Prioritization of Mobile Accessibility Guidelines for Visual Impaired Users

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Abstract: m-Government involves delivering public services to citizens through mobile applications. Naturally, such apps should benefit everyone, including citizens with disabilities. However, several Brazilian government apps still present accessibility issues, given the high demand of development teams, which end up working on functional requirements in detriment of other aspects such as usability. In this scenario, we investigate the prioritization of mobile accessibility guidelines extracted from e-MAG (the Brazilian Government Accessibility Model) to help dealing with limited resources while also addressing accessibility. We surveyed people with some kind of disability by asking them to rate the relevance of each guideline. They were supposed to consider the severity of problems faced by them due to non-compliance. Most respondents were visual impaired users (66 out of 103 overall responses), so we considered this group of respondents in our analysis. Results show variations on the perception of relevance among subgroups with different levels of visual impairment. Moreover, results allowed us to propose a priority list of the evaluated mobile accessibility guidelines. Ultimately, the idea is to help developers with a strategy to remediate accessibility issues on existing apps and also to avoid them during the early development phases of new ones.

1 INTRODUCTION

With the increasing use of smartphones, mobile applications have been gaining ground for e-government services, which are also referred as m-government (Kushchu and Kuscu, 2003; Trimi and Sheng, 2008). In the Brazilian scenario, a population survey of 2018 shows that many households (56%) use only smartphones to access the Internet[1].

Ideally, m-government applications should be usable by everyone, guaranteeing broad access by citizens. However, users can face many problems while interacting with mobile apps, especially people with disabilities (Carvalho et al., 2018; Acosta-Vargas et al., 2020).

Aiming to address these problems, some standards have been established to help developers avoid inserting barriers in digital content, such as WCAG[2] and BBC[3] accessibility guidelines. Still considering the Brazilian scenario, the eMAG model[4] (based on WCAG) was created for the context of e-government.

Both accessibility and e-MAG compliance are enforced by law in Brazil for government websites (Law No. 13.146/2015, Ordinance No. 3/2007). Despite that, many of these websites still present accessibility issues (Oliveira and Eler, 2015; Oliveira et al., 2017). Reasons may include the high demand faced by development teams, which end up implementing functional requirements first, in detriment of other aspects such as accessibility.

Similarly, Brazilian m-government apps also present many accessibility issues (Serra et al., 2015). For this reason, in a previous work we identified a set of mobile accessibility guidelines, based on eMAG, aiming to address government mobile applications as well (Quispe and Eler, 2018). However, there is still a lack of methods and time that support the application of accessibility standards endorsed by the government (Oliveira and Eler, 2017).

In this sense, prioritization is a good strategy for dealing with limited resources and decision-making (Berander and Andrews, 2005). Hence, we further investigate accessibility in the context of Brazilian m-government, but aiming to help mobile app developers in terms of method to incorporate accessibility

[1] https://www.cetic.br/pesquisa/domicilios/indicadores
[2] https://www.w3.org/TR/WCAG
[3] https://www.bbc.co.uk/guidelines/futuremedia/accessibility/
[4] http://emag.governoeletronico.gov.br

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guidelines into their projects.

In this paper, we propose a prioritization of the mobile accessibility guidelines in Quispe and Eler (2018). To establish the priority ranking, we surveyed mobile device users with some kind of disability. We focused the analysis on results from people with visual impairment, which was our most significant group of respondents (66 out of 103 total responses).

The remainder of this paper is organized as follows. Section 2 describes the accessibility model investigated in this study. Section 3 presents the survey that we conducted with disabled people to find out their opinion on the mobile accessibility guidelines. Section 4 discusses the obtained results, i.e. the relevance rating of each guideline. Section 5 presents our proposed prioritization, based on survey results. Section 6 indicates related work and, finally, Section 7 presents conclusions, limitations and directions for future work.

2 BACKGROUND

There are many m-government apps in the Brazilian scenario, which cover several different areas, such as education, economy, citizenship and justice, science and technology, tourism, health, among others (Lima, 2017; Dutra and Soares, 2019).

In general, it is possible to observe user interface problems in such apps, especially related to accessibility (Serra et al., 2015; Isagah and Wimmer, 2017). In face of these problems, there is a need of guidelines concerning the quality of the content targeted at citizens (Lima, 2017).

