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RESEARCH

Scientific retractions: causes, processes, and implications for research integrity

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Abstract
Retractions serve as a critical self-corrective mechanism within the scientific enterprise, yet their implementation remains inconsistent and unevenly consequential across disciplines and institutions. This paper examines the causes, patterns, processes, and impacts of retractions. This paper accentuates that the retractions arise from a complex interplay of individual misconduct, systemic publication pressures, inadequate peer review, and cultural conditions that discourage honest error correction. Retraction notices are found to be frequently incomplete, poorly disseminated, and inconsistently linked across bibliographic databases, allowing flawed findings to persist in citation networks long after formal withdrawal. The paper further demonstrates that retraction impacts fall disproportionately on early-career researchers, particularly those in developing countries. These findings carry relevance for journals such as *Naunyn–Schmiedeberg's Archives of Pharmacology*, which publishes translational research with direct clinical and regulatory implications. The paper also is aligned with the goals of United Nations Sustainable Development Goal 3 (good health and well-being) and SDG 16 (peace, justice, and strong institutions), as strengthening scientific integrity infrastructure supports both evidence-based healthcare and accountable research governance. Concrete reforms are proposed, including standardized retraction notices and open-access policies, to ensure that retractions fulfill their promise as instruments of scientific self-correction.

Keywords Bibliometrics · Paper mills · Pharmacology · Research integrity · Retraction · Scientific misconduct

Introduction

Science is often characterized as a self-correcting enterprise. Retraction, in principle, operationalizes this ideal; it is the formal mechanism through which the scientific record is amended when published work is found to be flawed, fabricated, or ethically compromised. Yet, the practice of retraction reveals a far more complex reality. Over the past two decades, retraction rates have risen markedly across disciplines and regions, reflecting not only improvements in post-publication scrutiny but also deeper systemic pressures within the research ecosystem (Fang et al. 2012; Brainard 2018; Vuong 2020a). Advances in detection technologies including plagiarism software, forensic image analysis, and open databases such as Retraction Watch have made it increasingly difficult to conceal misconduct. At the same time, the intensification of "publish or perish" imperatives has heightened incentives for questionable research practices (Fanelli 2010; Edwards and Roy 2017), while the emergence of paper mills has industrialized fraudulent publication at an unprecedented scale (Else and Van Noorden 2021; Nash 2022; Parker et al. 2024). As argued by SeyedAlinaghi et al. (2024), the retraction phenomenon is not merely technical but fundamentally structural and ethical, rooted in the social organization of contemporary science.

These dynamics carry particular weight in pharmacology and allied health sciences, where the boundary between knowledge production and real-world application is exceptionally narrow. Pharmacological research directly informs drug discovery, dosing regimens, safety profiling, and

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therapeutic guidelines. Consequently, errors or misconduct in published studies may not remain confined to academic discourse but can propagate into clinical trials, regulatory decisions, and patient care. Retractions in pharmacology therefore represent not only epistemic corrections but also potential safeguards against harm. However, when retractions are delayed, opaque, or poorly disseminated, flawed findings may continue to influence prescribing practices, systematic reviews, and meta-analyses that underpin evidence-based medicine. In allied disciplines such as nursing, public health, and medical laboratory sciences, where protocols and interventions are often derived from aggregated evidence, the persistence of invalidated findings can compromise both practice standards and patient outcomes.

Retractions matter because scientific knowledge is cumulative and interdependent. Once published, flawed findings do not simply vanish; they diffuse through citation networks, inform subsequent studies, and may even become embedded in clinical guidelines, policy frameworks, and algorithmic training datasets. Early work by Sheth and Thaker (2014) conceptualized retracted studies as a form of "residual pseudoscience," continuing to exert epistemic influence despite formal withdrawal. More recent bibliometric evidence confirmed that retracted articles frequently continued to be cited, often without acknowledgment of their retracted status, thus perpetuating misinformation within the scholarly record (Madlock-Brown and Eichmann 2015; Bar-Ilan and Halevi 2017; Hsiao and Schneider 2022; Wang et al. 2022). In pharmacology, this persistence is particularly consequential; for example, retracted preclinical findings can misguide drug target validation, while compromised clinical studies may distort assessments of drug efficacy and safety. The downstream effects include wasted research investments, flawed therapeutic recommendations, and, in worst cases, adverse patient outcomes. The urgency of this issue was starkly illustrated during the COVID-19 pandemic, when accelerated peer review processes coincided with a surge in high-profile retractions linked to data integrity concerns and ethical violations (Yeo-Teh and Tang 2021; Schonhaut et al. 2022). Several of these retractions involved pharmacological interventions. This underscores how rapidly disseminated but unreliable findings can shape global treatment narratives before adequate validation.

Despite growing scholarly attention, the literature on retractions remains uneven and fragmented. Empirical studies have disproportionately focused on biomedical sciences and high-impact English-language journals, leaving other disciplines and geographic regions comparatively underexplored (Grieneisen and Zhang 2012; Vuong 2020b). Even within biomedical domains, pharmacology-specific analyses remain limited, particularly regarding how retracted evidence propagates through drug development pipelines and clinical practice guidelines.

Moreover, while quantitative analyses have mapped trends and causes, less attention has been given to the lived and professional consequences of retraction for authors, particularly early-career researchers navigating precarious academic environments. Institutional responses to retraction also vary widely, with inconsistent adherence to established ethical guidelines such as those proposed by the Committee on Publication Ethics (COPE). Notably, the quality and transparency of retraction notices, the primary communicative instruments of correction, differed substantially across journals, often obscuring rather than clarifying the reasons for retraction (Budd et al. 1998; Resnik and Dinse 2013; Heibi and Peroni 2024). In pharmacology and allied fields, such opacity is especially problematic, as practitioners and policymakers depend on clear, timely signals to reassess clinical evidence and ensure patient safety.

