Bad Science: Retractions and Media Coverage.

Eleonora Alabrese*

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Abstract

Flawed research can be harmful both within and outside of academia. Even when scientific work has been retracted and refuted by the scientific community, it may continue to be a source of misinformation. The media can play an important role in drawing broader attention to research, but may equally ensure that research, once retracted, ceases to feature in popular discourse. Yet, there is little evidence on whether media reporting influences the retraction process and authors’ careers. Using a conditional difference-in-differences strategy, this paper shows that articles that gained popularity in the media at publication and were subsequently retracted face heavy citation losses, while remaining citations become more accurate. Further, authors of such papers see a permanent decline in research productivity. Lastly, the paper provides evidence that media can influence both the likelihood of retraction and its timing, highlighting that the media can play an important role in contributing to the integrity of the research process.

Keywords: Science; Retractions; Media Coverage; Misinformation; Altmetric; Citations; Career impact.

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1 Introduction

Poor quality research, even when retracted, often continues to survive and spread misinformation to academic and non-academic audiences (Lewandowsky et al., 2012; The Economist, 2021; Peng et al., 2022). A recent case study illustrates how research continues to be cited positively and uncritically in support of medical intervention, without mention of its retraction for falsifying data (Schneider et al., 2020). Inattention (Woo and Walsh, 2021) or failure to update beliefs (Goncalves et al., 2021) are two possible channels that could explain the continuous use of retracted work. In general, the literature on retractions suggests the visibility and the accessibility of retractions and their associated retraction notices are decisive to the survival of flawed research (Bar-Ilan and Halevi, 2017; Teixeira da Silva and Bornemann-Cimenti, 2017; Cox et al., 2018; Bordignon, 2020). Yet, there is limited evidence on the potential role of media reporting of science.\footnote{See Hesselmann et al. (2017) for a review on scientific retractions.}

The media can play an important role in drawing broader attention to research, but may equally ensure that research, once retracted, ceases to feature in popular discourse. This work hence studies whether and how media attention (at the time of publication) impacts the survival of retracted work (i.e. future citations) and the future career outcomes of its authors (e.g. future publication rate).

Two recent examples of well-published fraudulent Covid-19 research (Mehra et al., 2020a,b) illustrate the role of media raising attention to research, while potentially interacting with the retraction process. These two studies attracted wide media coverage right after publication and led to a global halt of hydroxychloroquine trials. But, high scrutiny from the scientific community together with an investigation from the Guardian\footnote{https://www.theguardian.com/world/2020/jun/03/covid-19-surgisphere-who-world-health-organization-hydroxychloroquine} led to a prompt retraction, as the underlining data were fabricated. However, it is unclear whether this interaction with the media helps reduce the amount of misinformation (proxied by citations) or increases the cost of retraction (proxied by authors’ productivity). This paper sheds light on the empirical relevance of this media attention channel.

Studying the media attention channel is naturally not straightforward. There are concerns related to the timing and the content of the coverage. Media attention may increase the salience of a study leading to higher future citations (Phillips et al., 1991; Fanelli, 2013). But, media could also exert a monitoring role criticizing a study and...
updating the public about a paper change of status (Peng et al., 2022), potentially reducing future citations (see Whitely, 1994, for an example). Therefore, to test whether media attention leads to differential scrutiny and hence differential punishment, I contrast research articles that appear in the media in a tight window around publication, to those that did not. These early mentions (i.e. appearances in either newspapers or blogs within two weeks from publication) are assumed to advertise the original research findings. This approach is suitable given that early media coverage is informative about later coverage (see Serghiou et al., 2021; Peng et al., 2022).

Furthermore, the endogeneity of media creates potential issues of selection into retraction. Some authors may focus on research questions which are more likely to attract media attention or manipulate their findings to attract more coverage. However, due to their relevance, these questions may receive differential scrutiny that, in turn, could impact their likelihood of retraction and their retraction timing. In addition, popular studies featuring in the media often involve eminent authors (e.g. Ivanova et al., 2013) who might be less impacted by retractions (Azoulay et al., 2017; Jin et al., 2019). I tackle these challenges through employing a refined conditional difference-in-differences estimation strategy. This approach compares the evolution of citations of retracted papers to that of closely matched control group papers, before and after retraction — while contrasting papers with or without early mentions. Papers that serve as control group are selected to mimic multiple (ex-ante) characteristics of retracted papers, such that they could best simulate the citation path of retracted papers absent the retraction. Naturally, such an approach allows for a test of the common-trends assumption inherent to such a research design. To be more precise, papers serving as control group are required to (a) be published in the same journal and year, (b) have similar citation trends in the years prior the retraction, and (c) have attracted comparable media coverage at publication, as their retracted counterpart. The inclusion of early mentions as feature to match on, is further justified by recent findings that retracted papers experience more coverage than non-retracted papers published in the same journal, similar publication year and similar author characteristics (see Peng et al., 2022).

3However, Serghiou et al. (2021) finds that retracted articles may receive high coverage, but pre-retraction coverage far outweighs post-retraction coverage.

4From a methodological point of view, Furman et al. (2012); Lu et al. (2013); Azoulay et al. (2015); Mongeon and Larivière (2016); Azoulay et al. (2017); Jin et al. (2019) all adopt similar difference-in-differences strategies to estimate the effect of a retraction shock, with the exception of the matching on early mentions.
Relying on the matching strategy described above, I also conduct a difference-in-differences estimation at the author level. This estimation compares the productivity of authors of retracted papers to that of authors of matched control papers before and after their first observed retraction — distinguishing cases where the original publication had early mentions or not. Crucially, this analysis allows capturing heterogeneous effects by authors’ order of appearance in the coauthorship roster and by authors’ seniority (i.e. based on ex-ante H-index).

The validity of the estimates could be further challenged. For example, there could be unobservable paper- and author-specific factors, which, in turn, may interact with time to confound these estimates. To allay such concerns, both paper- and author-level exercises incorporate a large set of additional control variables. All paper-level specifications include age, calendar-year, and paper-specific effects. All author-level specifications include career length, calendar-year and author-specific effects.

Despite this rich econometric framework, there may still be concerns that the endogeneity of media attention — at the publication stage — may not be adequately accounted for. I employ two alternative strategies to tackle this concern. First, using methods from computational linguistics, I build a predictive model of media coverage based on words in paper titles. I then use this prediction to separate the impact of the arguably exogenous excess coverage on the likelihood of retraction, from the media coverage that a study may obtain due to its authors self-selecting into a general interest topic. Second, I study the relationship between the average coverage of non-retracted articles within a journal-year (journal visibility) and the timing of the (eventually) retracted articles that appeared in those journals.

This paper draws on one of the most comprehensive data collection effort to measure the representation of research in broader media through Altmetrics, along with papers’ citation history and authors’ publication history. But, consistent media coverage data are recent. For this reason, I select (eventually retracted) papers published (and retracted) strictly after 2010. Furthermore, I balance relevance and manageability of sample size by focusing on retractions published in highly ranked journals within each available discipline and extracted from the RetractionWatch database. Notice that top journals feature more into the media (Yin et al., 2022) allowing to observe a considerable proportion of papers with any coverage. Yet, this could potentially introduce a bias as Woo and Walsh (2021) find that top journal citations to retracted

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5I retain retractions that either appear in Scimago top ten journals or in Google scholar top publication journals for each available category.
articles are more likely to occur outside one’s field and are potentially more prone to misinformation. I argue that investigating the relationship between media and punishment after retraction is more compelling for high-impact research. Yet, the reader may be reassured that I observe an average penalty for the retracted papers I select (≈65% of forward citations) aligned with previous literature (Furman et al., 2012; Azoulay et al., 2015).

Using this sample, I first show descriptive evidence that retracted papers attract some media coverage, although publication and retraction events feature differently across outlets. Newspapers are more likely to cover the publication of a paper, while blogs are more likely to cover its retraction. However, blogs have a more scientific target.

Moreover, difference-in-differences estimates at the paper level show that retractions harm citations of retracted papers, and media coverage amplifies this effect (on average, media contributes to a ≈30% further reduction in forward citations). This aggravating effect is present only in hard sciences. The media effect is also more considerable for severe cases of misconduct. To prove this exacerbating effect of media on future citations is robust, I first show that media does not capture other paper features. Indeed, papers with high cumulative citations (ex-ante) do not drive nor confound media estimates. Estimates are not sensitive to including or excluding the year of retraction in the Post indicator. And, excluding non-actively cited papers does not impact estimates. Finally, alternative strategies that look at citation statements or study the relationship between citation penalty and journal visibility confirm that media intensifies the citation penalty after retraction.

I propose two mechanisms that might explain the effect of media on citations: (a) higher scrutiny by the scientific community of a paper that gained popularity; (b) additional information provided to some part of the scientific community which would have otherwise remained unaware of the retraction. For (b), I check whether

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6Visual differences emerge when looking at the leaning of (US) news coverage, based on Gentzkow and Shapiro (2010) index of media slant, which deserves further investigation in future work.
7RetractionWatch alone represents about one third of all blog mentions for the selected retractions.
8The heterogeneity for hard versus social sciences suggests distinct publication practices may impact the visibility of a retraction. The difference across disciplines may also reflect the public perceptions that social science research is less “absolute” as the object of study is more volatile.
9The separation between severe and non-severe cases of misconduct comes from the classification developed by Woo and Walsh (2021).
10The citation statements are textual paragraphs where a citation appears.
11The journal visibility is calculated by averaging the media coverage of non-retracted articles published in a specific journal and year.
the textual content of remaining citations significantly differs with media coverage. The presumption is that absent the information mechanism, retracted papers with media coverage would experience fewer citations after retraction but with no relative change in their level of accuracy. In contrast, I find that with media coverage, remaining citations mention more often the paper is indeed retracted. This finding suggests that, with media coverage, scientists become more aware of a retraction and correctly acknowledge it when citing the original paper, reducing potential misinformation.

Consistently, difference-in-differences estimates at the author level show that retraction have a negative impact on authors’ future productivity. However, this negative impact is large and permanent only if the original publication had some media exposure (≃10\% larger reduction in future publication rate relative to a case with no media). This differential effect of media is evident for first authors, senior authors, and in cases of severe misconduct.

Furthermore, I show suggestive evidence of selection into retraction. On the one hand, papers that attract predictable (endogenous) media coverage are less likely to get retracted. On the other hand, papers with exogenous excess coverage get retracted more often. However, both effects are modest. Finally, I show that journals publishing articles that are popular in the media are journals where retractions happen faster (one standard deviation increase in journal visibility implies a reduction in the timing for detection of 15\%).

Overall, this paper investigates whether media coverage of scientific articles influences the auto-correcting process of science, where research articles’ media coverage is directly observed across outlets and time. Specifically, media coverage — at the publication stage — amplifies the penalty for flawed research in terms of both future citations and authors’ future publication rate. Although media seems to help the auto-correcting process of science, this implies that (a) plenty of wrong science remains unnoticed and (b) that academia needs better strategies to raise the risk of scrutiny and lower incentives for poor-quality research.

The paper closely relates to the large body of research on scientific retractions. Specifically, it is closest to studies that look at the causal effect of retraction on citations of retracted papers (Furman et al., 2012), on authors’ previous publications (Lu et al., 2013; Azoulay et al., 2017; Jin et al., 2019), or their future research output (Mon-
geon and Larivière, 2016) and potential spillover on the related field (Azoulay et al., 2015). The main contribution to this literature is showing that media coverage — at publication — amplifies the causal effect of retraction on citations of retracted papers and substantially explains the negative and persistent impact on the future research output of retracted authors. Further, I show that media may impact the likelihood of retraction and its timing. The latter result may lead to a problem of selection into treatment. To address this, I also update the methodological approach used in this literature to include the early media exposure of papers as a feature to match on.