The set of guidelines in Quispe and Eler (2018) identify accessibility problems that hinder the use of mobile applications. They are based on eMAG, which is the model established for Brazilian e-government.

Since eMAG is focused on websites, the authors also considered other standards on mobile applications as input, such as BBC Mobile Accessibility Guidelines[5], recommendations of the Android platform[6] and the WCAG draft for mobile devices[7].

The guidelines are outlined in tables 1 to 6, sorted by the following aspects: structure (G1-G5), behavior (G6-G11), content/information (G12-G21), presentation/design (G22-G24), multimedia (G25-G29) and forms (G30-G35). There is an id and a brief description for each guideline.

Table 1: Mobile Accessibility Guidelines – Structure.

ID	Description
G1	Screen elements should be organized in a logical and semantic way.
G2	Screens should present a logical sequence of reading to navigate between links, form controls and other elements.
G3	Links on the screen should be organized to avoid confusion.
G4	Information should be divided into specific groups to ease finding and reading content.
G5	Users should be informed if links open new screens so they can decide whether or not they want to leave current screen.

Table 2: Mobile Accessibility Guidelines – Behavior.

ID	Description
G6	All functionalities on screen should be available from the keyboard.
G7	All interface elements on screen should be accessible.
G8	There should not be automatic redirect between screens.
G9	In a time-limited screen there should be options to turn off, adjust or extend such limit.
G10	There should not be any blinking, intermittent or sparkling visual effects on the screen.
G11	User control over time-related content changes should be ensured. Animated content should not start automatically.

Table 3: Mobile Accessibility Guidelines – Content/information.

ID	Description
G12	The language used on the screen should be specified.
G13	Changes in the content language should be always specified.
G14	Screen titles should be descriptive, informative and representative of the main content.
G15	There should be a mechanism to indicate users where they are at the moment in a set of screens.
G16	Link targets should be identified clearly, including information on whether they are working or direct to other screen.
G17	All images on screen should have a text description.
G18	Documents in accessible formats should be available.
G19	When a table is used in a screen, an appropriate title and summary should be provided.
G20	The text on the screen should be easy to read and understand.
G21	All acronyms, abbreviations and unusual words on screen should have an explanation.

All eMAG guidelines (45 in total) were considered to establish the mobile guidelines. Each one was analyzed to check whether it dealt with web-specific aspects, thus indicating a need to adapt it to the mobile context. For example, keyboard-related guidelines need to reflect the way users interact with mo-

[5]https://www.bbc.co.uk/guidelines/futuremedia/accessibility/mobile

[6]http://developer.android.com/design/patterns/accessibility.html

[7]https://www.w3.org/TR/mobile-accessibility-mapping

Table 4: Mobile Accessibility Guidelines – Presentation/design.

ID	Description
G22	There should be a minimum contrast ratio between foreground and background.
G23	Sensory characteristics (e.g color, shape, sound) cannot be the only means to distinguish screen elements.
G24	The element or area on focus should be visually evident.

Table 5: Mobile Accessibility Guidelines – Multimedia.

ID	Description
G25	Videos that do not include audio should provide alternatives, such as subtitles.
G26	There should be alternatives to audio, such as a transcript and sign language version.
G27	Visual content that is not available as audio should be audio described.
G28	There should be mechanisms to control any audio that plays on the application.
G29	There should be mechanisms to control any animation that starts automatically on the screen.

Table 6: Mobile Accessibility Guidelines – Forms.

ID	Description
G30	Image buttons or audio content in forms should have text alternative or description.
G31	Each form field should be identified.
G32	A logical order of form navigation should be ensured.
G33	There should not be automatic changes when a form element receives focus, so user does not get confused or disoriented.
G34	Forms should have filling instructions.
G35	Input errors should always be described and data submission confirmed.

bile devices, allowing them to also use gestures, such as swipe to left or right, click on an item or the use of assistive technologies.

As a result, 26 eMAG guidelines did not require any adjustment, since they were generic enough to guide both web and mobile development. Namely, the unchanged guidelines were: G6-G15, G17, G19-G30, G32, G34 and G35.

