

**International Journal of Emerging Multidisciplinary Research And Innovation
(IJEMRI)****Feature Density and Digital Inclusion: An Accessibility Burden
Analysis of Indian Academic Library Websites****¹Madhuri Kumari, ²Dr. Minaxi Parmar**¹Research Scholar, Central University of Gujarat, India,ORCID ID: <https://orcid.org/0000-0002-3205-0323>²Assistant Professor, Central University of Gujarat, India,ORCID ID: <https://orcid.org/0000-0003-0482-2055>**ABSTRACT**

Over the last 10 years, the academic library websites in India have increased their functional complexity significantly, but there is little systematic evidence of such expansion has led to greater inaccessibility of the websites to users with disabilities. The research question about the level of feature density, structural complexity and ARIA (Accessible Rich Internet Application) implementation had any relationship with accessibility in 100 academic library websites that were selected based on four administrative categories: Central, Deemed, Private and State universities. Based on accessibility audit data produced by the WAVE evaluation tool, the study proposes and implements the Accessibility Burden Index (ABI), a composite index that represents the ratio of the number of accessibility problems accrued by a website to the positive accessibility infrastructure. The ABI is meant to show reported problems relative to page content, which raw error counts do not capture. WAVE counts were strongly right-skewed, so the analysis used medians, Spearman correlations with bootstrap confidence intervals, and Kruskal–Wallis tests with Holm-adjusted post hoc comparisons. The sample had 13 Central, 38 Deemed, 10 Private and 39 State universities. The median ABI was 0.41 (mean 1.42), and 24 sites scored 1.00 or higher. Central universities had the highest median (1.11), but category differences were not statistically significant ($H = 6.02$, $p = 0.110$) and changed when ARIA was removed from the formula. ABI was unrelated to error counts ($\rho = -0.15$). It was driven mainly by its denominator, where structural elements and ARIA make up 92%. ARIA volume rose with errors ($\rho = 0.51$), which suggests that ARIA counts reflect interface complexity rather than accessibility effort. The paper proposes the ABI as an exploratory screening ratio. It should not be used as an accreditation threshold until it is validated with user testing, and raw WAVE counts should be reported beside it.

Keywords: *Academic Library Websites; Accessibility Burden Index; Digital Inclusion; Feature Density; Web Accessibility.*

DOI: <https://doi.org/10.65180/ijemri.2026.2.4.04>

1. Introduction

The role of an academic library website has changed considerably since the advent of the first online catalogue in the 1990s. What began as a search interface for physical holdings has become a complex digital environment integrating layers, institutional repositories, federal database access, an interlibrary loan system, a virtual reference service and personalised content recommendation engines. Such functional growth is indication of a genuine commitment to wide access to scholarly resources.

The inquiry this study addresses concerns related to the users who may not have benefited. Web accessibility, the extent to which a website can be used effectively to the disabled persons, is a substantial commitment must be actively maintained as a website becomes more complicated. Every new interactive element, each additional navigation layer, each embedded third-party elements creates conditions under which accessibility can fail unless design choices are not made with assistive technology by taking into consideration. A website widely accessible at 50 features might not be available at 500 unless the development process has been in progressing.

The Web Content Accessibility Guidelines (WCAG), maintained by the World Wide Web Consortium (W3C), offer internationally recognised web design accessibility guidelines. WCAG 2.1 introduced specific criteria for mobile accessibility and users with cognitive and learning disabilities (2018), the operative standard for institutional websites. Despite two decades of guideline development and growing legal pressure, including India's Rights of Person with Disabilities Act 2016, which mandates accessible information and communication services (Rights of Persons with Disabilities Act, No. 49 of 2016, 2016), compliance among Indian academic libraries has not yet been systematically examined through a framework that accounts for the relationship between interface growth and accessibility outcome.

Most prior research in the field measures compliance levels: how many errors does a site generate and how far does it fall from WCAG conformance? These measures are informative,

but they treat error counts as context-free. There is a vast difference between a site that has 30 errors and 600 positive accessibility features and a site that has 30 errors and 4 features. Raw counts do not capture those differences. This study can be conducted using the Accessibility Burden Index (ABI).

The ABI is a ratio metric that divides accumulated accessibility issues (confirmed errors, contrast failures, and alerts generated by automated testing) by positive accessibility indicators: features, structural elements and ARIA attributes. A high ABI means that the problem load on a web site exceeds the accessibility infrastructure of the web site; a low ABI indicates the reverse. The ABI is a descriptive ratio, not a validated measure of exclusion risk. Part of this study tests what the index does and does not capture.

The Indian higher education context is a particularly informative context for analysis. India has one of the largest university systems in the world which includes institutions across four categories: Central Universities (federally funded), Deemed Universities (Autonomous Universities with University equivalent status), Private Universities and State Universities. There are significant differences in terms of the form of governance, the level of funding, the technical capacity and the accountability mechanism. This variation can be used to consider the impact of institutional factors on accessibility outcomes other than those linked to individual design decisions.

This paper has the following structure. Section 2 discusses the literature on web accessibility testing, academic library accessibility and ARIA. The purpose of the study is detailed in Section 3. Section 4 describes the sample, the WAVE variables, the ABI formula and the statistical procedures. Sections 5 to 8 give descriptive, comparative and correlational results, with sensitivity analyses, tables and figures. Section 9 discusses the results, their limits, and their implications for policy and practice and section 10 is conclusion.

2. Review of Relevant Literature

2.1 Web Accessibility Standards and Their Application

Web accessibility refers to the design of digital content and interfaces such that individuals with visual, motor, auditory, cognitive, or neurological disabilities can use them efficiently. The conceptual basis for this requirement is clearly stated in the W3C's foundational document: universal access regardless of disability is an essential property of the web, not an optional enhancement (Consortium, 2023). The WCAG operationalise this principle through four guiding precepts: Perceivable, Operable, Understandable and Robust (POUR), each broken into guidelines and success criteria at three conformance levels: A (minimum), AA (standard), and AAA (enhanced). Most institutional websites, including academic libraries, are typically expected to reach level AA.

The WHO (2011) estimates that approximately one billion people (15 per cent of the global population) live with some form of disability (WORLD REPORT ON DISABILITY WHO Library Cataloguing-in-Publication Data World Report on Disability 2011., 2015). Among these, colour vision deficiency alone affects around 8 per cent of males (2023), while visual impairment, mobility limitation and cognitive disabilities each represent a substantial sub-population that interacts with digital content differently from non-disabled users. In instances where a library website does not meet WCAG criteria, the obstacles posed are not minor inconveniences but may impede task completion for users who must rely on screen readers, switch access devices or magnification software.

Although the requirements of WCAG are clear and evaluation tools which can identify most violations are available, the overall compliance of institutional web pages is inconsistent. In surveys of university and library websites in a variety of national settings, compliance is often partial at best and the same types of failure missing alternative text, contrast violations, lack of form labels, and disordered heading structures have been observed to recur across studies spanning years or decades.