Only a few studies on retractions mention the role of media (Sugawara et al., 2017; Sarathchandra and McCright, 2017; Serghiou et al., 2021). Concerning these, this paper is closest to Peng et al. (2022) who use the same data to show that retractions are ineffective at reducing online attention. Specifically, they find that retracted papers receive more coverage after publication than non-retracted control papers from the same journals with similar publication years, number of coauthors, and author impact.

The current paper addresses a different but complementary question, whether media attention intensifies the effect of retraction on papers’ citations and authors’ careers, thus reducing misinformation and increasing authors’ cost of retraction. As the question differs, the matching strategy also differs. In fact, I compare retracted papers to never-retracted control papers from the same journal and year, with similar pre-trends in citations, and with similar salience at publication (i.e. similar early mentions). The paper also relates to the literature investigating the relationship between science and the media (Weingart, 1998; Phillips et al., 1991; Fanelli, 2013; Ivanova et al., 2013; Sumner et al., 2014; Dumas-Mallet et al., 2020; Ziegler, 2021) to which I contribute by showing that media coverage of (eventually) retracted papers can influence the reputation of papers and authors, within science. This work further contributes to the literature on factors influencing citation rates (for example see Card and Dellavigna, 2020; Card et al., 2020; see also Tahamtan et al., 2016, for a review of the literature), to which I add that (ex-ante) salience impacts the citations of a paper and its authors’ careers in case of a negative event (such as a retraction). Finally, this work relates to the broad literature on misinformation and how media channels influence politics and public policies (for an example see Allcott and Gentzkow, 2017; Lazer et al., 2018; see also Prat and Strömberg, 2013, for a review of the literature). I contribute to this literature by showing that media coverage attenuates misinformation.

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14This choice is motivated by the fact that media may impact selection into retraction. Therefore, control papers should be equally likely to be detected (if wrong).
mation within academia. At the same time, I illustrate that newspapers cover more the publication of a paper rather than its retraction, which creates the potential for disseminating misinformation to a larger audience.

In the remainder of the paper, Section 2 illustrates the institutional context of retractions. Section 3 describes the data, the sample selection and the main empirical strategy. Section 4 presents descriptive results on the media coverage of retraction. Section 5 and Section 6 provide a detailed presentation of results at the paper- and author-level respectively. Section 7 concludes.

2 Background

Understanding the incentives and governance regulating scientific knowledge production, dissemination and accumulation is crucial to this work. In what follows I discuss relevant aspects of the publication system.

One of the most discussed institutional setting is the peer review system. Articles are submitted and reviewed by independent experts before being accepted for publication. This feature is used to maintain high quality standards while allowing a suitable publication timing, even though practices vary greatly across disciplines and journals. This system eventually provides only limited guarantee against bad science.

Another aspect is the practice of citing related literature which is crucial for scientific communication. It allows to effectively contextualise a research article with respect to pre-existing literature while acknowledging original contributions from previous authors. Citations are regarded as an indicator of the importance of scientific findings and of their creators and can be negatively impacted by a retraction (Furman et al., 2012; Lu et al., 2013; Azoulay et al., 2015; Mongeon and Larivière, 2016; Azoulay et al., 2017; Jin et al., 2019).

In academic publishing, a retraction is the result of a procedure used by journals to alert readers that a published article should be removed from the literature. A retraction may occur when a major error (e.g. in the analysis or methods) invalidates the conclusions of the article, or in presence of misconduct (e.g. fabricated data, manipulated images, plagiarism, duplicate publication, research without required ethical approvals etc). It differs from a correction issued in case of an error or omission which can impact the interpretation of the article, but where the scholarly integrity remains intact. The surge in the absolute number of retractions across all disciplines
has alarmed many in the scientific community (see Figure [1]). Nonetheless, retrac-
tions remain relatively rare involving 4 in every 10,000 published papers of which
60% due to some type of misconduct, though both rates have been rising steadily
over time (Brainard [2018]).

A retraction can be initiated by the editors of a journal, by some or all the authors
or their institution and are typically complemented by a notice meant to clarify the
reason of such decision. But, the information contained in notices vary significantly,
some explain the details which lead to the retraction outcome and inform on whether
an article results and conclusion should be disregarded entirely or in part, others are
rather succit and vague.

A further element of discussion is therefore the visibility and accessibility of both
retractions and notices. "Authors are responsible for checking that none of the ref-
erences cite retracted articles except in the context of referring to the retraction" (In-
ternational Committee of Medical Journal Editors 2019). Awareness of readers is
therefore decisive, yet the current institutional setting does not suffice. Retractions
are usually published and linked to the original publication and can be often identi-
fied via different sources (e.g. libraries, databases and search engines) but inaccurate
citations still remain. Schneider et al. [2020] found that in the case of an infamous
clinical trial (Matsuyama et al. [2005]), in which data were falsified leading to a re-
traction in 2008, the retraction is not mentioned by 96% of post-retraction citations
and 41% of these inaccurate citations describe the paper in detail leading to possi-
ble disinformation. On the other hand, Piller [2021] looked at the recent case of two
high-profile Covid-19 retractions (Mehra et al. [2020a,b]) and finds that 52.5% of the
citations do not correctly mention the paper status. In what follows I will illustrate
that the media attention attracted by the latter case could be a relevant factor behind
the difference in the two examples just discussed.

In this respect, recent efforts make use of media platforms to alert scientists of
retractions, as in the case of the specialised blog RetractionWatch which reports on re-
tractions and gathers information surrounding specific retraction events, such as which
of the authors is responsible for the article ultimate fate. Information which is usu-
ally hard to acquire based on the notice alone. New tools are also emerging as in the
case of Scite.ai, a recently launched platform which categorises references, monitors
retracted papers by searching through Crossref, PubMed, and the RetractionWatch
database, and flags both citing and retracted papers on Twitter.
3 Data and Method

3.1 Data

This study combines multiple data sources on scientific publications and their authors which I hereby list in details.

Retractions. The treatment sample is extracted from the RetractionWatch database which Brainard (2018) defines as "the largest-ever database of retracted articles". The dataset contains a list of retracted research articles together with the following information: title, doi, date of publication, date of retraction, journal, name of authors and their institutions, list of reasons for retraction, and when available, a link to the associated blog post reporting on the paper background story.

Journal ranking. I further select papers featuring in either Scimago or Google scholar rankings. The selected journals appear either as one of the ten highest ranked in Scimago in any of the available subjects or among those listed in Google scholar top publications in any of the existing categories.

Citations and authors' publications. Yearly citations and authors publications are the main outcome of this study and are collected for each article and author using Scopus, one of the two largest abstract and citation database of peer-reviewed literature.

Media coverage. Data on online mentions are gathered thanks to Altmetric, a company that since 2011 tracks the attention that research outputs receive online. For each paper I retrieve the Altscore, an aggregate measure of online mentions (i.e. it combines all mentions across outlets giving a higher weight to outlets such as newspapers, see appendix Table A.1), and details about single mentions (e.g. date, url, author, title, summary).

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15 Version obtained in July 2020.
16 Dense since the '80s.
17 For the period considered in the analysis, there exists little difference between Scoups and WoS in terms of coverage (see: https://www.internauka.org/en/blog/scopus-vs-web-of-science). Scopus though has the advantage of having an API easily accessible via rscopus, a library by John Muschelli available on R.
18 I here focus on sources with the highest number of mentions (i.e. newspapers, blogs and Twitter) though Altmetric collects mentions from numerous additional outlets (e.g. Pubpeer, Wikipedia).
Citation textual content. I obtained data on the content of citation statements quoting the research articles in the sample with the support of Scite.ai, a recently launched start-up that uses text analysis to categorize reference statements. For each pair of citing and cited study, statements are categorised as "mentioning", "contrasting" and "supportive". In addition, access is gathered for any statement containing the words "*etract*" or "*ithdraw*".

3.2 Empirical strategy

This work investigates the possibility that media coverage influences scientists’ awareness and assessment of research findings (looking at citations or retracted papers) and authors’ careers (looking at the publication rate of retracted authors, see Section 6 for author-level analysis). Holding other factors constant, a loss in citations and lower authors rate of publication, reflects an erosion of trust in the authors’ work by the scientific community.

To understand the interplay between the retraction of a paper and the information available online one needs to consider how scientific publications feature in the media and what challenges this poses in terms of identification.

First, a research article that is accepted for publication may endogenously attract media coverage. Online attention may depend on factors such as the salience of a topic, the importance of the findings, the prestige of authors and publishers, the presence of a press release (Sumner et al., 2014, 2016).

Furthermore, media coverage can bring publicity to a paper which can increase future citations (Phillips et al. 1991; Fanelli 2013) as well as prompt higher scrutiny from the scientific community making any fault more likely to emerge. Online attention can also inform about the fate of an article as in the case of an expression of concern or a retraction (Serghiou et al. 2021), news that could reach unaware scientists that would otherwise incorrectly cite a flawed article.

In light of this, I use a conditional difference-in-differences strategy which compares retracted papers to matched controls, before and after the retraction, while contrasting papers with or without early mentions (i.e. appearances in either newspapers or blogs within two weeks from publication) that are assumed to broadly advertise the original research findings. And, control papers are selected to mimic multiple

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19 According to Rosati (2021)

20 Manually checked to exclude any false positive.
(ex-ante) characteristics of retracted papers, such that they could best simulate the
citation path of retracted papers absent the retraction. Specifically, controls are (a)
published in the same journal and year, (b) have similar citation trends in the years
prior the retraction, and (c) attracted comparable media coverage at publication, as
their retracted counterpart.

The rest of this session explains in details the process of selection for both treated
and control papers as well as the main estimation strategy.

3.3 Treatment group

The full RetractionWatch database counts $N_r = 21,968$ retractions starting from 1980.
Provided that data availability on online mentions is only relatively recent, I select
retracted papers both published and eventually retracted after 2010 ($N_r = 11,258$).
Only research articles\footnote{Excluding for examples: conference abstracts and clinical studies, $N_r = 6,676$.} with non missing paper DOI and retraction notice DOI are
maintained\footnote{$N_r = 6,189$.}. To balance relevance and manageability of sample size, I focus on ar-
ticles published in journals featuring in either Google scholar top journals by field or
among the ten highest ranked journals in Scimago per subject category\footnote{$N_r = 1,163$.} Remaining
papers are certainly relevant for the scientific community, hence, it is important to
study whether in this case disinformation is halted or fostered by media coverage\footnote{Woo and Walsh (2021) find that top journal citations to retracted articles are more likely to occur
outside one's field and are potentially more prone to disinformation.}. In addition, publications in reputable journals may be more likely to attract media
coverage \cite{yin2022}, thus helping identification\footnote{This could potentially introduce a bias. Yet, the reader may be reassured that I observe an average
penalty for selected papers which is aligned with previous literature \cite{furman2012, azoulay2015}.}. Next, I exclude articles for
which I cannot find any author with at least one publication in the 9 years before the
retraction event\footnote{This is important to study the career impact for retracted authors', hence I need at least some
authors with a minimum reputation ex-ante ($N_r = 1,008$).}. Of these I retain cases for which I can find an appropriate control,
leading to a final sample of $N_r = 990$.