This paper strives to address these critical gaps by offering a cross-disciplinary analysis of retractions, with particular attention to their implications for pharmacology and allied health sciences. To be more particular, it (1) investigates the underlying causes and patterns of retracted publications across diverse fields and geographic contexts; (2) evaluates the processes and standards through which retractions are implemented; and (3) assesses their broader implications for authors, journals, and the integrity of scientific knowledge.

Causes and patterns of retractions

Retractions arise from a broad spectrum of failures, ranging from deliberate misconduct to unintentional error. Consistent with prior classifications, the most commonly documented causes can be grouped into three broad categories: (1) *ethical misconduct*, including plagiarism, data fabrication and falsification, duplicate publication, authorship disputes, and manipulated peer review; (2) *scientific distortion*, such as methodological flaws, irreproducibility, data misinterpretation, and unsupported conclusions; and (3) *administrative errors*, including publisher mistakes, editorial oversights, and technical failures. While these categories provide analytical clarity, they often blur in practice, reflecting the complex and layered nature of failure within contemporary research systems. Drawing on established classifications in the retraction literature, the major categories of retraction causes and their disciplinary manifestations are summarized in Table 1.

As noted by Casadevall et al. (2014), misconduct accounted for a substantial proportion of retractions across disciplines, although unintentional errors were more prevalent in experimental and data-intensive fields. Importantly, the distinction between honest error and intentional fraud is frequently obscured in retraction notices, which tended to

Table 1 Categories of retraction causes with disciplinary examples

Category	Subcategory	Representative disciplines	Example manifestation
Ethical misconduct	Plagiarism	Engineering, social sciences	Textual duplication without attribution
	Data fabrication/falsification	Biomedicine, pharmacology	Fabricated trial results, manipulated images
	Duplicate publication	All disciplines	Redundant submission across journals
	Manipulated peer review	Biomedicine, chemistry	Fake reviewer identities
Scientific distortion	Methodological flaws	Clinical sciences, psychology	Underpowered studies, flawed design
	Irreproducibility	Pharmacology, Biology	Failed experimental replication
	Data misinterpretation	Social sciences	Statistical errors, unsupported conclusions
Administrative error	Publisher/editorial mistakes	All disciplines	Erroneous duplication, formatting failures

Categories synthesized and adapted from prior literature on scientific retractions, including Casadevall et al. (2014), Redman et al. (2008), Ribeiro and Vasconcelos (2018), and Kohl and Faggion (2024). This classification represents an author-developed synthesis grounded in existing studies

lack transparency in attributing responsibility. This ambiguity not only complicates accountability but also limits the capacity of the scientific community to learn from failure. Barriers to initiating retraction further exacerbated the problem. Redman et al. (2008) highlighted institutional reluctance driven by concerns over reputational damage, legal liability, and the absence of clear procedural guidelines. As a result, flawed or compromised research may persist in the literature long after its deficiencies are recognized, an issue that directly reinforces the concern raised in the introduction regarding the prolonged circulation of invalidated knowledge.

Patterns of retraction also vary significantly across disciplines. This reveals how epistemic norms and institutional practices shaped the manifestation of scientific failure. In biomedical sciences, retractions are most associated with fraud, plagiarism, and ethical violations, including failures in human subjects' protection. These cases tend to be identified relatively quickly, often within two to three years of publication, reflecting both the high stakes and the intensity of scrutiny in these fields (Kohl and Faggion 2024). In contrast, social sciences exhibited a different profile, where retractions more frequently stemmed from data errors, statistical misinterpretations, and administrative issues (Craig et al. 2020). As observed by Basumatary and Verma (2024), awareness of retractions was comparatively lower in these disciplines, and the normative response to retracted work was less stringent. Technological and engineering fields present yet another pattern, where plagiarism and duplicate publication dominate. Notably, retraction rates rise sharply in several developing research systems, including China, Iran, India, and South Korea, a trend that Eldakar and Shehata (2023) attributed to systemic evaluation structures that prioritize publication volume over research quality.

Geographic distributions of retractions further underscored the structural dimensions of the problem. While countries such as China, the United States, and Russia contributed the highest absolute numbers of retractions, these figures must be interpreted in relation to overall research output (Ribeiro and Vasconcelos 2018; Lendvai and Sasvári 2025). More revealing were disproportionate retraction rates in emerging economies, which Feng et al. (2025) linked to institutional and cultural factors, including hierarchical research environments, limited enforcement of integrity policies, and constrained opportunities for junior researchers to challenge senior authority. These patterns reinforce the argument advanced in the introduction; retractions are not isolated anomalies, but indicators of deeper systemic pressures embedded in the global research enterprise.

Issues of data and image integrity illustrated these vulnerabilities with clarity. In biomedical and pharmacological research, inappropriate image duplication, manipulation, and fabrication remained pervasive, with detection increasingly reliant on forensic software tools. Dixit and Pandey (2024) argued that addressing these challenges required not only technological solutions but also the institutionalization of image verification as a standard component of peer review. Beyond images, broader data integrity concerns permeated clinical trials, pharmaceutical studies, and healthcare datasets, where poor documentation practices and inconsistent reporting standards created conditions in which both error and fraud could remain undetected. The implications are especially consequential in pharmacology and allied health sciences, where compromised data may influence drug development pipelines, therapeutic guidelines, and patient safety outcomes. Emerging technologies such as blockchain-based audit trails offer potential solutions for enhancing transparency and traceability, although their adoption remains limited.