2.2 Academic Library Websites Accessibility Research

The systematic review of the accessibility of academic library websites dates to the early 2000s. A first large-scale audit of the websites of US academic libraries is credited to Schmetzke (Schmetzke, 2001). The audit identified non-compliance and missing alternative text and unlabelled form controls as the most common types of failure. His methodological contributions in the form of replicable, quantitative, multi-institutional evaluation with automated tools formed the paradigm for other studies in this field.

A decade later, Comeaux and Schmetzke re-examined the same research question and discovered that, although some progress was made, the basic patterns of failure remained (Comeaux & Schmetzke, 2013). Their longitudinal comparison resulted in a crucial inference: because the same errors persisted over time, it was not a technical issue but a governance issue that needed to be addressed. Websites that are developed without accessibility testing or training, websites that are not audited, and institutional practices that exclude disabled users in design review will exhibit the same level of faults regardless of the quality of the guidelines.

International comparisons have been made and qualified to this study. Ahmi and Mohamad discovered that Malaysian public universities performed better than the private ones in terms of WCAG 2.0 compliance, but neither was fully compliant with Level AA. Their finding that institutional resource and governance capacity were more predictive of accessibility than institutional type is reminiscent of the comparative results of the present study among categories of Indian universities. A high-quality comparison of automated accessibility evaluation tools by Vigo, Brown, and Conway revealed that no single tool identified all types of violation, that different tools had blind spots, and that automated tools cannot identify semantic and cognitive accessibility concerns, which require human interpretation (Vigo et al., 2013).

Accessibility of Indian academic libraries has not had much scholarly attention. The most comprehensive initial analysis was by Ismail and Kuppusamy, who used automated evaluation

tools to analyse many Indian university websites and found the most prevalent types of failure to be the absence of alternative text, no hierarchy of headings, and no assigned landmark areas. Their research forms a useful compliance base but fails to explore the interface growth-accessibility burden relationship. Kumar and Kaur applied this lens to library websites as a subset and validated similar patterns of failure, suggesting a systematic audit as a recommendation, which this study aims to validate with a more specific analytic tool.

2.3 Automated Accessibility Evaluation and the WAVE Tool

Automated accessibility evaluation tools occupy an essential role in large-scale accessibility research. Without them, evaluating hundreds of websites against detailed WCAG criteria would be impractical. The WAVE tool (WebAIM, 2023), used in this study, has achieved the widest adoption in library and information science accessibility research, partly because its output categories map directly onto the dimensions most relevant to comparative analysis: confirmed errors, contrast errors, alerts, accessibility features, structural elements and ARIA attributes.

Brajnik, Mulas and Pitton compared sampling strategies in accessibility evaluation and demonstrated that page sampling changes the conclusions drawn about a site (Brajnik et al., 2007). This is important for each library website. Automated tools have also been used to assess accessibility. They identify technically testable violations, such as missing alternative text, contrast errors and absent form labels, but cannot determine the usability of content (Vigo et al., 2013). Results should be interpreted as technically detectable conditions on a single page, not as the full range of barriers a disabled user might meet. The alerts are part of the ABI since WAVE identifies them as possible issues requiring human intervention. They are not confirmed failures. Section 6 examines the extent to which this decision influences the outcomes.

Vigo, Brown and Conway stated that different tools produced meaningfully different results on the same page, reflecting specific detection algorithms and coverage areas (Vigo et al., 2013). WAVE was selected because it is freely available, widely used in accessibility research, and reports

six separate output categories that can be combined into a composite measure.

2.4 ARIA: Specification, Intent and Implementation Quantity

ARIA is a W3C technical specification (Consortium, 2017) that defines roles, states and properties for interactive interface elements that standard HTML cannot describe semantically. Without ARIA, a custom dropdown menu built in JavaScript is opaque to screen readers: the readers have no way to announce the element's identity, its current state (expanded or collapsed), or the keyboard interaction it supports. Correctly implemented ARIA resolves this by providing the semantic layer that native HTML omits for custom components.

This critical qualification is correctly implemented. W3C guidance has the same caution. Native HTML elements should be used where they exist, and incorrect ARIA can leave a page less usable than no ARIA at all.

Power, Freire, Petrie, and Swallow studied blind users on live websites. Only about half of the problems they encountered (50.4%) were covered by WCAG 2.0 success criteria (Power et al., 2012). Meeting the guidelines therefore does not guarantee that a page works with assistive technology. Their study did not count ARIA attributes. It supports a wider point: a count of detected items is not the same as quality of experience.

Lopes, Gomes, and Carriço examined accessibility barriers on Portuguese government websites and why they persist (Lopes et al., 2014). The WebAIM survey of one million home pages found more detected errors on pages with ARIA (59.1 on average) than on pages without it (42.0) (2026). The report notes that this may partly reflect the greater complexity of ARIA-heavy pages rather than an effect of ARIA itself. We found no study that tests whether ARIA volume tracks accessibility quality on library websites. Two readings are possible. ARIA counts may signal deliberate accessibility work, or they may only reflect interface complexity, for example attributes generated automatically by a framework. Sections 7 and 8 test which reading the data favour.

2.5 Digital Inclusion in Indian Higher Education

India adopted the United Nations Convention on the Rights of Persons with Disabilities Nations (2009) in 2007, committing to a progressive realisation of digital and physical accessibility for disabled citizens. This commitment was accorded legal status in the Rights of Person with Disabilities Act (2016), which clearly stated that information and communication technology services should be made accessible (Rights of Persons with Disabilities Act, No. 49 of 2016, 2016). As information services run by educational institutions, academic library websites are within the bounds of this requirement.

Academic libraries are often a student's main route to scholarly resources, including for students who lack personal devices or reliable home internet access. For students with disabilities, an inaccessible library website can block that route. The failure of a library website to meet the requirement of accessibility means not only inconvenience but also the possible deprivation of access to scholarly resources that are accessible to fellow learners who are not disabled.

Warschauer distinguished between physical access to technology devices and connectivity and meaningful access, which requires that content be genuinely navigable and usable by the people who need it. This distinction is operationally significant for accessibility research: a website that exists and loads is not automatically accessible in any meaningful sense. The ABI, by measuring the ratio of accessibility investment to accessibility burden, is designed to assess meaningful access rather than mere technical availability.

The differences in governance, resourcing and accountability between the four categories of universities in India offer a natural analytic lens to look into whether the accessibility outcomes relate to the institutions' characteristics or individual design decisions. The findings of the present study corroborate the hypothesis that institutional capacity has a stronger relationship with accessibility performance than institutional

type, which was previously hypothesized by comparison studies in other national contexts (Vigo et al., 2013).

3. The Research Gap

The existing literature provided a relatively consistent picture that academic library websites (including Indian ones) resulted in significant numbers of WCAG violations, that these violations have been difficult to improve over time, and that outcomes of accessibility seem to lie in the institutional governance structure more than the technical resources. The literature does not sufficiently discuss the net impact of interface growth on the burden of accessibility in the Indian context, at least.

