RESEARCH ARTICLE

Open access journals lack image accessibility guidelines

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ABSTRACT

In recent decades, there has been a move to "open" science and research. One component of open access is "accessibility," often used to mean that data and other products are free to use by others. However, accessibility also refers to considering and meeting the needs of people with disabilities. Our objective was to evaluate how open access journals incorporate disability accessibility as part of publishing. Using a random sample of 300 English-language journals and image accessibility as a lens, we assessed author guidelines. Of 289 journals with guidelines, 38 (13%) included color choice, six (~2%) included contrast ratios, and none included alternative text. We also assessed the open access statements for the same 300 journals to understand how they conceive of openness and accessibility. Of the 298 journals with open access statements, 228 (~77%) included the words *access* or *accessibility.* Yet none included *disability* or *disabled* and only two journals (<1%) mentioned *inclusive* or *inclusion.* Our findings indicate that the open access journals sampled are not considering disability accessibility in their submission guidelines or open access frameworks. Incorporating disability accessibility into open scholarship considerations is critical to bridge, and not exacerbate, information inequalities for people with disabilities.

an open access journal

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1. INTRODUCTION

In recent decades, there has been a move to "open" research, that is, to increase the reach of research products to broader audiences. Open scholarship can refer to one or all of the different elements of research, such as shareable data and code, collaborative platforms, or licensing work without copyright and cost (Program for Open Scholarship and Education [POSE], 2020). Open access (OA) is one part of the open scholarship umbrella (Figure 1). OA is a broad movement to make data and deliverables (papers, books, and other outputs) available for a public audience, without needing to visit or have membership in a subscribing academic library. OA for scholarly publishing, such as peer-reviewed journal articles, was formally defined as "free and unrestricted online availability" by the Budapest OA Initiative [BOAI] (2002). There are many potential ways to publish OA (Figure 2). While there has been more

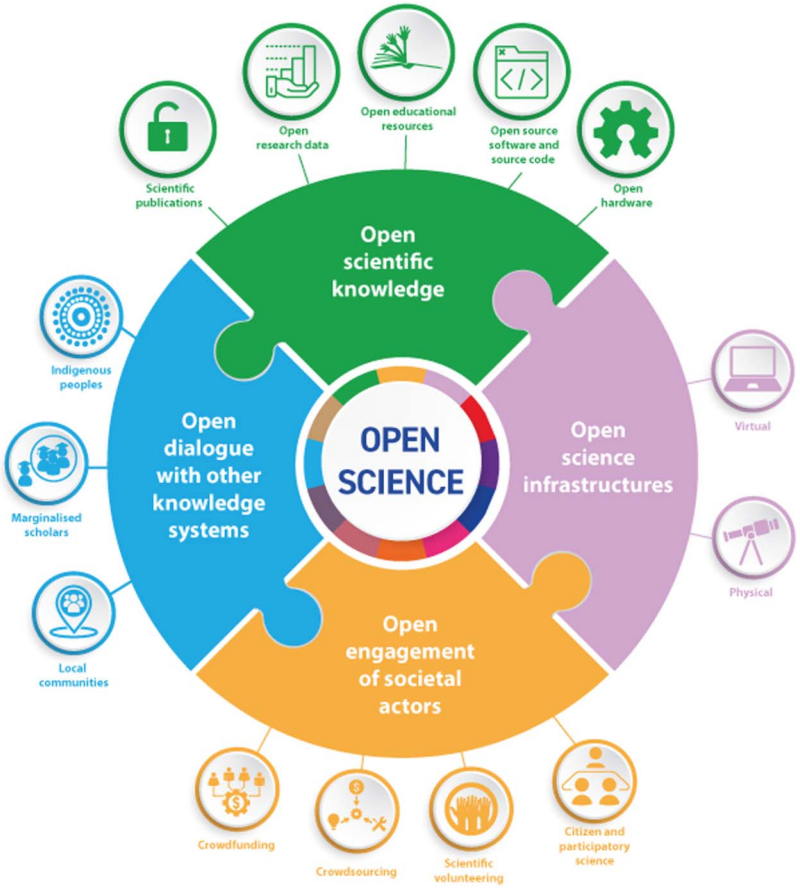


Figure 1. The United Nations Educational, Scientific and Cultural Organization (UNESCO) definition of open science includes open scientific knowledge, open science infrastructures, open engagement of societal actors, and open dialogue with other knowledge systems (United Nations Educational, Scientific and Cultural Organization, 2022). ("UNESCO-Open_science-pillars-en.png" by UNESCO.org (CC BY-SA 4.0) via Wikimedia Commons) Figure 1 image description: A complex pie chart representation of open science includes four slices drawn like interlocking puzzle pieces, each representing a different domain of open science. The first, open scientific knowledge, is at the top in green and has five listed elements that fall within this area (scientific publications, open research data, open educational research, open source software and source code, and open hardware) each represented as an icon within a circle with a text label underneath. The second domain, open science infrastructures, is on the right side of the circle and colored purple. It has two listed elements (virtual and physical), both represented as icons within a circle with text underneath. The third domain, open engagement of societal actors, is represented in yellow at the bottom of the circle. It includes four elements (crowdfunding, crowdsourcing, scientific volunteering, and citizen and participatory science) as icons within a circle with text labels underneath. The fourth domain, open dialogue with other knowledge systems, is on the left side of the circle and shown in blue. It lists three elements (Indigenous people, marginalized scholars, and local communities) as icons within circles with text labels.

attention on science and affiliated disciplines within open movements, open research includes all disciplines, such as the social sciences and humanities. For example, the U.S. National Endowment for the Humanities has a fellowship program to fund OA book publishing for humanities scholars (Bobley, 2019). Advocates of OA point to many potential benefits for scholars who opt in, including higher citation rates (Figure 3).

