Disinformation in Science: Ethical Considerations for Citing Retracted Works

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ABSTRACT
This paper discusses the ethical implications of citing retracted biomedical literature, particularly in the context of spreading misinformation within scholarly discourse. It examines the responsibility of scientists to combat disinformation and uphold ethical standards in their research practices. To guide our discussion, we studied citations of the most often cited retracted works containing disinformation in Web of Science. Our findings confirm prior research and demonstrate that most citations to retracted papers reference them to bolster arguments or use methodologies without acknowledging their status. We conclude by interpreting our findings through a framework of moral obligation and argue that scientists have a special responsibility to combat disinformation, which may harm others. Cognitive authorities, namely scientists, citing invalid publications may perpetuate false beliefs and erode trust in scientific integrity.

KEYWORDS
Scientific communication; misconduct; retraction of publications; disinformation; information ethics

INTRODUCTION
In his introduction to virtue ethics, Richard Taylor (2010) describes a transformative shift that occurred some 2,000 years ago, where the notion of obligation underwent a profound metamorphosis into what he terms "moral obligation" (p. 77). This evolution in ethical thinking underscores the intrinsic responsibility individuals bear towards others, emphasizing the imperative to act in accordance with what is morally right. Scientists, too, find themselves entangled in webs of ethical quandaries, with Murray Edelman (2001) observing how the encroachment of politics on scholarly pursuits may promote the spread of misinformation and threaten the integrity of scientific inquiry writ large. Thomas Froehlich (2017) further delves into the ethical complexities of information dissemination, urging a critical examination of misinformation and its impact on the infosphere (the landscape of information production, collection, dissemination, and use). Against this backdrop, we examine citations to a high-profile sample of retracted works and frame their utilization as a moral issue, calling attention to scientists' obligation to combat the spread of *disinformation* through citations. Disinformation is false information created to deceive, while misinformation is simply false information spread by individuals.

MISINFORMATION
Scientific research faces many challenges, as highlighted by R. Grant Steen (2011), who points out several factors that cast doubt on research findings. These include:

- Small study sample sizes,
- Small effect sizes,
- Too many hypotheses tested by researchers with a single dataset,
- Excessive flexibility in study designs, and
- Authors rushing to report preliminary results (p. 498).

According to Steen, these factors create fertile ground for the spread of misinformation, with the intensity of a research field directly correlating with its susceptibility to being tainted by falsehoods (p. 498). This susceptibility is apparent in studies related to the COVID-19 virus, as exemplified by Levin and Bradshaw's analysis (2022), showing that public attitudes are politically and religiously conditioned. In their work, politically conservative and biblical literalist beliefs predicted if individuals were COVID-19 vaccine skeptics. Further illustrating the issue, J. B. Carlisle's (2021) examination of clinical trials submitted to *Anaesthesia* uncovered a 14% incidence of falsified data among 526 trials between 2017 and 2020. Although this percentage may seem low, its potential impact on subsequent research should not be understated, especially when scholars build upon flawed or fabricated findings. Carlisle categorizes such studies as "zombies" because they are intellectually dead but continue to live on in the scholarly record. Falsified papers accounted for 8% of their sample and, by association, cast doubt on the validity of related work.

The proliferation of false or erroneous information among scientists may occur regardless of an individual's intent, as noted by Don Fallis (2015). Whether stemming from honest error, negligence, unconscious bias, intentional deception (disinformation), or misinformation, the dissemination of inaccurate information may have far-reaching consequences, causing emotional, financial, and even physical harm (p. 402). VanNoorden (2023a) echoes this sentiment, emphasizing that fraud in scientific research is far from victimless (p. 456). Their argument extends to inaccurate information that researchers accidentally spread, regardless of the increasing pressures they feel to "hype their results because productivity metrics have taken on a greater role on scientific achievement" (West & Bergstrom, 2021, p. 2).

