

# Comment

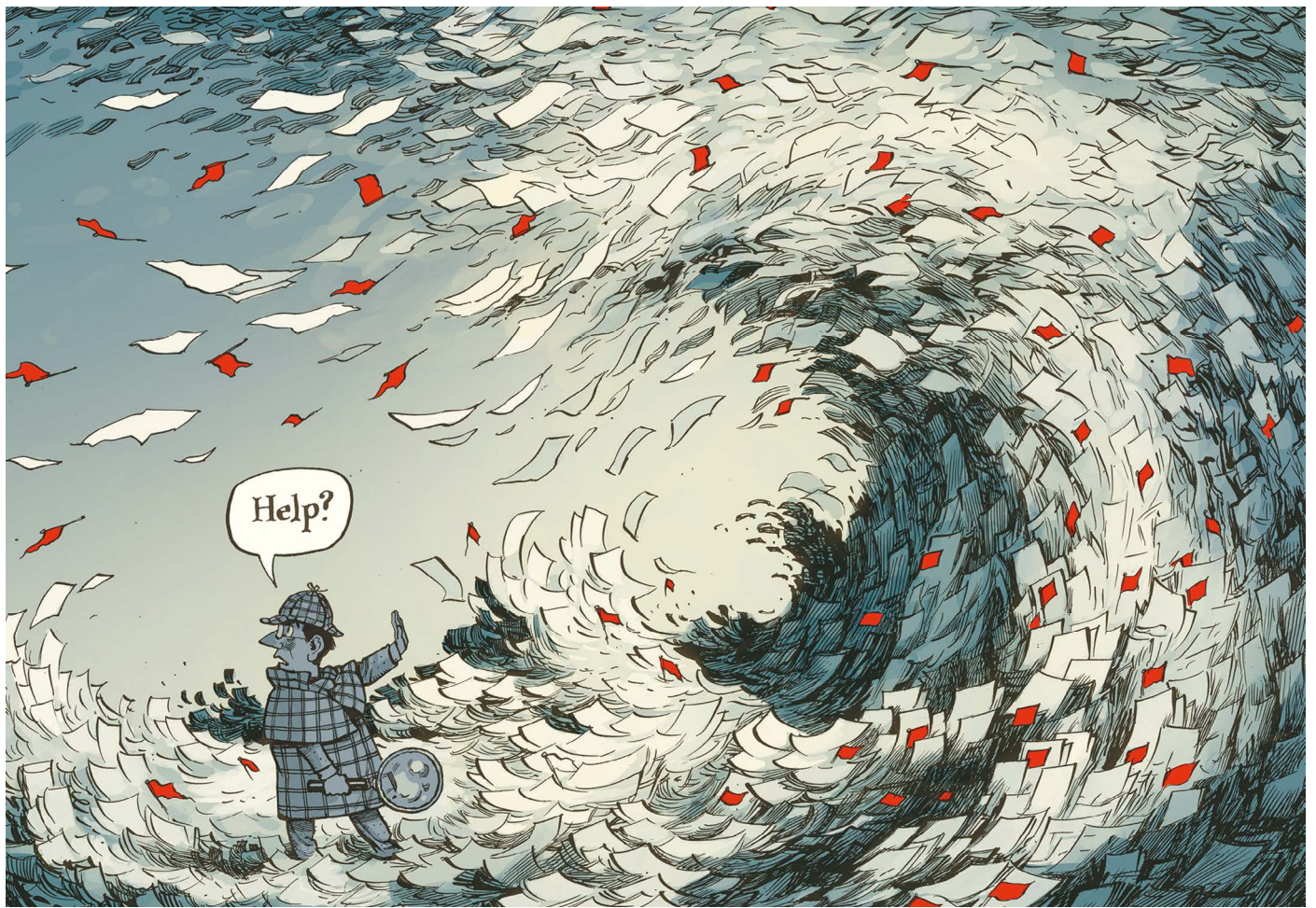


ILLUSTRATION: DAVID PARKINS

## ‘Stamp out paper mills’ – science sleuths on how to fight fake research

Anna Abalkina, René Aquarius, Elisabeth Bik, David Bimler, Dorothy Bishop, Jennifer Byrne, Guillaume Cabanac, Adam Day, Cyril Labbé & Nick Wise

A group of scientists who are experts at spotting problematic research outline five essential steps to combat industrialized scientific misconduct.