The number of errors may also increase the more features' websites and the more complex the structure and use of ARIA. Yet so there can be their positive accessibility signals.

This study is, to the author's knowledge, the first application of such a composite burden metric to Indian academic library website data.

4. Research questions

1. Is there a statistically discernible relationship between websites' feature count and the accumulation of accessibility errors across Indian academic library websites?
2. Does structural complexity, measured through heading hierarchies, landmark regions and list structures predict higher alert frequencies?
3. Is the volume of ARIA implementation associated with accessibility burden, and does the way the ABI is built affect that relationship?
4. Does the Accessibility Burden Index rank websites differently from raw error counts, and what drives the difference?
5. Does accessibility burden differ across Central, Deemed, Private and State university categories, and is the difference statistically supportable?

5. Methodology

5.1 Research Design

This study adopts a quantitative content analysis framework. This approach – applied systematically in prior library accessibility research (Schmetzke, 2001), (Comeaux & Schmetzke, 2013), (Vigo et al., 2013) – produced replicable, comparable measurements across a large sample without requiring direct observation of disabled users. Its acknowledged limitation is that automated evaluation cannot capture all the barriers that a disabled user may encounter during realistic task completion. The study's findings should therefore be read as evidence of technically detectable accessibility conditions rather than as a complete account of user experience.

Ethics statement: This study analysed publicly accessible library websites. No human participants were involved. Ethical approval was therefore not required.

5.2 Population and Sample

The study examines 100 Indian academic library websites drawn from UGC-recognised universities ranked by NIRF 2021 across all four administrative categories: Central Universities (n = 13), Deemed Universities (n = 38), Private Universities (n = 10) and State Universities (n = 39). Category was assigned from each institution's status. Only the library homepage of each institution was tested, once. Catalogues, repositories and inner pages were not audited, so the results describe homepages, not whole library sites. Data were collected from January 2025 to March 2025.

5.3 Data Collection Instrument

Each website was evaluated using WAVE (Web Accessibility Evaluation tool) (WebAIM, 2023). The WAVE Chrome extension was used to access the homepages of library websites. WAVE generates six quantified accessibility output categories per page:

- Errors: confirmed violations that will block users' access to assistive technology
- Contrast Errors: Failures to meet the WCAG 2.1 Success Criterion 1.4.3

minimum contrast ratio of 4.5:1 for standard text.

- Alerts: flagged conditions that can cause accessibility issues based on context, including unclear link text, missing captions and uneven heading order.
- Features: Positive accessibility characteristics include navigation links, properly labelled inputs, defined landmark areas, and descriptive alternate text in images.
- Structural Elements: heading hierarchies, list structures, and semantic page regions that organize content for assistive technology navigation.
- ARIA: Accessible Rich Internet Applications attributes embedded in the page markup

These six variables constitute the complete data set for all descriptive, correlational and comparative analysis.

WAVE also indicates pass columns for contrast at WCAG levels AA and AAA. In the dataset every site is marked "Pass" on both, although 89 of the 100 sites have at least one contrast error. These columns were not used.

5.4 The Accessibility Burden Index: Formula and Rationale

The ABI was formulated to express the ratio between a website's accumulated accessibility failures and its positive accessibility infrastructure:

$$\text{ABI} = (\text{Errors} + \text{Contrast Errors} + \text{Alerts}) / (\text{Features} + \text{Structural Elements} + \text{ARIA})$$

The numerator sums the three problem counts reported by WAVE. The denominator adds the three counts of detected content. The index is not limited, and it is undefined when the denominator is equal to zero. In this sample the smallest denominator was 6, so every site has a value. Two properties matter for interpretation. First, the denominator is dominated by structural elements and ARIA. Together they make up 92% of the mean denominator (structural 96.6 and ARIA 207.2, against 26.8 for features). Most of the variation in ABI therefore comes from these two

counts, not from the problem counts. Second, structural elements and ARIA are measures of what exists, rather than quality. Adding ARIA attributes to a page can increase the denominator and decrease its ABI, without repairing even a single error. Section 6 reports versions of the index with ARIA removed from the denominator and with alerts removed from the numerator.

5.5 ABI Classification Framework

Table A presents the classification scheme applied to ABI values throughout the analysis.

Table A: ABI Classification Framework

ABI Score	Classification	Operational Interpretation
< 0.25	Very Low Burden	Few reported problems relative to detected content.
0.25 to < 0.50	Low Burden	Fewer reported problems than most sites.
0.50 to < 1.00	Moderate Burden	Reported problems are fewer than detected content.
1.00 to < 2.00	High Burden	Reported problems exceed detected content.
≥ 2.00	Very High Burden	Reported problems are at least twice the detected content.

Intervals are closed at the lower bound and open at the upper bound, so every value falls in exactly one band. They are chosen by the authors and were not derived from user outcomes. For comparison, the sample quintile cut-offs are 0.17, 0.29, 0.51 and 1.17. The thresholds are conventions anchored at ABI = 1.00, where reported problems equal detected content, and they step by halving (0.50, 0.25) and doubling (2.00), which suits a skewed ratio with no upper limit. Accordingly, the bands only describe position on the index, and all main results are also reported as medians and non-parametric tests that do not use them.

describe the index. They are not independent findings about websites.

5.6 Analytic Procedures

Because the counts are strongly right skewed, the analysis reports medians and interquartile ranges (IQR) alongside means. Relationships were measured with Spearman rank correlation (ρ), with 95% confidence intervals from 3,000 bootstrap resamples. The 21 pairwise tests were adjusted with the Holm method. Categories were compared with the Kruskal–Wallis test, with epsilon-squared as the effect size and Dunn’s post hoc test (tie-corrected, Holm-adjusted). The significance level was 0.05. The calculations were done in Python 3 with the pandas, NumPy and SciPy libraries. Correlations between ABI and its own components are partly mechanical, because those components form the ratio. They

6. Descriptive Statistics

Table 1: Descriptive Statistics of Accessibility Variables (n = 100)

6.1 Summary of Findings

Table 1 presents descriptive statistics of all six Wave output variables and the ABI across the full sample of 100 websites.

Statistic	Errors	Contrast Errors	Alerts	Features	Structural Elements	ARIA	ABI
Count	100	100	100	100	100	100	100
Mean	35.46	17.13	91.92	26.84	96.55	207.22	1.42
Std. Dev.	48.34	20.76	158.62	64.09	65.05	199.87	3.60
Min.	0.00	0.00	2.00	0.00	0.00	0.00	0.07
Q1	14.00	3.00	23.75	4.00	47.75	25.50	0.19
Median	23.00	9.00	46.00	10.00	95.50	266.00	0.41
Q3	35.00	24.00	75.25	28.00	127.00	288.25	0.91
Max.	285.00	110.00	1205.00	600.00	297.00	923.00	29.00

6.2 Variable-Level Interpretation

6.2.1 Errors

The median of 23.00 is less than the mean error count of 35.46, which means that the distribution is positively skewed. The difference between the two central tendency measures is an indication of a few high error values, and the highest number of critical violations is 285 on one page. WAVE counts every instance, so one faulty template element can account for many errors. Even so, 285 errors point to a page with many confirmed barriers.