Individuals drive the spread of inaccurate information in science, but we must consider other factors to understand the phenomenon. Brian Southwell et al. (2022) note, "Much communication research has proceeded from an assumption of information as measurable and existent in an objective reality, and yet we [… should] acknowledge the limitations that we face as human beings in claiming to know reality. But even if we stop short of a focus on absolute truth, it is reasonable to focus on accuracy relative to shared understanding" (p. 99). The reasonableness of their expectation diminishes if we acknowledge that human flaws extend to outright dishonesty when communicating truth, even in scientific research. West and Bergstrom (2021) speak about systemic incentives for dishonesty because "Changing economic models have created new opportunities for [… bad actors]. The rise of electronic distribution established a market for online open access, in which [authors, not readers, bear the cost of publishing]" (p. 4). This has given rise to predatory publishers, who seek to profit from the pressure that researchers face to publish. There is also concern about "paper mills" flooding scientific journals with papers generated solely to provide publications to authors who need them for tenure and promotion purposes (see, for instance, Joelving, 2024).

What can be done to combat false information in science? Steven de Peuter and Stijn Conix (2023) provide a strategy for institutions that includes a set of processes, policies, and procedures, including:

- Rules, codes of conduct, and guidelines,
- Assessing researchers, and
- Ethical leadership and collective openness (pp. 134-36).

They urge that individuals who do not adhere to codes of conduct (i.e., they fail to fulfill their moral obligations) be held accountable—violations should have consequences. However, how do we identify violations? Examining retracted papers provides a starting point, and in this paper, we explore the spread of intentionally produced falsehoods in biomedical literature.

RETRACTIONS

Scholarly communications researchers study retracted papers, not merely as an academic exercise but because they provide insight into how, when, and why researchers fail to disseminate accurate information or violate shared codes of conduct. Budd, Coble, and Abritis (2016) write: "When something has been determined seriously problematic with an article, it might be retracted. This action means the article should no longer be considered valid research" (p. 1). Although retractions do not account for all scientific dis- and misinformation, they document cases where publishers decide publications should no longer remain in circulation. S. M. Yentis (2010) speaks about publication ethics or "the principles and standards associated with the process of publishing the results of scientific research" (APA, 2022). They separate publication from research ethics, noting that scientists must grapple with questions about their broader social influence. In this sense, retractions are decidedly moral acts that protect others from using false information and disincentivize research misconduct.

Retractions are not a monolith and have changed over time. The Retraction Watch database (www.retractiondatabase.org) indicates that 81.7% of retractions in U.S.-based academic journals are in the life or health sciences—retractions in business and technology (6.4%) or the social sciences (7.6%) are less common, as of July 28, 2022. Extending a prior study, Budd et al. (2011) found that misconduct (i.e., outright fabrication, falsification, or plagiarism in research) caused 55% of retractions in PubMed between 1997 and 2009. Their findings represented an increase of 19% compared to the period between 1966 and 1996 (Budd et al., 1999). Nicoll et al. (2023) found an even greater degree of misconduct (68%) in nursing papers retracted between 1977 and 2022 (p. 1). Nevertheless, it bears mentioning that retractions are not always due to misconduct (Teixeira de Silva & Al-Khatib, 2019). Budd and colleagues (2011) distinguish between academic misconduct, replication issues, methodological and data-related errors, duplication of publication, and other reasons (p. 392), some of which are accidents.

A surge in retractions during the past decade presents researchers with an increasingly common ethical dilemma. Van Noorden (2023b) reports that from 2013 to 2023, the ratio of retracted to published works grew (roughly 0.03% to 0.23%). Therefore, we ask—should authors cite retracted works? When is doing so appropriate, and how?

Citations serve multiple purposes. They provide references or sources to others' work, promote intellectual honesty, support claims by providing evidence, define the state of knowledge regarding a topic, and note intellectual gaps in the literature. A well-established body of literature (e.g., Asknes, Langfielt, & Wouters, 2019) demonstrates that citations do many things. Still, fundamentally, citations support truth claims by providing evidence.