3.4 Control group

Trends in citations vary across disciplines, age and media coverage, hence, control
publications were selected to mimic pre-retraction characteristics of the treated. This
strategy draws from the approach first used in the literature on retractions by Furman et al. (2012) and further developed by Lu et al. (2013) and Jin et al. (2019). The main assumption is that treated papers would continue to perform similarly to control ones in absence of a retraction event.

The selection of the control group proceeds in steps. For each retracted paper I search in Scopus for studies published in the same journal and year of the treated. For each retracted \( i \) and potential control pair \( j \) I compute the measures listed below.

- **Absolute arithmetic distance** in citations.
  \[
  |AD| = \left| \sum_{t=pub}^{retr-1} (c_{it} - c_{jt}) \right|;
  \]

- **Euclidean distance** in citations.
  \[
  ED = \left[ \sum_{t=pub}^{retr-1} (c_{it} - c_{jt})^2 \right]^{1/2};
  \]

where \( c_i \) indicate the citations paper \( i \) receives in year \( t \) in the time span between the year of publication \( pub \) and the year of retraction \( retr \). These measures capture the disparity in citation trends in different ways. AD allows for positive and negative yearly differences to balance over time while any discrepancy is accumulated over time in the case of ED.

- **Early mentions absolute distance** (MD) of blog \( b \) and newspaper \( n \) mentions within two weeks from publication.
  \[
  MD_b = \left| (b_{i,2w} - b_{j,2w}) \right| \quad \& \quad MD_n = \left| (n_{i,2w} - n_{j,2w}) \right|
  \]

The reason for choosing a two weeks cutoff draws from observing that notable studies attract most online publicity around their publication as suggested by Figure 3 for treated papers, and it is even more evident for control papers (see Figure A.4). On the other hand, a flawed article, that will eventually be retracted, may later prompt critical mentions. To capture whether a contribution is newsworthy, without

\footnotetext{27}{Articles or reviews.}
\footnotetext{28}{\( N_c = 586.281 \) overall results.}
including mentions that may relate to the treated article misfortune, I hence focus on a two weeks cutoff from publication date.\textsuperscript{29}

I then retain for each \(i\) all \(j\) with \(|AD| \leq 10; MD_b \leq 10;\) and \(MD_n \leq 10\).\textsuperscript{30} I rank the remaining \(j\) in terms of smallest \(MD_b + MD_n\) and select two controls (or one depending on availability) with the minimum ED among those. This final selection leads to a sample of \(N_c = 1,969\) control articles.

The quality of selected controls is assessed in Figure A.1 and A.2 of the appendix. The Euclidean distance between the selected controls and the treated paper is dense around zero (in over 68% of the cases this selection yields a perfect match), and the arithmetic distance is fairly centred around zero. No significant difference emerges when comparing treated and control distributions of cumulative citations pre-retraction. Similarly, there is no significant difference in the distribution of early mentions across treated and control groups for either newspaper articles or blog posts.\textsuperscript{31} Control papers are marginally more likely to have little citations and no media mentions pre-retraction. In general, the vast majority of published articles have little citations and no mentions in either media outlets at publication.

3.5 Selected summary statistics

Table 1 illustrates a set of distinct summary statistics for treatment and control group. The top of the table looks at variables which should be similar across the two groups for the identification strategy to be successful. ED and AD are on average somewhat close to zero (0.93 and 0.17 respectively) and both groups of papers attracted an average of about 7 citations in the pre-retraction period, substantially confirming the finding reported in Figures A.1 and A.2. Within two weeks from publication papers experience comparable online mentions on newspapers and blogs, even though eventually retracted papers have on average moderately higher coverage (1.04 vs. 0.79 news articles, and 0.24 vs 0.15 blog posts). The age for the two groups of papers is almost identical by construction. Moving to the bottom of the table one can observe that papers take on average two years to be retracted. Furthermore, yearly citations have a distribution that is very skewed, with 32.2% observations actually equal to 0, a

\textsuperscript{29}This threshold is also less sensitive to publication date imprecisions and allows to select controls with a smaller MD as compared to shorter cutoff.

\textsuperscript{30}These cut offs allow to maximise the number of matches while limiting the maximum conceded distance in either citations or media mentions. These thresholds lie at the extremes of the distribution of distances and improve the quality of matches without affecting results.

\textsuperscript{31}This remains true when removing observation with no mentions, as shown in Figure A.3.
Poisson model would therefore better approximate the distribution of the dependent variable. Unsurprisingly, treated papers cumulate substantially less citations over the years as compared to controls (16.8 vs. 33.9 respectively), but attract generally higher online attention with an *Altscore* of 37.5 for retracted papers and 19.1 for controls. In general, a non negligible share of articles experiences some online coverage, most articles are mentioned on social media (60% of retracted papers and 44% of controls) while only a limited fraction appears in newspaper articles (13% and 12% respectively), in addition blogs actively mention over one third of retracted papers while significantly less attention is devoted to controls. Finally, about one tenth of papers in either group appears in either newspapers or blogs around the publication date.

### 3.6 Estimating Specification

The study employs a difference-in-differences strategy that allows to compare the evolution of citations of retracted papers before and after retraction relative to citations of a control group of non-retracted studies published in the same journal and year and with a comparable trend in yearly citations before retraction. Treatment and control papers also have similar number of online mentions (on blogs and newspapers) within two weeks from the day of publication (i.e. *early mentions*) to account for unobservable characteristics which make a study newsworthy and could therefore create a problem of selection into retraction.

Therefore, the regression model is the following:

\[
E[Y_{igt} | X_{igt}] = \exp[\alpha + \gamma_1 Post_{igt} + \beta_2 R_i * Post_{igt} + \beta_3 Post_{igt} * Media_i + \beta_4 R_i * Post_{igt} * Media_i + \delta_i + f(age_{it}) + \delta_t]
\] (1)

where \(i\) is the treatment (or control) paper, \(g\) is the case-level group and includes the retracted paper and its respective controls, \(t\) are years relative to the retraction. The dependent variable \(Y\) represent a paper yearly citation count and exclude self-citations, as the estimation wants to capture the reaction of the scientific community other than that of the authors involved. *Post* is an indicator variable equal to one for all years after retraction, \(R\) is an indicator for retracted articles, and *Media* captures the exposure of an article to online coverage. Different media dummies will be used to indicate articles with or without media mentions. Due to previously discussed issues related to the timing and the content of coverage, the media indicator which is
best identified is equal to one if a paper receives at least one online mention within two weeks from publication in either newspapers or blogs and zero otherwise (i.e. \(1[\text{Early Mentions} > 0]\)). Early mentions are assumed to broadly advertise the original research findings and are generally balanced across treatment and control papers. Other media indicators equal one for research papers that receive at least one overall mention in any of the media outlet analysed (i.e. social media, newspaper articles, or blog posts). In order to look at different levels of media exposure of each paper, indicators are also derived from the distribution of Altscore, an aggregate measure of weighted online mentions.\(^{32}\) The coefficient \(\beta_2\) captures the effect of a retraction shock on citations of retracted papers as compared to similar control papers. The coefficient \(\beta_4\) captures any difference in the effect of the shock for papers that received online attention. Fixed effects are included for each paper \(\delta_i\) and each calendar year \(\delta_t\) while \(f(\text{age}_i)\) represents a full set of dummies for years since publication (age) and is meant to flexibly control for the age of the articles.\(^{33}\) To look at the dynamics of the differential effect of Media, estimates will be presented for a model that replace the indicator Post with a full set of dummies for each year relative to the year of retraction.\(^{34}\) Given the skewed nature of the dependent variable, I follow a long-standing tradition in bibliometric studies, hence I use a pseudo Poisson regression model developed by Correia et al. (2020)\(^{35}\) where consistency is achieved under the only assumption that the conditional mean of the dependent variable is correctly specified (Gourieroux et al., 1984). Finally, standard errors are clustered at the case level.

4 Descriptives results: coverage of retractions

Popular online media like newspapers, blogs and social media, whose target is often beyond the scientific community, have been recently active in advertising retracted articles (see Figure 2)\(^{36}\) In general, media platforms seem to cover both original publications and retractions, but the two events feature to a different extent across

\(^{32}\)See Table A.1 for details about Altscore weights across outlets.

\(^{33}\)Note that the interaction term \(R_i \times \text{Media}_i\) is absorbed by the paper fixed effect.

\(^{34}\)\(E[Y_{igt} | X_{igt}] = \exp\left[\sum_{r=-4}^{-2} \gamma_{1r} \times d_i + \sum_{r=-6}^{-5} \gamma_{2r} \times d_i + \sum_{r=-4}^{-2} \beta_{2r} \times d_i \times R_i + \sum_{r=-6}^{+6} \beta_{2r} \times d_i \times R_i + \sum_{r=-4}^{-2} \beta_{3r} \times d_i \times \text{Media}_i + \sum_{r=-6}^{+6} \beta_{3r} \times d_i \times \text{Media}_i + \sum_{r=-4}^{-2} \beta_{4r} \times d_i \times R_i \times \text{Media}_i + \sum_{r=-6}^{+6} \beta_{4r} \times d_i \times R_i \times \text{Media}_i + \delta_i + f(\text{age}_it) + \delta_t\right] \)

\(^{35}\)http://scorreia.com/software/ppmlhdfe/

\(^{36}\)Notice that recent years are likely underreported given rejections take some time to arise and hence feature in the database.
outlets, giving raise to potential disinformation. Indeed, Figure 3 shows that men-
tions in newspaper articles appear predominantly close to the publication date of a
study and generally inform the public about its discovery, less often this information
is updated with a new mention at the time of retraction. On the other hand, blog
posts occur mostly around the retraction event. These blogs are often specialized and
directly target academic37 while a wider audience is exposed to information which
is not always complete. This could lead to unintended consequences that deserve
further work.

To shed some light into factors that could shape an outlet decision to cover a
retraction event or not, I look at US news coverage classified based on Gentzkow
and Shapiro (2010) measure of media slant.38 Figures A.6 to A.9 contrast the ob-
served mentions for relatively left- or right- leaning outlets. Limited differences seem
to emerge as left leaning news show a somewhat more balanced reporting which
deserve to be further studied.

In essence, the rise of the internet and the appearance of new platforms has the
potential to direct scientists (and non-scientists) attention towards "interesting" con-
tributions which in some cases prove to be less reliable (Serra-Garcia and Gneezy,
2021). It is therefore important to investigate whether positive remaining citations,
and the retraction process more in general, relate to the media visibility of a research
paper and its retraction.

## 5 Paper-level results

Table A.3 shows results for a simple difference-in-differences analysis for the pooled
sample of retracted papers and selected controls. Estimates imply that relative to
controls, retracted papers experience a 65% ($1 - \exp(-1.06) = 0.65$) loss in yearly
citations after the shock and the magnitude is comparable to previous studies (Fur-
man et al., 2012; and Azoulay et al., 2015) which rely on different samples, disciplines
and time periods.39 Figure A.10 illustrates the dynamic of the effect of a retraction.

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37 Around a third of blog coverage is from RetractionWatch, the single outlet most committed to
inform about scientific retractions (Figure A.5 exclude RetractionWatch mentions).

38 To maximize the number of observable US press mentions, I take the sample of research articles
published and retracted after 2010 with non missing DOI and whose DOI is different from that of
its retraction notice ($N_r = 4,763$) and retain only mentions matching the list of outlets classified by
Gentzkow and Shapiro (2010). I remain with 53 retracted papers for which I observe at least one news
mention with measurable slant.

