Are Ivy League Library Website Homepages *Accessible*?

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ABSTRACT

As a doorway for users seeking information, library websites should be accessible to all, including those who are visually or physically impaired and those with reading or learning disabilities. In conjunction with an earlier study, this paper presents a comparative evaluation of Ivy League university library homepages with regard to the Americans with Disabilities Act (ADA) mandates. Data results from WAVE and AChecker evaluations indicate that although the error of Missing Form Labels still occurs in these websites, other known accessibility errors and issues have been significantly improved from five years ago.

INTRODUCTION

An academic library is "a library that is an integral part of a college, university, or other institution of postsecondary education, administered to meet the information and research needs of its students, faculty, and staff."[1] People living with physical disabilities face barriers whenever they enter a library. Many blind and visually impaired persons need assistance when visiting a library to do research. In such cases, searching the collection catalog, periodical indexes, and other bibliographic references are frequently conducted by a librarian or the person accompanying that individual to the library. Thus, professionals in these institutions can advance the use of academic libraries for the visually impaired, physically disabled, hearing impaired, and people with learning disabilities.

Library websites are libraries' virtual front doors for all users pursuing information from libraries. Fichter stated that the power of the website is in its popularization.[2] Access by everyone regardless of disability is an essential reason for its popularization. Whether users are students, parents, senior citizens, or elected officials navigating the library website to find resources, or sign up for computer courses at the library, the website can be either a liberating or a limiting experience.[3] According to the Web Accessibility Initiative (https://www.w3.org/WAI/), website accessibility means that people with disabilities can use the websites. More specifically, website accessibility means that people with disabilities can perceive, understand, navigate, and interact with websites and that they can contribute to the websites. Incorporating accessibility into website design enables people with disabilities to enjoy the benefits of websites to the same extent as anyone else in their community.

This study evaluated the current state of the accessibility of university websites of the American Ivy League university libraries using guidelines established by the Americans with Disabilities Act

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(ADA) for those who are visually or physically impaired or who have reading or learning disabilities. ADA's Section 508 and the Web Content Accessibility Guidelines (WCAG), by the World Wide Web Consortium (W3C) provide guidelines for website developers which define what makes a website accessible to those with physical, sensory, or cognitive disabilities. Since a broad array of disabilities are recognized under the ADA, websites seeking to be compliant with the ADA should use the Act's technical criteria for website design. This study used two common accessibility evaluation tools—WAVE and AChecker—for both Section 508 and the WCAG version 2.0 Level AA.

Among universities in the United States, the eight Ivy League universities—Brown, Columbia, Cornell, Dartmouth, Harvard, Princeton, University of Pennsylvania, and Yale—all have a long and distinguished history, strict academic requirements, high-quality teaching, and high-caliber students. Because of their good reputations, they are expected to lead by example, not only in terms of academic philosophy and campus atmosphere, but also by the accessibility of their various websites. Of course, any library website, whether an urban public library or a university library, should be accessible to everyone. Hopefully, this study of their accessibility can enlighten other universities on how to better develop and maintain library websites so that individuals with disabilities can enjoy the same level of accessibility to academic knowledge as everyone else.

LITERATURE REVIEW

In 1999, Schmetzke reported that emerging awareness about the need for accessible website design had not yet manifested itself in the actual design of library websites. For example, at the fourteen four-year campuses within the University of Wisconsin system, only 13 percent of the libraries' top-level pages (homepages plus the next layer of library pages linked to them) were free of accessibility problems.[4] Has this situation changed in the last twenty years? To answer this question, a number of authors have suggested various methods for evaluating software/hardware for accessibility and usability.[5] Included in the process of compiling data is "involving the user at each step of the design process. Involvement typically takes the form of an interview and observation of the user engaged with the software/hardware."[6]

Providenti & Zai conducted a study in 2007 focused on providing an update on the implementation of website accessibility guidelines of Kentucky academic library websites. They tested the academic library homepages of bachelor-degree granting institutions in Kentucky for accessibility compliance using Watchfire's WebXACT accessibility tester and the W3C's HTML validator. The results showed that from 2003 to 2007, the number of library homepages complying with basic accessibility guidelines was increasing.[7]

Billingham conducted research on Edith Cowan University (ECU) Library websites. The websites were tested twice, in October 2012 and June 2013, using automated testing tools such as code validators and color analysis programs, resulting in findings that 11 percent of the guidelines for WCAG 2.0 Level A to Level AA were passed in their first test. Additionally, there was a small increase in the percentage of WCAG 2.0 guidelines passed by all pages tested in the second test.[8]

While quite a few research studies focus on library website accessibility rather than the university websites, the conclusions diverge. Tatiana & Jeremy (2014) tested 509 webpages at a large public university in the northeastern United States using WAVE (http://wave.webaim.org) and Cynthia Says (http://www.cynthiasays.com). The results indicated that 51 percent of those webpages

passed automated website accessibility tests for Section 508 compliance with Cynthia Says. However, when using WAVE for WCAG Priority 1 compliance, which is a more rigorous evaluation level, only 35 percent passed the test.[9]

Maatta Smith reported that not one of the websites of 127 US members of the Urban Library Council (ULC) was without *Errors* or *Alerts*, with the average number of *Errors* being 27.[10] Such results were similar with Liu.[11] [12]They also found that about half (58 of 127) of the urban public libraries provided no information specifically for individuals with disabilities. Of the 127 websites, some were confusing by using the variety of verbiage to suggest services for individuals with disabilities. Sixty-six of them provide some information about services within the library for individuals with disabilities. The depth of the information varied, but in all instances contact information was included for additional assistance.

Liu, Bielefield, and McKay examined 122 library homepages of ULC members and reported on three main aspects. First, only seven of them presented as *Error* free when tested for compliance with the 508 standards. The highest percentage of *Errors* occurred in accessibility Sections 508(a) and 508(n). Second, the number of issues was dependent on the population served. That means libraries serving larger populations tend to have more issues with accessibility than those serving smaller ones. Third, the most common *Errors* were *Missing Label* and *Contrast Errors*, while the highest number of *Alerts* was related to the device-dependent event handler, which means that a keyboard or mouse is a necessary piece of equipment to initiate a desired transaction.[12]

Although they were interested in overall website accessibility, Theofanos and Redish focused their research on the visually impaired website user. The authors investigated and revealed six reasons to bridge the gap between accessibility and usability. The six reasons were:

1. Disabilities affect more people than you may think worldwide. 750 million people have a disability, and three of every ten families are touched by a disability. In the United States, one in five have some kind of disability, and one in ten have a severe disability. That's approximately 54 million Americans.
2. It is a good business. According to the President's Committee on the employment of People with Disabilities, the discretionary income of people with disabilities is $175 billion.
3. The number of people with disabilities and income to spend is likely to increase. The likelihood of having a disability increases with age, and the overall population is aging.
4. The website plays an important role and has significant benefits for people with disabilities.
5. Improving accessibility enhances usability for all users.
6. It is morally the right thing to do.[13]

Lazar, Dudley-Sponaugle, and Greenidge validated that most blind users were just as impatient as most sighted users. They want to get the information they need as quickly as possible. They don't want to listen to every word on the page just as sighted users do not read every word.[14] Similarly, Foley found that using automated validation tools did not ensure complete accessibility. Students with low vision found many of the pages hard to use even though they were validated.[15]

Outcomes of all the research revealed that most university library websites have developed a policy on website accessibility, but the policies of most universities had deficiencies.[16] Library staff

must be better informed and trained to understand the tools available to users, and when reviewing web pages, the audiences of all kinds must be considered.[17]

RESEARCH DESIGN AND METHODS

This study, as a continuing effort from an earlier study on urban library websites, made use of content analysis methodology to examine the website accessibility of the university libraries against the Americans with Disabilities Act (ADA), with a focus on those with visual or cognitive disabilities.[18] Under the ADA, people with disabilities are guaranteed access to all postsecondary programs and services. The evaluation of accessibility focuses on the main pages of these university library websites, as shown in table 1, because these homepages considerably demonstrate the institution's best effort or, at least, most recent redesigns. It was the intent of the authors of this research to reveal the current status of the Ivy League library homepages' accessibility and the importance that Ivy League universities attach to the accessibility of their websites.

Commonly recognized website evaluators (WAVE, AChecker, and Cynthia Says), along with other online tools, evaluate a website's accessibility by checking its HTML and XML code. WAVE and AChecker were selected for this study for the robustness of their evaluation based on W3C guidelines, comprehensiveness of evaluation reporting, and ready availability to any institution or individual conducting website evaluations.

WAVE is a web evaluation tool that was utilized to check websites against Section 508 standards and WCAG 2.0 guidelines. This assessment was conducted by entering a uniform research locator, URL, or website address in the search box. The evaluation tool provided a summary of *Errors*, *Alerts*, *Features*, *Structural Elements*, *HTML5 and ARIA*.

AChecker is a tool to check single HTML page content for conformance with accessibility standards to ensure the content can be accessed by everyone. It produces a report of all accessibility problems for the selected guidelines by three types of problems: *Known Problems*, *Likely Problems* and *Potential Problems*. Both WAVE and AChecker help website developers make their website content more accessible.

Data from different periods were compared to show statistically whether enough attention was paid to accessibility issues by the Ivy League university systems. The study team collected the first data set in February 2014, using WAVE for Section 508. In 2018, AChecker accessibility checker was used for both Section 508 and WCAG 2.0 AA.

The Access Board published new requirements for information and communication technology covered by Section 508 of the Rehabilitation Act (https://www.access-board.gov/guidelines-and-standards/communications-and-it/about-the-ict-refresh) on January 18, 2017. The latest WCAG 2.0 guidelines were updated on September 5, 2013 (https://www.w3.org/TR/wcag2ict/). While the WAVE development team indicated that they have updated the indicators in WAVE regarding WCAG 2.0, the current indicators regarding Section 508 refer to the previous technical standards for Section 508, not the updated 2017 ones. According to AChecker.ca, the versions of the Section 508 standards and WCAG *2.0 AA* guidelines used were published on March 12, 2004 and June 19, 2006, respectively, with neither being the latest versions.

This study centered on three research questions:

1. Are the library websites of the eight Ivy League universities ADA compliant?
2. Are there easily identified issues that present barriers to access for the visually impaired on the IVY League university library homepages?
3. What should Ivy League libraries do to achieve ADA compliance and to maintain it?

Table 1. Investigated Websites of Ivy League University Libraries.

| Library	Website Address
Brown University Library	https://library.brown.edu
Columbia University Libraries	http://library.columbia.edu
Cornell University Library	https://www.library.cornell.edu
Dartmouth Library	https://www.library.dartmouth.edu
Harvard Library	http://library.harvard.edu
Princeton University Library	http://library.princeton.edu
Penn Libraries	http://www.library.upenn.edu
Yale University Library	https://web.library.yale.edu

RESULTS & DISCUSSION

All five evaluation categories employed by WAVE for Section 508 standards, as shown in figure 1, were examined, with a more in-depth review of the homepage of the University of Pennsylvania library. Similar results in numbers of the five categories are presented in the library homepages of Brown University, Columbia University, and Cornell University. Interestingly, WAVE indicates more *Errors* and *Alerts* on the homepage of Yale University.
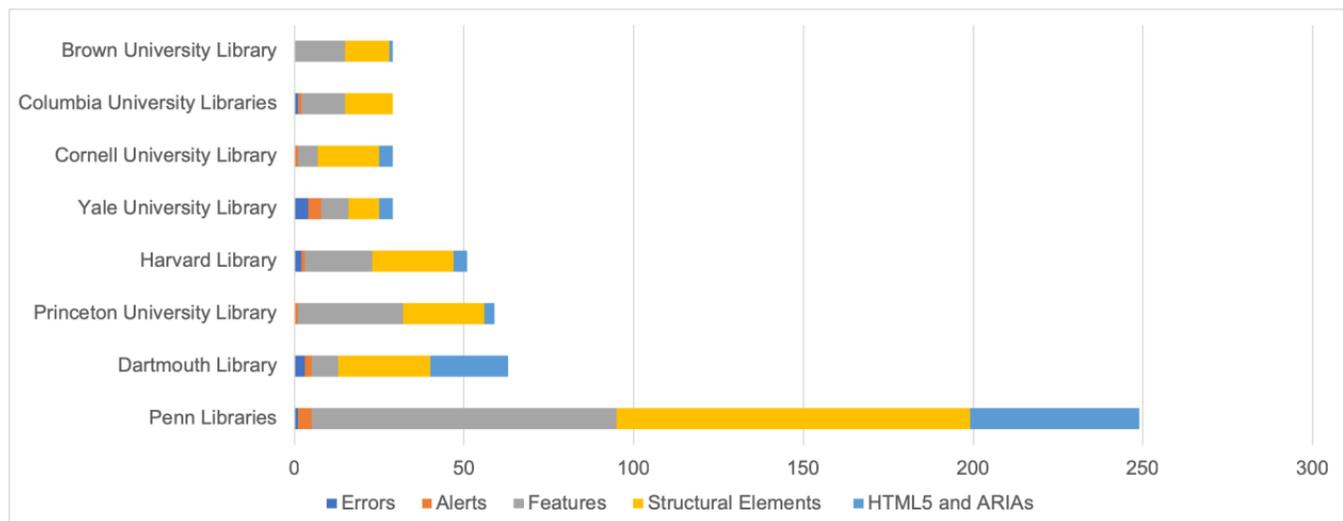
Figure 1. WAVE Results for Section 508 Standards.