The difference between the 14.00 at Q1 and 35.00 at Q3 indicates that the middle 50 per cent of websites fell in a more moderate range. This distribution is consistent with patterns documented in longitudinal North American studies (Comeaux & Schmetzke, 2013), where library websites' accessibility performance tends to split between sites that are reasonably managed and a tail of severely non-compliant outliers, rather than being distributed symmetrically around a central value.

6.2.2 Contrast Errors

A mean of 17.13 contrast errors across the sample is not trivial. WCAG 2.1 Success Criterion 1.4.3 requires a minimum contrast ratio of 4.5:1 for standard text and 3:1 for large text – requirements for a broad user base. Colour vision deficiency affects approximately 8 per cent of males globally (2023), and contrast failures also create barriers for users with low vision, cataracts or conditions that reduce contrast sensitivity under typical lighting conditions. The maximum was 110 contrast errors on one site. Eleven sites had none.

The median of 9.00 is significantly lower than the mean, indicating that most sites had modest contrast error counts, with the mean inflated by a right-hand tail. This suggests targeted intervention in the worst-performing institutions would have a disproportionately large effect on population-level contrast error rates.

6.2.3 Alerts

The alerts variable produces the most extreme distributional characteristics in the dataset: a mean of 91.92, a standard deviation of 158.62 and a maximum of 1205. The coefficient of variation is 1.73. This is high, but below that of

features (2.39) and ABI (2.54). Alerts are potential issues that need human review, so a count of 1205 is a reason to inspect the page, not proof of failure.

Alerts are weakly and not significantly related to ABI ($\rho = 0.14$, 95% CI -0.07 to 0.33 ; Section 7). The earlier reading that alerts are a primary driver of burden is not supported by the data.

6.2.4 Features

Any reasonable standard would indicate that a Q1 value of 4.00 positive accessibility features is very low. A site that includes four or fewer features, such as skip links, labeled inputs, image alt text, defined landmarks, has invested little in proactive accessibility. Twenty-eight sites have four or fewer features. The 600 maximum and standard deviation of 64.09 attest to a broad institutional variation. The range is wide, but WAVE counts alone cannot show why.

6.2.5 Structural Elements

Structural Elements headings, lists, form labels and landmark regions show the most symmetrical distribution in the dataset. The mean (96.55) and median (95.50) are nearly identical, indicating that structural implementation is relatively consistent across the sample compared to the strongly skewed error and alert variables. This suggests that basic page structure is the accessibility dimension where the most uniform progress has been made, though structural quantity alone does not guarantee structural quality. A heading hierarchy that uses heading levels for visual styling rather than content organization will be counted among structural elements but will actively mislead a screen-reader user navigating by heading.

6.2.6 ARIA

The ARIA distribution is not smooth. Thirty-seven sites have 50 or fewer ARIA items, and 43 sites have between 266 and 340. The median is 266 and the mean 207.22 (SD 199.87, range 0 to 923). ARIA counts depend on how a site is built, so they cannot serve alone as a measure of accessibility quality.

6.2.7 Accessibility Burden Index

The mean ABI is 1.42, but the median is 0.41 (IQR 0.19 to 0.91), which is in the Low Burden

band. The typical site is therefore not in the High Burden band. A few very high values pull the mean up. The highest ABI is 29.0. That site had 78 errors and contrast errors and 96 alerts, against only 6 detected items (no features, 5 structural elements and 1 ARIA item). Its error count was higher than that of 83% of sites but not extreme. The score of 29.0 comes mainly from a very small denominator.

The lowest ABI is 0.07. That site had 71 problems against 954 detected items, 743 of them ARIA, and its WAVE error count (27) was above the sample median (23). A low ABI therefore does not mean few problems. The two extremes show how strongly the denominator shapes the index.

6.3 Summary Observation

Three patterns stand out. First, errors, contrast errors and alerts are all right-skewed, so a minority of sites accounts for a large share of the problems. Second, features are scarce (median 10) while problems are common (median 23 errors and 46 alerts). Third, the mean ABI (1.42) is more than three times its median (0.41), so the mean describes a few very high values, not the typical site. Medians should be reported.

7. Comparative Analysis by University Category

7.1 Category Means

Table 2 presents mean values for key accessibility variables by university category. Because a few sites inflate the means, Tables 2A to 2C add medians, band counts and significance tests.

Table 2: Mean Accessibility Variables by University Category

University Category	Errors	Contrast Errors	Alerts	Features	ABI
Central University	66.85	12.77	137.00	25.23	2.11
Deemed University	31.68	20.00	102.29	36.58	1.02
Private University	29.80	8.10	54.20	35.60	1.46
State University	30.13	18.10	76.46	15.64	1.57

Table 2A: Median (IQR) of accessibility variables by university category

Category	n	Errors	Contrast Errors	Alerts	Features	ABI
Central	13	24 (14–70)	5 (2–15)	51 (39–171)	13 (3–47)	1.11 (0.20–2.72)
Deemed	38	25 (14–40)	13 (3–25)	40 (23–60)	11 (5–28)	0.40 (0.20–0.68)
Private	10	28 (22–42)	8 (3–12)	44 (39–56)	35 (12–48)	0.18 (0.17–0.38)
State	39	20 (14–28)	11 (3–26)	42 (21–82)	7 (4–18)	0.42 (0.21–0.93)

Table 2B: Number of sites in each ABI band, by university category

Category	n	Very Low	Low	Moderate	High	Very High	Share ≥ 1.00
Central	13	4	1	1	1	6	54%
Deemed	38	12	12	7	3	4	18%
Private	10	7	1	1	0	1	10%
State	39	12	10	8	4	5	23%
All sites	100	35	24	17	8	16	24%

Table 2C: Kruskal–Wallis tests across the four categories (df = 3)

Variable	H	p	ϵ^2
Errors	2.75	0.432	0.000
Contrast Errors	3.60	0.308	0.006
Alerts	2.90	0.408	0.000

Features	4.14	0.247	0.012
Structural Elements	5.34	0.149	0.024
ARIA	3.52	0.319	0.005
ABI	6.02	0.110	0.032

No variable differed significantly across categories. For ABI, the results were $H = 6.02$, $p = 0.110$, and $\varepsilon^2 = 0.032$, indicating a small effect. Central–Private (unadjusted $p = 0.018$) had the greatest pairwise gap, which was not significant after Holm adjustment ($p = 0.107$). There are 13 Central and 10 Private sites, which may limit power to detect a real difference. The statistics cannot substantiate it.

Table 2 and Table 2A show different aspects using means and medians respectively. All four mean ABI values are above 1.00, but the medians for Deemed (0.40), Private (0.18) and State (0.42) are all below 0.50. A whole category should not be put in the High Burden band on the basis of its mean. A total of 59 out of 100 sites have a value below 0.50 and 24 are 1.00 or above.