COVID-19 pandemic brought these dynamics into sharp relief. Accelerated publication timelines and expedited peer review processes, implemented in response to urgent global demand for knowledge, exposed tensions between speed and rigor. Anderson et al. (2021) documented a surge in

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ORIGINAL ARTICLE

RETRACTED ARTICLE: LncRNA XIST inhibits ovarian cancer cell growth and metastasis via regulating miR-150-5p/PDCD4 signaling pathway

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The Editor in Chief retracted this article (1) because of significant concerns regarding a number of Figures presented in this work, which question the integrity of the data.

Figure 2C and 6B - some plots appear to have been re-use between the two figures. Additionally, there is a close similarity between a scatter plot in these two figures and one published in an earlier article by unrelated authors (2)

Figure 8B (sh-XIST) and C (shRNA) -these images appear to have been published previously in an unrelated publication (3)

The authors were unable to provide raw data and stated that the figures were obtained through a commercial lab hired to perform some of the experiments for this study.

Author Guanzhen Li agrees to this retraction. Author Shuli Wang has not responded to any correspondence from the editor or publisher about this retraction.

The online version of this article contains the full text of the retracted article as electronic supplementary material.

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1) Wang, S., Li, G. LncRNA XIST inhibits ovarian cancer cell growth and metastasis via regulating miR-150-5p/PDCD4 signaling pathway. Naunyn-Schmiedeberg's Arch Pharmacol (2020). https://doi.org/10.1007/s00210-020-01808-2

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◂**Fig. 1** Example NSAP retraction note. This is a formal retraction note for the study on ovarian cancer; it details the specific reasons the NSAP discredited the work. It explains that multiple figures were reused from unrelated publications and that the authors admitted the experiments were outsourced to a commercial lab, which is a common indicator of "paper mill" activity. While one author accepted the retraction, the other failed to respond to the publisher's inquiries, leading to the permanent removal of the study's validity

retractions during this period, many linked to data integrity failures, ethical lapses, and methodological weaknesses. While rapid dissemination facilitated timely scientific exchange, it also amplified the downstream consequences of flawed research, particularly in fields such as pharmacology, where preliminary findings on therapeutic interventions quickly informed clinical and public health decisions.

A further transformation in the landscape of retractions has been marked by the rise of paper mills, signaling a shift from isolated instances of individual misconduct to coordinated, industrialized deception that exploits systemic vulnerabilities in peer review, editorial oversight, and authorship verification, as first highlighted by Marcus and Oransky (2014). This shift reflects both an increase in the volume of misconduct and a change in its organization and execution, a trend substantiated by empirical evidence documenting the rapid proliferation of paper mill, generated publications across disciplines, characterized by fabricated data, manipulated images, recycled text, and falsified authorship (Candal-Pedreira et al. 2022; Mascato Fontaíña et al. 2025). Compounding these challenges is the unethical use of artificial intelligence, including AI-assisted ghostwriting, automated text generation, and advanced plagiarism techniques, which further enhances the efficiency, scalability, and apparent credibility of fraudulent submissions and increasingly blurs the boundaries between legitimate and deceptive scholarship (Giray et al. 2026; Oliveira et al. 2026; Subaveerapandiyan et al. 2025). The proliferation of such practices underscores the inadequacy of viewing retractions solely through the lens of individual ethical failure. Instead, the causes and patterns of retractions point to structural vulnerabilities in how scientific work was incentivized, evaluated, and disseminated.

Retraction processes and effectiveness

The formal process of retraction is straightforward in principle: a paper is identified as flawed or fraudulent, a notice is issued, and the scientific record is corrected (see Figs. 1, 2, and 3). In practice, however, this process remained slow, inconsistent, and frequently opaque. As noted by Bakker et al. (2024), many retracted publications were not clearly marked or properly linked to their retraction notices across bibliographic databases, allowing withdrawn studies to persist in circulation without visible warning. This problem was compounded by the quality of retraction notices themselves. Notices often omitted the reason for retraction, failed to assign responsibility, and provided little or no information regarding whether an institutional investigation had taken place. Xu and Hu (2023) argued that such opacity reflects deeper institutional reluctance to assume public accountability.

Standardization of retraction notices is therefore not a bureaucratic formality but a substantive mechanism for safeguarding research integrity. Best practices, informed by guidelines from COPE, emphasized transparency, completeness, and traceability. These included clearly stating the reason for retraction, identifying responsible parties, documenting investigative processes, and specifying corrective actions. The key quality indicators for retraction notices are outlined in Table 2. Empirical evidence supported the effectiveness of such standardization. Shi et al. (2025) demonstrated that rubric-based retraction notices significantly improved clarity and reduced ambiguity, while clearer labeling was shown to decrease improper post-retraction citations by more than fifty percent. Similarly, Cunningham et al. (2025) found that in clinical subfields such as otolaryngology, the clarity of retraction notices was directly associated with the extent to which retracted studies ceased to be treated as credible evidence. To evaluate the transparency and quality of retraction notices, established criteria from the Committee on Publication Ethics (COPE) are adopted, as summarized in Table 2.

While these formal mechanisms remained central, the processes leading to retraction are increasingly shaped by informal, decentralized forms of scrutiny, most notably through social media platforms such as X (formerly Twitter), Reddit, and Facebook (see Fig. 4). Emerging evidence suggested that critical discourse on these platforms often preceded formal investigations, effectively functioning as an early warning system for problematic research (Fieldhouse 2026). Negative commentary, including methodological critiques and allegations of misconduct, rapidly amplifies concerns that might otherwise have remained unnoticed within traditional peer review systems. This dynamic introduces a new layer of post-publication review, accelerating the identification of flawed work and, in some cases, prompting journals to initiate retraction proceedings more quickly. However, this acceleration is not without risk. The same mechanisms that enabled rapid accountability may also have exerted pressure on editorial decision-making, raising concerns about premature or insufficiently investigated retractions driven by public scrutiny rather than rigorous evaluation. In this sense, social media is not merely an auxiliary tool but an emerging force reshaping the governance of scientific integrity.

