and incoming traffic change according to the country's HDI?
- Does an average number of accessibility errors on the municipality websites change according to the country's HDI?
- Is there a difference between the countries with different HDI levels in terms of the number of websites that achieved conformance levels A, AA and AAA?
- Does municipal website performance vary based on the country's HDI?

2 Related literature

2.1 Studies evaluating the accessibility of government websites in a single country

Accessibility of government websites has been investigated for more than 20 years. Studies focusing on web accessibility have analyzed many different public institutions under public websites. The majority of studies in the literature focus on the evaluation of web accessibility in a single country. For example, Kuzma (2010) analyzed the accessibility issues of 130 websites of the UK members of Parliament based on both UK disability law and Web Content Accessibility Guidelines (WCAG) rules. Using Truwex 2.0 online software accessibility evaluation tool, the author found that only 30 websites satisfied the minimum conformance level according to the WCAG rules. The most violated accessibility errors were the lack of alt text explanation for each non-text element on the website.

Olsen et al. (2009) evaluated the accessibility of Norwegian municipality websites using Unified Web Evaluation Methodology mainly based on the WCAG criteria. They randomly selected 600 pages from the URL database and conducted 23 web accessibility tests. The results of the study showed that the municipal websites in the country had several barriers and significant accessibility problems that prevented people with disabilities from effectively utilizing them. Similarly, Pribeanu et al. (2012) conducted a study on the accessibility evaluation of municipal websites in Romania and tested 60 websites on the basis of WCAG 2.0 criteria using accessibility checking tools. The evaluated websites had notable accessibility problems and none passed the minimum conformance level of the guidelines. Another study focusing on the accessibility of municipal websites was conducted by Kopackova et al. (2010), who evaluated 39 government websites in the Czech Republic with a variety of online testing tools. The results of the study showed that most of the websites had severe accessibility problems according to the WCAG rules.

As revealed by the literature review, the majority of studies evaluated the accessibility of government websites according to the W3C WCAG guidelines, and only a few used section 508 rules. For example, Al-Khalifa (2012)

evaluated the Arabic version of 36 government websites from different sectors in Saudi Arabia, such as directories, ministries, and departments. The homepage of these websites was assessed on the basis of WCAG. The author identified several accessibility problems on these websites, and none passed the minimum conformance level of the accessibility guidelines. In 2016, authors carried out another tests on the same websites to evaluate the effect of new policies enforced by Saudi Arabian government to meet WCAG guidelines. Although the number of violated checkpoints decreased, yet, authors suggest that further improvement should be done (Al-Khalifa et al. 2017). Bakhsh and Mehmood (2012) analyzed 45 government websites in Pakistan according to W3C accessibility standards to determine whether people with disabilities could use them effectively. They used Total Validator and FAE online web analysis tools and reported that most of the evaluated websites were not appropriate for people with disabilities due to critical accessibility errors.

Similarly, Karaim and Inal (2017) analyzed the accessibility of a total of ten Libyan government websites according to the WCAG 2.0 criteria using AChecker and TAW online evaluation tools. All the websites failed to pass accessibility evaluation, with the most frequently violated issue being the inclusion of an alternative text for non-text elements on the websites. Kamoun and Almourad (2014) evaluated the accessibility of 21 government websites in Dubai based on the WCAG guidelines using the Web Accessibility Assessment Tool. None of these websites passed WCAG level A, which corresponds to the minimum level of accessibility conformance. Furthermore, the authors found that there was not a strong correlation between the ranking of government websites and their accessibility features.

Shi (2007) analyzed the accessibility of 339 Chinese government websites according to the WCAG criteria using an online accessibility test, and found that all the evaluated websites had violations concerning accessibility guidelines. The author concluded that in China, people with disabilities would have significant problems when using government websites. Lee et al. (2007) focused on the accessibility evaluation of the Korean e-government portal according to the W3C guidelines. They reported that very few numbers of checkpoints were met and there were critical errors regarding accessibility checkpoints.