A total of nine guidelines were adjusted to comprise the mobile platform characteristics, i.e. G1-G5, G16, G18, G31 and G33. Hence, the original guidelines were rewritten to reflect the context of mobile applications. For example, the G1 counterpart stated originally: "Organize HTML code in a logical and semantic way". It was adjusted to: "Screen elements should be organized in a logical and semantic way".

Still, 10 eMAG guidelines were not included nor adjusted, since there was no relation with mobile applications. For example, "comply with web standards" and "provide other specific security strategies rather than CAPTCHA".

3 SURVEY DESIGN

The proposed prioritization involves using ranks to gauge the relevance of accessibility guidelines. We assessed the relevance of each guideline based on the opinion of potential end users with disabilities, since they are the most affected people by non-compliance.

To that end, we designed a survey targeted at people with disabilities. We recruited respondents through emails to our academic community and posts on social media groups for people with disabilities. The message included the informed consent and a link to a web-based questionnaire.

The questionnaire was composed of three sections. In the first section we aimed to identify the respondent profile, by asking their age and type of disability, with the following options: vision impairment, hearing loss, physical disability, mental/intellectual disability, multiple, other or none. These questions were presented equally for all respondents.

Next, we asked the disability level with appropriate options according to the informed type of disability. For example, vision impairment had the following level options: partially sighted, low vision, legally blind and totally blind.

The second section had the purpose to identify accessibility problems. Firstly, we asked what assistive technologies they use in their mobile devices, such as screen reader, braille terminal, speech synthesizer and so on.

Then, we presented the model discussed in Section 2 and asked respondents to rate each guideline in a 5-point Likert scale, from "minor relevance" (1) to "major relevance" (5). We transcribed the guidelines into statements with simpler wording, so respondents could understand the purpose of each guideline.

Depending on the informed type of disability, a different subset of the mobile accessibility guidelines was presented to the respondent. This distinction had the purpose to narrow respondents' rating to aspects that indeed are impacted by their type of disability. For example, a blind user did not have to rate guidelines related to text color or the use of subtitles in videos.

Finally, the third section was composed of one optional question where respondents could include additional information on mobile accessibility deemed necessary.

We calculated the overall relevance for each

guideline using a weighted average, similarly to Oliveira (2005):

$$R_g = \frac{\sum_{i=1}^{5} F_i V_i}{N}$$

where:

R_g	=	relevance rating for guideline g
i	=	traverses the Likert scale options
V_i	=	value of Likert option i
F_i	=	frequency of i in responses for guideline g
N	=	total number of respondents

If the resulting value is close to five, it means that users find the respective guideline of the most important degree and, therefore, that such guideline prevents more severe barriers to visual impairment. On the other hand, if it is close to one, although still important, the guideline addresses less severe barriers.

4 RESULTS

In total, 103 people answered the survey. More than half (64.08% – 66) of respondents declared having visual impairment. The other kinds of disability had a minimal representation in results: there was one respondent with hearing impairment and one with multiple disability (less than 1% each). Surprisingly, a significant number of respondents (34% – 35) declared not having any kind of disability.

When considering only respondents that indeed have some disability (a total of 68 people), the great majority of respondents (97.06% – 66) are visually impaired. Hence, we limited the analysis of results to this group. It is important to mention that visual impaired respondents rated the following guidelines: G1, G6-G11, G15, G22-G25, G27 and G28.

Still, we also considered the informed levels of visual impairment to further divide respondents into subgroups: Partially Sighted (40 – 60.6%), Low Vision (15 – 22.7%), Legally Blind (6 – 9.1%) and Totally Blind (5 – 7.6%). We refer to these subgroups from now on by using their initials, respectively PS, LV, LB and TB.

Table 7 shows the resulting relevance (R_g), in average, for each guideline (rows) rated by respondents with visual impairment. The average relevance ratings are given both for separate subgroups and for all visually impaired respondents (columns).

Note that, in general, the relevance rating increases with the severity of visual impairment. It is possible to observe that most guidelines presented a high relevance rating, with an average above 3. Also, a subset of guidelines stands out with values above 4, namely G7, G9, G22, G25 and G28.