In order to determine the accuracy of the results, the team also used AChecker to reevaluate these homepages in the year 2018. *Known Problems* as the category in AChecker are as serious as *Errors* in WAVE. They have been identified with certainty as accessibility barriers by the website

evaluators and need to be fixed. *Likely Problems* are problems that could be barriers which require a human to decide whether there is a need to fix them. AChecker cannot identify *Potential Problems* and requires a human to confirm if identified problems need remediation. Figure 2 shows the numbers for each category as detected by AChecker on June 18, 2018, on the eight Ivy League university libraries' homepages. The library homepage of the University of Pennsylvania was found to contain the most, which was the same as the result from WAVE. However, among the seven remaining libraries' homepages, the homepage of Harvard University library displayed the same number of problems as the University of Pennsylvania detected by AChecker.
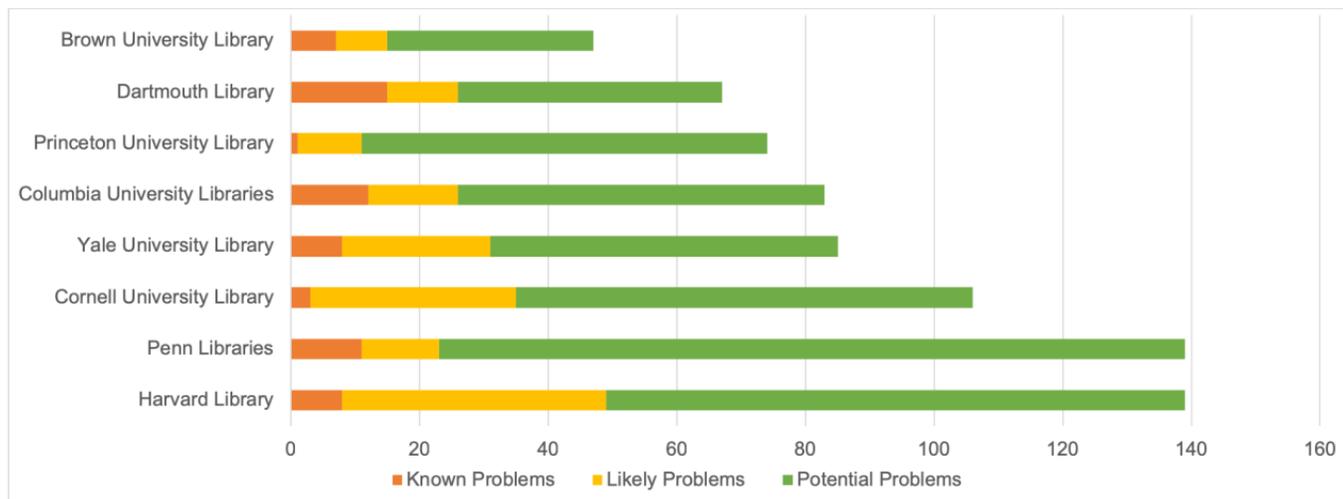

Figure 2. AChecker Results for Section 508 Standards.

There was significant improvement between 2014 and 2018
The results of this research from WAVE for Section 508 standards signify a significant shift in the accessibility of these websites between the years of 2014 and 2018. Among the five WAVE detection categories in the eight library homepages, the total of *Errors* and *Alerts* decreased during this period. For instance, the total number of *Errors* was 36 in 2014 decreasing to 11 in 2018, and the number of *Alerts* decreased from 141 to 14.

Figure 3 shows the number of *Errors* in each library homepage, and figure 4 shows the number of *Alerts*. They all show a downward trend from 2014 to 2018. But *Features*, *Structural Elements* and *HTML/ARIA* were all on the rise when comparing the two years' data sets. The green sections in table 2 indicate a decrease of the numbers in three categories from 2014 to 2018, and the yellow sections indicate an increase in numbers. These data results revealed that *Errors* and *Alerts*, the most common problems related to access, had been better controlled during these years, while others might still remain unchanged.
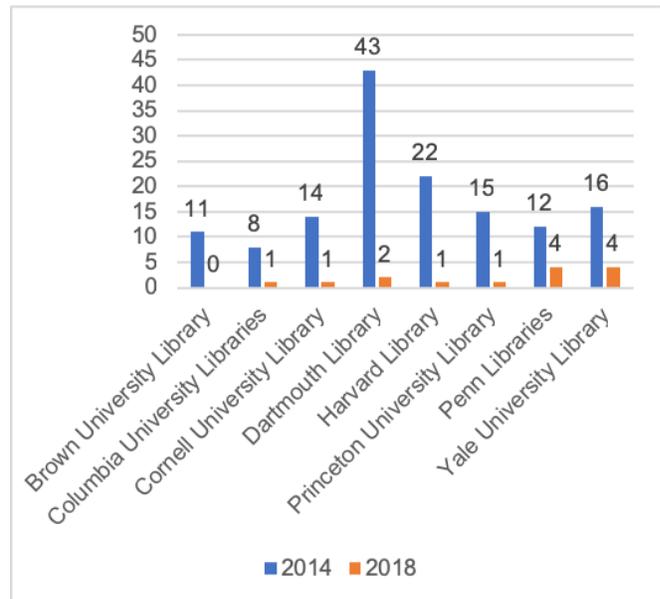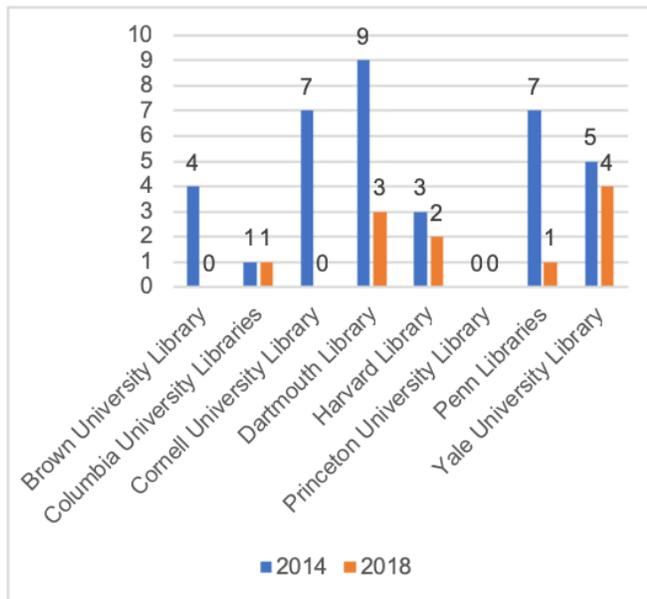
Figure 3. Change of *Errors* from 2014 to 2018.   **Figure 4.** Change of *Alerts* from 2014 to 2018.