Mitsamarn et al. (2007) tested 267 government websites according to the W3C guidelines on web accessibility. These websites had severe accessibility errors and only three passed the accessibility test based on the guidelines. Patra et al. (2014) analyzed the accessibility of a total of 15 Indian government, education and commercial websites based on the WCAG guidelines using AChecker online evaluation tool. The results revealed violation of several accessibility checkpoints, thus indicating the need for improving the websites to provide people with disabilities access without difficulties.

2.2 Studies comparing the accessibility of government websites in different countries

There are a very limited number of studies in the literature evaluating the accessibility of government websites in different countries in a comparative manner. For example, Abanumy et al. (2005) compared the accessibility of ministry websites of two countries, Saudi Arabia and Oman, using online assessment tools. The authors found that both countries needed to devote more effort to making their government websites accessible to people with disabilities. Similarly, Doulani et al. (2013) conducted a comparative study regarding the accessibility of ten university websites in the United Kingdom and Iran using W3C Link Checker, W3C markup validation service, web page analyzer and website extractor tools. The results showed that the university websites in Iran violated accessibility guidelines more and contained more errors compared to those in the UK. Ismailova and Inal (2017) analyzed the accessibility of ministry websites of Kyrgyzstan, Azerbaijan, Kazakhstan and Turkey, and found that although some government websites had more accessible features compared to others, all four countries needed to further improve the accessibility of their government websites to make them more accessible for all citizens.

Miranda et al. (2009) performed a quantitative assessment of 85 European municipal websites. They used the Web Assessment Index and evaluated the websites according to the four criteria of accessibility, speed, navigation, and content. The authors found that among all the evaluated websites from European countries, those from Italy had the best performance. Lujan-Mora et al. (2014) evaluated the accessibility of 12 South American countries using the online evaluation tools of AChecker, eXaminator, TAW, and Wave. The majority of the evaluated websites had accessibility problems and failed to pass the evaluation. Kuzma et al. (2009) focused on the accessibility issues of government websites of countries in different continents; 12 countries in Europe, four countries in Asia, and four in Africa. The authors reported that the majority of the evaluated websites were not able to satisfy the accessibility criteria, indicating that in these countries, it was not possible for people with disabilities to use these websites properly.

A very small proportion of the studies in the literature focused on evaluating the accessibility of government websites on a wide scale or on the basis of global ranking. For example, Goodwin et al. (2011) analyzed the accessibility of national government portals and ministry websites on a global scale. The authors examined 192 United Nation Member States, for the first time focusing on the relationship between web accessibility and development levels of

countries around the world. According to the results, the countries with a higher development level had more accessible government websites.

2.3 Studies evaluating the performance of websites

There are few studies that focus on the performance of government websites. For example, Al-Soud and Nakata (2010) analyzed thirty Jordan government websites. Results were compared to government websites' global average score. According to the results, in 37% of Jordan websites there were more errors and broken links than global average; 7% of websites were worse than the global average in terms of browser compatibility. Akgül (2016) tested 51 Turkish e-government websites in terms of size of websites' components (HTML, CSS, image scripts), load time, response errors, broken links and browser compatibility. Results showed that all parameters but total number of HTML files do not comply with quality guidelines. The study by Cumbie and Kar (2016) on the 101 municipality websites from Mississippi showed that there were average of 96.50 errors and an average of 49.78 compatibility issues per websites, meaning that of every 100 pages, 66 had some issues. There issues were counted over entire websites, and each of 101 websites, analyzed in this study, had in average 742 web pages. Analysis of Indian government websites (Malik et al. 2017) also showed that regular efforts are needed to increase the quality of government websites.

Choudrie et al. (2004) conducted one of the first comparative analyses of government websites. In the study, government web portals of Singapore, Finland, Canada, Hong Kong and Australia were evaluated in terms of accessibility, quality and privacy. The potential browser compatibility problems were found in all tested websites, while the broken links were present in all websites but one. Authors stated that to ensure the presence of e-government portals in web, developers payed less attention to the quality of them. In 2009, Jati and Dominic measured the quality of Hong Kong, Japan, Singapore, Malaysia, and Korea e-government websites. The tests were conducted based on five criteria—average server response time, number of components per page, webpage loading time, webpage size in byte and number of broken links. The authors reported that in e-government websites in these countries, the web quality criteria were neglected.