7.2 Category-Level Analysis

7.2.1 Central Universities (ABI = 2.11)

Central universities have the highest mean ABI (2.11) and the highest median (1.11). Seven of 13 score 1.00 or higher, and six are in the Very High band. The mean error count of 66.85 is raised by three sites with 162, 208 and 285 errors. The median is 24, close to the other categories. The Central and Private difference in ABI is not significant after adjustment (Holm $p = 0.107$).

One might expect Central universities, which are federally funded and bound by the RPwD Act, to perform better. The data do not show that they do. They do not show that they perform worse either.

Possible explanations are hypotheses that this dataset cannot test. Central Universities websites tend to incorporate a broader range of services – government information portals, e-government systems, research databases and student administration platforms – each of which creates additional surface area for accessibility errors when not implemented with WCAG compliance in mind. Legacy content management systems,

common in government-affiliated institutions, may lack the built-in accessibility scaffolding of more recent platforms. Distributed web management across departments and units can also produce a fragmented development environment in which no single team bears responsibility across the full site.

7.2.2 Deemed Universities (ABI = 1.02)

Deemed universities have the lowest mean ABI (1.02) and a median of 0.40, in the Low band. Seven of 38 sites score 1.00 or higher. Their mean feature count is 36.58 (median 11) and their mean error count is 31.68 (median 25). Their mean contrast error count (20.00) is the highest of any category.

7.2.4 Private Universities (ABI = 1.46)

Private universities have the lowest mean errors (29.80), contrast errors (8.10) and alerts (54.20), and relatively many features (mean 35.60). Only one of the ten sites scores 1.00 or higher, with an ABI of 12.62, and that site lifts the category mean to 1.46. The median is 0.18, the lowest of any category.

With only ten sites, these figures are unstable. A single site can change the category mean.

7.2.5 State Universities (ABI = 1.57)

State universities have the lowest mean feature count (15.64) and the lowest median (7). Their mean ABI of 1.57 is raised by a few very high values, including the highest in the sample (29.0, a site with only 6 detected items). The median ABI is 0.42, close to that of Deemed universities.

7.3 Cross-Category Inference

Three observations follow. First, category means above 1.00 are driven by a few sites. The medians are 1.11 for Central, 0.42 for State, 0.40 for Deemed and 0.18 for Private. Second, no category difference is statistically significant ($H = 6.02$, $p = 0.110$). Third, the idea from earlier

work (Vigo et al., 2013) that institutional capacity matters more than institutional type can be neither confirmed nor rejected here, because staffing and budget data were not collected.

Table 3 presents Spearman rank correlation coefficients between all six WAVE variables and the ABI. Spearman is used because the counts are skewed and contain extreme values.

8. Correlation Analysis

Table 3: Spearman Correlation Matrix of Accessibility Variables (n = 100)

8.1 Correlation Matrix

Variable	Errors	Contrast Errors	Alerts	Features	Struct. Elem.	ARIA	ABI
Errors	1.00	0.10	0.37	0.27	0.42	0.51	-0.15
Contrast Errors	0.10	1.00	-0.24	0.07	-0.15	-0.13	0.17
Alerts	0.37	-0.24	1.00	0.22	0.40	0.35	0.14
Features	0.27	0.07	0.22	1.00	0.36	0.41	-0.35
Struct. Elem.	0.42	-0.15	0.40	0.36	1.00	0.77	-0.64
ARIA	0.51	-0.13	0.35	0.41	0.77	1.00	-0.67
ABI	-0.15	0.17	0.14	-0.35	-0.64	-0.67	1.00

Table 3A: Selected Spearman correlations with 95% bootstrap confidence intervals

Pair	ρ	95% CI	p	p (Holm)
Errors – Features	0.27	0.06 to 0.45	0.007	0.072
Alerts – Structural	0.40	0.22 to 0.57	<0.001	<0.001
Errors – ARIA	0.51	0.33 to 0.67	<0.001	<0.001
Errors – Alerts	0.37	0.16 to 0.54	<0.001	0.002
Errors – Contrast	0.10	-0.11 to 0.31	0.324	0.802
Errors – ABI	-0.15	-0.35 to 0.06	0.140	0.802
Contrast – ABI	0.16	-0.02 to 0.35	0.101	0.708
Alerts – ABI	0.14	-0.07 to 0.33	0.160	0.802
Features – ABI	-0.35	-0.53 to -0.15	<0.001	0.004
Structural – ABI	-0.64	-0.76 to -0.48	<0.001	<0.001
ARIA – ABI	-0.67	-0.78 to -0.51	<0.001	<0.001
Structural – ARIA	0.77	0.63 to 0.87	<0.001	<0.001

8.2 Interpretation of Key Relationships

8.2.1 Errors and ABI ($\rho = -0.15$)

ABI is not related to the error count ($\rho = -0.15$, 95% CI -0.35 to 0.06). The data do not support the earlier reading that the most beneficial ABI lever is error reduction. ABI mostly follows the size of its denominator.

The high mean ABI is due to sites having small denominators, as at one site with 6 detected items and an ABI of 29.0. It is not found on those sites that contain the large number of errors.

8.2.2 Alerts and ABI ($\rho = 0.14$)

Alerts are weakly and not significantly related to ABI ($\rho = 0.14$, 95% CI -0.07 to 0.33). There is no indication that alerts influence accessibility burden.

Alerts need human review and are not confirmed failures. They should be checked, but this analysis gives no basis for ranking them above confirmed errors in an audit.

8.2.3 Contrast Errors and ABI ($\rho = 0.16$)

Contrast errors are weakly related to ABI ($\rho = 0.16$, 95% CI -0.02 to 0.35 , not significant). Contrast is important in terms of reading performance among users with dyslexia, as demonstrated by Rello and Baeza-Yates (Rello & Baeza-Yates, 2012). Its number, however, does not cause ABI to move in a predictable manner.

8.2.4 Features and ABI ($\rho = -0.35$)

Features and ABI are negatively related ($\rho = -0.35$, 95% CI -0.53 to -0.15 , Holm $p = 0.004$).

Attributes in the denominator are part of the mechanical link. It fails to demonstrate that the inclusion of features decreases errors. There is a positive and weak relationship between features and errors ($\rho = 0.27$).

8.2.5 ARIA and ABI ($\rho = -0.67$; with errors $\rho = 0.51$)

ARIA and ABI are strongly and negatively related ($\rho = -0.67$, 95% CI -0.78 to -0.51). This is largely mechanical, because ARIA sits in the denominator. It is not to be interpreted as an indication that ARIA enhances accessibility. The

direct comparison is between ARIA and errors. The link is positive ($\rho = 0.51$, 95% CI 0.33 to 0.67). Sites with more ARIA tend to have more errors, not fewer.

The median error was 33 in the seven sites that had over 500 ARIA items, as compared to 22 in the other sites. It was number 12 out of 37 sites of 50 or less. This is consistent with the reading that ARIA counts reflect interface complexity in track interfaces. It is not evidence that ARIA leads to errors. Multiplexed pages can simply contain more of either.