Table 2. Changes of *Features, Structural Elements*, and *HTML/ARIA* between 2014 and 2018.

Categories	Features		Structural Elements		HTML/ARIA	
Year of Data Collection	2014	2018	2014	2018	2014	2018
Total	108	191	184	233	24	89
Brown University Library	13	15	6	13	0	1
Columbia University Libraries	12	13	23	14	17	0
Cornell University Library	5	6	20	18	0	4
Dartmouth Library	10	8	15	27	0	23
Harvard Library	20	20	14	24	0	4
Princeton University Library	15	31	45	24	0	3
Penn Libraries	12	90	29	104	7	50
Yale University Library	21	8	32	9	0	4

Missing Form Labels were the Top Error Against the ADA
The data used in the analysis below were all the test data collected in 2018. All *Errors* appearing in data results were collected and analyzed. Figure 5 shows the number of *Errors* that were identified based on the specific requirements contained in Section 508 of the Rehabilitation Act as evaluated by WAVE.
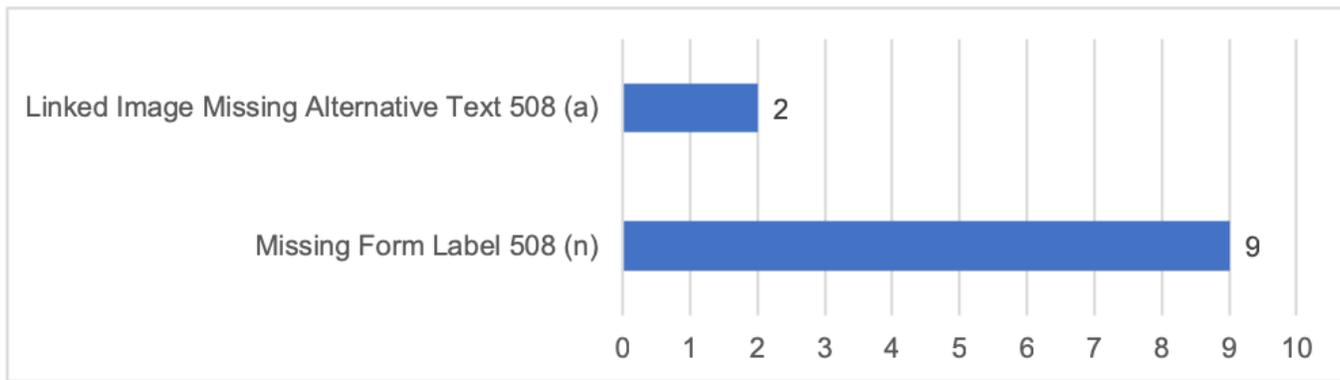
Figure 5. Occurrences of Specific *Error* per Specific 508 Standards.

The term *Error* refers to accessibility errors that need to be fixed. *Missing Form Label* was the highest frequency *Error* type shown. Only two types of *Errors* occurred in Ivy League university libraries' homepages. But these *Errors* didn't appear on every homepage. There are several *Errors* in some homepages while others had no *Errors*. For example, *Linked Image Missing Alternative Text* occurred on the library homepage of Harvard University twice. Table 3 shows the distribution of *Errors* in eight homepages.

Table 3. Distribution of *Errors* in Eight Homepages.

	Missing Form Label	**Linked Image Missing Alternative Text**
Brown University Library		
Columbia University Libraries	1	
Cornell University Library		
Dartmouth Library	3	
Harvard Library		2
Princeton University Library		
Penn Libraries	1	
Yale University Library	4	

Missing Form Label is listed in Section 508 (n) and means there is a form control without a corresponding label. This is important because if a form control does not have a properly associated text label, the function or purpose of that form control may not be presented to screen reader users. *Linked Image Missing Alternative Text* occurred only in the Harvard library homepage among the eight Ivy League university libraries' homepages. It indicated that an image without alternative text results in an empty link. If an image is within a link that does not provide alternative text, a screen reader has no content to present to the user regarding the function of the link. These website accessibility issues may be easy fixes and considered minor to some; however, if they are not detected, they are major barriers for persons living with low vision or blindness. As a result, users are left at a disadvantage because they are lacking critical information to successfully fulfill their needs. Examples of such *Error* icons in WAVE are displayed in figures 6 and 7.

Figure 6. *Missing Form Label* Icon from Yale University Library Homepage.
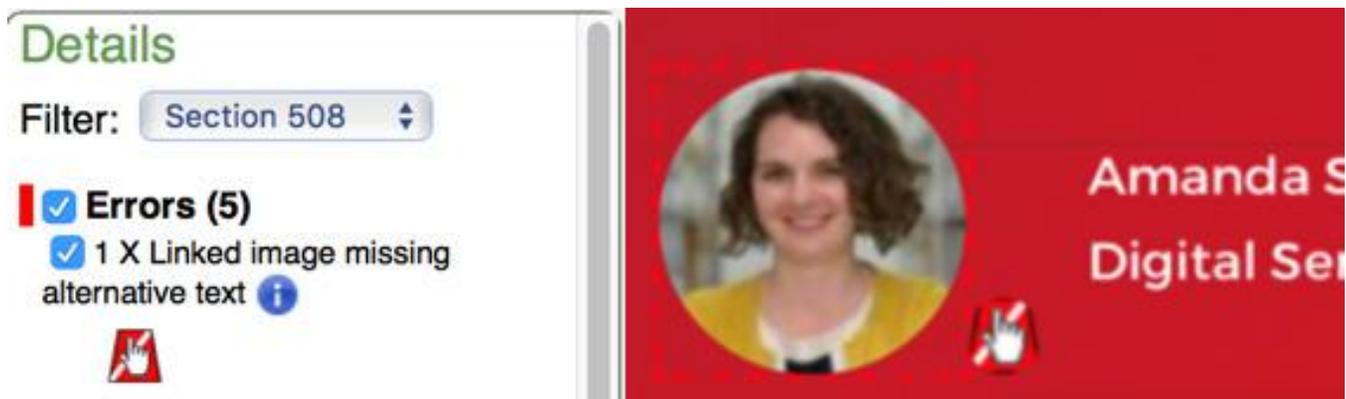
Figure 7. *Linked Image Missing Alternative Text* Icon from Harvard Library Homepage.