3 Materials and method

This study aimed to analyze the relationship between the HDI of countries and the level of accessibility and quality in use of the municipality websites of their capital cities. The list of countries was taken from the 2016 Global Human Development Report of the United Nations (UN 2016), where there was a ranking of HDI of countries provided. Based on the scores, in the report, countries were divided into four groups, namely, countries with very high, high, medium and low HDI. For each country, the capital cities were listed and the official website of their municipality was found. SimilarWeb (2016) and Alexa tools (Chrome extension versions) were used to determine the global rank of the websites and their rank within the country of location. SimilarWeb tool was also used to obtain other data, such as the estimated number of visits and bounce rates of the websites. To test the accessibility of websites, AChecker tool, developed by the Adaptive Technology Resource Centre (Gay and Li 2010), was utilized. The performance of the websites was assessed using the tool Pingdom AB. The Chrome extension of LinkMiner tool by Cooper (2015) was used to count the numbers of broken links on the selected websites. The choice of these tools was made based on the fact that they are publicly available and their effectiveness has been proven in the previous studies.

The websites of capital city municipalities of 188 countries were searched manually and the websites of 146 countries were found. The study was conducted in 2018, however, since no information on the HDI for 2017 was available, HDI of countries was taken from 2016 Global Human Development Report. According to the 2016 Global Human Development Report, of 188 countries, 49 (out of 51) had a very high HDI, 42 (out of 55) had a high HDI, 33 (out of 41) had a medium HDI, and 22 (out of 41) had a low HDI. Table 1 presents the list of countries, for which the capital city municipality websites were evaluated.

For each website, tests were conducted using automated evaluation tools to provide an overview of how they functioned and obtain their global rank, rank within the country of location, and the number of broken links. Then, the number of WCAG A, AA and AAA accessibility errors was calculated for each website. The compliance was tested to accordance with WCAG 2.0 standard, which has emerged as a result of work of many people and organizations to ease the access to web content by wider range of people with disabilities (W3C 2008). The three levels of conformance are defined as A (lowest, or minimum requirements), AA and AAA (highest, or additional requirements). Finally, the performance rates were obtained using the web version of the automated tools based on the number of images, total html and cascading style sheets collected. Finally, the ANOVA test was conducted to determine if a municipal website's accessibility and performance vary based on the country's HDI. The mean scores of collected data were compared for each group of countries at 95% confidence interval.

Table 1 List of countries for which capital city municipality websites were evaluated

	Very high HDI	High HDI	Medium HDI	Low HDI
Countries	Norway, Australia, Switzerland, Germany, Denmark, Netherlands, Ireland, Iceland, United States, Canada, Hong Kong, China (SAR), New Zealand, Sweden, Liechtenstein, United Kingdom, Japan, Korea (Republic of), Israel, Luxembourg, France, Belgium, Finland, Austria, Slovenia, Italy, Spain, Czech Republic, Greece, Estonia, Brunei Darussalam, Andorra, Cyprus, Malta, Poland, Lithuania, Saudi Arabia, Chile, Slovakia, Portugal, United Arab Emirates, Hungary, Latvia, Argentina, Croatia, Bahrain, Montenegro, Russian Federation, Romania, Kuwait	Belarus, Oman, Uruguay, Kazakhstan, Bulgaria, Bahamas, Malaysia, Panama, Seychelles, Mauritius, Trinidad and Tobago, Serbia, Costa Rica, Iran (Islamic Republic of), Georgia, Venezuela (Bolivarian Republic of), Turkey, Sri Lanka, Albania, Lebanon, Mexico, Azerbaijan, Brazil, Bosnia and Herzegovina, The former Yugoslav Republic of Macedonia, Algeria, Ukraine, Armenia, Jordan, Peru, Thailand, Ecuador, China, Fiji, Saint Lucia, Mongolia, Colombia, Tunisia, Dominican Republic, Libya, Belize, Uzbekistan	Moldova (Republic of), Botswana, Gabon, Paraguay, Egypt, Turkmenistan, Indonesia, Palestine (State of), Viet Nam, Philippines, El Salvador, Bolivia (Plurinational State of), South Africa, Kyrgyzstan, Iraq, Cabo Verde, Nicaragua, Namibia, Guatemala, Tajikistan, Honduras, India, Bhutan, Timor-Leste, Congo, Equatorial Guin, Zambia, Ghana, Bangladesh, Cambodia, Nepal, Myanmar, Kenya, Pakistan	Swaziland, Syrian Arab Republic, Angola, Tanzania (United Republic of), Nigeria, Zimbabwe, Papua New Guinea, Madagascar, Rwanda, Senegal, Uganda, Togo, Benin, Yemen, Côte d'Ivoire, Ethiopia, Congo, Guinea-Bissau, Eritrea, Mozambique, Burundi, Burkina Faso