39 Estimates are similar when using an IHS (Inverse hyperbolic sine) transformation of the dependent
variable.
The post-retraction loss in citations increases over time and there is no evidence of pre-trends\(^{40}\)

### 5.1 Main results

Table 5 to A.5 report results from the main specification. The tables differ by measures of media coverage, using indicators for papers with at least one mention within two weeks from publication (early mentions), papers with at least one mention overall in a certain online outlet (any news, blog or social media) or papers that fall in some part of the Altmetric score (Altscore) distribution. The tables highlight the difference-in-differences coefficient $Post \times Treatment$, according to which the average citation penalty of a paper after its retraction amount to 56-62% across all specifications. The relative effect for papers that experienced some media coverage is estimated by the triple interaction $Post \times Treatment \times Media$.\(^{41}\) Retracted papers which attracted media coverage experience an additional penalty in post-citations of about 28-36% and the effect seems monotonically increasing in the amount of coverage received (see Table A.5). The almost entirety of these estimates is highly significant. Figure 4 represents the dynamics of the additional penalty in presence of (alternative measures of) media coverage. The loss in yearly citations becomes progressively more evident over time without any sign of recovery, and I find no evidence of pre-trends.

### 5.2 Robustness checks

#### 5.2.1 Highly cited papers differencial

In what follow I intend to increase confidence that the exacerbating effect I showed, is solely due to the presence of online attention. It could be that media exposure is actually capturing some alternative paper features, related to media presence, and confound my estimates. To address this concern I repeat the main excersise looking at whether the effect of retraction on forward citations differs for papers which are highly cited ex-ante. The rational being that influencial papers may face higher scrutiny as well as higher chances of featuring in the media (Yin et al., 2022). Reassuringly, Tables A.6 to A.8 show that papers with high cumulative citations before

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\(^{40}\)Note that effects in the year of retraction are also small due to the fact that papers in the sample get retracted at different points within the year.

\(^{41}\)Where the Media variable is defined in alternative ways across specifications as described at the top of this paragraph.
the year of retraction do not drive nor confound media estimates.

5.2.2 Including retraction year into Post indicator

Previous estimates illustrate effects on citations for all years strictly after the one of retraction (i.e. excluding the year of retraction). The rationale behind this choice is the fact that papers can get retracted at any point during the year and this can therefore act as a confounder. Nonetheless, Tables A.9 to A.11 show that the main results are not sensitive to this decision. If anything, the additional effect of early mentions is smaller in case of blog mentions (see Table A.9 column (2)). This difference may relate to the fact that most blog mentions appear later when the paper gets discredited. In addition, the fact that effect of early mentions are less significant, may speak to a possible information effect of media which emerges more clearly at a later stage, as captured by overall measures of online coverage in A.10 and A.11.

5.2.3 Actively cited papers

The algorithm for selecting controls attempts to choose papers that could likely mimic the citation path of retracted papers absent the retraction shock. Finding good controls for retracted papers that are not actively cited soon after publication may be challenging and could bias estimates. For this reason I here exclude all retracted papers (and respective controls) with zero citations in any year before retraction. This exercise halves the original sample. Even so, Tables A.12 to A.14 confirm the results all remain robust.

5.2.4 Citation textual content

One additional exercise is that of looking directly at the textual content of citations. Scite.ai (a newly launched platform featuring in Nature) scans article PDFs for references to papers and categorises these references as mentioning, contrasting or supporting. With the platform support, I built a dataset of yearly citation statements for each classification, paper and year and performed an exercise equivalent to that

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42 Figure A.10 and Figure 4 show smaller or insignificant effects in the year of retraction relative to the previous year.
43 48% observations left in either treated or control group.
44 https://www.nature.com/articles/d41586-020-01324-6
45 The classification is according to Rosati (2021)
of Section 5.1. Tables A.24 to A.26 substantially corroborate the main findings. Retracted papers experience a penalty in all type of citation statements after the retraction shock, and for citation statements that only mention the study, this penalty is aggravated in presence of media coverage. No additional change is detected for either contrasting or supporting references. One caveat is that almost the entirety of the citation statements is classified as mentioning.

5.2.5 Journal visibility and loss in citation

In a last robustness exercise I relate the individual loss in citations obtained comparing each retracted paper to its selected controls for different pre- and post-time windows ($DiD = [E(cit_1^T) - E(cit_1^C)] - [E(cit_0^T) - E(cit_0^C)]$) to the average media coverage of (non-retracted) articles published in the same journal and year (journal visibility).

Figure A.22 shows that a retracted paper experiences a significantly larger loss in citations if published in a journal with higher average visibility. Notice this negative relationship becomes stronger when looking at wider time windows around the year of retraction. These same conclusions are evident in Table A.23 were alternative measures of media exposure are also used. These findings substantially confirm the main results presented in section 5.1.

5.3 Heterogeneity

5.3.1 Hard vs. Social sciences

Various disciplines have distinctive publication practices which could create different incentives at publication and therefore lead to heterogeneous effect. Table 6 and A.15 together with Figure 5 illustrate that this may indeed be the case. What consistently emerges across specifications is that, in the case of social sciences, there is no additional penalty associated to retracted papers with media attention. Perhaps one interpretation is that the timing of publications in hard sciences is generally fast; while working papers in social sciences may circulate for longer inside the scientific community. In the latter case, media coverage may therefore offer little room for

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46 Controlling for year of publication effects, age of paper at retraction effects, number of non-retracted articles within same journal and year, the average Euclidean distance of those non-retracted articles, and the level of (non-self) cumulative citations of the retracted paper before retraction. See Section 5.6 for further details.

47 Disciplines are identified using Scopus journal classification. Social sciences are: business and technology, humanities and other; while hard sciences are: life sciences, environment, health and physical sciences.
update on the validity of the study as compared to the former case where online attention may further stimulate the academic discussion around a paper.\footnote{Related to this, Wohlrabe and Bürgi (2021) suggests that in the case of economics, the practice of releasing working papers before their publication in a journal has a positive impact on citations.} One caveat is that the subsamples of disciplines are quite small in particular in the case of social sciences.\footnote{Over 80% of retraction appears in hard sciences (809) of which 12% (95) with early visibility and 59% (475) with Altscore above median. Of the 179 retraction in social sciences 8% (15) have early visibility and 53% (95) have Altscore above median.}

5.3.2 Cause of retraction

One aspect I investigate is whether the aggravating effect of online attention differs depending on the reason behind the retraction. Retractions can occur because of honest mistakes or actual misconduct of the authors. Distinguishing the two is relevant as original findings should be entirely discarded in cases of severe misconduct, leading to higher concerns over the spread of disinformation. On the other hand, cases of misconduct may be newsworthy and online discussion may play a special role by circulating detailed information on the case. I therefore divide reasons for retraction in minor, moderate and severe cases of misconduct using the classification developed by Woo and Walsh (2021) (see Table A.17).\footnote{The selected sample is divided in 30% (301) cases of minor misconduct, 26% (261) of moderate misconduct and 43% (428) of severe misconduct.} Table 7 (and A.16) suggests media attention plays a bigger role in presence of severe cases of misconduct and there is little additional penalty associated to minor cases with media attention.

5.4 Information mechanism

This work has so far shown that retractions disappear from the literature at a faster pace in presence of media coverage. This additional effect of media may be derived by two different mechanisms: (a) higher scrutiny by the scientific community to a paper that gained publicity; (b) additional information provided to some part of the scientific community which would have otherwise remained unaware of the retraction. Although difficult to distinguish, one way to corroborate the information mechanism is to check whether the content of remaining ex-post citations is more "accurate" in presence of media coverage. With the help of Scite.ai, I collected for each retracted paper all yearly citation statements that mentioned the retraction. Citation
statements were searched for the terms "*extract*" or "*withdraw*", manually excluding false positives. I then estimate the following regression model:

\[ E[Y_{it}|X_{it}] = \exp[\alpha + \beta_1 Post_{it} \ast Media_i + \delta_i + \delta_t + f(age_{it}) + \delta_\tau] \]  

where for each retracted paper \( i \) and year relative to retraction \( t \), \( Y \) represents the number of citation statements mentioning the paper is retracted, \( Post \) is an indicator for year strictly after retraction, \( Media \) is an indicator for whether a paper gained some kind of online coverage. Estimates of \( \beta_1 \) capture the differential change in number of citations "correctly" mentioning the retraction (after the shock) in presence of media coverage. Fixed effects are included for each paper \( \delta_i \), each year relative to retraction \( \delta_t \), each year since publication \( f(age_{it}) \) and each calendar year \( \delta_\tau \). Standard errors are clustered at the retraction level.

Table 9 confirms that the number of references correctly mentioning the cited paper is retracted increases significantly in presence of media coverage. This result support the hypothesis that media coverage provides additional information on retractions, hence favouring the belief update of part of the scientific community which would have otherwise remained unaware. One caveat to consider is the small sample of retractions for which an "accurate" yearly-citation is indeed observed (slightly less than 10% of the treated sample).

5.5 Media and likelihood of retraction

In section 3.2 I argued that a challenge one faces when trying to understand the interaction between the retraction process and media coverage, arises from the endogeneity of the latter. To circumvent this issue to some extent and study the relationship between media and likelihood of retraction, I turn to the text analysis of titles of research articles. This in turn allows me to use the presence of specific words to control for papers’ endogenous coverage.

More specifically, I start with the full sample of eventually retracted articles published (and retracted) after 2010 and for each of these articles I add to the sample twenty randomly selected articles that appear in the same journal and year but were

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\footnote{This is consistent with previous work by \cite{schneider2020} which finds that, for the case considered, the retraction is not mentioned in 96\% of direct post-retraction citations.}
never retracted. I then use the titles of these papers as corpus of analysis. After cleaning the text according to Porter (1980) algorithm, Figure 6 shows the most frequent words present in the titles of papers that experience some (Panel A) or no (Panel B) online coverage (in newspapers or blogs) within two weeks from publication. On the one hand, popular papers mention more often words such as "cancer", "patient" and "disease", on the other, articles that did not feature in the media often quote different words such as "model" or "system". In what follow I try using this differences to predict articles coverage.

After building the document-term matrix of words (unigrams and bigrams) that appear in at least 100 titles I randomly split the observations into 90% training and 10% testing subsample. The training sample is used to select words with some predictive power for papers’ media coverage based on lasso selection procedure. The testing sample is then used to compute the out-of-sample performance of the predicted media coverage based on the selection.

The lasso estimates and the set of selected variables (words) depends on the penalty level $\lambda$. I obtained alternative lists of selected words using different procedures that choose the optimal penalty level using: (a) EBIC information criteria; (b) AICC information criteria; (c) K-fold cross-validation and (d) Rigourous (theory-driven) penalty levels. These procedures are then repeated including a full set of subject fixed effects, publication year fixed effects and excluding retracted articles from the sample. This strategy allows me to then estimate the following model:

$$ Retraction_{ijp} = \beta_1 Media_{ijp} + \beta_2 \hat{Media}_{ijp} + \delta_j + \delta_p + \epsilon_{ijp} \quad (3) $$

where for each article $i$ published in year $p$ and journal $j$, $Retraction$ is an indicator for whether the article was retracted, $Media$ is a dummy taking value one if the article gained any online coverage (in either newspapers or blogs) within the first two

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52This selection facilitate a speedy computation without restricting the corpus of titles. Among the 1008 retracted papers in the sample, 44 have less than 20 associated random controls due to the respective scarcity of potential controls found in Scopus.