A total of eleven *Errors*, as shown in figure 8, were located on the homepages of the eight Ivy League libraries and illustrated the number of *Errors* that occurred in each library homepage. The average number of *Errors* for each homepage was 1.375. Yale University library homepage had the most *Errors* with a total of four. Library homepages of Brown University, Cornell University and Princeton University performed best with zero *Errors*.
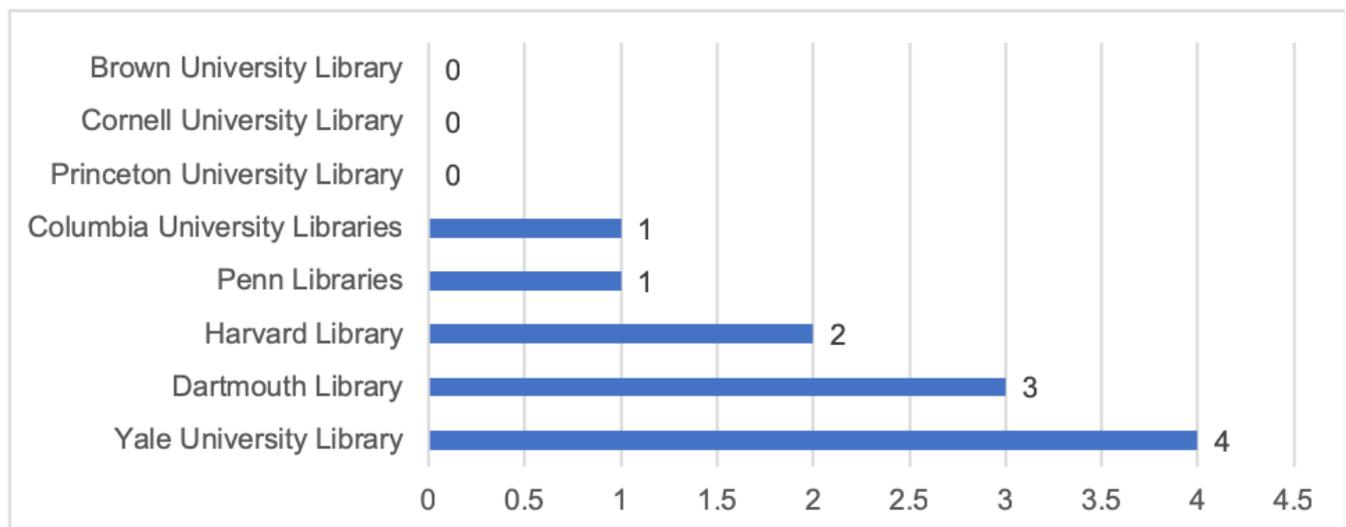
**Figure 8.** The Total of *Errors* in Ivy League Libraries' Homepages.

Six Alerts appear among ADA requirements

The issues that *Alerts* identify are also significant for website accessibility. Figure 9 shows there are six different kinds of *Alerts* that were identified based on the specific requirements contained in Section 508 of the Rehabilitation Act.
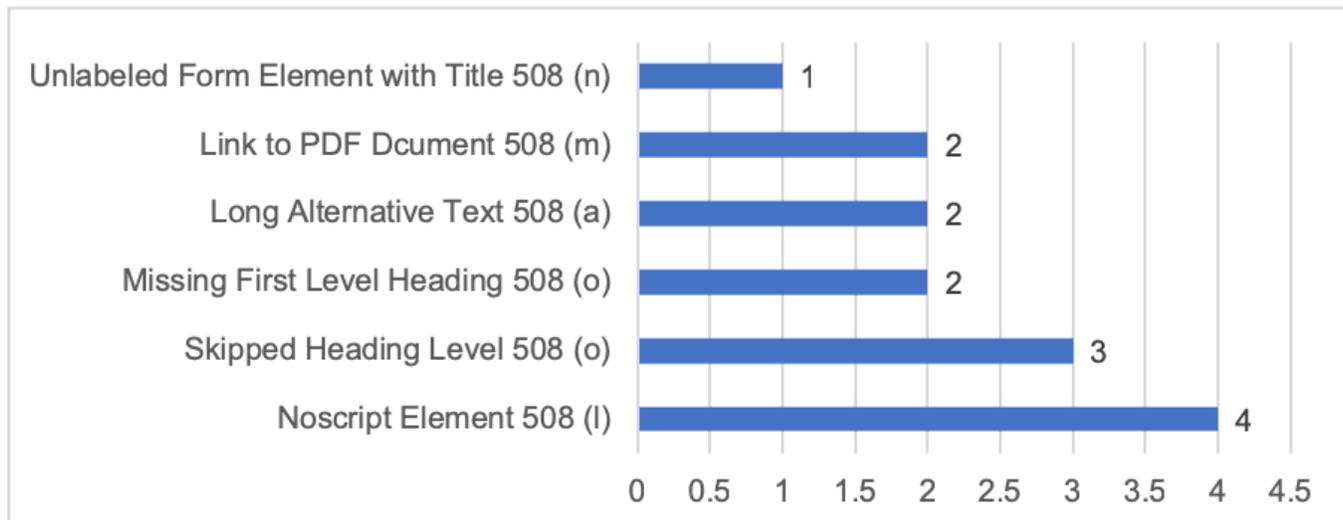

Figure 9. Occurrences of Specific *Alert* per Specific 508 Standards.

The *Noscript Element* was the most encountered *Alert* issue. *Alerts* that WAVE reports need close scrutiny, because they likely represent an end-user accessibility issue. The *Noscript Element* is related to the 508 (l) requirement and means a *Noscript Element* is present when JavaScript is disabled. For users of screen readers and other assistive technologies, almost all have JavaScript enabled, so Noscript cannot be used to provide an accessible version of inaccessible scripted content. *Skipped Heading Level* ranked was second in number. The importance of Headings is in their provision of document structure and facilitation of keyboard navigation for users of assistive technology. These users may be confused or they may experience difficulty navigating when heading levels are skipped. Examples of icons of these *Alerts*, evaluated by WAVE, indicated these *Noscript Elements* as being to accessibility, as shown in figures 10 and 11.
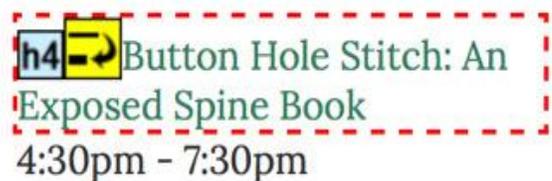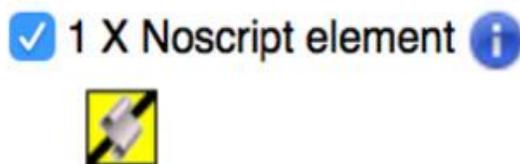