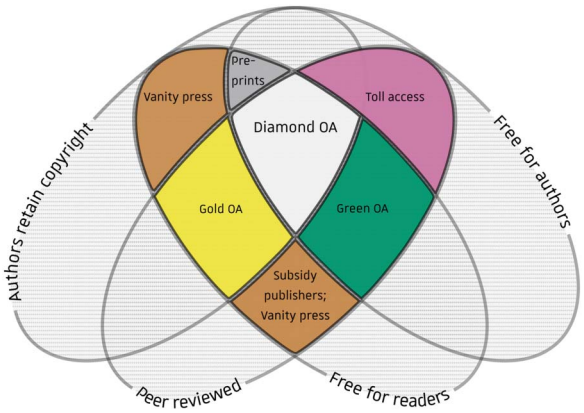


Figure 2. Venn diagram showing the different kinds of OA publishing, as functions of cost for different groups (authors, readers), review, and copyright. (Image "Open Access colours Venn.svg" by wikimedia user Evolution and evolvability (CC BY 4.0)) Figure 2 image description: Complex Venn diagram showing the different kinds of open access (OA) in publishing, as functions of cost for different groups (authors, readers), review, and copyright. OA publications that are free to readers are: vanity press, preprints, Gold OA, Diamond OA, Green OA, and subsidy publishers. OA publications free for authors are: preprints, toll access, Green OA, and Diamond OA. Authors retain copyright for these kinds of OA publications: vanity press, Gold OA, Diamond OA, and preprints. The peer-reviewed kinds of OA publications are: Gold OA, Diamond OA, toll access, Green OA, subsidy publishers, and vanity press.

Studying the implementation of OA publishing and the broader open movement is critical for two reasons. The first is that, enabled by the connectivity of the internet, this publishing model and research philosophy has experienced enormous growth in recent decades. Over 5,600 publishers are involved in publishing at least some OA journals and, as of 2018, the Directory of OA Journals has indexed 12,416 OA journals (Gul, Gupta et al., 2019). Open publishing's importance has continued to grow since the start of the COVID-19 pandemic. For example, a recent study found that 89.5% of COVID-19 research found through the Web of Science database published in the first 3 months of 2020 was OA (Capocasa, Anagnostu, & Bisol, 2022). Second, this rapid growth is partly due to increasing mandates for OA among funders and institutions. For instance, an August 25, 2022 memo from the U.S. Office of Science and Technology Policy (OSTP) announced that by December 31, 2025, U.S. federal agencies will be implementing plans for public access to research results for projects they fund, including a requirement for publication repositories (Office of Science and Technology Policy, 2022). These requirements can be very effective. For example, PubMed Central has archived research funded by the U.S. National Institutes of Health (NIH) since its creation in 2000. As of January 2022, it has 7.6 million full-length articles hosted there and this repository receives over 3 million views per weekday (National Library of Medicine, 2022). Various policies across the European Union and other parts of Europe also encourage or require OA publishing (Burgelman, Pascu et al., 2019).

Despite many institutions advocating for OA of research products and open scholarship more broadly, there is debate over what exactly constitutes "openness." Interviews with UK scientists several years ago identified common themes in their perceptions of open research, including data standards and knowledge sharing practices, yet most often reached consensus on what they perceived open *not* to be (or exist in opposition to) (Levin, Leonelli et al., 2016). Many open practitioners refer to the FAIR Data Principles; FAIR stands for findability, accessibility, interoperability, and reusability (Wilkinson, Dumontier et al., 2016). Many other frameworks also specifically use the word *accessibility* as an OA principle (e.g., Finch, Bell et al.,

Figure 3. Advocates of OA publishing believe there are many benefits to authors who opt into OA. (Image "Benefitsofopenaccess cc-by logo.pdf" by Danny Kingsley and Sarah Brown. https://aoasg.files.wordpress.com/2013/02/benefitsofopenaccess_cc-by_logo.pdf) Figure 3 image description: A conceptual diagram listing the benefits of OA publishing. The list is oriented in a circle around a decorative icon for OA, represented by an orange unlocked symbol. The individual list items have text and a corresponding decorative image. The list of benefits is: more exposure for your work; practitioners can apply your findings; higher citation rates; your research can influence policy; the public can access your findings; compliant with grant rules; taxpayers get value for money; and researchers in developing countries can see your work.