Table 7: Relevance of Guidelines (R_g).

g	PS	LV	LB	TB	All visual impaired
G1	2.8	3.4	4.0	4.8	3.75
G6	3.1	3.4	3.2	4.8	3.6
G7	3.8	3.8	4.2	4.6	4.1
G8	3.2	3.3	3.4	5.0	3.7
G9	3.5	4.3	3.9	4.6	4.1
G10	3.3	3.7	3.7	3.4	3.5
G11	3.4	4.2	4.2	4.2	4
G15	3.2	3.5	2.9	4.6	3.5
G22	3.5	3.8	4.2	5.0	4.1
G23	2.7	3.2	3.4	5.0	3.6
G24	3.6	3.2	4.5	4.6	4
G25	3.7	4.0	4.2	4.8	4.2
G27	3.3	3.4	4.0	4.6	3.8
G28	3.8	4.2	4.5	4.8	4.3

4.1 Partially Sighted (PS)

There were 40 partially sighted respondents, 32 of them with ages between 18 and 29 years and eight between 30 and 59 years. Table 8 shows, for each guideline, the frequency of each level of relevance (i.e. how many respondents chose each Likert option) and the resulting relevance rating for that guideline in the last column. For example, considering guideline G1, ten respondents chose option 1, nine chose 2, 11 chose 3, and so on, resulting in a weighted average relevance of 2.8.

Table 8: Results for Partially Sighted Respondents.

g	Frequency (by level of relevance)					R_g
	1	2	3	4	5	
G1	10	9	11	2	8	2.8
G6	7	10	8	3	12	3.1
G7	0	7	12	4	17	3.8
G8	2	8	19	4	7	3.2
G9	2	7	16	2	13	3.5
G10	5	7	11	5	12	3.3
G11	2	8	14	4	12	3.4
G15	4	11	9	8	8	3.2
G22	2	7	11	9	11	3.5
G23	6	12	16	2	4	2.7
G24	2	6	12	7	13	3.6
G25	1	7	12	5	15	3.7
G27	6	5	13	5	11	3.3
G28	1	4	15	3	17	3.8

Note that most values are between 2 and 4, indicating a medium level of relevance for users. Also, it is interesting to note that, for partially sighted users, there is

not much difference in the level of relevance of accessibility issues. The guidelines with higher relevance in this subgroup are G7 and G28, both with 2.8. On the other hand, the guideline G23 had the lower relevance rating (2.3).

Most partially sighted users (37) stated that do not use or feel the need to use assistive technology. Nonetheless, two users stated that sometimes use a screen reader and another one use the zoom feature of mobile devices.

In the free text question, one user left the following comments on mobile accessibility:

"Large fonts or options to increase font size are very useful, although still little used. Mobile devices present a bad resizing."

4.2 Low Vision (LV)

There were 15 users with low vision, 11 of them with ages between 18 and 29 years e four between 30 and 59 years. Table 9 shows the frequencies of each level and the respective relevance rating for this user subgroup.

Table 9: Results for Respondents with Low Vision.

g	Frequency (by level of relevance)					R_g
	1	2	3	4	5	
G1	3	1	3	3	5	3.4
G6	0	5	5	0	5	3.4
G7	1	3	2	1	8	3.8
G8	3	1	4	3	4	3.3
G9	1	0	3	1	10	4.3
G10	1	2	4	2	6	3.7
G11	1	0	2	5	7	4.2
G15	0	2	7	3	3	3.5
G22	1	1	4	4	5	3.8
G23	3	2	3	3	4	3.2
G24	4	1	2	4	4	3.2
G25	2	1	0	5	7	4.0
G27	1	3	5	2	4	3.4
G28	1	1	2	2	9	4.2

Note that, unlike partially sighted users, there is more variation among the relevance ratings of different guidelines, demonstrating that some accessibility problems have greater impact than others on users with low vision. Namely, guidelines G9, G11 and G28 are the most relevant ones according to users ($R_g > 4$), while G23 and G24 had the lower values, but still above three.

In this subgroup, 10 users informed not using any assistive technology, while two indicated using it, but did not specify which one, and two users informed using speech synthesizer and screen reader. In the last question, one respondent of this subgroup said the following:

"I think it is very important that mobile applications offer ease of use, with a simple interface that allows users to navigate and understand all functionalities easily. Nowadays there are apps whose features are difficult to understand and, consequently, use."

4.3 Legally Blind (LB)

There were six legally blind users that responded the questionnaire, five of which with ages between 18 and 29 years, and one between 30 and 59 years. Table 10 shows results for this subgroup.