Despite citations providing evidence to support truth claims, scientists do much more than cite retracted literature—they frequently treat it as valid. In 1998, Budd, Sievert, and Schultz examined 2,034 citations to 235 papers and found that just 19 citations in citing papers noted cited papers were withdrawn. Subsequent studies have found comparable, albeit not identical, results (Neale, Dailey, & Abrams, 2010; Piller, 2021; Schneider et al., 2020; Suelzer et al., 2019). For example, Neale, Dailey, and Abrams (2010) report that for a random sample of 603 citations to 102 articles in Web of Science (WoS), only 5% "indicated any awareness that the cited article was retracted or named in a finding of misconduct" (p. 251). Other studies evaluate the tone of citation-related text (Hamilton, 2019; Theis-Mahon & Bakker, 2020; Yang, Qi, & Diao, 2020), finding that most citation-associated paragraphs are positive (Bar-Ilan & Halevi, 2017, p. 547). De Cassai et al. (2022) provide a first-of-a-kind empirical study explaining why researchers cite retracted papers. After contacting 1,297 authors, 89% reported that they cited a retracted publication because they did not know it was invalid. Xu et al. (2023) attribute unacknowledged positive citations to flawed retraction notices, but a lack of awareness does not absolve researchers of their responsibility to validate papers they cite.

Scientists do pay attention to the validity of the papers they cite, so we should not overstate the problem. Oransky (2020) notes that citations drop when researchers retract papers for fraud. Still, there is no equivalent reduction in retractions for "honest error" (p. 146). His finding suggests that researchers try to prevent the spread of disinformation (i.e., the worst of the worst), but combatting misinformation is more difficult. Unfortunately, both disinformation and misinformation alike may harm individuals and society. Hill et al. (2019) say that "Without exaggeration, significant harm, to society and individual, derives from the wonton spread of medical misinformation" (p. 300). Menezes (2016, p. 604) agrees, suggesting scientists must conceive the issue as an ethical matter and act accordingly.

STUDYING HIGH-PROFILE FRAUDULENT RETRACTIONS

Our study accomplishes two things.

1. It contributes to research examining retractions, focusing on papers that spread *disinformation* through citations. We treat citations as an *ideal type*. See Weber (1949, pp. 42-44) for more information. Based on our literature review, we believe that prior research inadequately differentiates among the types of falsehoods that retractions spread. For example, some retractions are caused by legal issues (e.g., failure to obtain IRB approval) and do not spread falsehoods. Other retractions unintentionally disseminate false/inaccurate information. Studies examining retractions have classified post-retraction citations by their type (e.g., Hsiao & Schneider, 2021), but we have yet to find work tracing mis- and disinformation's spread.
2. Capitalizing on this distinction, we contribute more broadly to an ethics of "ignorance, disinformation, misinformation, missing information, lies and deceit," as espoused by Thomas Froehlich (2017, p. 2). We do this by focusing on information ethics as they apply to knowledge creators, specifically calling attention to scientists' responsibilities as learned persons to fight disinformation.

Our Study

In December 2023, we conducted a search using WoS to identify the 50 most cited, retracted academic publications available. We limited our sample to the period between December 7, 1973, and December 6, 2023. Using information provided by the Retraction Watch database and filtering them with Froehlich's (2017) definition of disinformation, we found 13 papers where authors *falsified or fabricated data*, *manipulated images*, or *falsified or fabricated their research results*. Scientists cited these papers 11,598 times. Twenty-six percent (n=2,996) of retraction citations occurred after publishers withdrew papers. We excluded preprints (because they are not peer-reviewed) and limited our analysis to papers in English only. One paper originated from a chemistry journal, and 12 were from biomedical and life science journals.

Selecting Citations to Analyze

We were unable to review every citation to the 13 papers in our sample. In response, we followed a two-step process to choose citations and learn why authors cite and disseminate disinformation. Recall that citations support truth claims by providing evidence. In step one, we normalized paper citations, setting their retraction year as "0," unveiling a major decline in post-retraction citation counts, which corroborates prior studies (e.g., Oransky, 2020). However, as shown in *Figure 1*, citations never stopped, simultaneously supporting research that has repeatedly expressed concerns about citations to retracted works and the harm that might result (e.g., Budd, Coble, & Abritis, 2016).

In step two, we examined a subset of 274 citations in eight papers, focusing on those occurring two years post-retraction. We examined these citations to give authors time to learn that papers were invalid. We also excluded five citing papers from our analysis because four were retracted before our two-year cutoff point. The fifth was an already-studied outlier (see *Figure 2*) that continues to receive citations in the form of negative coverage (Suelzer et al., 2019; Heibi & Peroni, 2021). Wakefield et al. (1998) is an infamous paper because it empowered the anti-vax movement, promoted vaccine hesitancy, and was arguably "the most damaging medical hoax of the last 100 years" (Flaherty, 2011, p. 1,302). *Table 1* provides a complete list of retractions in our sample, including those we analyzed and excluded.