These developments extend the scope of retraction processes beyond traditional editorial and peer review

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ORIGINAL ARTICLE

Treatment with a brain-selective prodrug of 17β-estradiol improves cognitive function in Alzheimer's disease mice by regulating klf5-NF-κB pathway

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Abstract

10β,17β-dihydroxyestra-1,4-dien-3-one (DHED) which is a brain-selective prodrug of 17β-estradiol has been reported to improve the cognitive function in Alzheimer's disease (AD) mice model. However, little is known about the potential mechanism for cognitive improvement. In the present study, we used AD mice to investigate the effects and mechanisms of DHED treatment. Female Tg2576 transgenic AD mice were ovariectomized and then treated by implanting Alzet osmotic minipumps containing DHED or vehicle subcutaneously for 8 weeks. Consistent with previous report, DHED treatment ameliorated cognitive function of AD mice with decreasing Aβ levels in the hippocampus. Besides, we also found DHED treatment could reduce oxidative and inflammatory stress and the level of p-tau. The mechanisms underlying the cognitive function improvement may be linked with estrogen receptor (ER)-klf5-NF-κB pathway, demonstrated by decreased expression of klf5 and the secretion of inflammatory cytokines. However, the effects of DHED treatment could be reversed when ERα was inhibited by ICI182780. Taken together, our findings uncovered a new mechanism for DHED to improve the cognitive function of AD mice and may provide a viable therapy to treat AD.

Keywords Alzheimer's · klf5 · DHED · ICI182780 · Inflammation

Introduction

Alzheimer's disease (AD) is a major cause of dementia which is characterized by a progressive cognitive and neuronal dysfunction clinically, neuroinflammation, and neuronal death (Assoc 2018; Congdon and Sigurdsson 2018). Accumulative deposits of aggregated amyloid-β peptide (Aβ) in the brain is believed to be the primary pathogenic cause of AD (Rajmohan and Reddy 2017; Rangachari et al. 2018). The number the AD patients in America is expected to increase from 5.7 million today to 13.8 million by 2050 according to the World Alzheimer report. However, there has been no effective therapy for AD currently (Vina and Sanz-Ros 2018). Therefore, it is important to develop effective agents to slow or halt the neurodegenerative process and alleviate pathology of AD.

It is well known that estrogen has a wide range of beneficial effects in the maintenance of normal brain function, loss of which in aging may increase the risk of AD (Bimonte-Nelson et al. 2010). The reason for the higher prevalence and greater severity of AD in the postmenopausal women than age-matched men is closely linked with the reduced concentration of estrogen (Baum 2005; Irvine et al. 2012; Pike 2017). Now, the neuroprotective effects of estrogen have been stressed by several investigations, which are associated with decreased neuroinflammation and Aβ accumulation (Li et al. 2014; Yun et al. 2018). Besides, estrogen receptor α (ERα) is thought to be an indispensable element from estrogen to regulate the estrogen-sensitive activities (Audet-Walsh and Giguere 2015; Lan et al. 2015; Tang et al. 2018). Although

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◂**Fig. 2** Example NSAP retraction paper. This is an original research paper from NSAP regarding Alzheimer's disease treatments, but it is now stamped with a prominent, diagonal "RETRACTED ARTICLE" watermark. This visual overlay serves as a critical warning to researchers, signaling that the paper is no longer considered part of the reliable scientific record

mechanisms. Editorial oversight, while foundational, has long exhibited variability in effectiveness. Horbach and Halffman (2019) showed that different peer review models differed significantly in their capacity to detect problematic submissions, and many journals still lacked clear protocols for handling ethical concerns. Compounding this issue, Teixeira da Silva (2022) highlighted the paradox of editorial accountability, arguing that editors with histories of misconduct may continue to occupy positions of authority, thereby undermining the credibility of the very systems they are meant to uphold.

At the same time, digital infrastructures are transforming what is possible in retraction management. Platforms such as Retraction Watch (see Fig. 5) provide integrated systems for tracking retracted publications and their citation networks, enabling more systematic monitoring of the diffusion of invalidated knowledge (Li et al. 2024). Advances in automated detection tools, statistical anomaly identification, and AI-assisted manuscript screening further enhance the capacity to detect misconduct in both pre- and post-publication contexts. Also, Wang (2023) emphasized the need for information retrieval systems to more effectively incorporate retraction metadata, ensuring that researchers are alerted to the status of withdrawn work during literature searches.

The effectiveness of retractions as a corrective mechanism ultimately depends on how these formal and informal processes interacted. When retraction notices are transparent, detection systems are robust, and dissemination channels clearly signal the status of invalidated work, retractions could meaningfully reduce citation rates and redirect the trajectory of scientific inquiry. As demonstrated by Furman et al. (2012), retractions in biomedicine could significantly influence subsequent research directions, discouraging reliance on flawed findings. However, the increasing involvement of decentralized actors such as social media communities and AI systems reveals that retractions are indicators of broader systemic strain. The challenge, therefore, lies not only in improving procedural efficiency but in ensuring that emerging mechanisms of accountability enhance, rather than compromise, the rigor, fairness, and credibility of the scientific enterprise.

Impacts of retractions on the scientific community

A retraction is not merely a bibliographic event. Its consequences extend across careers, citation practices, institutional accountability, and the geographic landscape of scientific knowledge. For researchers directly involved, the professional costs can be severe. For example, Memon et al. (2025) demonstrated that retractions impose measurable career penalties, including reduced publication rates, diminished citation counts, and disrupted collaboration networks. Also, Han et al. (2025) found, in their analysis of Chinese medical researchers, that junior authors were significantly more likely to leave academia following a retraction, while senior researchers tended to preserve both their productivity and institutional standing.