**T**he production of fake research is now a thriving industry, thanks to paper mills. These networks sell paper authorships and poor-quality or fabricated scientific manuscripts to researchers, or violate the peer-review process by providing fake reviews. And they have become so prolific that current self-correction mechanisms no longer work.

The first evidence<sup>1</sup> of authorships for sale was reported in 2013. The paper-mill industry has since mushroomed (see ‘Paper mills explode’). One estimate suggests that the

problem might have started even earlier – at least 400,000 papers published between 2000 and 2022 show the hallmarks of having been produced by paper mills (see *Nature* **623**, 466–467; 2023). Yet only 55,000 were retracted or corrected in the same period, according to the database of the website Retraction Watch. Fraudulent research pollutes the literature, slows down scientific progress, delays the discovery of therapies and reduces public trust in science.

We are integrity sleuths. Scientists by training, we now spend time sniffing out

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publications from paper mills. After initially working mostly alone, each specializing in a certain discipline or symptom of paper-mill activity, in the past three years, we've begun to join forces. Together, we are skilled at spotting the signs of a paper mill, from manipulated images to plagiarism, fake peer reviews and fake reviewers to unusual patterns of co-authors and paid-for citations.

Collectively, we've discovered thousands of problematic papers. We shouldn't need to do this work, which is mostly unpaid. But each of us was drawn to sleuthing by frustration and concern about dishonest scholars and the harm that industrialized fabrication of research can do.

Despite our expertise, we have little power to tackle publications from paper mills. We depend on institutes to investigate suspicious actions by scientists, and on journal editors and publishers to correct or retract the articles that we flag. In our view, scientists, journals and publishers are woefully underprepared to do this work.

Some initiatives have begun to take on the problem. United2Act, for instance, is a collaboration of stakeholders in academic publishing – such as researchers, sleuths, publishers and institutes – that's attempting to raise awareness of paper mills, improve post-publication correction and facilitate research on paper mills. To stem the tide of fraudulent research, the scientific community must build on this momentum by making concerted efforts to seek out and stamp out paper mills.

### A welcoming environment

Paper mills flourish because of research systems that evaluate scientists using publication metrics, thereby inadvertently providing an incentive for misconduct. People with paper-mill publications might be promoted over those who have more modest – but honest – publication records. One study, for instance, reported that 95% of biomedical faculties use the number of peer-reviewed papers that a researcher has had published as a performance metric<sup>2</sup>. And 40% of research-intensive institutions in the United States and Canada consider the impact factor of the journals in which an individual has had work published when making decisions about their promotion and tenure<sup>3</sup>. Institutions seldom seem to punish researchers for using paper mills, perhaps owing to a lack of awareness, or concern about reputational or legal risks.

If a paper-mill client becomes an influential researcher, they might then facilitate the production of more paper-mill publications, through academic editing roles. One of us (N.W.) was involved in an investigation that found that mills seemed to be offering money to editors in exchange for accepting publications in their journals<sup>4</sup>. Guest issues,

organized by academics with little oversight from a journal's editors, can be particularly problematic. Academics working for paper mills can propose themselves as guest editors, manipulate the peer-review process and accept articles from the mill.

Publishers are often slow to act on reports of paper-mill content. One of us (E.B.) reported<sup>5</sup> 800 papers with apparent image duplication in 2014 and 2015 – of which only half had been corrected or retracted by March 2024. There are various reasons for this. For one, retractions can damage a journal's brand. Publishers are often concerned about the level of evidence required to justify retraction, and could be at risk of legal action by disgruntled authors. In addition, they might lack the staff to quickly tackle the problem, or staff might lack the expertise to detect specific 'red flags' or problematic issues with individual paper mills.