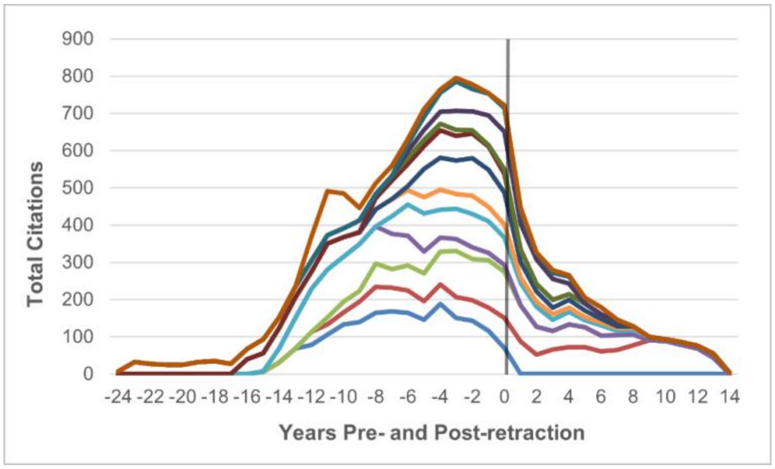

Figure 1. Total citations of retracted works by year, pre- and post-retraction year (normalized)

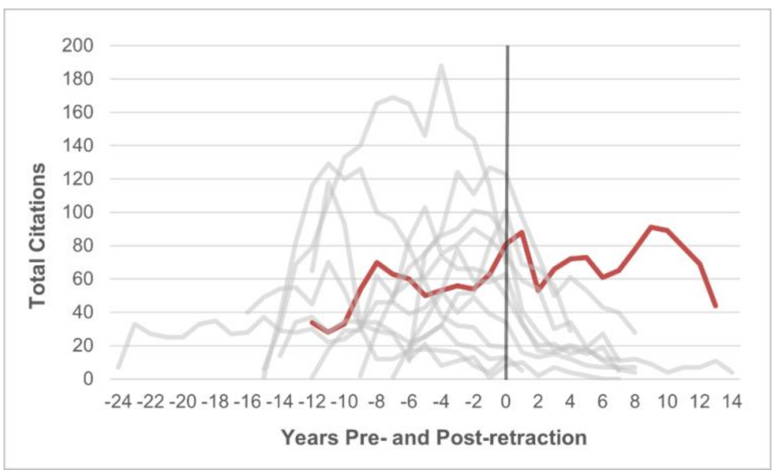

Figure 2. Total citations of retracted works by year, pre-and post-retraction year (Wakefield et al., 1998, highlighted in red)

Analyzing Citations

Hsiao and Schneider (2021) provide an already-validated framework to classify post-retraction citations. We adopted their framework and excluded every citation of retractions from our sample (n=14) that was not in English or available for download. We obtained papers that contained citations through the University of Michigan Libraries. Below are the codes we used:

- **Related work or use**—Citations referencing related work or using content from within a retraction.
- **Comparison of results**—Compared findings to another paper.
- **Corrections**—Corrected an article based on retractions.
- **Replication of retraction**—Attempted to replicate a study reported by a retracted paper.
- **Example of problematic science**—Provided citations that exemplify bad or problematic science.

- **Exclusion rationale**—Explains why authors did not use a retracted paper to write their literature review, synthesis review, or discussion section.
- **Notification of retraction included**—Authors noted a paper's retraction in-text.
- **Subject of study**—Presented a retraction as the study's subject (e.g., research examining retractions specifically).
- **Other**—Citations that did not fit other categories.

When coding citations, we applied codes to each citation describing retracted papers. We chose the best-fit code in instances where more than one could describe paper citations. Hsiao and Schneider (2021) treat "related work" and "use" citations as distinct categories within their framework. Still, we combined these categories because they supported truth claims made by authors—either by using methods the retracted work pioneered or describing related work and presenting evidence from within the retraction to make some sort of argument. We coded each paper in Excel and analyzed our findings by calculating descriptive statistics for average paper citations, total citations, mean and mode citations, standard deviations, maximum citations, and minimum citations. We present our most noteworthy findings below.