Zhang and Fu (2022) corroborated this pattern, showing that authors with retracted publications in clinical medicine exhibited markedly altered career trajectories, with early-career researchers most vulnerable to long-term productivity loss. Mistry et al. (2019) added a further dimension, documenting that biomedical researchers who accumulated multiple retractions showed substantially reduced post-retraction output, raising questions about whether such penalties were proportionate to individual culpability. This asymmetry is particularly troubling when early-career researchers are co-listed on papers where misconduct originated with senior colleagues.

The stigma associated with retraction extends beyond career metrics. Joshi and Minirani (2024) noted that this stigma actively deterred self-correction: researchers who discovered errors in their own work may have weighed the costs of retraction against the risk of quiet inaction and chosen the latter. This chilling effect on honest self-reporting undermines the very mechanism retractions were meant to support. Meanwhile, Marcus and Oransky (2017) argued that destigmatizing genuine error correction was not a peripheral concern but a precondition for a healthier scientific culture. In pharmacology specifically, where research outcomes bear on drug efficacy, dosing, and patient safety, this culture of avoidance allows flawed data to persist in the literature long after researchers have privately recognized its limitations.

Retractions led, on average, to a sixty percent reduction in citation frequency, a significant but incomplete effect. A substantial portion of retracted papers continued

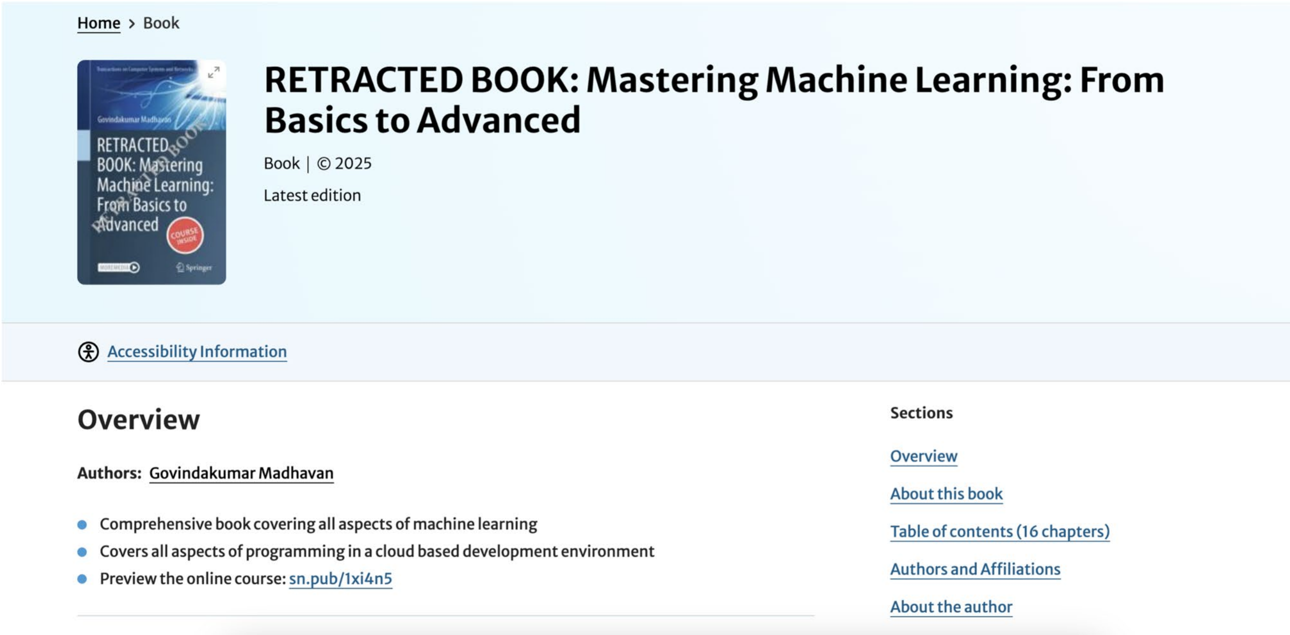

Fig. 3 Example retracted book. An entire academic book, *Mastering Machine Learning: From Basics to Advanced*, has been formally withdrawn by the publisher after its initial release. The prominent "RETRACTED BOOK" watermark and title modification serve as a permanent warning to readers. Retracting a complete textbook is relatively rare compared to retracting individual research papers. This suggests that the issues with the book were catastrophic and pervasive, such as widespread plagiarism, severe copyright infringement, or fundamentally flawed/fabricated content that could not be fixed with a simple correction

Table 2 Quality indicators for retraction notices based on COPE guidelines

Quality indicator	Description	Observed gap in practice
Stated reason for retraction	Clear explanation of the specific cause	Frequently absent or vague
Attribution of responsibility	Identification of the party or parties at fault	Routinely omitted
Documentation of investigation	Reference to institutional review or inquiry process	Often absent entirely
Corrective actions specified	Description of steps taken following identification of the problem	Rarely included
Visibility and linking	Notice linked to original article across bibliographic databases	Inconsistent across platforms
Timeliness	Time elapsed between problem identification and formal retraction	Highly variable across journals
Accessibility	Retraction notice available in open access format	Limited in subscription-based journals

Indicators derived and adapted from the retraction guidelines of the Committee on Publication Ethics (COPE, 2019). Observed gaps are synthesized from prior empirical studies on retraction practices

to accumulate citations as though they remained credible contributions. Tang (2023) identified several reinforcing factors: low visibility of retraction notices, continued online availability of the original paper, and researchers' reliance on secondary sources rather than primary databases. Yang et al. (2024) examined retraction effectiveness in psychology and found that withdrawn papers continued to be cited at rates that rendered the corrective function of retraction largely symbolic.