In particular, it is possible to observe that most guidelines presented values above four ($R_g > 4$), thus indicating that most accessibility problems are very important for this subgroup. Still, guidelines G24 and G28 presented the higher relevance ratings ($R_g > 4.5$), while G15 had the lowest value (2.9).

Table 10: Results for Legally Blind Respondents.

g	Frequency (by level of relevance)					R_g
	1	2	3	4	5	
G1	1	0	0	2	3	4.0
G6	0	1	4	0	1	3.2
G7	0	0	2	1	3	4.2
G8	0	1	3	1	1	3.4
G9	0	0	2	3	1	3.9
G10	0	1	2	1	2	3.7
G11	0	0	2	1	3	4.2
G15	1	1	2	2	0	2.9
G22	0	0	2	1	3	4.2
G23	1	0	2	2	1	3.4
G24	0	0	1	1	4	4.5
G25	0	0	2	1	3	4.2
G27	0	0	3	0	3	4.0
G28	0	0	1	1	4	4.5

About assistive technologies, five legally blind users informed not using any aid, while one indicated using large fonts and invert colors features.

4.4 Totally Blind (TB)

There were five totally blind users that responded the questionnaire, one of which with age between 18 and 29 years, and four between 30 and 59 years. Table 11 shows frequencies of options and respective relevance ratings of each guideline for this particular subgroup.

Results clearly demonstrate that totally blind users are the most impacted subgroup by the lack of mobile accessibility. Note that most guidelines present values above 4.5 and many are close to 5.

Guidelines G8, G22 and G23 presented relevance rating of five, which is the maximum value, while G10 presented the lower value (3.4), but still above average. Four users informed using assistive technologies for interacting with mobile applications, but did not specify which ones.

Table 11: Results for Totally Blind Respondents.

g	Frequency (by level of relevance)					R_g
	1	2	3	4	5	
G1	0	0	0	1	4	4.8
G6	0	0	0	1	4	4.8
G7	0	0	1	0	4	4.6
G8	0	0	0	0	5	5.0
G9	0	0	1	0	4	4.6
G10	1	0	2	0	2	3.4
G11	1	0	0	0	4	4.2
G15	0	0	1	0	4	4.6
G22	0	0	0	0	5	5.0
G23	0	0	0	0	5	5.0
G24	0	0	0	2	3	4.6
G25	0	0	0	1	4	4.8
G27	0	0	1	0	4	4.6
G28	0	0	0	1	4	4.8

5 PRIORITIZATION OF MOBILE ACCESSIBILITY GUIDELINES

Table 12 presents our prioritization of guidelines, which is based on the survey results. Positions in the first column reflect values of relevance rating, i.e. guidelines with the higher value are in the first position, therefore indicating highest priority of the underlying accessibility problem, and so on.

We defined five different lists in the subsequent columns. There is one list for each level of visual impairment (identified by the abbreviations PS, LV, LB and TB) in the intermediate columns. Also, there is one overall list for visual impaired users in the last column. Note that some guidelines are in the same position of a given priority list (i.e. some table cells have more than one guideline). This overlap indicates that the corresponding guidelines resulted in the same relevance rating. For example, considering subgroup PS, guidelines G7 and G28 are in the first position, because both present the same relevance value.

These lists of prioritization can be used by developers as an implementation strategy, so that guidelines with higher priority can be considered earlier in the mobile app development process. If developers address accessibility in an orderly way, they ensure that barriers causing more impact to users are avoided before.

Developers can create strategies for the different levels of visual impairment, according to the potential users of the mobile application. Also, the overall list can be used to develop an app that comply with guidelines related to visual impairment as a whole.

6 RELATED WORK

There are studies addressing prioritization of usability problems to deal with limited resources, such as Hassenzahl (2000), Hertzum (2006) and Harrison and Petrie (2007). Our approach is similar to the ones adopted in these studies, which are described as, respectively, “judgment-driven priorities”, “user-made severity assignments” and “severity ratings”. In other words, ratings based on users’ opinions. Eler et al. (2019) gathered information from user reviews on the Google Play Store to understand which accessibility violation types result in higher or lower scores, but there is no systematic study on the severity of each violation type found withing different user reviews.