53$N = 20755$

54The lasso estimation minimizes the mean squared error subject to a penalty on the absolute size of coefficient estimates and where $\lambda$ controls the overall penalty level.

$$ \hat{\beta}_{lasso} = \arg\min \frac{1}{n} \sum_{i=1}^{n} (Media_i - \sum_{j=1}^{p} \beta_j \text{Word}_{ij})^2 + \frac{\lambda}{n} \sum_{j=1}^{p} \psi_j | \beta_j | $$

Due to the nature of the penalty, the lasso sets some coefficients exactly to zero and in doing so removers some predictors from the model.
weeks from publication, while $\delta_j$ and $\delta_p$ absorb journal fixed effects and publication year fixed effects respectively. Estimating the Media impact on the likelihood of a retraction ($\beta_1$) is challenging as it is difficult to exclude that researchers may choose to investigate salient topics that, given their relevance, are scrutinized differently from the scientific community (see for example Serra-Garcia and Gneezy, 2021) leading to different retractions rates, despite the fact that these topics may be of interest to the general public and hence attract media coverage.

The inclusion of $\hat{\text{Media}} = \sum \hat{\beta}_s \text{SelectedWords}_s$ as predicted from the lasso procedure, where SelectedWord represents the number of times a selected n-gram appears in the title of a paper $i$, allows me to control for endogenous topic selection that could otherwise lead to bias.  

Table A.19 shows the correlation between some of the most powerful lasso selected predictors and the Media indicator variable. The n-grams with the largest coefficients provide insights into which articles receive media coverage. For example, the word "climate" appears. Similarly, the n-grams "brain", "graphen", "genom" and "stem" all represent research topics of large interest. Also, some research methodologies seem popular as suggested from the n-gram "meta analysis" and "trial". Accuracy ranges between 60 and 76% across procedures and more parsimonious lasso (and logit lasso) seem to provide better performing selections. The fraction of correctly classified observations reaches up to 86% when a full set of subject and year fixed effects are included and when retracted papers are excluded.

Equation (2) estimates are reported in Table 8 (Panel A) where despite the differences in n-gram selection and predictive accuracy across models, very similar results emerge across all specifications (mirroring results are displayed in Table A.20 for logit estimations and in Table A.21 where lasso procedures are trained within subjects and years and excluding retracted articles). The evidence suggests that articles with higher predicted media coverage are less likely to experience a retraction. The interpretation of this result is twofold. On the one hand, the fact that popular articles are retracted less often seems reassuring and could be due to experienced academics answering salient research questions. On the other, it could indicate that

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55 Summary statistics of main variables and a selection of n-grams are displayed in Table A.18.
56 Accuracy is calculated after estimating the optimal positive cutoff threshold using the Matthews Correlation Coefficient (MCC). In the area of machine learning with binary classification the MCC is the preferred single metric, especially for imbalanced data (Chicco and Jurman, 2020).
57 The most powerfull predictors selected with these alternative strategies remain fairly similar (not shown and available upon request).
58 Notice that predicted coverage is endogenous.
"interesting" research articles may be reviewed with a laxer standard (as suggested in Serra-García and Gneezy, 2021). Under the assumption that predicted media coverage effectively controls for endogenous topic selection, the remaining variation in media coverage is arguably exogenous and therefore allows to estimate the impact of additional attention on the likelihood of being retracted. Estimates show that wider media coverage at publication leads to higher chances of retraction, but the magnitude of this effect remain small. This result justifies selecting controls with early media presence similar to that of their retracted counterpart as allowing the however small selection into treatment of more popular articles would otherwise bias the main results reported in section 5.1. Finally, one could be concerned about the common inclusion of both the media indicator and its text-based prediction due to their positive correlation ($\rho \approx 0.3$). To this respect, Table 8 additionally reports the impact of the two regressors separately (see Panel A column (1-2) and Panel B respectively), the magnitudes of coeficients varies only slightly in this case, ressuring us against a collinearity issue.

5.6 Journal visibility and retraction timing

In the following section I offer one way to circumvent media endogeneity and study the relationship between coverage and timing of retractions. In what follows I argue that non-retracted articles published in the same journal and year as a retracted one, attract online coverage which is arguably exogenous to the retracted article own coverage. Based on this, a good proxy for online visibility of a specific journal and year is the average coverage of all non-retracted papers published in there\footnote{The measure is based on the entire pool of papers published in same year and journal as the retracted ones (and excluding the retracted ones).}

\[
\text{JVisibility}_{jp} = \frac{1}{n} \sum_{k \neq i} \text{Altscore}_{kjp} 
\]

where $k$ are non-retracted papers published in same journal $j$ year $p$ as the retracted paper $i$. Alternatively I use the average share of $k \neq i$ published in $j$ and $p$ with some media mentions. Hence, I can study the following relationship using an OLS regression in a cross-sectional context:

\[
Y_{ijp} = \beta \text{JVisibility}_{jp} + \delta_p + \nu X_{ijp} + \epsilon_{ijp} 
\]
where for each retracted paper $i$ published in $j$ in year $p$, $Y$ represents either one of the dependent variables: Time to retract = $(Retraction\ date - Publication\ date) \times \frac{12}{365}$ or $DiD = [E(cit^T) - E(cit^C)] - [E(cit^T_0) - E(cit^C_0)]$ the individual loss in citations obtained comparing each retracted paper to its selected controls for different pre- and post- time windows (see Section 5.2.5 for results on loss in citations). In addition, $\delta_p$ indicate publication year fixed effects, while $X_{ijp}$ control for $N_{jp\neq i}$ number of non-retracted papers in same journal-year as retrieved from Scopus, $\frac{1}{n} \sum_{k\neq i} ED_{kjp}$ their average Euclidean distance in citation from the retracted one, and $\sum_{p\leq t<r} cit_{ijpt}$ cumulative citation of $i$ before retraction year $r$. Standard errors are clustered at the journal level.

Figure 7 shows that papers are retracted faster when published in journals where the average article attracts higher online coverage. Table A.22 (column (1)) illustrates that one standard deviation increase in journal visibility (measured as the average Altscore of non-retracted articles in a journal-year) reduces time to retraction by approximately 15% of its average. Looking across the remaining columns, the relationship is robust to different measures of visibility. The negative association between journal visibility and retraction timing could be driven by higher scrutiny from the scientific community for salient research, together with better detection technologies for visible outlets.

6 Author-level analysis

Previous sections have shown how media coverage impacts the scientific recognition of retracted papers (i.e. citations) as well as the chances and pace of discovery of faulted research. I now turn to investigate the potential impact of online attention on the subsequent research output of the authors of retracted papers. Low authors output after retraction may reflect a combination of factors: (a) erosion of trust in the authors’ work by the scientific community, (b) loss of individual resources for research, or (c) any other direct consequence in terms of academic employment. Studying retracted authors’ output is important to measure the individual overall cost of "bad science" and allows to discern the potential role of media on authors’ future careers.
6.1 Selected sample

Using the same selection of papers illustrated in Section 3.3 and 3.4, I search all authors of retracted and control papers available in the Scopus library, the retrieved list contains $N_a = 17,991$ distinct authors with any prior publication. For each of these authors, I retrieve their (non-retracted) publications and their corresponding yearly citations and I compute individual output measures focusing on a window of 5 years around the retraction.

Before proceeding to the analysis, I select my sample as follows. First, I observe that some retracted authors appear multiple times, therefore I retain only observations relative to their first (in-sample) retraction. Second, I keep cases for which I observe at least one retracted and one control author. Finally, when available, I retain a maximum of three authors per paper (first, mid and last) which provide a final sample of $N_a = 6,718$ authors of which $N_{a,r} = 2,047$ retracted authors, $N_{a,c} = 4,671$ control authors, corresponding to $N_r = 874$ undelining retractions.

In this analysis I intend to study heterogeneous effects by ranking of appearance in the authorship list, by seniority (based on H-index prior retraction), and by severity of misconduct. Table 2 and 3 therefore provide all relative sub-sample sizes.

6.2 Summary statistics

To measure authors’ research output I look at: (a) the number of papers published per author per year, (b) the number of papers published per author per year mentioning any source of funding, and (c) the average number of authors across all papers published within the same year. The first is a measure of output productivity, the second is an imperfect measure of access to funding, while the last is an indicator for individual collaboration practices. Despite being imperfect, these measures allow to assess, in a within author analysis, for the presence of career effects of retractions due to media exposure.

Table 4 illustrates the average outputs for this selected sample of academics. In general, authors publish 5.5 papers per year, of which 2.8 with some declared funding support and with 5.8 authors per paper. First authors seem relatively more junior

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$N_{a,r} = 4,105$ retracted authors and $N_{a,c} = 13,886$ control authors, corresponding to the original sample of retractions $N_r = 900$.

61 Reducing the underlining sample of retractions, $N_r = 987$.

$N_a = 17,148$, of which $N_{a,r} = 4,077$ and $N_{a,c} = 13,071$ corresponding to $N_r = 874$.

63 Note these three categories are mutually exclusive and single authors are considered as first authors.
while last authors are generally more senior (with 3.3 vs. 8.3 publications per year). In medical research, last authors are usually senior researchers with stable careers, whereas first and middle authors can be transient authors who may not pursue a scientific career. Large differences also emerge when comparing authors with high and low (ex-ante) H-index. The formers indeed publish more papers (8.3 vs 2 per year) and with a larger set of authors (7 vs. 4 per paper). Output measures of authors associated to different causes of misconduct are generally balanced. Finally, Table A.2 compares average outputs across all authors whose original publication gained initial online attention (or not). Across all categories, authors of newsworthy research have higher publication rates, higher funding support and a larger set of coauthors.

6.3 Estimating Specification

This section investigates whether media coverage influences authors’ careers after the reputational shock of a retraction. The worsening of authors’ output may reflect a combination of destruction in access to resources for research as well as an erosion of trust in authors’ work by the scientific community. To study this I employ a difference-in-differences strategy that compares output measures of retracted authors to that of control authors of similar never retracted studies before and after their first observed retraction. Crucially, I further contrast authors whose original publication obtained any media exposure at publication (i.e. early mentions > 0) to those who did not.

Therefore, the regression model is the following:

\[
E[Y_{ait} \mid X_{ait}] = \exp[\alpha + \gamma_1 Post_{ait} + \beta_2 R_{ait} * Post_{ait} + \beta_3 Post_{ait} * Media_{ai} + \beta_4 R_{ai} * Post_{ait} * Media_{ai} + \delta_a + f(CareerLength_{ai}) + \delta_t] \tag{6}
\]

where \(a\) are authors of treatment (or control) paper \(i\) of case-level group \(\gamma\) in the years \(t\) relative to the retraction. The dependent variable \(Y\) is either one of the measures of author outputs: (a) the number of publications in each year, (b) the number yearly publications with grant support, and (c) the average number of authors across all publications of each year. \(R\) is an indicator for retracted authors, \(Post\) is an indicator variable equal to one for all years after retraction, and \(Media\) captures the

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64 See Section 3.4 for details on the selection of control papers.