2013). *Accessibility* is a slippery term, though; it has many meanings in English. It could indicate low or no cost—as in, open software and hardware is cheaper and therefore more people can purchase and use the tools and protocols. It could also stand in for the learning curve—as in, open tools may be easier to learn than some proprietary ones, therefore barriers for non-experts or nonacademics to participate are lowered. In the FAIR framework, accessibility generally refers to data and other products (such as protocols) being free and open to use by others (GO FAIR, n.d.). At other times, accessibility is used to mean being able to physically acquire from a repository (e.g., Lee, Burnett et al., 2015).

Critically, the term *accessibility* also refers to considering and meeting the needs of people with disabilities for participation and inclusion (National Center on Birth Defects and Developmental Disabilities, 2020). This definition of accessibility, focused on removing barriers for people with disabilities, is relevant for OA, especially as that is now synonymous with sharing *online*. The World Wide Web Consortium (W3C), a collective that develops international web standards, explicates as an organizing principle that "the Web is fundamentally designed to work for all people, whatever their hardware, software, language, location, or ability" (World Wide Web Consortium, 2018). Much of the internet—both content and the architecture

Table 1. Universal design principles (Center for Universal Design, 1997) and how they may apply to OA

Universal design principles	Example applications for OA
Equitable use	OA materials should be usable by everyone
Flexibility in use	Facilitate autonomy in choosing preferred formats and tools to access information
Simple and intuitive use	No matter how the material is being accessed, it should be easy to understand
Perceptible information	Information should be provided in multiple sensory formats
Tolerance for error	Minimize errors
Low physical effort	Using materials should minimize fatigue and discomfort
Size and space for approach and use	Materials are legible by people using different formats and tools to access information

itself—is largely inaccessible to people with disabilities (Reid, 2020). The longer the internet has been around, the more websites have generally become complex—and often less accessible (Hackett, Parmanto, & Zeng, 2003). As of 2022, 96.8% of the top 1 million visited websites surveyed had accessibility errors (Web Accessibility in Mind, 2022). This has led to the ongoing exclusion of people with disabilities from communities and structures, including, ironically, those used most by members of the OA movement. For example, a recent study of over 11,000 accessibility issues in GitHub projects found that the issues seem to be caused by lack of development awareness and knowledge about both accessibility concerns and existing tools and standards to address them (Bi, Xia et al., 2021). Similarly, many kinds of documentation (online books, blogs, and package documentation) about R, a popular open source programming language, are often inaccessible to some people with print disabilities (Canelón & Hare, 2021). Incorporating disability accessibility into OA has the potential to bridge existing information inequalities for people with disabilities—and to make sure that mandates for open research do not exacerbate them (Swenor & Rizzo, 2022). Addressing disparities in disability accessibility on the web has the potential for global benefit (or harm), as people with disabilities are an estimated 15% of the world population (World Health Organization, 2011).

Using universal design principles can make information more accessible to more people. Seven universal design principles were formalized by the Center for Universal Design, and they include perceptible information and equitable use (Center for Universal Design, 1997). Flexible and equitable use are two of the universal design principles, and representing information, such as data, analyses, and figures in scholarship, in multiple formats is one such intervention to provide information to meet a variety of sensory needs and abilities while doing so (Table 1). Representing information in different ways is also a core component of the Universal Design for Learning framework (UDL). UDL includes guidelines for engagement, representation, and expression to best facilitate learning and participation across fields (CAST, 2018). For example, multiple formats could mean pairing audio context with corresponding text (Table 2).

Table 2. Universal Design for Learning (UDL) principles (CAST, 2018) and how they may apply to OA

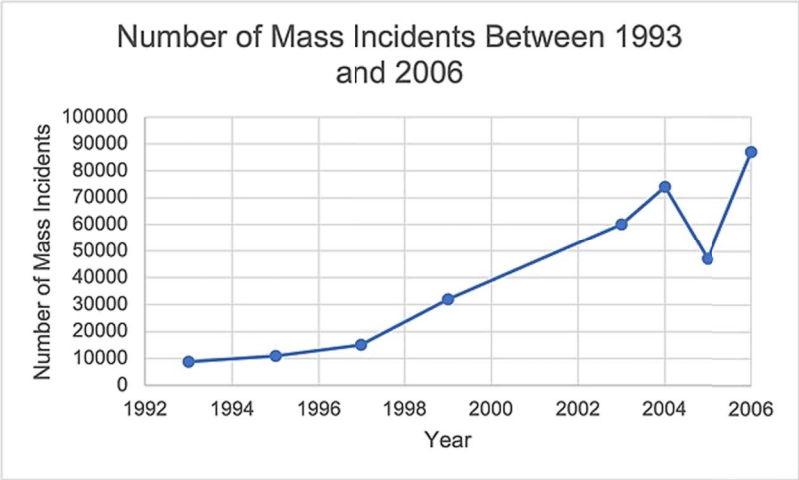
Universal Design for Learning principles	Example applications for OA
Provide multiple means of engagement	Facilitate autonomy in choosing preferred formats and tools to access information
Provide multiple means of representation	Information should be provided in multiple sensory formats
Provide multiple means of action and expression	Enable multiple ways for people to contribute to open projects