4 Results

4.1 General overview

The ranking characteristics of the municipality websites of capital cities is given in the Table 2. The traffic rank for each HDI group of countries was calculated as an average estimate obtained from two metrics, Alexa and SimilarWeb. Other estimates were obtained using SimilarWeb. Table shows that the higher the HDI of a country, the higher the traffic rank and the estimated number of visits to the municipality websites of that country. An exception to this was observed in countries with a high HDI, for which the global rank of municipality websites was higher than that of countries with a very high HDI. Considering the rank of websites within the country of location, no obvious pattern was observed; however, this rank was also parallel to HDI.

In countries with a low HDI, nearly half of the visits to the evaluated websites were from abroad, and 54.18% was from within the country. In countries with a medium, high or very high HDI, the number of visits was much higher. The data clearly showed that the number of estimated visits over the last 30 days (prior to the date of data collection) was higher in countries with a very high HDI. There was also a difference in the number of users who navigated away from these websites; on average, in countries with a low HDI, only 45.19% left the websites after visiting a single page, without browsing any other page of the website. In countries with a medium, high or very high HDI, this percentage was 43.26, 43.67 and 46.16, respectively.

Further analysis using analysis of variance (ANOVA) showed that there were statistically significant differences regarding the global rank of municipality websites, their rank within the country of location and percent of traffic to these websites within the country of location. Multiple comparison post hoc tests revealed differences mostly between countries with a low HDI and the other countries ($p < 0.05$). For the websites of countries with a medium, high or very high HDI, the difference was not statistically significant, and thus can be considered as inconsequential. In brief, search engine optimization characteristics of the municipality websites were mostly similar in countries with a medium, high or very high HDI but different in those with a low HDI.

4.2 Accessibility analysis

The accessibility evaluation was undertaken separately for each website using AChecker. The results obtained were grouped depending on the HDI of each country. The websites of countries with a very high HDI had less accessibility errors than others (Table 3).

Table 2 The ranking characteristics of websites by HDI

	Global rank	Rank in country of location	% of traffic from country of location	Estimated visits	Time on site	Bounce rate
Number of countries						
Low HDI	5,399,890	157,271	54.18	5140	2.15	45.19
Medium HDI	2,085,699	17,461	74.54	144,217	3.27	43.26
High HDI	1,263,483	3011	85.28	306,624	3.08	43.67
Very high HDI	1,300,867	19,228	85.71	1,990,320	2.88	46.16

Table 3 Average number of accessibility errors by conformance and HDI levels

Countries with	Average number of errors by conformance level		
	A	AA	AAA
Low human development	26	22	2
Medium human development	47	10	7
High human development	25	8	10
Very high human development	10	15	5

The average number of conformance level A errors in countries with a very high HDI was 10; however, there was an outlier; a website contained 1174 errors in 2.1.1, which is related to keyboard functionality. In Table 3, the average numbers of errors are given without the outlier. Among the websites of countries with a high HDI, the average number of A level errors was 25, which was the second-best score. The municipality websites of countries with a medium HDI had more average number of errors violating conformance level A than those of countries with a low HDI. When all conformance levels were considered, the websites of countries with a medium HDI contained more errors than those of other countries. Furthermore, ANOVA was performed to determine if there was a significant difference between the HDI of countries and the number of accessibility errors in their websites. The results of the test revealed a statistically significant difference in the number of conformance A level errors, $F(3, 129) = 2.824$, $p < 0.10$. The post hoc test showed differences between the websites of countries with a medium HDI ($M = 46.79$, SD 68.47) and a very high HDI ($M = 10.02$, SD 14.94).