Each of us, along with other sleuths, identifies paper-mill products regularly – enough papers to overwhelm publishers with cases, making swift retractions or corrections nearly impossible. Scientists urgently need to make running and using paper mills less attractive. The following five steps would help.

### Research to understand mills

With research into paper mills scant and fragmented, little is known about their business models and publication techniques<sup>6</sup>. It's hard even to identify them, because they depend on staying one step ahead of publishers and sleuths, and are constantly developing fresh ways to hide their activity. Mills operating in different regions or specializing in different subjects use differing approaches to solicit business and avoid detection.

Even for papers from the same mill, this can be true. Last year one of us (A.A.) received a message on social media from the owner of a paper mill that the sleuth had investigated. Her analytics undoubtedly deserved respect, the message read, but had many shortcomings,

because the 1,000 papers she'd identified as coming from the mill were just the tip of the iceberg.

Answers to some key questions would help to focus preventive efforts<sup>6</sup>. These include: where are paper mills located? What fields are they targeting? And how are they using artificial intelligence (AI)?

Paper mills have been found in a wide range of countries, including: China, Russia, Ukraine, Kazakhstan, India, Iran, Iraq, Latvia and Peru<sup>7</sup>. But there are large parts of the world in which paper mills are expected to operate but where few have been identified, notably in much of Latin America, where many journals are targeted. To make a start, local researchers and sleuths might scour social-media posts and the wider Internet to look for paper-mill offers.

Certain research fields seem to be particularly susceptible, namely those in which the number of possible experiments far exceeds the available scientific resource. Fields we know of include non-coding RNAs in human cancer and crystallography – vast numbers of different RNA combinations and crystal structures can potentially be investigated. In chemistry, 44% of papers that are retracted owing to fraud are published in crystallography<sup>8</sup>. There are sure to be other fields.

Paper mills are already exploiting large language models (LLMs) to avoid plagiarism detectors and AI image generators to mass-produce papers. One preprint<sup>9</sup> suggests that at least 10% of all PubMed abstracts published in 2024 were written with LLMs – although it is challenging to differentiate between papers from mills and those by legitimate authors who want to improve their writing. We predict further exploitation of AI-generated images to produce figures in future paper-mill products. These are likely to be difficult to detect. Journals can help by promoting open science and demanding the raw data for studies – the more information is available about papers, the easier it is to spot new tricks by paper mills.

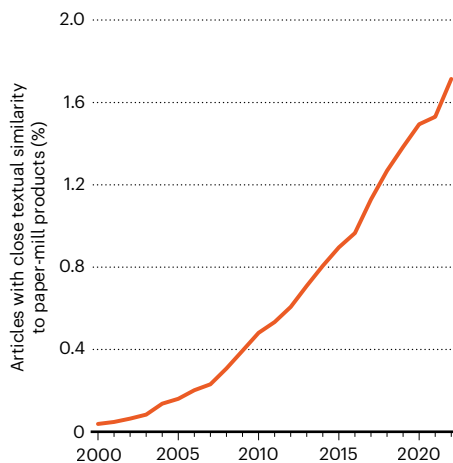
### Educate stakeholders

We're often asked to speak at universities and conferences, and consistently come across academics and PhD students who have never heard of paper mills. By preparing people to recognize and call out fake research, the scientific community can build up immunity against paper mills.

Everyone involved in disseminating and digesting research – editors, publishers, students, authors, funding organizations, institutions, bibliographic databases and governments – needs to understand what paper mills are and know how to spot the tell-tale signs of fake papers. Anyone can learn to look out for image falsification or duplication in papers in their field, as well as for nonsensical text or equations, problematic references and reagents, irrelevant citations and

### PAPER MILLS EXPLODE

The proportion of scientific articles with close textual similarities to paper-mill products is increasing.



implausible co-authorships. Free tools such as the Problematic Paper Screener<sup>10</sup> developed by one of us (G.C.) can help researchers to spot papers that might be fraudulent.