Ensuring that visual content is understandable is a major component of ensuring OA publications are accessible. There are many kinds of images that communicate critical information in research publications, including data visualizations, such as charts and graphs, and other figures, such as illustrations and conceptual diagrams. Depending on how they are designed and published, images can be inaccessible to people with vision disabilities and/or people navigating publications using screen-reader or other assistive technologies. Vision disabilities are common and may include colorblindness, blindness, and low vision. The WHO estimates that globally 2.2 billion people have a vision-related disability (WHO, 2022). Other estimates are that over 3% of the world population has a vision disability impacting their life, including people who are blind or have low vision (Bourne, Flaxman et al., 2017). Screen readers are assistive technologies that some blind and low vision people use, which read printed text on screen as spoken language or Braille (American Federation of the Blind, n.d.a). People with other disabilities may also use similar software programs. For example, some dyslexic people, some autistic people, or some intellectually disabled people may choose to use text-to-speech programs (Disability Insider, n.d.). Images cannot be read by screen readers or other text-to-speech programs, unless they are intentionally designed and published to be accessible. Colorblindness is also a common visual disability, which an estimated 1 in 12 men and many others experience (National Eye Institute, 2019). Images with similar shades of colors or in red and green would not be accessible to people with many forms of colorblindness.

Alt text is a common way to make inaccessible images and nontext content more accessible. *Alt* is short for *alternative*, and alternative text is a text substitute describing screen-based visual media (Web Accessibility in Mind, 2021). Screen readers and other software can read this alternative text because of the presence of ALT tags inserted into HTML code, for example (Pennsylvania State University Information Technology Accessibility Group, n.d.). For the text to be considered effective as image description, the text should describe the function and context of the image, prioritizing the critical information first and keeping text concise (American Federation of the Blind, n.d.b). Different kinds of images require different kinds of information to appropriately describe them and their function within context (Web Accessibility Initiative, 2022b). For example, scholarly publications often have complex images, such as charts, graphs, and other complicated content and context that will generally require longer descriptions. These images have distinct alt text recommendations (e.g., Digital Image and Graphic Resources for Accessible Materials Center, 2019; Web Accessibility Initiative, 2022a). We have provided a hypothetical example in Figure 4. Several high-quality tutorials exist to help people write meaningful and accurate alt text for complex and other images (e.g., Consumer Financial Protection Bureau, n.d.; Web Accessibility Initiative, 2017). Alt text can also be automatically generated, using browser extensions (e.g., Twitter A11y, per Gleason, Pavel et al., 2020 and Caption Crawler per Guinness, Cutrell, & Morris, 2018) or other computation tools. However, computer-generated descriptions may be incomplete or inaccurate and require higher cognitive load to fill in the context and content gaps (MacLeod, Bennett et al., 2017).

There is a growing body of research on if and how disability accessibility, including image accessibility, is included in open scholarship and OA. A study on publishing platforms that host scientific journals published online found that in 2011 and 2016, both of the study years, all 233 web pages analyzed had accessibility errors that could impact users' access to content (Navarro-Molina, López-Gil et al., 2018). In 2019, another study examined the accessibility of 131 English-language OA journal websites and found most websites had image accessibility errors. Specifically, 70.08% did not have alt text with every image and 56.49% had alt

A



B

Line graph titled 'Number of Mass Incidents Between 1993 and 2006' with *x*-axis labeled Year and *y*-axis labeled 'Number of Mass Incidents' ranging from 0 to 100,000. The trend line starts at just under 10,000 in 1993, rises slowly to ~15,000 in 1997, increases to ~75,000 in 2004, dips to just under 50,000 in 2005, and then rises to a peak of ~85,000 in 2006. Overall, the number of mass incidents between 1993 and 2006 is increasing year over year, except for the decrease in 2005, before peaking in 2006.

Figure 4. A: Example of a figure that may appear in an OA publication. (Image "Graph of Number of Mass Incidents in China.jpg" by Wikimedia user Steggy1 (CC BY-SA 4.0)). B: Example of corresponding alt text for Figure 4A. Guidelines for alt text for complex images vary, as do personal preferences on what to include. This example includes the title and axis labels, and description of the trend line. Without also representing the data in the chart in another format, such as alt text or providing the raw data, the information in the chart may not be accessible to everyone who wants it.

text with insufficient information (Marino & Mason, 2020). The same study found that 91.6% of the websites lacked high-contrast images. A similar study examining websites for 101 OA science journals in Latin America found that most did not meet web accessibility standards, including image accessibility (Hallo, Hallo, & Luján-Mora, 2017). Studies that look inside the content of journals have found similar results. For example, an analysis of the figures in 30 articles found that while 97% of articles had the potential for alt tags, only 14% of the articles (four of 30) had alt tags (Splendiani & Ribera, 2014). Similarly, a study examining 7,493 figures in 2,278 conference publications in the computer-human interaction discipline found that only 40% contained image descriptions (Jung, Mehta et al., 2021). The broad trends observed across these studies suggest that many OA journals and publishing platforms are generally not conforming to image accessibility guidelines, in both the content and the websites hosting them. However, most studies did not explicitly examine whether the publications required (or even encouraged) image accessibility of the authors making and submitting the images as part of their open scholarship. One study surveyed ornithology journals to determine what author guidelines were in place for colorblind-friendly figures—and found only four (three of which were OA) of the 27 journals in their sample did (Pollet & Bond, 2021). They also examined the 2,873 figures from 1,031 articles, 317 of which were OA, in those 27 journals and found that over 90% were colorblind compatible (Pollet & Bond, 2021). The study did not examine image descriptions

in the articles or whether author guidelines also included alt text requirements or instructions.