Figure 10. *Noscript Element* Icon from Cornell University Library Homepage.
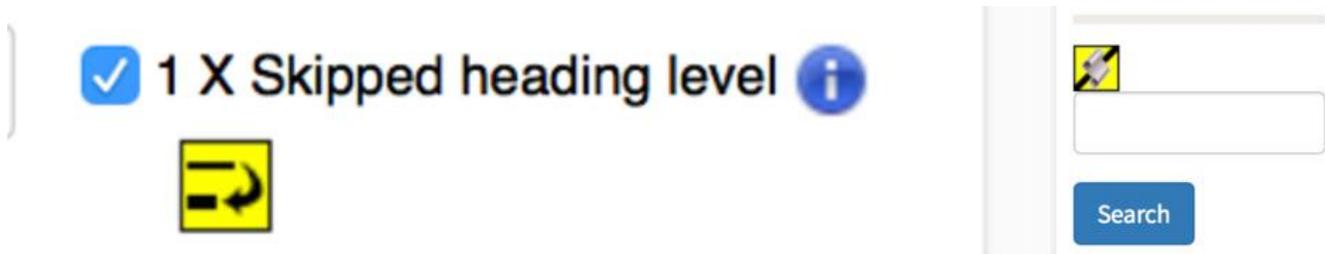
Figure 11. *Skipped Heading Level* Icon from Dartmouth Library Homepage.

A total of fourteen *Alert* problems were detected. Figure twelve illustrates the number of *Alerts* that occurred on each library homepage. On average, there were 1.75 *Alerts* present on the eight websites. The library homepages of Yale University and the University of Pennsylvania had the most *Alerts* with 4 on each site. Only the Brown University library's homepage had zero *Alerts*.
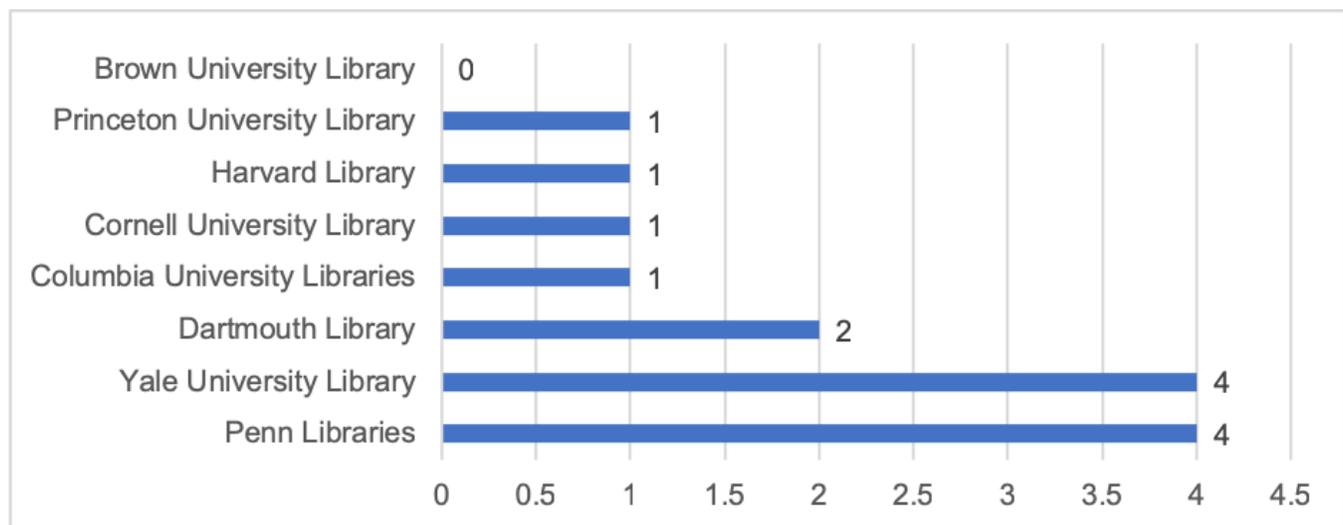
Figure 12. The Total of *Alerts* in Ivy League Libraries' Homepages.

Linked Image with Alternative Text was the most frequently found Feature issue
Features as a category of issues indicates conditions of accessibility that probably need to be improved and usually require further verification and manual fixing. For example, if a *Feature* is detected on a website, it means that further manual verification is required to confirm its accessibility. Figure 13 shows the number of *Features* that were identified, based on the specific requirement contained in Section 508 of the Rehabilitation Act.
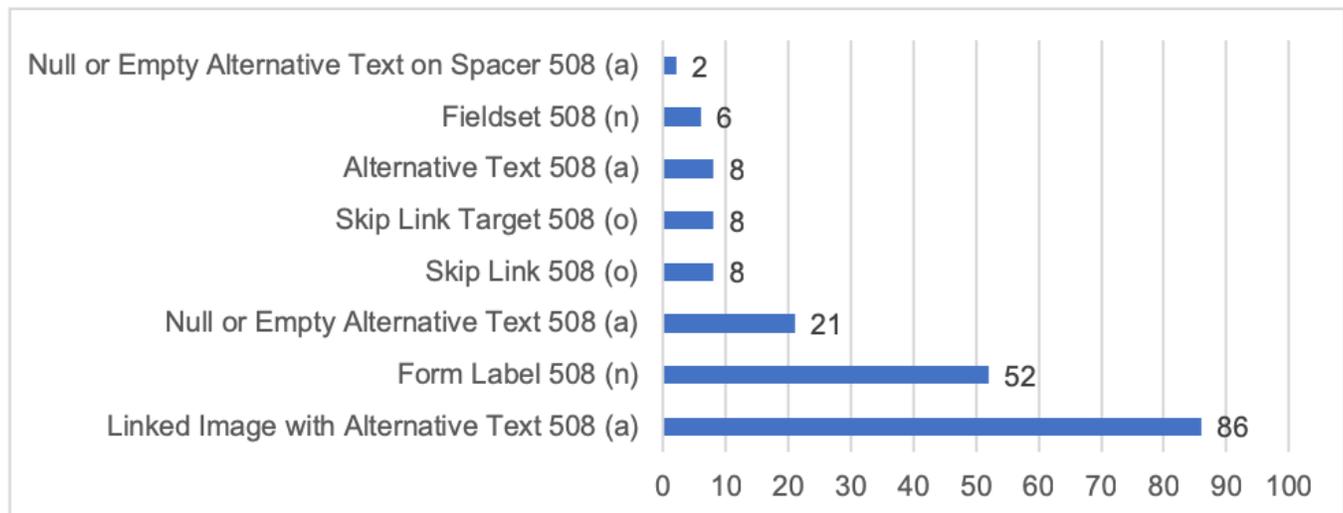
Figure 13. Occurrences of Specific *Features* per Specific 508 Standards.