Retracted Paper	**Exclude**
Taylor, D. D., & Gercel-Taylor, C. (2008). MicroRNA signatures of tumor-derived exosomes as diagnostic biomarkers of ovarian cancer. *Gynecologic oncology, 110*(1), 13–21.	Yes, retracted during the past two years
Wakefield, A. J., Murch, S. H., Anthony, A., Linnell, J., Casson, D. M., Malik, M., ... & Walker-Smith, J. A. (1998). Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. *The Lancet 351*(9103), 637–641.	Yes, a well-studied outlier
Voinnet, O., Rivas, S., Mestre, P., & Baulcombe, D. (2003). An enhanced transient expression system in plants based on suppression of gene silencing by the p19 protein of tomato bushy stunt virus. *The Plant Journal, 33*(5), 949–956.	No
Macchiarini, P., Jungebluth, P., Go, T., Asnaghi, M. A., Rees, L. E., Cogan, T. A., ... & Birchall, M. A. (2008). Clinical transplantation of a tissue-engineered airway. *The Lancet, 372*(9655), 2023-2030.	Yes, retracted during the past two years
Reyes, M., Lund, T., Lenvik, T., Aguiar, D., Koodie, L., & Verfaillie, C. M. (2001). Purification and ex vivo expansion of postnatal human marrow mesodermal progenitor cells. *Blood, 98*(9), 2615–2625.	No
Brigneti, G., Voinnet, O., Li, W. X., Ji, L. H., Ding, S. W., & Baulcombe, D. C. (1998). Viral pathogenicity determinants are suppressors of transgene silencing in nicotiana benthamiana. *The EMBO Journal, 17*(22), 6739–6746.	No
Valastyan, S., Reinhardt, F., Benaich, N., Calogrias, D., Szász, A. M., Wang, Z. C., ... & Weinberg, R. A. (2009). A pleiotropically acting microRNA, miR-31, inhibits breast cancer metastasis. *Cell, 137*(6), 1032–1046.	No
Tsukumo, D. M., Carvalho-Filho, M. A., Carvalheira, J. B., Prada, P. O., Hirabara, S. M., Schenka, A. A., Araújo, E. P., ... & Saad, M. J. (2007). Loss-of-function mutation in Toll-like receptor 4 prevents diet-induced obesity and insulin resistance. *Diabetes, 56*(8), 1986–1998.	No
Hong, K., Hinck, L., Nishiyama, M., Poo, M. M., Tessier-Lavigne, M., & Stein, E. (1999). A ligand-gated association between cytoplasmic domains of UNC5 and DCC family receptors converts netrin-induced growth cone attraction to repulsion. *Cell, 97*(7), 927–941.	Yes, retracted during the past two years
Kumar, P. T., Lakshmanan, V. K., Anilkumar, T. V., Ramya, C., Reshmi, P., Unnikrishnan, A. G., ... & Jayakumar, R. (2012). Flexible and microporous chitosan hydrogel/nano ZnO composite bandages for wound dressing: in vitro and in vivo evaluation. *ACS Applied Materials & Interfaces, 4*(5), 2618–2629.	No
Wenz, T., Rossi, S. G., Rotundo, R. L., Spiegelman, B. M., & Moraes, C. T. (2009). Increased muscle PGC-1alpha expression protects from sarcopenia and metabolic disease during aging. *PNAS, 106*(48), 20405–20410.	No
Hwang, W. S., Ryu, Y. J., Park, J. H., Park, E. S., Lee, E. G., Koo, J. M., ... & Moon, S. Y. (2004). Evidence of a pluripotent human embryonic stem cell line derived from a cloned blastocyst. *Science, 303*(5664), 1669–1674.	No
Wang, J., Shiozawa, Y., Wang, J., Wang, Y., Jung, Y., Pienta, K. J., ... & Taichman, R. S. (2008). The role of CXCR7/RDC1 as a chemokine receptor for CXCL12/SDF-1 in prostate cancer. *The Journal of Biological Chemistry, 283*(7), 4283–4294.	Yes, retracted during the past two years

Table 1. Sample of most-cited (n=13) retracted works containing disinformation and exclusion rationale

Our analysis revealed that most citations (81.9%, n=244) referenced papers containing disinformation (e.g., falsified data) to use methods or data presented therein to bolster arguments. *This means that the citing paper's arguments were not necessarily dependent on falsified, fabricated, and manipulated content, but their authors failed to explain their citations to papers containing known disinformation*. A far smaller proportion (13.1%, n=39) of papers compared study results to retracted studies. A negligible fraction of citations referenced retracted works as the subject of study (3%, n=9), provided examples of problematic science (1%, n=3), or cited retractions for unclassified reasons (0.7%, n=2). One (0.3%) citation we identified acknowledged a paper's retracted status.