65 See details on sample selection in Section 6.1.

66 Notice that a group is composed by all authors of a retracted paper and its paired control papers.
exposure of the original (retracted or control) paper to online coverage at the time of publication. Specifically, the indicator is equal to one if the paper received at least one online mention within two weeks from publication in either newspapers or blogs and zero otherwise (i.e. $1[\text{Early Mentions} > 0]$). Notice that early mentions are assumed to broadly advertise the original research findings and are generally balanced across treatment and control papers. The coefficient $\beta_2$ captures the effect of a retraction shock on retracted authors careers as compared to control authors. The coefficient $\beta_4$ captures any difference in the effect of the shock for authors whose papers received online attention. Fixed effects are included for each author $\delta_a$ and each calendar year $\delta_t$ while $f(\text{CareerLenght}_{at})$ represents a full set of dummies for years since the author first publication (ever observed in the Scopus library) and is meant to flexibly control for the academic experience of authors. To look at the dynamics of the differential effect of Media, estimates will be presented splitting the sub-samples of authors exposed or not to media and replacing the $\text{Post}$ indicator with a full set of dummies for each year relative to the year of retraction. Given the skewed nature of the dependent variables (e.g. almost 20% of yearly observations see 0 published papers), I use a pseudo Poisson regression model developed by Correia et al. (2020) where consistency is achieved under the only assumption that the conditional mean of the dependent variable is correctly specified (Gourieroux et al., 1984). Finally, standard errors are clustered at the case level.

6.4 Results

Author-level estimates are presented in Table 10. On average, authors’ future outputs are negatively impacted by a retraction (about 8.6% loss in forward yearly publications and number of collaborators, corresponding to about half publication per year and half author per paper per year) and more so for senior authors and severe cases of misconduct. Media exposure adds a further loss in output which is never significant.

Looking more closely into sub-groups, estimates suggests that authors appearing first in the co-authorship list are the ones whose productivity is differentially and sig-

67 Note that the interaction term $R \times Media$ is absorbed by author fixed effect.

68 $E[Y_{aigt} | X_{aigt}] = \exp[\sum_{r=-5}^{5} \gamma_{11} \ast d_t + \sum_{r=-5}^{5} \gamma_{11} \ast d_t \ast R_{ai} + \sum_{r=-5}^{5} \beta_{21} \ast d_t \ast R_{ai} + \sum_{r=-5}^{5} \beta_{31} \ast d_t \ast Media_{ai} + \sum_{r=-5}^{5} \beta_{41} \ast d_t \ast R_{ai} \ast Media_{ai} + \sum_{r=-5}^{5} \beta_{41} \ast d_t \ast R_{ai} \ast Media_{ai} + \delta_t + f(\text{age}_{aigt}) + \delta_i]$ separately for the subsample of original papers with $Media = 1$ (or $Media = 0$).

69 http://scorreia.com/software/ppmlhde/
nificantly impacted by media (≃45% loss in yearly publications and grant supported publications, corresponding to 1.5 less papers published per year, half of which with grant support.). Senior authors and severe cases of misconduct also display a further loss with media which is never significant. This could explain previous findings by Mongeon and Larivière (2016) that first authors are most punished after retractions.70

However studying the dynamics of this effect, Figure 8 (together with Figures A.14 and A.18) shows that the negative impact of retraction is large and permanent only if the original publication had some media exposure (≃10% larger reduction in future publication rate relative to a case with no media). Absent media coverage author outputs are only moderately impacted and fully recover by the end of the 5 year window. The differential impact corresponds to 1 less publication per year for authors with media exposure, against half publication less per year, compared to their respective averages. This differential effect of media is evident for first authors (see Figures A.11, A.15, A.19), for authors with high ex-ante H-index (see Figures A.12, A.16, A.20) and authors whose paper was retracted for severe misconduct (see A.13, A.17, A.21). These figures are all based on split regressions illustrated in Table A.27.

7 Conclusion

Flawed research can be harmful both within and outside of academia. The literature document that scientific publications lose significant citations after a retraction. Worriingly though, studies also show that retracted publications still get cited long after they are removed from the literature, potentially disseminating misinformation. In the context of scientific retractions, their visibility is a crucial factor, yet there is little evidence on how media reporting may influence the retraction process and authors’ careers. This paper shows that media coverage shapes the auto-correcting process of science by reducing the amount of misinformation and increasing punishment for retracted authors.

I use a conditional difference-in-differences strategy to show that articles that gained popularity in the media — at the time of publication — face heavy citation losses after their retraction while remaining citations become more accurate in acknowledging the retraction. This differential effect is considerable for cases of se-

70Excluding few single authors cases does not change the results (not shown).
vere misconduct, and it is present only for publications in hard sciences, suggesting distinct publication practices or different topic salience may impact the visibility of a retraction. In addition, retracted authors’ future productivity is permanently reduced, but only with media coverage (specifically for first authors). I also produce evidence that media can influence the likelihood of retraction and its timing.

Overall, the media seems to help the auto-correcting process of science. At the same time, this implies that plenty of wrong science goes unnoticed. The scientific community, thus, needs better strategies to increase the risk of scrutiny and lower incentives for bad science. For example, journals could increase transparency at submission and systematically check references of newly accepted papers before publication. This research also proves that media platforms can be a useful communication tool, as in the case of RetractionWatch and, more recently, the Twitter bot from Scite.ai.

Yet, the scientific information that appears in the media spreads beyond the scientific community. Indeed, while media helps scientists to update beliefs about the credibility of a study and its authors, one question remains about whether this could generate unintended consequences for the main audience of mainstream media: the general public. I show that newspapers, as opposed to blogs, are more likely to advertise the publication of a paper rather than inform about its later retraction. This possible misinformation can impact public perceptions and behaviour, therefore, deserves further research.

References


71 See: https://twitter.com/sciterefcheck


S. J. Woo and J. P. Walsh. On the Shoulders of Fallen Giants What do references to retracted research
tell us about citation behaviors? 2021.


Figures

Figure 1: Retractions over time and across subjects.

Note: Numbers reflect the full RetractionWatch database as of July 2020, for visual purposes one outlier publisher (e.g. IEEE) was excluded.
Figure 2: Media coverage of sample of retracted papers.

Panel A: N. of retractions with media

Panel B: Sh. of retractions with media

Panel C: Sh. of retractions with early mentions

Note: Panel A shows the absolute number of retracted articles in the sample (green) which ever featured in blogs (orange), newspapers (blue), or social media (red), ordered by the year when the retraction occurred. Panel B shows the share of retracted papers that ever appeared in blogs (green), newspapers (orange), or social media (blue), again ordered by year of retraction. Panel C represents the share of retracted articles that were ever mentioned in blogs (green), newspapers (orange) or at least one of the two (blue) within two weeks from publication (i.e. *early mentions*), ordered by year of publication.
Figure 3: Newspaper and blog mentions of retracted articles.

Panel A: News mentions (N=135 retractions)

Panel B: Blog mentions (N=365 retractions)

Note: Each line connects the first to the last mention of a single research article on either newspapers (Panel A) or blogs (Panel B) within the considered time window. Dots represent the number of mentions at a certain point in time. The window of analysis focuses on two events: the paper publication date (indexed with 0) and the paper retraction date (indexed with 100). The time score is allocated following the formula \( \frac{(t_{\text{mention}} - t_{\text{publication}})}{(t_{\text{publication}} - t_{\text{retraction}})} \times 100 \). The sources of publication date and retraction date are Altmetric and RetractionWatch respectively.
Figure 4: Dynamics of retracted papers penalty with media coverage

Panel A: Early news mention

Panel B: Any news mention

Panel C: Any blog mention

Panel D: Any social media mention

Note: Estimates replicate the following models: Table 5 column (3) for Panel A; Table A.4 column (3)-(4)-(1) respectively for Panel B, Panel C and Panel D. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction \((t - 1)\) excluded. The coefficients displayed are that of the interaction between time dummies, a treatment indicator and a media indicator while vertical lines represent 95% CI.
Figure 5: Dynamics of retracted papers penalty with media coverage by discipline

Panel A: Hard sciences with visibility
Panel B: Social sciences with visibility
Panel C: Hard sciences with Altscore >p50
Panel D: Social sciences with Altscore >p50

Note: Hard sciences: life sciences, environment, health and physical sciences. Social sciences: business and technology, humanities, other social sciences. Estimates replicate the following models: Table 6 column (3)-(4) for Panel A and Panel B; Table A.15 column (3)-(4) respectively for Panel C and Panel D. Models are estimated replacing the $Post$ indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). The coefficients displayed are that of the interaction between time dummies, a treatment indicator and a media indicator, for different subsamples of discipline, while vertical lines represent 95% CI.
Figure 6: Papers’ titles wordclouds

Panel A: Titles with media (N=1961)  
Panel B: Titles without media (N=18794)

Figure 7: Months to retraction and Journal-year average visibility

Panel A: Raw data  
Panel B: Absorb Controls + FE

Note: The vertical axis represents the time intercurring between an article publication and its retraction, expressed in months. The orixontal axis represents the inverse hyperbolic sine transformation of journal visibility, measured as the average Altscore of non-retracted papers that appear in the same journal and year of the retracted one. Controls include the number of non-retracted articles within same journal and year of the treated, the average Euclidean distance of those from the retracted paper, and the level of (non-self) cumulative citations of the retracted paper before retraction. Publication year fixed effects are included. * p<0.1, ** p<0.05, *** p<0.01.
Figure 8: Dynamics of Author "productivity" with media coverage

Panel A: With Media
Panel B: Without Media

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27 Panel A column (1) and (9) respectively. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). Vertical lines represent 95% CI.
## Tables

Table 1: Selected summary statistics

<table>
<thead>
<tr>
<th>BALANCING VARIABLES</th>
<th>TREATMENT (N=990)</th>
<th>CONTROL papers (N=1969)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euclidean distance</td>
<td>0.937</td>
<td>0.171</td>
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<tr>
<td>Arithmetic distance</td>
<td>2.661</td>
<td>1.699</td>
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<td>Cum. (no self) citations (t - 1)</td>
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<td>6.807</td>
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<td>Early news mentions</td>
<td>1.037</td>
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<tr>
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<td>Age</td>
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</table>

<table>
<thead>
<tr>
<th>ADDITIONAL VARIABLES</th>
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<th>CONTROL papers (N=1969)</th>
</tr>
</thead>
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<td>2.067</td>
<td>0.529</td>
</tr>
<tr>
<td>Yearly citations (no self)</td>
<td>2.628</td>
<td>12.27</td>
</tr>
<tr>
<td>Cum. (no self) citations</td>
<td>16.83</td>
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<td>AltScore</td>
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<tr>
<td>Tweeters count</td>
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<td>Blog count</td>
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<td>Any early mentions</td>
<td>0.111</td>
<td>0.0945</td>
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Note: Self-citations are excluded from citation count. *Early mentions* include all news and/or blog posts published within 2 weeks from publication. *AltScore* is a weighted average of all online mentions across outlets. Media *counts* are the number of outlets/accounts referring to a paper at any point in time. All papers are published/retracted between 2011 and 2020.
Table 2: Author level sample size

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<th></th>
<th>First author</th>
<th>Mid author</th>
<th>Last author</th>
<th>H-index &gt;p50</th>
<th>H-index &lt;=p50</th>
<th>Media</th>
<th>Not media</th>
<th>Severe misconduct</th>
<th>Non-Severe misconduct</th>
<th>Total</th>
</tr>
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<tr>
<td>Treatment</td>
<td>708 (35%)</td>
<td>650 (32%)</td>
<td>689 (34%)</td>
<td>922 (45%)</td>
<td>1125 (55%)</td>
<td>265 (13%)</td>
<td>1782 (87%)</td>
<td>851 (42%)</td>
<td>1196 (58%)</td>
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<td>Control</td>
<td>1639 (35%)</td>
<td>1437 (31%)</td>
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<td>2259 (48%)</td>
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<td>3334</td>
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Table 3: Author level sub-sample size