Linked Image with Alternative Text, which is a 508 (a) requirement, was shown to be the most encountered *Features* issue. This means that an alternative text should be presented for an image that is within a link. By including appropriate alternative text on an image within a link, the function and purpose of the link and the content of the image are available to screen reader users even when images are unavailable. Another high occurring *Feature* was *Form Label*, which means a form label is present and associated with a form control. A properly associated form label is presented to a screen reader user when the form control is accessed. These evaluation steps were the same ones used for *Errors* and *Alerts*. Example icons of *Features* evaluated by WAVE are displayed as figures 14 and 15.
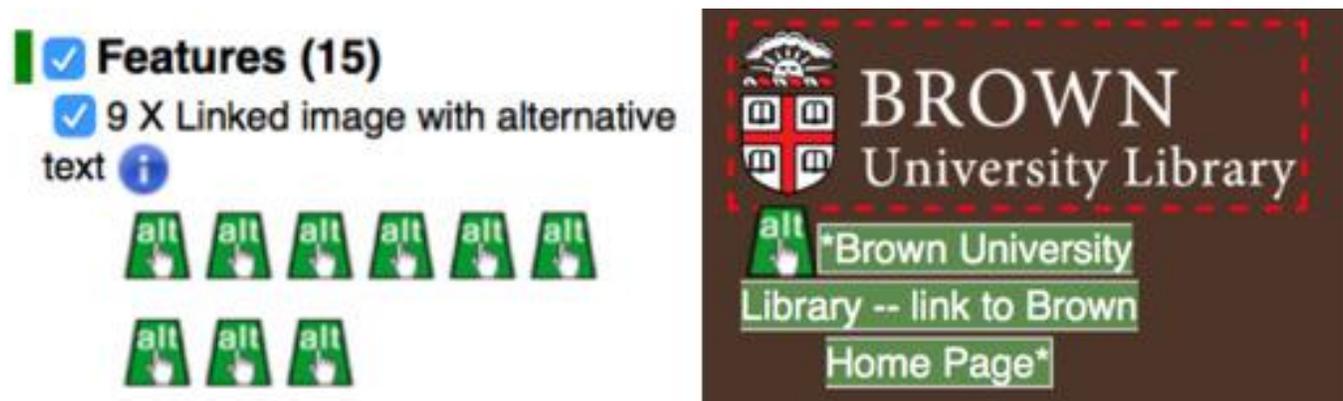
Figure 14. *Linked Image with Alternative Text* Icon from Brown University Library Homepage.
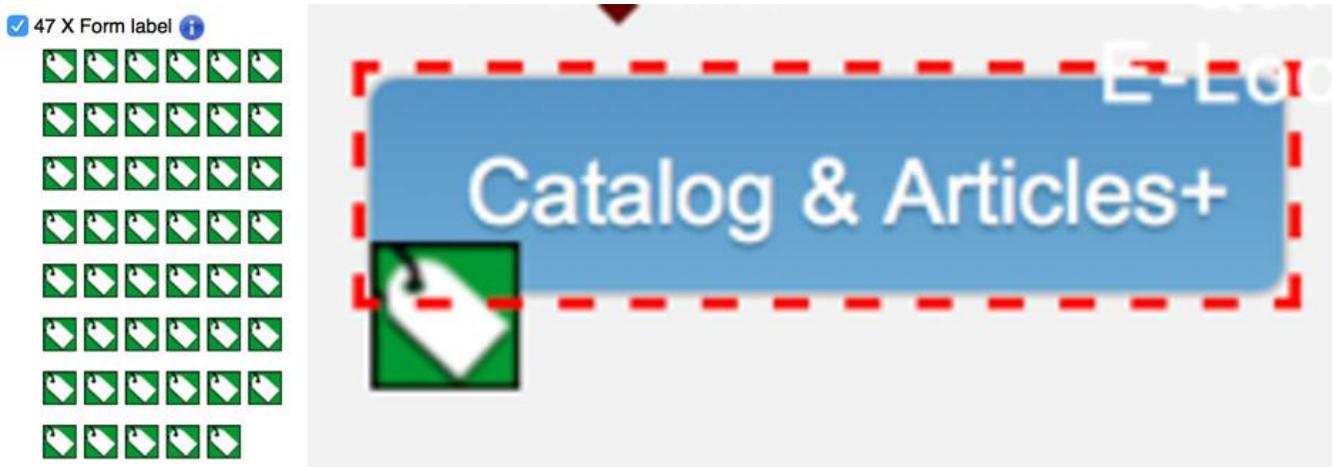
Figure 15. *Form Label* Icon from Penn Libraries Homepage.

This study also ranked the number of *Features* that were detected by WAVE in the eight Ivy League library homepages. Figure 16 displays the number of *Features* that occurred on each library homepage. In total there were 191 *Features* detected by WAVE in the eight Ivy League university libraries' homepages. The homepage of the University of Pennsylvania library was found to have 90 *Features*, by far the most of all the libraries. No library was entirely free of *Features* according to the WAVE measurement using Section 508 standards.
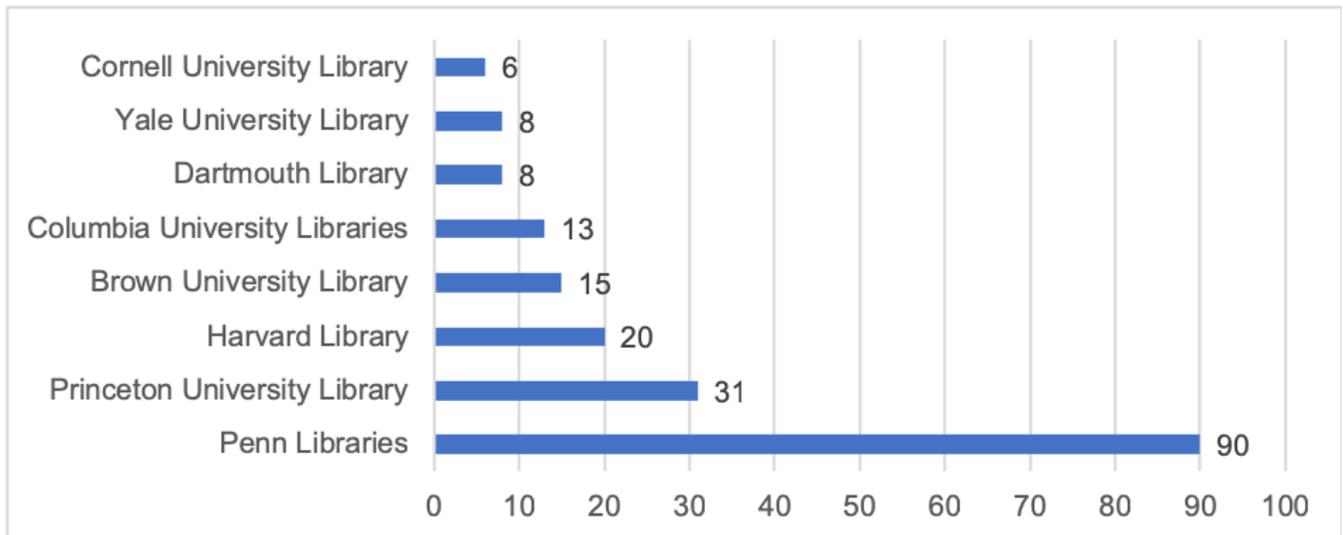
Figure 16. The Total of *Features* in Ivy League Libraries' Homepages.