The first step is to check whether a published paper has been flagged in a database that lists retractions and corrections, such as the Retraction Watch database, or on PubPeer – an online platform for post-publication peer review, on which errors and questionable content might be flagged. There might be innocuous reasons for retractions or PubPeer comments, but by checking these databases, researchers can identify suspicious activity. There are browser extensions and reference managers (for example, Zotero) that have integrated these databases to indicate problematic references.

Universities should invest in education on paper mills as a standard part of PhD courses and training for staff, and should put in place clear policies that detail how to report a suspected paper-mill article. They should support researchers who report suspicious papers. Journal editors and research-integrity experts should receive regularly updated training organized by publishers or sleuths, and publishers should share experiences of new types of fraud with one another.

### Ensure best practice in publishing

The best time to detect fraudulent research is before it is published. Publishers should work together to identify papers submitted simultaneously to multiple journals – a common tactic from paper mills to increase the probability of publication. The STM Integrity Hub, set up in 2023, offers a platform to check articles for research-integrity issues, and is currently used by more than 25 publishers and societies. Currently, its duplicate-submission-checker tool screens around 60,000 papers per month, identifying around 1.5% of submissions as duplicates.

Editors should look out for violations of the peer-review process. These might include authors suggesting peer reviewers with fake identities or affiliations. Anomalies in e-mails, such as a domain that doesn't correspond with the university or affiliation country of a scholar, can be a telltale sign of a fake peer reviewer or author – either someone impersonating a real scholar or a completely fake identity. Publishers can verify peer reviewers by checking for indicators of honesty known as trust markers, which include an institutional e-mail address and a publication record in which no papers are flagged on PubPeer or elsewhere. Groups of collaborators from disciplines that rarely interact, publishing far outside their own fields, might also indicate that a paper warrants thorough scrutiny.

A rigorous industry-wide system for author disambiguation would also help to detect authors or editors who are repeatedly

associated with paper-mill activity. Often it's hard to be sure whether a single dubious paper is from a paper mill, but when many such articles can be linked to a single author or editor, then the probability of paper-mill involvement is greater. Verified scholar identification such as that provided through ORCID is not enough<sup>11</sup> – it must be built into a system that also includes trust markers.

Peer-review reports written by paper mills are habitually formulaic, superficial and repetitive, and can often be distinguished from genuine ones<sup>12,13</sup>. If these signs are not picked up by editors, making peer-review reports open

## “Funders, institutions and publishers must clamp down on those who use mills.”

can help sleuths and the scientific community to detect fake peer reviews after publication<sup>14</sup>.

Open-access journals, which charge researchers article-processing fees to publish papers, earn more money the more papers they publish. But publishers should understand that continuing to grow without jeopardizing the quality of peer review is hard because there is a finite supply of worthwhile papers and a limited pool of expert reviewers to draw on. The case of the Hindawi brand journals – which retracted more than 8,000 papers in 2023 before the brand was discontinued by its owner, Wiley – should act as a cautionary tale.

### Hold bad actors to account

Funders, institutions and publishers must clamp down on those who use mills. Paper mills will find it harder to thrive if the potential gains for individuals no longer outweigh the risks of using a mill.

Funders should thoroughly investigate and hold to account anybody who can be connected to a paper mill through problematic papers flagged by the Retraction Watch database, the Problematic Paper Screener or PubPeer. They should also look for applicants who rely heavily on problematic papers in their grant applications. Sleuths can detect issues after the grant has been awarded. But funders can do more during the process, such as checking PubPeer for signs that proposals are built on fake research. Guilty authors should be banned from receiving funding for a set period and from acting on grant-review boards.

Institutions need to expand what they consider to be scientific misconduct to include purchasing papers from known paper mills, submitting fake reviews or abusing editorial positions.