8.2.6 Structural Elements and ARIA ($\rho = 0.77$)

There is a strong positive correlation between structural elements and ARIA (0.77 , 95% CI 0.63 to 0.87). They both increase with interface complexity. The relationship fails to indicate that both counts are accessibility safeguards.

8.2.7 Errors and Contrast ($\rho = 0.10$)

Errors and contrast errors are not related ($\rho = 0.10$, 95% CI -0.11 to 0.31). The sites that fail in one do not necessarily fail in the other, so the previous claim that failures co-occur is not validated. Contrast has its own check.

8.2.8 Features and Errors ($\rho = 0.27$)

Feature count and errors show a weak positive link ($\rho = 0.27$, 95% CI 0.06 to 0.45). The unadjusted p is 0.007 , but after Holm adjustment it is 0.072 . This is suggestive, not established. Sites with more detected features do not have fewer errors.

8.2.9 Structural Elements and Alerts ($\rho = 0.40$)

Structural elements and alerts are positively related ($\rho = 0.40$, 95% CI 0.22 to 0.57 , Holm $p < 0.001$). Pages that contain a lot of headings, lists and regions tend to contain more alerts. This is consistent with the premise that complexity creates more items for review. It does not indicate that the structure is faulty.

8.3 Structural Implications and the Correlation Findings

Overall, the correlation results suggest that ABI is not associated with the error counts. Therefore, error counts should be reported separately to provide a clear status of website accessibility issues. Second, ARIA volume rises with errors

and with structure and should not be reported as evidence of accessibility compliance. Third, most ABI correlations reflect the size of its denominator and describe the index, not websites.

8.4 What the ABI Adds Beyond Error Counts

Sites were ranked by this combined measure and split into quartiles. Table 3B compares those quartiles with ABI bands. The rank correlation between ABI and errors plus contrast errors is 0.10.

Table 3B: ABI bands by quartile of errors plus contrast errors (Q1 = fewest)

Error quartile	Very Low	Low	Moderate	High	Very High
Q1	5	10	4	1	5
Q2	16	1	2	4	2
Q3	11	5	5	1	3
Q4	3	8	6	2	6

12 of the 24 sites with an ABI of 1.00 or higher are in the lower half for errors, so the ABI does flag sites different from those identified by error counts. The reason is mostly the denominator. These sites have small denominators and, in several cases, very large alert counts (for example 292 and 318 alerts). Whether the flagged sites face a higher exclusion risk is not shown by WAVE counts alone. Task-based testing with disabled users would be needed.

8.5 Sensitivity of the ABI to Its Construction

Table 3C repeats the key results for two variants of the index.

Table 3C: Sensitivity of ABI results to its construction

Version	Median	Sites ≥ 1.00	p with standard ABI	KW H	KW p
Standard ABI	0.41	24	1.00	6.02	0.110
Without ARIA in denominator	0.85	48	0.89	8.05	0.045
Without alerts in numerator	0.14	10	0.80	4.53	0.210

The choice of formula changes the picture. Without ARIA, the median ABI rises to 0.85 and 48 sites reach 1.00 or higher. The category test becomes significant ($p = 0.045$) and the median of the category is 1.79 for Central, 1.02 for State, 0.74 for Deemed and 0.55 for Private. The median is not significant ($p = 0.210$) without warnings, and only 10 locations reach 1.00; this is the category test. A category difference that is found in one of three forms and only by chance is not a strong finding. Reporting based on the ABI must provide the formula used and indicate at least the ARIA-free version.

9. Graphic Interpretation of Key Figures

Figure 1: Feature Density versus Accessibility Errors

Figure 1 plots feature count (x-axis) against error count (y-axis) for the 100 websites, using symmetric log axes. The rank correlation is weak and positive ($\rho = 0.27$).

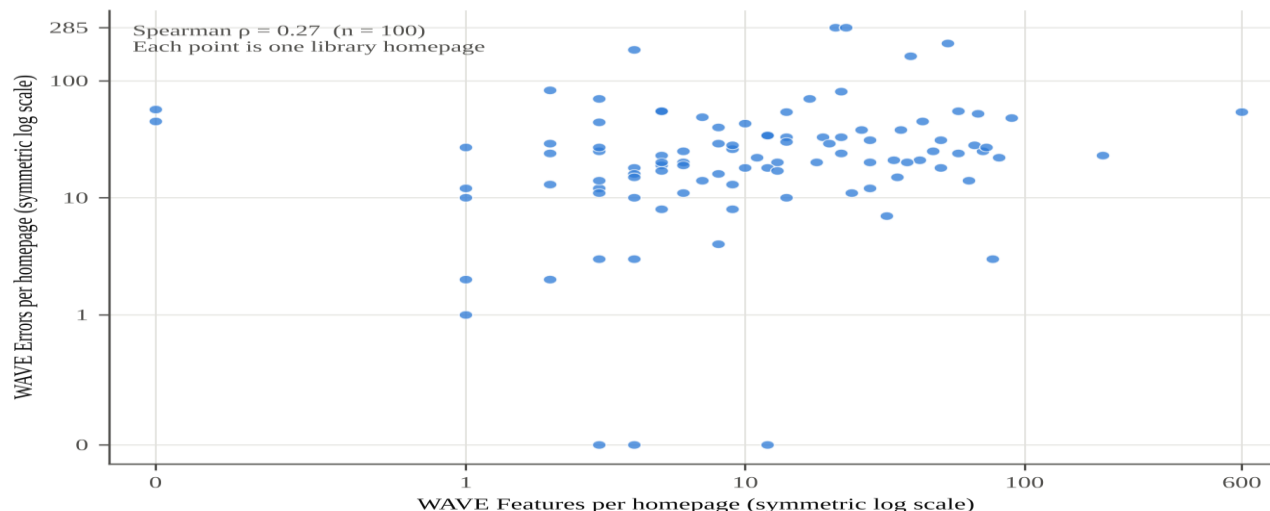


Figure 1. WAVE features and errors per homepage (symmetric log axes). Each point is one website.

Twenty-eight sites have four or fewer features. Their median error count is 14.5, with a range from 0 to 184. The wide scatter at similar feature counts shows that features do not determine errors.

Only two sites have more than 100 features (190 features with 23 errors, and 600 features with 54 errors). Two sites are too few to describe a pattern, so the earlier description of two clusters has been removed.

At the low end of the feature distribution, minimal websites show low error counts. This is a floor effect rather than an accessibility achievement. A library homepage with four features has few opportunities to generate errors, but it also provides almost no positive accessibility value to disabled users. Few errors on a minimal site should not be interpreted as inclusive design.

Figure 2: ARIA Implementation versus Accessibility Errors

Figure 2 plots ARIA count against error count. The rank correlation is moderate and positive (ρ

$= 0.51$), so sites with more ARIA tend to have more errors.