In the same vein, Palla et al. (2023) documented a comparable pattern in Indian-authored retracted papers, where post-retraction citation rates remained high enough to suggest that the retraction notice had not reached a meaningful portion of the readership. This pointed to a newer dimension of this problem: retracted articles on stem cells continued to be cited in active research and incorporated into outputs generated by AI tools such as ChatGPT, embedding flawed findings in contexts where their retracted status may never surface. This is consequential in pharmacology and allied biomedical fields. Zhu et al. (2024) showed that retracted microRNA biomarker articles continued to be cited in subsequent publications. This shows how invalidated findings in translational research could infiltrate clinical reasoning well after formal withdrawal.

Journals faced their own accountability pressures. Managing retractions demanded transparent editorial processes, clear

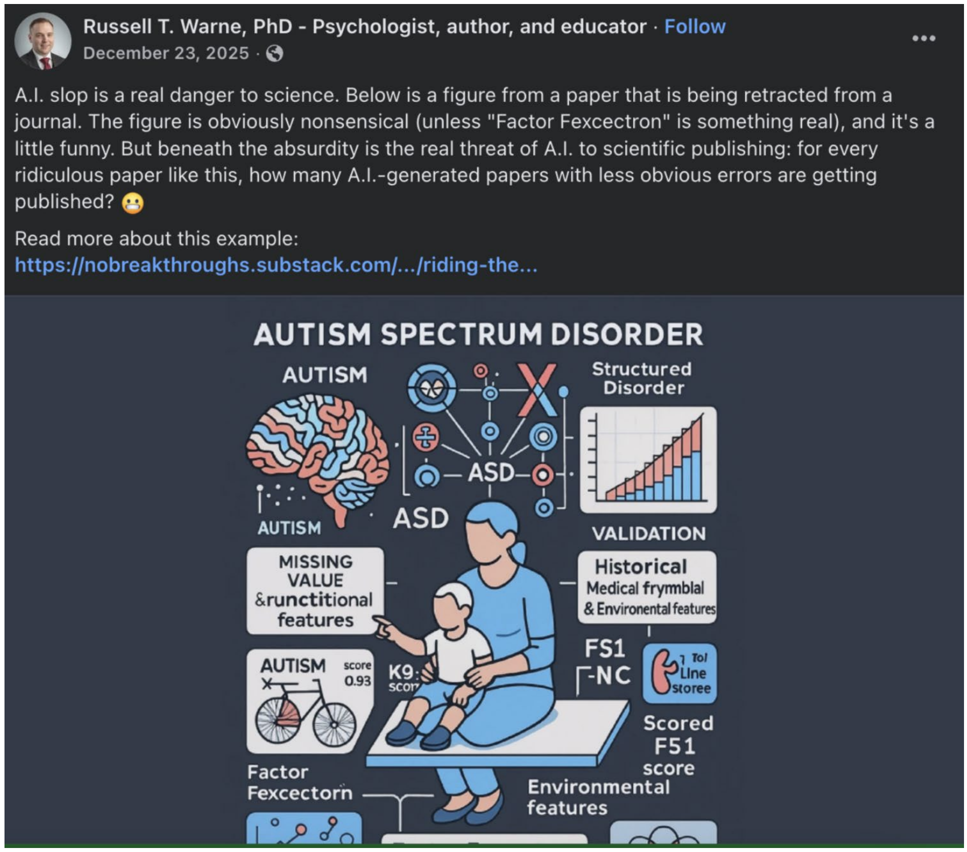

Fig. 4 Dr. Warne's post on AI hallucinations in a retracted paper. This is a post by Dr. Russell T. Warne featuring a nonsensical AI-generated infographic from a paper published in *Scientific Reports* in November 2025. Replete with hallucinations, the figure bypassed editorial scrutiny until scholars and netizens shared the absurdity on social media. The resulting public outcry forced the journal to retract the paper

Fig. 5 Retraction watch website. Note: Retraction Watch (retractionwatch.com) is a nonprofit watchdog website and database dedicated to tracking scientific papers withdrawn due to errors or academic fraud. Through its investigative blog, it reports the specific reasons why research is pulled, such as fake peer reviews or plagiarism, while its comprehensive, searchable database helps scientists avoid accidentally citing invalid studies. The platform promotes transparency and upholds the integrity of academic publishing by ensuring that mistakes and misconduct are made public

communication with authors and readers, and a willingness to absorb reputational costs. Katavić (2014) argued that responsibility for retraction is frequently diffused among authors, institutions, and journals in ways that allowed each party to defer action until another moved first. Indeed, this is a structural problem, not simply a failure of individual will. For a pharmacology journal such as NSAP, where published findings may directly inform experimental design, drug development decisions, or therapeutic practice, this diffusion carried particular risk: a retracted pharmacological study that continued circulating unchallenged could exert downstream influence on clinical or regulatory outcomes long after its formal withdrawal.

Geographic and collaboration patterns added a further layer of complexity, as summarized in Table 3. International research collaborations are associated with lower retraction rates than purely domestic ones (Zhang et al. 2020). This suggests that cross-institutional accountability exerted some protective effect. Developing countries, particularly in health and life sciences, showed disproportionately higher retraction rates, and domestic collaborations in these contexts were more prone to misconduct (Bhattacharyya et al. 2025; Stavale et al. 2019). Rossouw et al. (2020) examined retraction patterns among African-region authors, finding that limited institutional infrastructure and insufficient investment in research integrity training contributed to heightened vulnerability in these settings.