Panel A: With (early) media

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<th>Mid author</th>
<th>Last author</th>
<th>H-index &gt;p50</th>
<th>H-index &lt;=p50</th>
<th>Severe misconduct</th>
<th>Non-Severe misconduct</th>
<th>Sub total</th>
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<td>86 (32%)</td>
<td>154 (58%)</td>
<td>111 (42%)</td>
<td>138 (52%)</td>
<td>127 (48%)</td>
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<td>172 (34%)</td>
<td>161 (32%)</td>
<td>167 (33%)</td>
<td>300 (60%)</td>
<td>200 (40%)</td>
<td>279 (56%)</td>
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<td>253</td>
<td>454</td>
<td>311</td>
<td>417</td>
<td>348</td>
<td>765</td>
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Panel B: Without (early) media

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<th>H-index &gt;p50</th>
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<th>Non-Severe misconduct</th>
<th>Sub total</th>
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<tr>
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<td>568 (32%)</td>
<td>603 (34%)</td>
<td>768 (43%)</td>
<td>1014 (57%)</td>
<td>713 (40%)</td>
<td>1069 (60%)</td>
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<td>Control</td>
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<td>Panel E: H-index above median</td>
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<tr>
<td>N of coauthors</td>
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<td>4.320</td>
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<tr>
<td>Panel G: Severe cases of misconduct</td>
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<tr>
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<td>Panel H: Non-severe cases of misconduct</td>
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</table>

Note: All statistics are reported by year. N of articles are yearly publications per author. N of articles with grant are yearly publications per author that mention any source of funding. N of coauthors is the average number of authors across papers published by an author within a year.
Table 5: Retracted papers penalty with early mentions

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<tr>
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<tbody>
<tr>
<td>Post * Treatment</td>
<td>-0.959***</td>
<td>-0.983***</td>
<td>-0.977***</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.058)</td>
<td>(0.058)</td>
</tr>
<tr>
<td>Post * Treatment * Early mentions</td>
<td>-0.449***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.158)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Early blog mentions</td>
<td></td>
<td>-0.396**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.185)</td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Early news mentions</td>
<td></td>
<td></td>
<td>-0.418***</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>(0.149)</td>
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<table>
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<td>Y</td>
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<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Pseudo R2</td>
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<td>0.709</td>
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<td>N</td>
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<td>15438</td>
<td>15438</td>
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<tr>
<td>N clusters</td>
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<td>966</td>
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<tr>
<td>N full</td>
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Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \( (1 - \exp[\beta]) \times 100 = x \) coefficients can be interpreted as elasticities (i.e. \( x\% \) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *\( p < 0.10 \), **\( p < 0.05 \), ***\( p < 0.01 \).
Table 6: Retracted papers penalty and early mentions by discipline

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<td>Citations</td>
<td>Citations</td>
<td>Citations</td>
</tr>
<tr>
<td>Post * Treatment * Early mentions</td>
<td>0.592</td>
<td>0.364</td>
<td>-0.520***</td>
<td>0.366</td>
</tr>
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<td>Post * Treatment * Early mentions * Business/Technology</td>
<td>-0.155</td>
<td>(0.396)</td>
<td>(0.262)</td>
<td>(0.163)</td>
</tr>
<tr>
<td>Post * Treatment * Early mentions * Life sciences</td>
<td>-1.169**</td>
<td>(0.522)</td>
<td>(0.457)</td>
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</tr>
<tr>
<td>Post * Treatment * Early mentions * Environment</td>
<td>-0.917**</td>
<td>(0.458)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Early mentions * Health</td>
<td>-1.195**</td>
<td>(0.529)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Early mentions * Physics</td>
<td>-0.938**</td>
<td>(0.455)</td>
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<tr>
<td>Post * Treatment * Early mentions * Hard sciences</td>
<td>-0.887***</td>
<td>(0.309)</td>
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</table>

Note: Estimates derive from pseudo Poisson specifications. Hard sciences: life sciences, environment, health and physical sciences. Social sciences: business and technology, humanities, other social sciences. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \( (1 - e^{\beta}) \times 100 = x \) coefficients can be interpreted as elasticities (i.e. \( x\% \) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
### Table 7: Retracted papers penalty and early mentions by severity of misconduct

<table>
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<tr>
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<th>Minor Citations</th>
<th>Moderate Citations</th>
<th>Severe Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post * Treatment * Early mentions</td>
<td>-0.158</td>
<td>-0.142</td>
<td>0.096</td>
<td>-0.566***</td>
</tr>
<tr>
<td></td>
<td>(0.335)</td>
<td>(0.360)</td>
<td>(0.196)</td>
<td>(0.193)</td>
</tr>
<tr>
<td>P * T * Early mentions * Moderate misconduct</td>
<td>0.239</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.389)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P * T * Early mentions * Severe misconduct</td>
<td>-0.418</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.389)</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Article, Age &amp; Year FE</th>
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<th>Y</th>
<th>Y</th>
<th>Y</th>
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</thead>
<tbody>
<tr>
<td>Pseudo R2</td>
<td>0.710</td>
<td>0.593</td>
<td>0.694</td>
<td>0.739</td>
</tr>
<tr>
<td>N (N clusters)</td>
<td>15438 (966)</td>
<td>4312 (295)</td>
<td>3857 (256)</td>
<td>7269 (415)</td>
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<tr>
<td>N full</td>
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<td>4859</td>
<td>4157</td>
<td>7695</td>
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</table>

Note: Estimates derive from pseudo Poisson specifications. Causes of retractions are classified based on [Woo and Walsh (2021)](Woo2021). The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \( (1 - \exp(\beta)) \times 100 = x \) coefficients can be interpreted as elasticities (i.e. \( x\% \) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.

### Table 8: Likelihood of retraction and media coverage

#### Panel A: Retraction

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<tr>
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<th>OLS</th>
<th>EBIC</th>
<th>AICC</th>
<th>CV</th>
<th>Rigorous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media coverage</td>
<td>0.009** (0.004)</td>
<td>0.019*** (0.007)</td>
<td>0.014*** (0.005)</td>
<td>0.021*** (0.007)</td>
<td>0.016*** (0.005)</td>
</tr>
<tr>
<td>Predicted media</td>
<td>-0.075*** (0.025)</td>
<td>-0.074*** (0.028)</td>
<td>-0.067*** (0.017)</td>
<td>-0.068*** (0.022)</td>
<td>-0.135*** (0.043)</td>
</tr>
<tr>
<td>Predicted media</td>
<td>-0.059*** (0.022)</td>
<td>-0.065*** (0.026)</td>
<td>-0.048*** (0.015)</td>
<td>-0.060*** (0.021)</td>
<td>-0.048*** (0.015)</td>
</tr>
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</table>

#### Panel B: Retraction

<table>
<thead>
<tr>
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<th>EBIC</th>
<th>AICC</th>
<th>CV</th>
<th>Rigorous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted media</td>
<td>-0.059*** (0.022)</td>
<td>-0.065*** (0.026)</td>
<td>-0.048*** (0.015)</td>
<td>-0.060*** (0.021)</td>
</tr>
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<td>Pub. year FE</td>
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<td>Y</td>
<td>Y</td>
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<td>Y</td>
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<tr>
<td>N clusters</td>
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<td>1008</td>
<td>1008</td>
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</tbody>
</table>

Note: Estimates from OLS regression. The dependent variable Retraction is an indicator for whether a paper was retracted. Media coverage is an indicator for whether a paper attracted online coverage at publication. Predicted media is predicted from the respective lasso procedures. Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table 9: Citation statements mentioning paper is retracted

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<tr>
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<td></td>
<td>(0.457)</td>
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</tr>
<tr>
<td>Post * Altscore &gt;p50</td>
<td></td>
<td>1.562**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.670)</td>
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</tr>
<tr>
<td>Post * Altscore 3rd quintile</td>
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<td>-0.101</td>
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<td></td>
<td></td>
<td></td>
<td>(1.344)</td>
</tr>
<tr>
<td>Post * Altscore 4th quintile</td>
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<td>1.137</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(1.223)</td>
</tr>
<tr>
<td>Post * Altscore 5th quintile</td>
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<td>2.305**</td>
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<td></td>
<td>(1.155)</td>
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</tbody>
</table>

| Article FE | Y | Y | Y |
| Age FE | Y | Y | Y |
| Year FE | Y | Y | Y |
| Relative yr FE | Y | Y | Y |
| Pseudo R2 | 0.361 | 0.341 | 0.355 |
| N | 531 | 531 | 531 |
| N clusters | 95 | 95 | 95 |
| N full | 5591 | 5591 | 5591 |

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations statements received by each paper in a particular year which explicitly mention the retraction. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects, article age indicator variables and dummies for each year relative to the retraction. Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table 10: Impact on authors’ careers (interaction)

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<th>(4)</th>
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<td>Last</td>
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<td>Non-Severe misconduct</td>
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<td>-0.090</td>
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<td>(0.051)</td>
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</tr>
</tbody>
</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variables are: N. published articles x author x year; N. published articles with grant support x author x year; or Avg. n collaborators across all author’s publications x year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Media is an indicator for cases where the original publication (either retracted or control papers) had at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate author fixed effects, a full suite of calendar-year effects and career length indicator variables. Using the following transformation \((1 - \exp(\beta)) \times 100 = x\) coefficients can be interpreted as elasticities (e.g. \(x\)% loss in publication rate). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Appendix

Figures

Figure A.1: Control quality: citations

Panel A: AD

Panel B: ED

Panel C: Cum. citations

Note: All panels refer to pre-retraction measures. The year of retraction in that of the corresponding treated paper. Panel A shows the distribution of arithmetic distance (AD), panel B shows the distribution of Euclidean distance (ED), and panel C shows the distribution of cumulative citations from publication to the year before retraction and display the result of the Kolmogorov-Smirnov test of the equality of distributions between treatment and control group.
Figure A.2: Control quality: early mentions

Panel A: Newspaper early mentions

Panel B: Blog early mentions

Note: Panels display the distribution of online mentions within two weeks from publication in newspapers (panel A) and blogs (panel B) across treated (green) and control (orange) papers. Both graphs report the result of the Kolmogorov-Smirnov test of the equality of distributions across groups.

Figure A.3: Control quality: early mentions (Mentions > 0)

Panel A: Newspaper early mentions

Panel B: Blog early mentions

Note: Panels display the distribution of online mentions within two weeks from publication in newspapers (panel A) and blogs (panel B) across treated (green) and control (orange) papers. Publications with no mentions are excluded. Both graphs report the result of the Kolmogorov-Smirnov test of the equality of distributions across groups.
Figure A.4: Newspaper and blog mentions of selected control articles.

Panel A: News mentions (N=235 controls)

Panel B: Blog mentions (N=216 controls)

Note: Each line connects the first to the last mention of a single research article on either newspapers (Panel A) or blogs (Panel B) within the considered time window. Dots represent the number of mentions at a certain point in time. The source of publication date is Altmetric.
Figure A.5: Newspaper and blog mentions of retracted articles (excluding Retraction Watch from blogs)

Panel A: News mentions (N=135)  
Panel B: Blog mentions (N=171)

Note: Each line connects the first to the last mention of a single research article on either newspapers (Panel A) or blogs (Panel B) within the considered time window. Dots represent the number of mentions at a certain point in time. Blog mention from Retraction Watch are excluded. Source of publication date and retraction date: Altmetric and RetractionWatch respectively.
Figure A.6: US News media coverage of retracted papers by slant (within sample median).

Panel A: Left news mentions (N=45)
Panel B: Right news mentions (N=31)

Note: Each line connects the first to the last mention of a single research article on left leaning newspapers (Panel A) or right leaning (Panel B) within the considered time window. Right (left) leaning newspapers have a slam index (GS10) above median. The sample includes retractions in lower ranked journals. Dots represent the number of mentions at a certain point in time. Source of publication date and retraction date: Altmetric and RetractionWatch respectively.
Figure A.7: US News media coverage of retracted papers by slant (within sample median and balanced sample).