Given that accessibility of information is a key component of the mission of OA publishing, our objective in the present study was thus to evaluate how OA journals incorporate disability accessibility as part of OA publishing. We had two specific research questions. The first was to understand if media requirements in OA are currently inclusive, as measured by evidence-based practices for image accessibility. The second was to understand whether disability accessibility and inclusion are part of the culture of OA, by examining the OA statements of the journals. The outcomes can inform ways to align open and reproducible scholarship with access and inclusion. This is critical to identifying and then eliminating barriers to reproducible and open research.

2. METHODS

2.1. Journal Selection

Our sample population of journals was derived from those listed in the Directory of Open Access Journals (DOAJ) as of May 12, 2021. The full DOAJ data set on that date was 16,231 journals (Directory of Open Access Journals, 2021). These journals represented a wide variety of topics and publishers from across the world. We sorted the data set by publishing language and kept all the English-language journals, resulting in 7,330 journals. We then used a random sequence generator to assign the journals a unique identifier between 1 and 7,330 (Random.org, n.d.). We then sorted by integer order and selected the journals with the numbers 1 through 300, to result in a random sample of 300. The resulting data set represented 4% of the English-language OA journals in DOAJ at the time. We also retained the accompanying DOAJ metadata with the journal titles, including journal URL, keywords, languages in which the journal accepts manuscripts, publisher, country of publisher, and subjects.

2.2. Author Guidelines

Starting from the public-facing website for each journal, we navigated to and saved the web page URL for the author submission guidelines. To ensure we compared guidelines from the same time period (May 2021), we copied the content of the author guidelines into a plain text document saved locally. This preserved the data for the time point used for evaluation, even if the website content changed in the future. Within the author instruction data, we evaluated the content relative to the following criteria:

- Are there specific guidelines for images?
- Are the guidelines for supporting text elements (such as captions, titles, and legends) for images?
- Are image descriptions (such as alt text) required for images?
- Are there contrast requirements (such as high contrast) for images?
- Are there color choice requirements (such as colorblind-friendly palettes) for images?

2.3. OA Statements

Starting from the journal website, we navigated to and saved the web page URL for the OA statement. For example, the journal *Heritage and Sustainable Development* has an "OA Statement" as part of the web page labeled "About the Journal" (*Heritage and Sustainable Development*, n.d.). Some journals call this slightly different things, such as *OA policy*. As described

for author guideline text, we copied the text of the OA statement into a plain text document saved locally to ensure that our data set represented May 2021 data consistently across the journal sample. We specifically looked within the text of the OA statements for the journals to ask

- Is there mention of "access" or "accessibility"?
- Is there mention of "disability" or "disabled"?
- Is there mention of "inclusion" or "inclusive"?

3. RESULTS

3.1. Journals

The 300 journals we surveyed represented 174 publishers (Table S1 in the Supplementary material). Journals from Elsevier (n = 18) and BMC (n = 18) had the highest representation in our data set, followed closely by Hindawi Limited (n = 13) and Sciendo (n = 11), Wolters Kluwer Medknow Publications (n = 10), and MDPI AG (n = 9). Most publishers were represented by only one journal in our data set (n = 137). The publishers of the journals in our sample were headquartered in 56 countries (Table S2 in the Supplementary material). The United Kingdom was the country of publication with the highest number in our sample (n = 72); 24% of journals in our data set are from publishers there. Several other countries of publication had high representation, including the United States (n = 32), Islamic Republic of Iran (n = 21), Poland (n = 19), and Indonesia (n = 14). About half of the countries represented (n = 24) had one journal in our data set. The journals also covered a wide range of subjects (Table S5 in the Supplementary material). Just over one third (n = 101) of the journals were focused on medicine. Other common journal topics included social sciences (n = 34), nonphysics sciences (n = 33), and engineering (n = 29).

3.2. Author Guidelines

Of the 300 journals in our data set, 289 had author guidelines, and 11 journals did not provide author guideline documents on their public websites. Of the journals with author guidelines for submissions (n = 289), 213 (~74%) had guidelines for images as part of the author instructions, while 76 journals did not (Figure 5). Guidelines commonly provided instructions on where to put images within a submitted manuscript document or the file formats that images should be provided in. Of the study sample, 139 journals (~48%) required descriptive elements accompanying images, such as captions, titles, or legends. Yet none specifically had requirements for alternative text, only 38 journals (~13%) had color choice guidance, and only six (~2%) had contrast ratio guidelines.