A note to *Naunyn–Schmiedeberg's* archives of pharmacology

Naunyn–Schmiedeberg's Archives of Pharmacology (NSAP) is not a bystander in the crisis of scientific fraud; it is a documented target. What Sabel and Seifert (2021) called criminal science publishing gangs have infiltrated this journal, and NSAP has retracted papers into 2026 as direct evidence of that assault. This speaks plainly to everyone who touches NSAP that the problem is real, that it is ongoing, and that each has a role in containing it.

Sabel et al. (2026) calculated that true fake publishing runs approximately 19 times the number of formally retracted papers, meaning the 5671 biomedical retractions recorded in 2023 represent only a fraction of actual fraud. NSAP has felt this directly. Seifert (2021) identified 20 characteristic features of paper mill submissions targeting the journal, while Wittau et al. (2024) found that among 2056 rejected NSAP manuscripts later published elsewhere, four had their entire authorship replaced: the same fabricated science, new names purchased to carry it. Paper mills exploit interjournal blindness, submitting simultaneously and swapping authors when original buyers withdraw (Wittau et al. 2024). Teixeira da Silva (2025) has asked whether a formal blacklist is now warranted.

What makes this crisis acute is the deceptive quality of the product. Wittau and Seifert (2023) compared 12 retracted fake papers against 733 legitimate NSAP articles and found them largely indistinguishable at the metadata level. Reviewers should not rely on the sense that a paper merely looks fine. These manuscripts are engineered to pass. Worse, retraction does not undo the contamination: fake papers continue to accumulate citations after withdrawal, and in pharmacology, where findings touch drug efficacy and toxicity thresholds, that silent propagation carries clinical consequences (Wittau and Seifert 2023; Wang 2023).

How pharmacology journals discuss the retraction problem

Pharmacology journals differ in how openly they discuss retractions. While some include reporting retractions as part of their public obligation to protect the scientific record, others generally include only individual retraction notices or

Table 3 Geographic and collaborative patterns in retractions

Region/context	Retraction profile	Key contributing factors	Source
China	High absolute retraction volume; elevated rates in technology and biomedical fields	Publication pressure, paper mill activity, hierarchical research culture	Feng et al. (2025)
United States	High absolute numbers; relatively lower proportional rates	Strong institutional oversight; active post-publication scrutiny	Ribeiro and Vasconcelos (2018)
Russia	Elevated retraction rates, particularly in engineering and chemistry	Plagiarism, duplicate publication	Ribeiro and Vasconcelos (2018)
Iran, India, South Korea	Rising retraction rates in recent decades	Quantity-over-quality publication incentives	Eldakar and Shehata (2023)
Africa	Disproportionate vulnerability in life sciences	Limited research integrity infrastructure; insufficient training	Rossouw et al. (2020)
International collaborations	Lower retraction rates compared to domestic-only collaborations	Cross-institutional accountability and peer oversight	Zhang et al. (2020)

general statements about publication ethics. The distinction between these approaches is significant because it defines how retractions are perceived, either as a threat to reputation or as a necessary mechanism of scientific correction.

Naunyn–Schmiedeberg's Archives of Pharmacology provides a clear example of direct editorial engagement. Seifert (2021) describes that this journal issued a statement acknowledging that it was the target of a large number of manuscript submissions produced by paper mills and describes the specific warning signs that may help prevent such submissions. This approach frames retraction-related activity not as evidence of journal failure, but as part of an active integrity response. It also helps readers, reviewers, and editors understand that fraudulent submissions are often systemic and professionally engineered, rather than easily detectable through conventional peer review alone. It also helps readers, reviewers, and editors understand that submissions from paper mills are usually both systemic and professionally engineered, and are usually difficult to detect using traditional peer review processes.

Similarly, the British Journal of Pharmacology has also examined article retractions within its own publication record and linked the issue to broader strategies for reducing fraud-containing articles (van der Heyden 2024). Such self-examination is valuable because it shifts the discussion beyond the correction of individual papers toward what retractions reveal about editorial screening, post-publication monitoring, and research integrity risks. However, this level of reflection remains uneven across pharmacology journals. Many journals still engage with retractions mainly at the procedural level, by issuing notices or referring to publication ethics policies, without wider discussion of paper mills, post-retraction citation, or reputational barriers to transparent correction.

This limited public discussion may reflect reputational anxiety. Journals may fear that visible retractions will suggest weak editorial control or damage their standing among authors and readers. However, failing to openly discuss retractions creates additional risk to the integrity of research. In pharmacology, unreliable findings may influence drug development, toxicity assessment, clinical reasoning, systematic reviews, and regulatory decisions. For this reason, retraction transparency should be treated as a marker of editorial responsibility rather than reputational weakness. Pharmacology journals should therefore move beyond minimum procedural compliance and discuss more explicitly how retractions are detected, communicated, and monitored after publication.

What journals can do: proactive and risk-based responses

NSAP has responded with notable seriousness yet the scale of the problem demands more than reactive corrections. Journals are increasingly moving toward risk-based screening, where the track record of both the author and their home institution serves as a critical signal for editorial scrutiny. Several layers of intervention are now available and merit wider adoption.

1. Risk-based triage and flagging

Journals may use internal databases to flag submissions from authors or institutions with significant retraction histories. Manuscripts from high-risk sources can undergo a pre-technical review by an ethics committee or research integrity officer before they reach subject–matter peer reviewers. In severe cases of misconduct, data fabrication in particular, journals may blacklist specific authors or place them on probationary status for a defined period. van Diest et al. (2025) described NSAP's own post-publication surveillance, which includes image forensics and physiological plausibility checks, as a model for this kind of front-loaded scrutiny.