The number of errors at each checkpoint was also examined and the total numbers of errors by checkpoint are presented in Table 4. According to the results, in countries with a very high HDI, almost half the municipality websites (45.78%) violated checkpoint 1.4.4 at conformance level AA, which refers to the webpages being readable at least at 200% zoom at various viewport dimensions. In the websites of countries with a high, medium or low HDI, this error was the second most common error. Violation of checkpoint 1.4.4 was the source of 16.78% of errors on the websites of countries with a high HDI, 9.37% of errors in those of countries with a medium HDI, and 28.69% for those in countries with a low HDI.

The most common error in websites of countries was the violation of checkpoint 1.1.1 at conformance level A, which is related to providing a text equivalent for non-text objects. The violation of this checkpoint was observed in 35.28, 47.47 and 39.06% of all errors in countries with a high, medium or low HDI, respectively. In the municipality websites of countries with a very high HDI, this percentage was lower (22.01% of all errors). The third most violated checkpoint was 1.4.6, which states that there should be enough contrast between text and its background. In the websites of the countries with a high HDI, this success criterion was violated very often (23.82% of all violations of checkpoints). In countries with a very high, medium or low HDI, the violation of this checkpoint corresponded to 15.73, 12.00 and 3.93% of all errors, respectively. Overall, there was a noticeable pattern concerning the number of websites that passed all WCAG 2.0 success criteria.

Although the percentage of websites that passed all WCAG success criteria was low, the number of websites in countries with a very high HDI was much higher than in those with a low HDI: 14 for the former and 1 for the latter. In addition, in countries with a very high HDI, this number was almost five times higher than in countries with a high or medium HDI, in which only three websites each satisfied all success criteria (Table 5). The ANOVA test undertaken to determine whether the country's human development level had an impact on their municipality website's compliance with WCAG 2.0 success criteria revealed statistically significant differences between the number of websites that achieved conformance levels A [$F(3, 131) = 3.672$, $p < 0.05$], AA [$F(3, 131) = 3.119$, $p < 0.05$] and AAA [$F(3, 131) = 4.211$, $p < 0.05$] depending on HDI.

Further analysis using multiple comparison post hoc tests showed that for conformance levels A and AAA, there was mostly a difference between the number of websites of countries with a very high HDI and those of countries with a high or low HDI ($p < 0.05$). However, the comparison of websites of countries with a medium HDI with those of other

Table 4 The frequency and percentage of accessibility checkpoints violated by municipality websites by HDI

Checkpoints	Very high HDI		High HDI		Medium HDI		Low HDI	
	Freq	%	Freq	%	Freq	%	Freq	%
Conformance level A								
1.1.1	326	22.01	597	35.28	704	47.47	407	39.06
1.3.1	52	3.51	105	6.21	186	12.54	30	2.88
1.4.1	0	0.00	1	0.06	2	0.13	0	0.00
2.1.1	22	1.49	80	4.73	55	3.71	57	5.47
2.2.1	1	0.07	0	0.00	0	0.00	0	0.00
2.2.2	0	0.00	3	0.18	1	0.07	0	0.00
2.4.1	0	0.00	0	0.00	1	0.07	0	0.00
2.4.2	2	0.14	2	0.12	8	0.54	1	0.10
2.4.4	66	4.46	69	4.08	30	2.02	3	0.29
3.1.1	21	1.42	33	1.95	26	1.75	22	2.11
3.2.1	0	0.00	0	0.00	0	0.00	2	0.19
3.3.2	36	2.43	60	3.55	45	3.03	22	2.11
4.1	9	0.61	14	0.83	11	0.74	4	0.38
Conformance level AA								
1.2.4	0	0.00	0	0.00	0	0.00	1	0.10
1.4.3	4	0.27	19	1.12	78	5.26	143	13.72
1.4.4	678	45.78	284	16.78	139	9.37	299	28.69
2.4.6	31	2.09	22	1.30	19	1.28	10	0.96
Conformance level AAA								
1.4.6	233	15.73	403	23.82	178	12.00	41	3.93