3.3. OA Statements

Of the 300 journals surveyed in our data set, 298 had OA statements, and two journals did not provide a statement of this type on their website. Of the journals with OA statements (n = 298), 228 (~77%) referenced the terms *access* and/or *accessibility* as part of their statement (Figure 6) Fewer than 1% (n = 2) of journals surveyed mentioned *inclusion* or *inclusive* as part of their OA statement. None of the journals surveyed used the words *disability* or *disabled* as part of their respective statements.

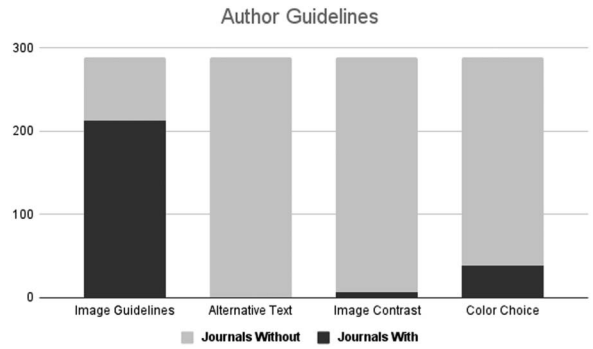


Figure 5. We assessed author guidelines for journals in our data set (n = 300) for journals with and without stipulations for image guidelines, alternative text, contrast guidelines for images, and color choice guidelines. Of the 300 journals surveyed in the study, 289 had author submission guidelines, and of those, 213 (~74%) had guidelines for images. Light gray bars show journals without those elements and dark gray bars show journals with those guidelines. No journals required alternative text to accompany images, a small number (13%) included guidance about color choices, and very few included contrast ratio guidelines for images (~2%) This data is also available as a text table in Table S4 in the Supplementary material. Figure 5 image description: Bar chart with x-axis of four columns: image guidelines, alternative text, image contrast, and color choice. The y-axis is a numeric bar of 0 to 300. Header says "Author Guidelines." Light gray bars represent the number of surveyed journals out of 300 that are without these parameters in the author submission guidelines and black bars represent the journals with those parameters in the author submission guidelines. Of the 289 journals with author guidelines, 213 (~74%) have some kind of image guidelines. Zero journals out of the 289 with guidelines require alternative text for images. Very few (~2%) require images to be high contrast, and 38 (~13%) include consideration or requirements for color choices, often focused on colorblind-friendly palettes.

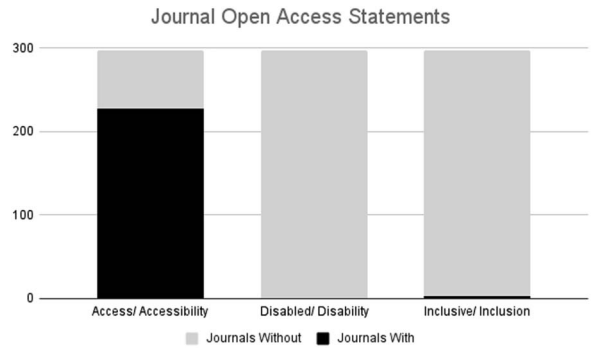


Figure 6. We assessed OA statements for the journals (n = 300) in our data set for journals with and without the terms access/accessibility, disabled/disability, and inclusive/inclusivity in their statements. Of the journals with OA statements (n = 298), 228 (~77%) included the terms access or accessibility. None mentioned the terms disabled/disability, and very few (<1%) mentioned inclusive/inclusion. Light gray bars show journals without those elements and dark gray bars show journals with those guidelines. This data is also available as a text table in Table S5 in the Supplementary material. Figure 6 image description: Bar chart with three columns: left to right, the columns are access/accessibility, disabled/disability, and inclusive/inclusion. The gray bars are the number of journals out of the 300 surveyed without these parameters in their OA statement or vision; and the black bars represent the number of journals out of the 300 surveyed that include these parameters in their OA statements or vision. The bars do not sum to 300 because only 298 journals in the study sample had OA statements. Of the 298 journals with OA statements, 228 (~77%) journals include mention of access or accessibility. Yet none of the journals mention disability or disabled and almost none (<1%) mention inclusive or inclusivity as part of the statement.

4. DISCUSSION

We found that most OA journals do not include disability accessibility elements in their guidelines to authors when submitting images as part of their scholarship. This omission was not because journals did not have guidelines at all; almost all had author guidelines generally, and 213 had instructions for authors about images. Moreover, almost half of the journals specified wanting accompanying text such as captions and legends. Notably absent from most author guidelines documents were considerations of image accessibility. However, several (six) journals incorporate guidance to authors for image contrast standards. High-contrast images and colorblind-friendly palettes can make images more accessible for people with colorblindness and other vision disabilities. The lack of color specifications and contrast guidelines in most of the journals sampled indicates that editorial policy at many journals does not specifically encourage (or acknowledge) those dimensions of research communication and accessibility. No journals among those sampled required alt text for images or figures. A single journal out of our sample of 300 had three of the four considerations we assessed; that journal had a section of the author guidelines explicitly focused on color choice and contrast but still did not include image descriptions in the guidelines. We also noted commonalities in approach among multiple journals published by the same publisher; often, all the journals of a publisher had the same or similar guidelines. For example, one publisher in our sample provided the same guidelines regarding preparing images for colorblindness.