2. Mandatory raw data audits

While many journals encourage data sharing, for high-risk researchers, it should become a strict precondition for review rather than a recommendation. Editors may require submission of original, unedited raw data files (e.g., blots, spreadsheets, and time-stamped lab notes) to verify authenticity before any editorial decision is made. Independent statisticians can re-run analyses on flagged papers to check whether results are, as the field sometimes puts it, too good to be true. Wittau et al. (2024) proposed interpublisher metadata sharing as a parallel mechanism for detecting authorship substitutions across journals, a structural reform that could make raw data fraud far harder to hide.

3. Institutional integrity certificates

If an institution carries a history of systemic issues, such as inadequate oversight of paper mill activity, journals may shift the burden of proof back to the university. This can take the form of a formal letter from the research integrity officer or dean, certifying that submitted data has been internally audited. Where multiple retractions point to an institutional pattern, publishers may issue expressions of concern for all pending papers from that organization until a full investigation is completed. A mandatory attestation stating that no paper mill involvement or AI misuse has occurred already accompanies review submissions at NSAP (Seifert 2021); requiring institutional co-signature extends that logic.

4. Specialized peer reviewer briefing

Editors may select reviewers with forensic detection expertise, not only subject–matter knowledge. Reviewers can be explicitly briefed to look for signs of data manipulation or tortured phrases (i.e., nonstandard synonyms used to evade AI detectors or plagiarism checkers) particularly when an author's retraction history involves those specific issues. Journals are also increasingly likely to perform identity verification, including checks of institutional email addresses and ORCID profiles, to guard against fake persona networks. If a researcher with a problematic record submits a paper raising even minor questions, journals may issue an expression of concern while investigation is ongoing rather than waiting for a formal retraction. This alerts the community immediately rather than months later.

5 AI-assisted detection, with caution

As paper mills use AI to generate fabricated content at scale, journals must use AI to fight back. Automated screening tools can detect image manipulation, AI-generated text, and tortured phrases at the submission stage. However, their accuracy remains limited (Giray et al. 2025, 2026) and false accusations are a genuine risk (Giray 2024; Wang et al. 2026). AI tools are best understood as a first filter that escalates cases for human review, not as a final arbiter.

6. Open data as a prerequisite

The inability to verify raw data is among the primary drivers of retractions. Requiring authors to deposit raw, de-identified data and analysis code in public repositories, such as Zenodo or OSF, before a paper is accepted for review removes one of the most exploited blind spots. Random spot-checks on deposited data can further ensure that what is submitted actually supports the claims in the manuscript.

7. Living documents and tiered amendments

The traditional binary view of publication, either a paper stands or it is retracted, discourages honest self-correction. A tiered amendment system would introduce graduated responses: minor corrections for typographical errors, substantial amendments for figure corrections that do not alter findings, and retraction reserved for fundamental flaws. Services like CrossMark can ensure that any downloaded PDF displays a live status badge when viewed online, so researchers encounter corrections automatically rather than by accident.

8. Strengthened post-publication peer review

Journal responsibility should not end at publication. Formally monitoring platforms such as PubPeer and Retraction Watch for community-raised concerns, and establishing dedicated in-house integrity offices to investigate allegations promptly, would reduce the years-long delays that currently characterize institutional inquiries. The editor should also proactively notify authors who have cited retracted work, a step that is rarely taken but that would materially slow the silent citation accumulation documented by Wittau and Seifert (2023).

9. Transparent retraction notices

When retraction does occur, the notice itself must be informative. Vague labels such as "administrative retraction" serve no one. Notices should explicitly state whether the cause was honest error, data fabrication, or plagiarism and should record the results of any institutional investigation. Xu and Hu (2023) and Bakker et al. (2024) have documented how frequently this basic standard is not met, and Xu et al. (2023) found that institutional investigation results often go unrecorded entirely. Standardizing retraction notices is among the lowest cost, highest signal reforms available.

Underreporting continues to be reinforced by hierarchical research cultures and institutional risk aversion (Feng et al. 2025; Redman et al. 2008). To address these systemic conditions, Mertkan et al. (2026) call for a sustained and coordinated research agenda. Concrete actions are necessary across roles: editors should standardize retraction notices and notify authors of cited retractions; reviewers should request raw data, verify affiliations, and engage critically with inconsistencies; researchers should audit reference lists before submission, recognizing that an indexed paper is not automatically a valid one. Trust in science does not repair itself. NSAP demonstrates that integrity can be defended, but doing so requires deliberate and collective action across the entire research community.

Conclusion

This paper has reaffirmed that retractions are vital mechanisms for safeguarding scientific credibility rather than mere administrative corrections. Their importance aligns with the goals of the United Nations Sustainable Development Goal 3: good health and well-being and Sustainable Development Goal 16: peace justice and strong institutions, as stronger research integrity systems support both reliable healthcare and accountable governance. Retractions reflect science honoring its commitments and acknowledging error while correcting the record. As noted by Sheth and Thaker (2014), leaving flawed work unchallenged threatens the credibility of the entire enterprise. However, current practices remain inconsistent, often burdening vulnerable researchers and failing to fully prevent the continued circulation of retracted studies.

Also, this paper has shown that retractions arise from structural pressures such as publication demands, limitations in peer review, and academic cultures that discourage transparency. Addressing these issues requires clearer retraction notices, stronger institutional oversight, and the use of emerging detection tools, alongside a cultural shift that frames retractions as responsible scholarship. For NSAP, strengthening transparency and post-retraction monitoring are especially critical. Advancing these practices can help ensure a more reliable scientific record and reinforce evidence-based medicine.

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Declarations

Competing interests The authors declare no competing interests.

Declaration of generative AI use We disclose that we used ChatGPT (free version) solely for language improvement. We confirm that no paper mill or third-party writing service was used. We take full responsibility for the content and originality of the manuscript.

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