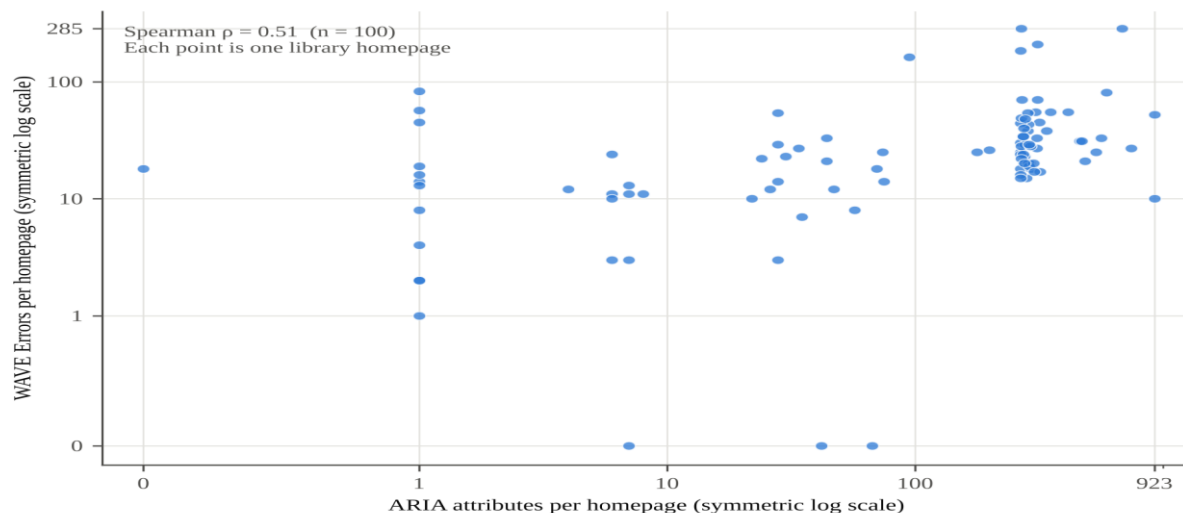


Figure 2. WAVE ARIA items and errors per homepage (symmetric log axes). Each point is one website.

There are 37 sites with 50, or fewer ARIA items and the median error rate is 12. Low ARIA does not imply numerous mistakes.

There are seven sites with over 500 ARIA items. They have a median error of 33 as compared to 22 in the other sites. This trend is consistent with ARIA counts that indicate interface complexity. It does not indicate that ARIA leads to errors.

ARIA count as a measure of accessibility should never be used as an argument in institutional reporting, accreditation or policy compliance submissions.

Figure 3: ABI Comparison Across University Categories

Figure 3 shows the ABI of each site by university category on a log scale, with medians marked and reference lines at 1.00 and 2.00. The medians are 1.11 for Central, 0.42 for State, 0.40 for Deemed and 0.18 for Private. The boxes overlap widely, which matches the non-significant category test.

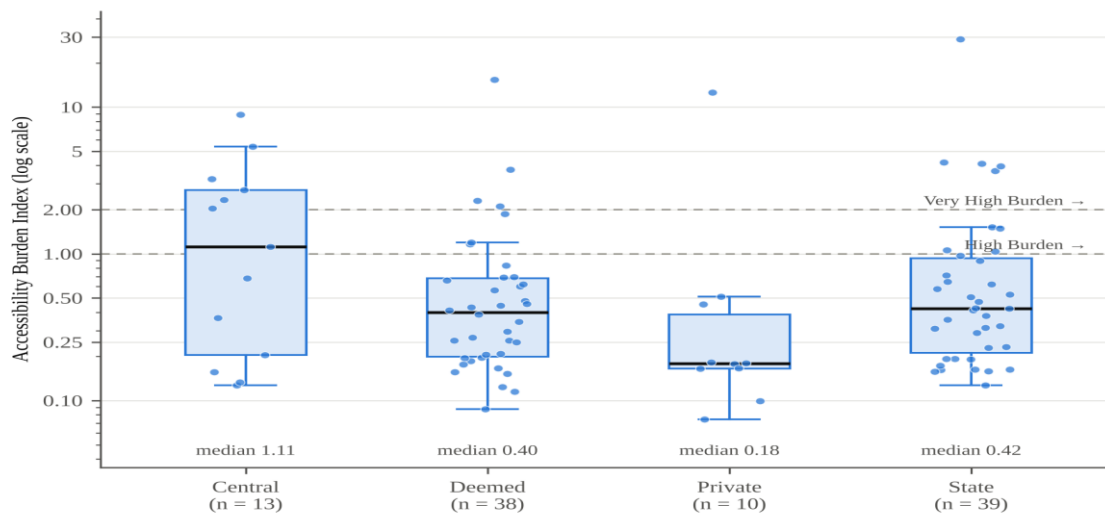


Figure 3. ABI by university category (log scale). Boxes show the IQR; the black line shows the median, and dots represent individual sites.

The means exceed 1.00 in all categories due to a small number of high values (Table 2); however, most of the sites in Deemed, Private and State universities are below 1.00.

The highest ABI in the State group (29.0) and in the Private group (12.62) come from sites with very small denominators.

10. Discussion

10.1 Interface Growth and Accessibility Accountability

The typical library homepage in this sample carries a median of 23 errors and 46 alerts. Most sites fall in the Low or Very Low band (59 of 100), and 24 score 1.00 or higher. The study is cross-sectional, so it cannot show whether interface complexity is growing faster than accessibility.

The pattern can be explained institutionally, as established by the accessibility literature, without necessarily referring to the Indian library context. The similarity in accessibility failures over time according to Comeaux and Schmetzke is a governance issue and not a technological impossibility (Comeaux & Schmetzke, 2013). When given a request to add features, development teams will add them; when accessibility review is needed, teams will add it as part of the process. Services are added to libraries based on funding and user need; they are

not audited systematically regarding the implications of their accessibility unless accountability structures require libraries to do so.

Accessible digital services in India are mandated by the Rights of Persons with Disabilities Act (Rights of Persons with Disabilities Act, No. 49 of 2016, 2016). Systematic change is impossible without its existence; it is not, in the light of evidence in this study, sufficient. The provisions of the Act have failed to translate into a uniform level of performance in terms of accessibility at the highest level in the category of the university subject to the most governmental regulation. Central universities have the highest median ABI, but the difference from other categories is not statistically significant. The gap between the regulatory requirement and the recorded results is a substantive policy finding that UGC and the ministries involved should consider.

10.2 The ARIA Problem: Complexity Mistaken for Care

ARIA correlates positively with errors ($p = 0.51$), which challenges a practice that is increasingly common in institutional accessibility reporting: citing ARIA implementation counts as evidence of accessibility investment. The data do not support this interpretation.

High ARIA counts are a structural consequence of their component architecture. When a developer implements a tab panel or a modal dialog using a component library, ARIA attributes are typically generated automatically, whether the developer has verified their semantic

accuracy. The result is a site with a high ARIA count and potentially no meaningful improvement in the experience of a screen reader user.