Our results highlight the effective vacuum that exists in attention to disability guidelines in journals outwardly professing access as part of their missions. Yet, established guidelines are essential to ensuring the usability of accessible practices, rather than simply encouraged or allowed. Previous work has shown that alt text is more likely, and more likely to be appropriate, when guidance is provided versus just being technically feasible (Bennett, Gleason et al., 2021; Gleason, Carrington et al., 2019; Mack, Cutrell et al., 2021). In interviews, screen reader users have outlined preferences for alt text to be accurate, complete, and concise (Mack et al., 2021). The same study interviewed nonscreen reader users, some of whom indicated that they did not know how to write alt text or the difference between captions and image descriptions. Another study interviewing blind and low vision people identified elements of data visualizations that are important to describe to make it accessible: the type of chart, axes, data trends, and a range of two to eight sentences, often wanting the underlying data also as a table (Jung et al., 2021). Journals can incorporate these findings to provide guidance for authors submitting nontext content in their submissions.

Yet, guidelines alone will likely not ensure accessibility without quality control or enforcement. For example, a recent study analyzing figures from 300 conference papers between 2019 and 2021 for a conference that did provide alt text guidelines and writing resources found that not all the images had alt text (Williams, de Greef et al., 2022). A similar study of conference papers from a conference with guidelines found that even when authors did include alt text, they were often missing elements requested in the guidelines (Jung et al., 2021). Additionally, a recent study examining three years of #TidyTuesday posts on the Twitter social media platform, where alt text is possible, found that of 7,136 tweets about data visualization in R programming software, a common tool in the open movement, only 215 (3%) of them included alt text (Canelón & Hare, 2021). Journals already have copyediting and proofing stages built into the publication process that may provide editorial steps to better ensure that alt text is present and of high quality.

Image descriptions and colorblind-friendly palettes are not the only ways to make images more accessible in journals. With equitable information access as the goal, there are many

potential approaches and preferences by individuals. Alt text, as is, is static and generic; some researchers have proposed other ways of designing alternative text that could be personalized or updated (Morris, Johnson et al., 2018). Many researchers have been developing automated tools to interpret visual data (e.g., review by Shahira & Lijiya, 2021), sound-based approaches (e.g., review by Lee, Lee, & Cho, 2021), or even touch exploration (e.g., Lee, Herskovitz et al., 2022). Some of these automated tools could be deployed by journals themselves, rather than individual scholars. For example, the publisher Taylor & Francis Online has enabled a text-to-audio read-aloud option for all its journal content (Taylor & Francis Online, 2022). However, adoption of these technologies relies on images to be described, so that they can be read. Moreover, complex or novel technologies are not necessarily better or more accessible. Accessible visualization design should follow existing best practice guidelines and be aligned with the needs of communities (Lundgard, Lee, & Satyanarayan, 2019). Access should be based on the needs and expertise of disabled scholars, following the "nothing about us without us" principle of the disability rights movement (Charlton, 2000, p. 3). This is critical, as studies on image description have found differences between what screen reader users and nonusers consider important to include (Mack et al., 2021; Morash, Siu et al., 2015). Examples of community-led approaches include Chartability, a collaboratively developed set of principles and criteria for accessible data visualizations (Chartability, n.d.). Other potential approaches to accessibility are curated in community bibliographies and repositories, such as the "Dataviz Accessibility Resources" list maintained by DataViz Accessibility and open to contributors on GitHub (DataViz Accessibility, 2022).

While OA journals are a growing facet of the research publishing ecosystem, improved accessibility in journals will not meaningfully improve accessibility without removing structural barriers throughout the rest of the system. For instance, a recent study of the accessibility of 124 academic library websites found that 75% had color contrast errors and 19% had missing alt text (McCann & Peacock, 2021). Academic libraries may represent a significant force for change in this sphere: Libraries have significant responsibility and power to negotiate and provide accessibility, especially for electronic resources (Rodriguez, 2020). Another survey found that academic library databases, where many scholars access journal articles, are largely not aligned with accessibility guidelines (Tatomir & Durrance, 2010). They found 72% of the 32 databases evaluated were marginally accessible or inaccessible. Beyond publishing, many other aspects of academic research have access considerations. For example, research conferences can present access barriers if not designed and implemented with people with disabilities in mind (Serrato Marks, 2018; Serrato Marks, Solomon, & Stack Whitney, 2021). A recent study on presentations found that 72% of visual elements in 90 presentation videos were insufficiently described (Peng, Jang et al., 2021). To build a truly accessible research ecosystem, all parts of the research creation, consumption, and sharing processes should incorporate disability accessibility.