Table 5 The number and percentage of municipality websites that passed accessibility checkpoints by HDI of countries

Checkpoints	Very high HDI		High HDI		Medium HDI		Low HDI	
	Freq	%	Freq	%	Freq	%	Freq	%
Conformance level A	17	34.69	4	9.52	3	9.09	2	9.09
Conformance level AA	14	28.57	4	9.52	3	9.09	1	4.55
Conformance level AAA	14	28.57	3	7.14	3	9.09	1	4.55

countries showed no statistically significant differences and can be considered as inconsequential. For conformance level AA, differences were observed only between the number of websites of countries with a very high or low HDI.

4.3 Quality in use analysis

The quality in use analysis included tests on load time and performance of websites, and the following factors that influenced the load score: the number of http requests, size of html, images, cascading style sheet (CSS), and scripts used on the website. In addition, the number of broken links was also counted for each website. Tests were performed using Pingdom and LinkMiner tools. Based on the results, the countries were grouped according to their HDI, and the average values were calculated.

The average load times were mostly similar with the differences between the HDI groups being less than one second, which was negligible. However, the higher minimal, average and maximal load times of municipality websites in countries with a very high HDI were still remarkable. For example, the maximal load time was 54 s among the websites of countries with a very high HDI but 44 s among those of countries with a low HDI, revealing a 10-s difference (Table 6).

To analyze the factors that affected the load time of websites, the size of elements used on these websites was evaluated. Parallel results were obtained concerning the average load time and average website size. For example, the websites of countries with a medium HDI had both the smallest average website size (3270.47 kB) and the lowest average load time (9.97 s) (Table 7). A similar pattern was observed in the maximum load times of the websites of countries with a very high or high HDI; however, there was no regularity in the load time and average website size of these websites. These results indicated that the load time of the websites could mostly be explained by the size of their components.

Table 6 Load time of capital city municipalities' websites by countries HDI

Countries' HDI	Load time (s)		
	Min	Average	Max
Very high HDI	1.69	10.67	54.04
High HDI	2.07	11.12	60.01
Medium HDI	1	9.97	60.00
Low HDI	1.12	15.08	44.02

Table 7 Size of website components (in kB) by HDI of countries

	Very high HDI	High HDI	Medium HDI	Low HDI
Total HTTP requests				
Min	21.00	1.00	3.00	34.00
Average	93.77	107.97	76.41	98.70
Max	261.00	280.00	148.00	247.00
Total HTML				
Min	1.88	1.84	1.16	5.11
Average	51.83	77.78	90.70	48.77
Max	193.85	493.94	714.75	161.81
Total images				
Min	1.23	2.99	1.62	1.04
Average	2009.67	2725.07	2160.66	189.80
Max	14,810.00	11,530.24	20,326.40	844.18
Total scripts				
Min	1.10	1.24	42.00	6.00
Average	403.02	3568.08	558.51	304.96
Max	2880.00	10,0945.00	2324.48	1007.65
Total CSS				
Min	0.70	5.00	11.00	6.00
Average	119.65	152.64	137.24	114.27
Max	673.00	544.00	508.00	379.00
Size (KB)				
Min	177.10	576.70	464.90	943.40
Average	3542.58	5164.37	3270.47	3864.34
Max	15,400.00	29,000.00	21,300.00	10,800.00

The size of most websites was increased due to images and scripts. In countries with a very high or high HDI, images occupied up to 56.43% and 52.77% of the total website size, respectively. In countries with a medium HDI, up to 66.07% of website size was taken up by images. Scripts were mostly used by developers in countries with a high HDI; in these countries, the size of scripts constituted up to 70% of the total website size.