Power et al. (Neville, 2012) showed that WCAG compliance alone leaves about half of the problems blind users encounter uncovered. ARIA attributes generated by frameworks without manual review or applied without understanding of the assistive technology behaviour they are meant to govern, do not by themselves show accessibility investment. Institutions and accreditation bodies that rely on ARIA counts as a proxy for accessibility quality are measuring the wrong thing.

10.3 Institutional Category and Remediation Strategy

Category differences are not statistically supported, so remediation advice should not be tailored by category on this evidence. Sites with high error or contrast counts need an audit of the specific violation types, such as missing alternative text, unlabelled form controls and keyboard-inaccessible elements, whatever their category.

10.4 The ABI as an Analytical and Policy Instrument

This study proposes the ABI as a contribution to both accessibility research methodology and institutional accountability. As a research instrument, it offers a richer analytical framework than raw error counts by incorporating both the burden and the investment sides of accessibility performance. The ABI ranks sites differently from error counts (p with errors plus contrast errors = 0.10), but whether the sites it flags face higher exclusion risk is untested.

The earlier proposal to set ABI thresholds for accreditation is not supported by this study. Adding ARIA or structural elements can move the index without fixing any failure; its category ranking depends on the formula, and its link to real exclusion risk is untested. For benchmarking, raw counts of errors and contrast errors, reported as medians with ranges, are safer. They can be tracked from year to year and compared across institutions. The ABI may still

serve as a screening ratio when it is reported beside the raw counts and the sensitivity versions in Table 3C.

11. Limitations

The test was conducted on the homepages of each library website in the specified time frame using an automated tool, and thus the results might vary across different pages or dates. Alerts are not failures and they are meant to be reviewed by a human reviewer. The ARIA counts depict a concentration of 43 sites which may share a component. The recorded results for WCAG AA and AAA could not be utilized. There are small groups of Central and Private universities. The correlation between ABI is partly mechanical. No users with disabilities were involved.

12. Conclusions

100 Indian academic library websites' homepages have been accessed across four university categories. The median ABI was 0.41, and 24 sites recorded 1.00 or higher. The means of categories were above 1.00 for all four, but they are skewed by a few sites. Central universities had the highest median (1.11), followed by State (0.42), Deemed (0.40) and Private (0.18) universities. The difference was not statistically significant ($p = 0.110$) and was based on the construction of the index.

Regarding the research questions, more features were associated with fewer errors ($p = 0.27$, not significant). There was a positive relation between structural elements and alerts ($p = 0.40$). ARIA volume increased with errors ($p = 0.51$), so ARIA counts could be an indicator or a measure of complexity, not quality. The difference between ABI rankings and error counts is due to its denominator.

The ABI offers a missing element in the literature: an analytical tool that brings interface growth and accessibility outcome together, not reflected by the traditional compliance-based measures. It should only be used in exploratory ways until it is proven that it increases the success of said tasks with users with disabilities. Future work may expand the index by adding more dimensions of semantic accessibility that cannot be automatically identified, confirm the relationship between the index and real user task

completion results by conducting user studies with disabled users, and test the index over time within the same institutions, to ensure that accessibility investment is in line with the increased growth of the Indian academic library websites.

The overall thesis of the study is that one cannot rely on periodic compliance activities to ensure digital inclusion in academic libraries. Accessibility must be seen as a constant design requirement in content management processes, development review and institutional decision making as currently it is not working in the institutions sampled. Whether the question is whether institutions and their regulators are ready to demand it.

References

- Brajnik, G., Mulas, A., & Pitton, C. (2007). Effects of sampling methods on web accessibility evaluations. *International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS)*, 59–66. <https://doi.org/10.1145/1296843.1296855>
- Colour Blind Awareness. (2023). *Colour Blindness*. <https://www.colourblindawareness.org>
- Comeaux, D. J., & Schmetzke, A. (2013). Accessibility of academic library web sites in North America. *Library Hi Tech*, 31(1), 8–33. <https://doi.org/10.1108/07378831311303903>
- Consortium, W. W. W. (2017). *Accessible Rich Internet Applications (WAI-ARIA) 1.1*. <https://www.w3.org/TR/wai-aria-1.1/>
- Consortium, W. W. W. (2023). *Introduction to Web Accessibility*. <https://www.w3.org/WAI/fundamentals/accessibility-intro/>
- Lopes, R., Gomes, D., & Carriço, L. (2014). Web accessibility in the Portuguese government: Key barriers and solutions. *Government Information Quarterly*, 31(1), 40–47. <https://doi.org/10.1016/j.giq.2013.10.003>
- Rights of Persons with Disabilities Act, No. 49 of 2016, (2016). <https://www.disabilityaffairs.gov.in>
- Nations, U. (2009). Convention on the Rights of Persons with Disabilities. *Jahrbuch für Wissenschaft und Ethik*, 14(1), 203–226. <https://doi.org/10.1515/9783110208856.203>
- Neville, K. (2012). Public Libraries and the Internet: Roles, Perspectives and Implications. Ed. By John Carlo Bertot, Paul T. Jaeger and Charles R. McClure. Santa Barbara, CA: ABC-CLIO/Libraries Unlimited, 2011. 295 pp. US\$45.00 soft cover ISBN 9781591587767 (available from Inbooks). *The Australian Library Journal*, 61(1), 71–72. <https://doi.org/10.1080/00049670.2012.10722318>
- Power, C., Freire, A. P., Petrie, H., & Swallow, D. (2012). Guidelines are only half of the story. *CHI Conference on Human Factors in Computing Systems*, 433–442. <https://doi.org/10.1145/2207676.2207736>
- Rello, L., & Baeza-Yates, R. (2012). Optimal colors to improve readability for people with dyslexia. *Proc. 9th Int. Cross-Disciplinary Conf. Web Accessibility (W4A 2012)*. <https://doi.org/10.1145/2207016.2207018>
- Schmetzke, A. (2001). Web accessibility at university libraries and library schools. *Library Hi Tech*, 19(1), 35–49. <https://doi.org/10.1108/07378830110384584>
- Vigo, M., Brown, J., & Conway, V. (2013). Benchmarking web accessibility evaluation tools. *International Cross-Disciplinary Conference on Web Accessibility (W4A)*, 1–10. <https://doi.org/10.1145/2461121.2461124>
- Warschauer, M. (2003). Technology and Social Inclusion. In *The MIT Press eBooks*. The MIT Press. <https://doi.org/10.7551/mitpress/6699.001.0001>
- WebAIM. (2023). *WAVE Web Accessibility Evaluation Tool*. <https://wave.webaim.org>
- WebAIM. (2026). *The WebAIM Million: An accessibility analysis of the top 1,000,000 home pages*. <https://webaim.org/projects/million/>
- WORLD REPORT ON DISABILITY WHO Library Cataloguing-in-Publication Data *World report on disability 2011*. (2015). <http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.649.3968>
- World Wide Web Consortium. (2018). *Web Content Accessibility Guidelines (WCAG) 2.1*.