Our sample suggests that most OA journals surveyed are not considering disability accessibility as part of OA, as measured by their statements of OA. While the majority were using the words *access* or *accessibility* in their OA statements, the vast majority did not include mention of inclusion or disability. This, in combination with our findings about author guidelines, indicates that OA journals are not considering disability accessibility as part of their definition of OA. This result is in line with previous work in other parts of the open ecosystem, such as a recent survey of librarians working with open education resources, which found that fewer than half of the respondents consider accessibility when creating, adapting, or adopting open education materials for their collections (Schultz & Azadbakht, 2021). A recent systematic review of accessibility research within open education found that these connections are still

understudied compared to the vast literature on OA generally (Zhang, Tlili et al., 2020). But inaccessibility is a barrier to, and incompatible with, the goals of open education and information. OA that does not include accessibility for people with disabilities can cause or exacerbate inequalities in information access (Swenor & Rizzo, 2022). Moreover, failure to make materials accessible at the point of creation or publication results in increased need for individual accommodations by institutions, resulting in redundancies and increased costs. For example, if a journal article is not accessible and someone needs it, their institution will need to make it accessible—often through staff time and energy, and often in a way that only provides local access.

Our findings speak to the limits of some of the current frameworks of OA. Openness is a "mode of valuing" research and its outputs (Levin & Leonelli, 2017, p. 282). Critics of open scholarship have highlighted other limitations, such as structural power imbalances of #bropenscience (Whitaker & Guest, 2020) and downplaying the reasons people may opt partially or entirely out of open research practice (Bahlai, Bartlett et al., 2019). The disconnect between open scholarship ideals and the journal-level enforcement of accessibility standards in practice indicates that OA is not yet living up to its goals of being "for all." Indeed, open research publication may not be for all, and these limitations may extend well beyond the disabled community. For example, while text may be a way to represent spoken interview information in print form word for word, interviews in signed languages cannot be shared without sharing the identity of the signer, as critical nonmanual markers in signs are on and in front of the face (Bragg, Koller et al., 2020), limiting the ability to anonymize data in accordance with open data publishing requirements. Yet other data may be sensitive for other reasons—there are legitimate reasons why people may not be able to (or not want to) participate in these practices (Bahlai et al., 2019). Open data can be harmful—for example, critical questions of tribal sovereignty arise over non-Indigenous researchers sharing data that is not theirs to open (Garrison, 2013). Open data portals have also been used by the illegal wildlife trade to source plants and animals, leading some scientists to advocate not publishing descriptions or data on sensitive species (Lindenmayer & Scheele, 2017).

Many scholars and communities are reimagining what OA and open scholarship can and should be; other ways of working "open" exist and could. This reconfiguring is not in opposition to, but rather in support of, open movements to achieving ideals stated in visions like the Budapest Open Access Initiative (2002). For example, feminist scholar Denisse Albornoz's work on power structures in OA argues that careful, considered openness with community consent can be "inclusive infrastructure" (Albornoz, 2018). Indigenous data scientists have proposed alternative frameworks to FAIR, such as CARE (collective benefit, authority to control, responsibility, and ethics), which centers community needs and accountability (Carroll, Garba et al., 2020). And disabled data visualization experts like Frank Elavsky push back on checklist or compliance-centered approaches to accessible information, reminding us that access requires not just something like accompanying text with an image, but "the skill of rendering care" (Elavsky, 2022). Building accessibility into openness is aligned with these visions of opening and sharing data in ways that can reduce harm and increase inclusivity.

Our findings also raise additional questions. We acknowledge that analyses of other OA journals or other subsets of journals not specifically aligned to OA values may lead to different results. For example, our study sample represented 4% of the English-language OA journals in DOAJ at the time. If a different subset of journals or larger number of journals were included in our sample, we may have reached different conclusions if the additional journals conform to patterns not captured in our original sample. For example, future research could be conducted with a nonrandom sample, such as intentionally balanced samples of various disciplines,

countries, or publishers. Future studies could also build upon this work to ask additional questions about accessibility in OA using larger and more diverse journal samples, such as the addition of non-English-language journals. Additionally, image accessibility is just one dimension of accessibility and universal design that journals and OA could be considering to make open scholarship more accessible and inclusive for more people. It is possible that journals and publishers would score differently if evaluated on aspects of accessibility that were not considered in this study. Future work could also consider comparing OA and non-OA journals and publishers. While few OA journals sampled seemed to be considering disability accessibility in their guidelines for authors, it may be more (or less) than non-OA journals if these guidelines were built using differing values and standards—and empirical studies could test these questions.

5. CONCLUSIONS

As currently implemented, the OA journals we surveyed are largely not considering an important and widely needed facet of accessibility at a policy level. Few journals provided any emphasis on disability accessibility in their guidelines to authors for submitting images nor in the journals' OA statements. While our sample may not represent all journals, these results are consistent with trends unveiled in other recent work, which has found that other parts of open scholarship are also not often considering disability accessibility as part of OA. Ensuring that visual content in OA journals, such as figures and charts, is understandable to people with vision disabilities is necessary to make OA true to its name and stated goals. Incorporating disability accessibility into OA has the potential to bridge existing information inequalities for people with disabilities—and to help make sure the growing OA movements and mandates do not exacerbate existing inequalities.

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Kaitlin Stack Whitney: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Visualization, Writing—original draft, Writing—review & editing. Julia Perrone: Conceptualization, Funding acquisition, Writing—original draft, Writing—review & editing. Christie A. Bahlai: Conceptualization, Funding acquisition, Writing—original draft, Writing—review & editing.

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The authors have no competing interests.

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DATA AVAILABILITY

All data were collected from already publicly available sources.

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