Severity of usability problems and relevance of accessibility guidelines are interrelated concepts, since the guidelines aim to address usability problems. Hence, it is possible to say that the relevance of a given guideline increases with the severity of the problem that it addresses.

Other studies, such as Carvalho et al. (2018), Damaceno et al. (2018) and Acosta-Vargas et al. (2020), focus on mobile accessibility problems for visual impaired users, which are in line with the user group and platform that we investigated. Still, both Serra et al. (2015) and Lara et al. (2018) are studies targeted at Brazilian m-government apps. All these studies present similar findings in the sense of encountering many recurrent accessibility problems in the evaluated mobile apps.

Prioritization of accessibility guidelines can also be related to WCAG[8] conformance levels, i.e. A, AA and AAA. Ultimately, both prioritization and conformance levels stratify accessibility requirements. However, there is a difference in how we stratified the accessibility guidelines. A WCAG criterion is assigned to a given level according to the number of users it benefits and ease of implementation (Holder, 2019). On the other hand, we assigned guidelines to different ranks according to relevance ratings determined by a specific group of people with disabilities, i.e. visual impaired users.

In another perspective, the prioritization of accessibility problems has been discussed in the context of “remediation” (Groves, 2011; Byrne-Haber,

[8]https://www.w3.org/TR/WCAG/

Table 12: Prioritization of Accessibility Guidelines for Visual Impaired Users.

Priority	Subgroups				All visual impaired
	PS	**LV**	**LB**	**TB**	
1st	G7, G28	G9	G24, G28	G8, G22, G23	G8
2nd	G25	G11, G28	G7, G11, G22, G25	G1, G6, G25, G28	G25
3rd	G24	G25	G1, G27	G7, G9, G15, G24, G27	G7, G9, G22
4th	G9, G22	G7, G22	G9	G11	G11, G24
5th	G11	G10	G10	G10	G27
6th	G10, G27	G15	G8, G23		G1
7th	G8, G15	G1, G6, G27	G6		G8
8th	G6	G8	G15		G6, G23
9th	G1	G23, G24			G10, G15
10th	G23				

2018). Basically, remediation is fixing accessibility issues/problems, which can be prioritized and tackled more efficiently.

Prioritization is done according to the impact of accessibility problems. There are several ways to account such impact[9], such as impact on users with disabilities, volume of repeated issues and traffic parts of the website/application. Again, our study considered the impact on users.

7 CONCLUSIONS

M-government applications present several recurrent accessibility problems, increasing the digital divide for citizens with disabilities. Factors include the high demand on development teams, which may focus on functional requirements, in detriment of other quality aspects such as accessibility. In this sense, prioritization is a way to deal with scarce resources while addressing accessibility at the same time.

In this paper we presented a prioritization proposal of mobile accessibility guidelines. We considered the model presented by Quispe and Eler (2018), which we adapted from eMAG in a previous work, since it is the standard enforced by law in Brazil for government websites.

To establish the priority ranks, we surveyed people with disabilities to consult their opinion on the relevance of each guideline. There were 103 respondents in total, but we limited the analysis for responses from visual impaired users, since it was the most significant group of respondents (66).

Results show that users indeed think there is a difference on the relevance of the mobile guidelines, thus enabling the prioritization. Also, it is possible to note a difference on the relevance perception among groups of different visual impairment levels.

From the obtained results we were able to create a priority list of the mobile accessibility guidelines, using as criterion the relevance perceived by visual impaired users. We also created additional priority lists for different levels of visual impairment. Ultimately, the proposed priority lists are supposed to help developers to define strategies to follow accessibility guidelines.

However, our study presents limitations. We used convenience sampling, which may introduce selection bias in the results. Also, some subgroups had a considerable low number of respondents, hence their responses may not be representative.

Still, we did not check beforehand whether respondents had trouble understanding the terms used in the questions, neither assessed their proficiency on the use of mobile devices or assistive technologies. In addition, users responded the questionnaire based on their personal experience with mobile applications and assumptions, rather than using a set of apps designated for the study.

As future work, we intend to expand the number of respondents, aiming to have a representative participation of people with other kinds of disabilities as well. Still, we intend to gather more details on respondents' profile to investigate whether the proficiency on mobile devices and assistive technologies affects relevance ratings.

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[9]https://web.accessibility.duke.edu/get-started/remediation/prioritization

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