We found citations in journal articles (80.0%, n=208), literature reviews (12.7%, n=33), book chapters (6.9%, n=18), and editorial reviews (0.4%, n=1). Although we did not contact the corresponding authors and ask them why they cited retracted works, our findings align with but do not explicitly confirm De Cassai et al. (2022) and Xu et al. (2023), who found that a lack of awareness explains most post-retraction citations. The composition of citations in our sample also matched those in other studies (Neale, Dailey, & Abrams, 2010; Piller, 2021; Schneider et al., 2020; Suelzer et al., 2019) because most citations did not acknowledge they cited retracted works. We, thus, conclude that the authors of the papers citing retractions failed in their moral obligation to combat disinformation, which is our primary contribution to scholarly literature and studies of retractions.

DISCUSSION

Our findings are not surprising because prior research demonstrates that post-retraction citations are common and portray retracted works in a positive light (Budd, Sievert & Schults, 1998; Hamilton, 2019; Hsiao & Schneider, 2021; Neale, Dailey, & Abrams, 2010; Piller, 2021; Schneider et al., 2020; Suelzer et al., 2019; Theis-Mahon & Bakker, 2020; Yang, Qi, & Diao, 2020). However, we demonstrate that citing authors did more—they disseminated disinformation even when given ample time to learn of retractions. More alarming is that we limited our study to retractions containing content published with malicious intent, but citing authors failed to recognize problems, errors, and inconsistencies within the papers they cited. Scientists are, ostensibly, experts armed with knowledge that justifies their position as what Wilson (1983) calls a *cognitive authority*. Society assumes scientists "know what they are talking about" (p. 13), but they did not know the papers in our sample were invalid or identify false content contained therein. And, while ineffective retraction notices (Xu et al., 2023), human fault (Southwell, 2022), and systemic incentives (West & Bergstrom, 2021; Joelving, 2024) explain our results, they do not absolve authors of their responsibility to accurately and effectively communicate the truth—scientists are obligated to "kill" Carlisle's (2021) "zombies" at every opportunity because their training equips them to see falsehoods that others cannot. Froehlich's (2017) ethics emphasize the information professional's role in society, but scientists are unique because the individuals who cited retracted papers in our study were knowledge creators who receive professional credit and prestige for publishing papers, bringing "first-hand" knowledge of phenomena to the world (Wilson, 1983). Others depend on their experience, only learning "second-hand," so scientists should be held to a higher standard.

The Sagan standard is an aphorism stating, "Extraordinary claims require extraordinary evidence." Presented by Carl Sagan (1986), this aphorism pertains to scientific skepticism, which holds that empirical truth claims should be evaluated based on evidence. To make a parallel argument, researchers who cite discredited papers carry a burden of proof to demonstrate how and why their citations are appropriate. However, we found few attempts to provide evidence justifying using retracted works in our sample.

Not all disinformation is created equal, and its spread through citations is not a foregone conclusion. However, the attributive function of citations is well understood, so it makes sense to judge scientists by whether they use them appropriately. Perhaps treating citations as an idealized "thing" that supports truth claims oversimplifies how knowledge production (and how it is documented in the scholarly record) works. Even so, treating citations as meaningless is far worse. If the authors who cited retracted works in our study treated citations as throwaways, they behaved in a performative manner without regard to the accuracy of their citations and the consequences to others. Marshall et al. (2017) find that throwaway citations in computer-human interaction research promote misinformation, which may create negative outcomes. The only way, it seems, for scientists to effectively avoid doing harm as cognitive authorities is to represent the truth accurately. In our study, communicating the truth required that authors ensure their cited papers were valid and acknowledge those that were retracted as problematic. Scientists' position as cognitive authorities obligates them to provide extraordinary evidence alongside citations whenever necessary to convey the truth.