Investigation of the response connection errors showed that in countries with a very high HDI, 36.73% of websites had a connection error. In these websites, the maximum and average numbers of errors in one page were 77 and 4.26, respectively. In countries with a high or medium HDI, the

Table 8 Number of websites with connection errors and number of errors on websites by HDI of countries

HDI level	Percentage of websites with connection errors	Response connection errors		
		Min	Average	Max
Very high HDI	36.73	0	4.26	77
High HDI	40.47	0	3.11	56
Medium HDI	45.46	0	1.96	22
Low HDI	63.64	0	1.36	7

Table 9 Number of websites with broken links and number of broken links in websites by HDI of countries

HDI level	Percentage of websites with broken links	Number of broken links		
		Min	Average	Max
Very high HDI	71.42	0	3.09	27
High HDI	54.76	0	5.97	78
Medium HDI	45.46	0	2.71	14
Low HDI	22.73	0	2.55	18

percentages of response connection errors were 40.47 and 45.46, respectively. Interestingly, in countries with a low HDI, although the maximum number of errors was seven, more than half the websites (63.64%) had connection errors (Table 8). Further analysis showed that in the websites of countries with a low HDI, there were more errors of other types; e.g., database connection error.

The analysis of broken links showed that countries with a low HDI had the lowest percentage of websites with broken links (22.73%). In addition, the lowest average number of broken links was observed among the websites of countries with a low HDI (on average, 2.3 errors per website), followed by those of countries with a medium HDI (2.71 errors per website) and a very high HDI (3.09 errors per website). However, broken links were present in 71.42% of all the evaluated municipality websites in countries with a very high HDI. For the websites of countries with a high HDI, this percentage was lower being 54.76%, but the average number of errors was high (5.97 errors per website) due to two websites having a high number of broken links (47 and 78 errors). The percentage of websites with broken links and the average and maximum numbers of errors for each group of websites are given in Table 9.

Surprisingly, according to the analysis conducted using Pingdom, the websites of countries with a low HDI had the highest average performance score (81.2 out of 100). However, none of the websites in this group achieved the highest score, with the maximum score being 94. The websites of countries with a high or very high HDI had the second and third highest average performance scores (80.2 and 79.0,

respectively). The lowest average score belonged to the websites of countries with a medium HDI (78.8); however, there were websites that scored 100. As a final step, an ANOVA test was conducted to test whether the performance of websites vary based on the country's HDI. According to the results, the mean differences in the performance grades of countries grouped by their HDI were not statistically significant, indicating no relationship between the performance of websites and HDI of countries.

5 Discussion and conclusion

Today, web accessibility is not merely a social responsibility; it should be considered as a civil right and public service. Indeed, it is such a critical web asset that all government websites are now expected to meet accessibility criteria (Karaim and Inal 2017). From underdeveloped to highly developed, all countries should provide equal opportunities to all citizens. However, as reported by almost all previous studies, people with disabilities face discrimination that prevents them from fulfilling fundamental needs including access to e-government services. The current study analyzed the accessibility and quality in use of government websites on a global scale. As a sample, we selected the municipality websites of capital cities and explored whether the development level of countries had an effect on the accessibility and quality in use of these websites. Since the websites were searched manually, only 146 websites were located from the list of 188 countries included in the 2016 Global Human Development Report of the United Nations.

The results of the study suggested that the global rank of municipality websites, their rank within the country of location, and percentage of traffic to these websites within the country of location varied depending on the HDI of countries. The higher the HDI of a country was, the higher the rank of their municipality website was on the internet. The number of estimated visits over the last 30 days (prior to data collection date) was higher in countries with a very high HDI. This is very similar to the results of the study by Ismailova and Inal (2017), in which countries with a higher HDI were found to have higher global rankings compared to those with a lower HDI. Moreover, in the present study, it was observed that in countries with a low HDI, half of the visits to the evaluated websites were from other countries.