Table 4A. Comparison between WAVE & AChecker Section 508 Standards on Brown and Columbia's library homepages.

Section 508 Standards	Brown University				Columbia University			
	WAVE		AChecker		WAVE		AChecker	
	April	June	April	June	April	June	April	June
Total	33	29	47	47	28	29	79	83
A	9	9	9	9	12	13	12	14
B								
C			14	14			26	28
D			8	8			14	14
E								
F								
G								
H								
I								
J			8	8			14	14
K								
L			6	6			12	12
M								
N	1	1	1	1	1	1		
O	23	19	1	1	15	15	1	1
P								

Table 4B. Comparison between WAVE & AChecker Section 508 Standards on Cornell and Dartmouth's library homepages.

Section 508 Standards	Cornell University				Dartmouth College			
	WAVE		AChecker		WAVE		AChecker	
	April	June	April	June	April	June	April	June
Total	30	29	107	106	59	68	65	67
A	2	2	2	2	8	8	10	11
B								
C			36	36			22	23
D			32	32			9	9
E								
F								
G								
H								
I								
J			33	32			9	9
K								
L			3	3			7	7
M								
N	7	7			23	29	8	8
O	21	20	1	1	28	31		
P								

Table 4C. Comparison between WAVE & AChecker Section 508 Standards on Harvard and Princeton's library homepages.

Section 508 Standards	Harvard University				Princeton University			
	WAVE		AChecker		WAVE		AChecker	
	April	June	April	June	April	June	April	June
Total	51	51	139	139	57	61	74	74
A	20	20	29	29	25	25	20	20
B								
C			43	43			32	32
D			32	32			10	10
E								
F								
G								
H								
I								
J			34	34			10	10
K								
L							1	1
M								
N	5	5			3	7		
O	26	26	1	1	29	29	1	1
P								

Table 4D. Comparison between WAVE & AChecker Section 508 Standards on Pennsylvania and Yale's library homepages.

Section 508 Standards	University of Pennsylvania				Yale University			
	WAVE		AChecker		WAVE		AChecker	
	April	June	April	June	April	June	April	June
Total	253	249	129	139	28	29	84	85
A	40	37	14	19	6	7	4	5
B								
C			82	87			28	28
D			11	11			21	21
E								
F								
G							1	1
H								
I								
J			11	11			21	21
K								
L	1	1	9	9	3	3	4	4
M	3	2						
N	103	104	1	1	8	8	4	4
O	106	105	1	1	11	11	1	1
P								

A Few 508 Standards Deviate from Comparison between two Evaluators
To determine whether the WAVE tool missed some specific requirements in Section 508, the authors comparatively examined these eight university homepages using both WAVE and AChecker from one site to another synchronously in April and again in June 2019.

There are sixteen principles in Section 508. They are arranged from A to P. Tables 4A–4D indicate issues for these Section 508's requirements in the eight universities' homepages respectively. Except the requirement G for Yale library homepage which shows one issue in AChecker, in neither WAVE nor AChecker during the time we conducted our examination, there was no issue found for the seven requirements (B, E, F, H, I, K, and P) below:

B.   Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation;

E.   Redundant text links shall be provided for each active region of a server-side image map;

F.   Client-side image maps shall be provided instead of server-side image maps except where the regions cannot be defined with an available geometric shape;

H.   Markup shall be used to associate data cells and header cells for data tables that have two or more logical levels of row or column headers;

I.   Frames shall be titled with text that facilitates frame identification and navigation;

K.   A text-only page, with equivalent information or functionality, shall be provided to make a website comply with the provisions of this part, when compliance cannot be accomplished in any other way. The content of the text-only page shall be updated whenever the primary page changes;

P.   When a timed response is required, the user shall be alerted and given sufficient time to indicate more time is required.

The results tabulated in tables 4A–4D indicate that these seven Section 508 requirements perhaps are not problematic to the websites.

CONCLUSIONS

Based on the results, this study determined that the eight Ivy League universities' homepages exhibited some issues with accessibility for people with disabilities. Considerable effort is necessary to ensure their websites ready to meet the challenges and future needs of web accessibility.

Users with visual impairments can navigate a website only when it is designed to be accessible with other assistive technology. While each institution presented both general and comprehensive coverage of services for users with disabilities, it would have been more practical and efficient if specific links were posted on the homepage. According to the American Foundation for the Blind (https://www.afb.org), "usability" is a way of describing how easy a website is to understand and use. Accessibility refers to how easily a website can be used, understood, and accessed by people with disabilities.

This study has concluded that expertise and specialized training and skill are still needed in this area. Principles of accessible website design must be introduced and taught, underscoring that design matters for people with disabilities just as it does in the physical environment. As highlighted earlier through the evaluation tool WAVE, most of the problems detected can be fixed with provided solutions. A frequent review is critical and websites should be assessed at a minimum on a yearly basis for accessibility compliance. There is much to be done if accessibility is to be realized for everyone.

LIMITATIONS

The authors recognize that this study, using free website accessibility testing tools, has certain limitations. As WAVE remarked in their HELP page, the aim of website developers is not to get rid of all identified problem categories except *Errors* that need to be fixed, but to determine whether a website is accessible. At the time of writing neither WAVE nor AChecker were updated with the latest general WCAG 2.1 AA rules. While the version of WCAG 2.1 is expected to provide new guidelines for making websites even more accessible, more careful and comprehensive studies against the WCAG 2.1 AA rules could further assist university library professionals and their website developers to provide those with disabilities with accessible websites. Moreover, while it is effective to conduct these machine-generated evaluations, it is equally important that researchers check the issues manually to impose human analysis in determining the major issues with content.

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