The consequences of authors citing disinformation bear mentioning. We did not attempt to evaluate the outcomes of authors citing retracted papers. However, one outlier we excluded from our study (i.e., Wakefield et al., 1998) provides a worst-case scenario of what might occur when scientists fail to stop lies from spreading. Steen (2011) reports that the consequences of anti-vaxxers believing Wakefield was catastrophic:

> In the United Kingdom, there were no mumps cases in 2003, but widespread vaccine rejection led to 63,500 mumps cases in 2005. In the United States, the MMR [mumps-measles-rubella] vaccination rate

> decreased from 93% before [article publicity] to 79% in 2003. Subsequently, there was a mumps outbreak in the United States, and the number of cases in 2006 was 21-fold higher than in the prior year (p. 2).

We do not believe any of our eight articles and subsequent citations produced as much harm as Wakefield et al. (1998). However, the retractions we examined each possessed clinical applications in chemistry and biomedicine, so they likely carried with them an increased risk for individual and societal harm. Further, there is the issue of scientists wasting time and money, which was a likely outcome of all retractions in our sample. Fanelli, Wong, and Mercher (2022) define efforts to correct the scientific record when retractions occur as an *epistemic cost*. They conclude that scientists contain costs for retracted falsified results in randomized clinical trials, meaning that they correct the scientific record without spending extra money that prevents future research. However, dollars and cents are just one part of the puzzle—immeasurable and indirect costs like a loss of faith in science (Kennedy & Tyson, 2023) and undocumented negative outcomes also exist. The result of scientists citing retracted papers may not always be catastrophic, but it does create conditions in which harm occurs.

LIMITATIONS AND FUTURE DIRECTIONS

This study has several limitations. First, we only examined the most cited, retracted works in WoS. Second, we limited our analysis to cases where retracted paper authors willfully produced disinformation. Third, we did not ask authors why they failed to mention that the papers they cited were retracted. Fourth, we did not study the consequences of authors continuing to cite retracted works. Nevertheless, we provide direction for future research because we limited our focus to disinformation and framed the issue as a moral one.

Future research should examine the ethics of authors (i.e., knowledge creators) citing papers that contain *misinformation* specifically. Like disinformation, misinformation can produce harm, and, as Oransky (2020) observes, authors cite papers retracted for honest mistakes at a much higher rate than their falsified and fraudulent cousins. Therefore, scientists citing misinformation might be a bigger social problem—the consequences might be worse. Researchers should also evaluate the harms that result from scientists citing and spreading all types of falsehoods, whether they originate from often-cited retractions or rarely-cited ones. Finally, we might also acknowledge scientists' challenges when identifying retractions before submitting their work for review. Scientists are obligated to do the right thing, even when it is difficult, but making it easier to identify retractions may encourage them to practice better citation hygiene. Xu et al. (2023) provide a starting point by acknowledging that retraction notices are often flawed—many are hard to understand and only reach small audiences.

CONCLUSION

To conclude, we contend that citing retracted articles often constitutes a form of dis- or misinformation because citations lend credence to problematic content. As is clear from the figures we provide, there are numerous, sometimes substantive, retracted biomedical literature citations. Our findings indicate, as does previously conducted work, that retraction and the use of these problematic works continue to be a challenge for scientific communication. Whether citations are intentional or accidental is not relevant because, through citations, retracted works continue to live on in the literature and are treated by others as documentary evidence. At the least, continued use of retracted works is a difficulty that must be overcome to guarantee the integrity of scientific work. At worst, clinical biomedical research and practice could affect patients' lives, and societal trust in science may decline. Dis- and misinformation, both generally and in scientific literature, is a societal problem worthy of information scientists' attention. People, including potential patients or physicians, can be negatively affected by using scientific work that is retracted and false. Awareness of incorrect information cannot be made too evident, so our work is important to everyone concerned with the efficacy of scientific communication.

GENERATIVE AI USE

We used ChatGPT 3.5 to organize citations for this paper and copy-edit. We did not use generative AI to create content. We affirm that we manually reviewed and edited all content to ensure accuracy.

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