Publishers should retract paper-mill products promptly. The current rules for retraction specified by the Committee on Publication

Ethics lean on often-lengthy investigations by journals and institutions, and emphasize authors' rights to respond – but this approach is not well-suited to dealing with industrial-scale fraud. Articles that are clearly off-topic, contain numerous tortured phrases or irrelevant citations, or have content that any expert in the field would deem nonsensical should be immediately retracted, in our view. In less obvious cases, for example involving suspected image or data manipulation, journals should give authors a limited time frame (we would suggest up to two weeks) to provide an explanation.

Publishers should also undertake due diligence when it comes to academic editors. A first step is to audit journals' editorial teams using PubPeer or Retraction Watch, and remove any editor who has systematically co-authored problematic papers. In our view, if an article was published despite clear indications of problematic content, the publisher should remove the editor from the editorial board. Journals should develop systems to track the publications accepted by editors – for instance by including editors' ORCID numbers in the metadata for each paper – to make it easier to identify those who repeatedly accept dubious work. Use of referees who recommended accepting problematic articles should also be put on hold while their previous review reports are scrutinized.

### Fund counteractive measures

Current resources are insufficient to investigate fake papers. One solution is for publishers and academic institutions to employ more research-integrity experts. Businesses can also offer solutions to detect problematic papers at scale, such as Clear Skies, created by one us (A.D.), or the Dimensions dashboard by Digital Science (part of Holtzbrinck, the majority shareholder in *Nature's* publisher, Springer Nature), which flags unusual co-author patterns<sup>15</sup>.

Another solution is to finance sleuths. Many sleuths receive regular online threats. Some of us face lawsuits, a prospect that can silence would-be whistle-blowers. Last year, a private Silicon Valley investor established a US\$1-million research-integrity fund to cover the legal costs of sleuths who were sued for reporting misconduct in research. This month, Retraction Watch announced a sleuth-in-residence programme. Such initiatives are to be applauded; more are needed.

It would be a game-changer if grant agencies and university associations could contract sleuths to investigate suspected cases of paper-mill misconduct. This would lower the risk of personal lawsuits and allow the sleuths to remain independent.

Article publication charges from paper-mill papers could go towards preventing publication of such articles. IOP Publishing in Bristol,

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UK, has a related initiative, donating charges from retracted papers to Research4Life – an organization that provides journal access to institutions in low-income countries.

### No cure in sight

These steps can hold back the tide. But as long as numbers of papers and citations remain the rewarded goal of scientific activity, there is an incentive for people to game the system. A structural shift in science is needed, if we are to wipe out commercialized fraud. Such a seismic shift will require conversation and collective actions between all stakeholders, to find new ways to assess and reward researchers.

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# Why farmers are taking their government to court over climate change

Charlotte E. Blattner, Robert Finger & Karin Ingold

## How a Swiss lawsuit is recasting agriculture's role in climate policy.

Farmers suing their government for failing to act on climate change might sound surprising – we're more used to seeing convoys of tractors in the streets with farmers protesting the imposition of climate and sustainability policies. But that's just what's happening in Switzerland – a country where average temperature increases have already hit 2.8 °C compared with preindustrial times.

In March last year, a group of farmers turned to the Swiss courts to force the government to do more to act on climate change before their farms become unviable.

Nine farmers and five farmers' associations, involved in producing crops, fruits and vegetables, viticulture, forestry and animal husbandry, submitted evidence that anthropogenic, climate-related drought and heat, increasing storms, hail and changes in the seasons have led to losses of 10–40% in annual turnover over the past three years (see [go.nature.com/4h4bzk6](https://go.nature.com/4h4bzk6)). Adapting to climate change is adding to those losses.

This case is yet to be settled – having been initially rejected, the farmers are still awaiting the outcome of an appeal. But it marks a big shift in the position of farmers on environmental issues. In the past few years, many lawsuits have been filed – and won – in the United States and beyond to hold 'methane majors', which include dairy farms, pork producers and other agricultural corporations, responsible for their contribution to global warming<sup>1</sup>.

By contrast, the Swiss case positions farmers as crucial advocates for protecting the



Cows graze in a drought-afflicted field near Les Brenets, Switzerland, during a 2022 heatwave.

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