The quality in use analysis showed a correlation between the average load time and average website size; however, the human development level of countries had only a slight impact on the load times of websites. Unexpected results were obtained considering the performance of websites, with the websites of countries with a low HDI having the highest average performance score. The websites of countries with a high or very high HDI had the second and third highest average performance scores, respectively. The lowest average score belonged to the websites of countries with a medium HDI. These differences were also found to be statistically insignificant, and the impact of a country's human development level on the quality in use of their municipality websites was negligible. This can be explained by the fact that quality in use is mostly associated with the programming skills of developers while accessibility criteria are regulated by governments. Yet, considering that municipality websites are part of governmental services, accessibility checkpoints should also be prioritized.

Studies evaluating the accessibility of government websites in different countries in a comparative manner showed that the vast majority of the evaluated government websites had considerable accessibility problems. For example, Kuzma et al. (2009) analyzed the accessibility of selected countries from Europe, Asia and Africa, and found that the majority of those counties failed to meet the minimum accessibility criteria. Lujan-Mora et al. (2014) evaluated the accessibility of 12 South American countries and concluded that almost none of the countries met the minimum level of accessibility requirements. The results of the present study were in line with those of previous studies in that only a limited number of websites passed all WCAG 2.0 success criteria. Among the 146 evaluated websites, the numbers of websites that passed all the checkpoints at conformance levels A, AA and AAA were 26, 22 and 21, respectively, which only corresponded to 14.38% of all evaluated websites.

Goodwin et al. (2011) found that countries with developed economies had more accessible government websites compared to those with undeveloped economies. The results of the present study confirmed the association between the development level of countries and the importance they attach to web accessibility. The percentage of websites that satisfied all criteria for conformance level A was much higher in countries with a very high HDI than in countries with a low HDI. In addition, in these countries, the percentage of websites that satisfied all success criteria was almost three times higher compared to countries with a high or medium HDI. The results also suggested that the human development level of countries had an effect on the websites' compliance with WCAG 2.0 success criteria for all conformance levels.

The analysis on whether the number of accessibility errors in the evaluated municipality websites depended on HDI of countries showed that for conformance level A, which represents the "must satisfy" checkpoints, the difference was significant. In countries with a higher HDI, the municipality websites had fewer accessibility errors. In other words, there was a linear relationship between human development level of countries and the web accessibility and quality in use of their municipality websites. Some of the previous studies (e.g., Kuzma et al. 2009; Lujan-Mora et al. 2014) highlighted that

having policies is not sufficient alone to make online government services accessible for people with disabilities. However, it can be claimed that they seem to constitute a valuable step considering that countries with a very high HDI have long-established regulations to ensure accessibility of government websites, which has also been demonstrated in the evaluation of their municipality websites in the current study.

Eliminating problems in the presentation of text alternatives is very important particularly for totally blind people that have to use assistive technologies, such as screen readers to effectively access and understand non-text content. In this study, the most violated checkpoints were found to be 1.1.1, which is related to providing a text equivalent for non-text objects and 1.4.4, which refers to readability at least at 200% zoom at various viewport dimensions. Similarly, in most previous accessibility studies evaluating government websites, lack of adequate explanations for all non-text elements on the website (e.g., Shi 2007; Latif and Masrek 2010; Al-Khalifa 2012; Ismail and Kuppusamy 2018) and problems regarding readability of the content (e.g., Karaim and Inal 2017) were reported to be the mostly violated accessibility checkpoints.

In conclusion, countries with a low, medium or high HDI are strongly recommended to develop action plans to regulate their accessibility policies in order to allow people with disabilities equal access to online government services as the other citizens. These countries may also choose to develop their own accessibility guidelines and standards, rather than adhering merely to the WCAG criteria. In this process, government institutions should also be encouraged to be inclusive and provide equal and constant access to all citizens (Lujan-Mora et al. 2014). Furthermore, the accessibility of these services should be maintained through regular assessments on the basis of local laws and reliable guidelines (Shi 2006).

This research has some limitations. Data was derived from automated evaluation tools, and analyses were based on the home pages of municipality websites. These tools provide quick results, which is necessary when the analysis of a large number of websites is desired. In order to obtain more accurate findings, data should be collected from all pages of websites and by accessibility experts or people with disabilities. As future research, the authors recommend evaluating accessibility of different e-government websites on the basis of different development indicators.

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