Panel A: Left news mentions (N=23)
Panel B: Right news mentions (N=23)

Note: Each line connects the first to the last mention of a single research article on left leaning newspapers (Panel A) or right leaning (Panel B) within the considered time window. Right (left) leaning newspapers have a slam index (GS10) above median. The sample includes retractions in lower ranked journals. Dots represent the number of mentions at a certain point in time. Source of publication date and retraction date: Altmetric and RetractionWatch respectively.
Figure A.8: US News media coverage of retracted papers by slant (GS10 median).

Panel A: Left news mentions (N=48)
Panel B: Right news mentions (N=24)

Note: Each line connects the first to the last mention of a single research article on left leaning newspapers (Panel A) or right leaning (Panel B) within the considered time window. Right (left) leaning newspapers have a slam index (GS10) above median. The sample includes retractions in lower ranked journals. Dots represent the number of mentions at a certain point in time. Source of publication date and retraction date: Altmetric and RetractionWatch respectively.
Figure A.9: US News media coverage of retracted papers by slant (GS10 median and balanced sample).

Panel A: Left news mentions (N=19)  
Panel B: Right news mentions (N=19)

Note: Each line connects the first to the last mention of a single research article on left leaning newspapers (Panel A) or right leaning (Panel B) within the considered time window. Right (left) leaning newspapers have a slam index (GS10) above median. The sample includes retractions in lower ranked journals. Dots represent the number of mentions at a certain point in time. Source of publication date and retraction date: Altmetric and RetractionWatch respectively.
Figure A.10: Dynamics of retracted papers penalty

Note: Estimates replicate the model in Table A.3 column (2) but replacing the $Post$ indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). The coefficient displayed are that of the interaction between time dummies and a treatment indicator while the vertical lines represent 95% CI.
Figure A.11: Author "productivity" by rank (with and without media)

Panel A: First author
Panel B: Mid author
Panel C: Last author
Panel D: First author
Panel E: Mid author
Panel F: Last author

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). Vertical lines represent 95% CI.
Figure A.12: Author "productivity" by seniority (with and without media)

Panel A: H-index > median  
Panel B: H-index ≤ median  
Panel C: H-index > median  
Panel D: H-index ≤ median

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction (t – 1 excluded). Vertical lines represent 95% CI.
Figure A.13: Author "productivity" by cause of retraction (with and without media)

Panel A: Severe misconduct
Panel B: Non-severe misconduct

Panel C: Severe misconduct
Panel D: Non-severe misconduct

With Media
Without Media

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). Vertical lines represent 95% CI.

Figure A.14: Author grant supported "productivity" (with and without media)

Panel A: With Media
Panel B: Without Media

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). Vertical lines represent 95% CI.
Figure A.15: Author grant supported "productivity" by rank (with and without media)

Panel A: First author  
Panel B: Mid author  
Panel C: Last author

Panel D: First author  
Panel E: Mid author  
Panel F: Last author

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction (t − 1 excluded). Vertical lines represent 95% CI.
Figure A.16: Author grant supported "productivity" by seniority (with and without media)

With Media
Panel A: H-index > median
Panel B: H-index ≤ median

Without Media
Panel C: H-index > median
Panel D: H-index ≤ median

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). Vertical lines represent 95% CI.
Figure A.17: Author grant supported "productivity" by cause of retraction (with and without media)

With Media

Panel A: Severe misconduct

Panel B: Non-severe misconduct

Without Media

Panel C: Severe misconduct

Panel D: Non-severe misconduct

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t-1$ excluded). Vertical lines represent 95% CI.

Figure A.18: Author n. of coauthors (with and without media)

Panel A: With Media

Panel B: Without Media

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t-1$ excluded). Vertical lines represent 95% CI.
Figure A.19: Author n. of coauthors by rank (with and without media)

Panel A: First author
Panel D: First author

Panel B: Mid author
Panel E: Mid author

Panel C: Last author
Panel F: Last author

With Media
Without Media

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). Vertical lines represent 95% CI.
Figure A.20: Author n. of coauthors by seniority (with and without media)

Panel A: H-index > median
Panel B: H-index ≤ median
Panel C: H-index > median
Panel D: H-index ≤ median

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction (t – 1 excluded). Vertical lines represent 95% CI.
Figure A.21: Author n. of coauthors by cause of retraction (with and without media)

Panel A: Severe misconduct
Panel B: Non-severe misconduct
Panel C: Severe misconduct
Panel D: Non-severe misconduct

Note: Estimates compare publication rate for authors of retracted papers vs those of control papers before/after their first (in sample) retraction. Estimates replicate the models from Table A.27. Models are estimated replacing the Post indicator with a full set of dummies for each year relative to the retraction ($t - 1$ excluded). Vertical lines represent 95% CI.
Figure A.22: Loss in citation and Controls average mentions

Panel A: Raw data

Panel B: Absorb Controls + FE

Note: The vertical axis represents the individual loss in citations obtained comparing each retracted paper to its selected controls for different pre- and post- time windows. The time window around retraction become larger moving left to right. The orixontal axis represents the inverse hyperbolic sine transformation of journal visibility, measured as the average Altmetric score of non-retracted papers that appear in the same journal and year of the retracted one. Controls include the number of non-retracted articles within same journal and year of the treated, the average Euclidean distance of those from the retracted paper, and the level of (non-self) cumulative citations of the retracted paper before retraction. Publication year fixed effects are included.
## Tables

Table A.1: Altmetric weights

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<td>Blog</td>
<td>5</td>
</tr>
<tr>
<td>Policy document (per source)</td>
<td>3</td>
</tr>
<tr>
<td>Patent</td>
<td>3</td>
</tr>
<tr>
<td>Wikipedia</td>
<td>3</td>
</tr>
<tr>
<td>Twitter (tweets and retweets)</td>
<td>1</td>
</tr>
<tr>
<td>Peer review (Publons, Pubpeer)</td>
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<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>F1000</td>
<td>1</td>
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<tr>
<td>Syllabi (Open Syllabus)</td>
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<td>LinkedIn (not trackable since 2014, but historical data kept)</td>
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<tr>
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<tr>
<td></td>
<td>Media</td>
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<td>-------------</td>
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Panel B: First author

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Panel C: Mid author

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Panel D: Last author

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Panel E: H-index above median

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Panel F: H-index below median

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<td>N articles with grant</td>
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Panel G: Severe cases of misconduct

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<tr>
<td>N articles</td>
<td>3,496</td>
<td>5.711</td>
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Panel H: Severe cases of misconduct

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Note: All statistics are reported by year. N of articles are yearly publications per author. N of articles with grant are yearly publications per author that mention any source of funding. N of coauthors is the average number of authors across papers published by an author within a year.
### Table A.3: Retracted papers penalty

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<th>Poisson Citations</th>
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<td>0.115***</td>
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<td></td>
<td>(0.024)</td>
<td>(0.025)</td>
<td>(0.025)</td>
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</tr>
<tr>
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<td>16711</td>
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Note: First two columns show estimates of pseudo Poisson specifications while third column shows OLS estimation with IHS transformed dependent variable. The dependent variable is the total number of citations (exclusive of self-citations) received by each article in a particular year. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp(\beta)) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *\(p < 0.10\), **\(p < 0.05\), ***\(p < 0.01\).

### Table A.4: Retracted papers penalty with any media coverage

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<th>(3) Citations</th>
<th>(4) Citations</th>
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</thead>
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<td>-0.831***</td>
<td>-0.798***</td>
<td>-0.944***</td>
<td>-0.840***</td>
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<tr>
<td></td>
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<td>(0.072)</td>
<td>(0.059)</td>
<td>(0.077)</td>
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<td><strong>Post * Treatment * Any social media</strong></td>
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<td></td>
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<td></td>
<td>(0.119)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post * Treatment * Any news-blog</strong></td>
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<td>-0.434***</td>
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<tr>
<td></td>
<td></td>
<td>(0.119)</td>
<td></td>
<td></td>
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<td></td>
<td>-0.377***</td>
<td></td>
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<td></td>
<td></td>
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<td>(0.127)</td>
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<td><strong>Post * Treatment * Any blog</strong></td>
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<td>Year FE</td>
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<td>Y</td>
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<tr>
<td>Pseudo R2</td>
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<td>N</td>
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Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Any socialmedia/news/blog is an indicator for papers with at least one overall mention in any of the indicated outlets. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp(\beta)) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *\(p < 0.10\), **\(p < 0.05\), ***\(p < 0.01\).
Table A.5: Retracted papers penalty and attention score

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<th>(3) Citations</th>
<th>(4) Citations</th>
</tr>
</thead>
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<td>-0.815***</td>
<td>-0.921***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.090)</td>
<td>(0.068)</td>
<td>(0.051)</td>
<td></td>
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Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp(\beta)) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.6: Retracted papers penalty with high cum. citations (pre-retraction)

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Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. Pre-retraction citations are indicators for papers with relatively higher cumulative citations before the year of retraction. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp(\beta_1)) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
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<td>(0.134)</td>
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Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Any socialmedia/news/blog is an indicator for papers with at least one overall mention in any of the indicated outlets. Pre-retraction citations are indicators for papers with relatively higher cumulative citations before the year of retraction. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp(\beta)) \times 100 = x\), coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.8: Retracted papers penalty with high cum. citations (pre-retraction)

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Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Altscore is an aggregate measure of weighted online mentions. Pre-retraction citations are indicators for papers with relatively higher cumulative citations before the year of retraction. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - e^{\beta}) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\)% loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *\(p < 0.10\), **\(p < 0.05\), ***\(p < 0.01\).
Table A.9: Retracted papers penalty with early mentions (Post \( t \geq 0 \))

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<td>(0.060)</td>
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</tr>
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<td></td>
<td>-0.347**</td>
</tr>
<tr>
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<td>(0.139)</td>
</tr>
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</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for the year of retraction and all subsequent years. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp[\beta]) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\)% loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.10: Retracted papers penalty with any media coverage ($Post \ t \geq 0$)

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<th>(3) Citations</th>
<th>(4) Citations</th>
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<td>(0.105)</td>
<td>(0.092)</td>
<td>(0.065)</td>
<td>(0.088)</td>
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<td>Post * Treatment * Any social media</td>
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<td>Post * Treatment * Any news-blog</td>
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<td>(0.129)</td>
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<td></td>
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</tr>
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</tr>
<tr>
<td>Post * Treatment * Any blog</td>
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<td></td>
<td></td>
<td>-0.339***</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>(0.129)</td>
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<td>Y</td>
</tr>
<tr>
<td>Age FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Pseudo R2</td>
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<td>0.701</td>
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<td>16711</td>
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</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for the year of retraction and all subsequent years. Any social media/news/blog is an indicator for papers with at least one overall mention in any of the indicated outlets. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation $(1 - \exp(\beta)) \times 100 = x$ coefficients can be interpreted as elasticities (i.e. $x\%$ loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. 
Table A.11: Retracted papers penalty and attention score ($Post \ t \geq 0$)

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<th>(3) Citations</th>
<th>(4) Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post * Treatment</td>
<td>-0.452*** (0.118)</td>
<td>-0.467*** (0.083)</td>
<td>-0.572*** (0.058)</td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Altscore &gt;p50</td>
<td>-0.339** (0.133)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Altscore &gt;p75</td>
<td></td>
<td>-0.439*** (0.118)</td>
<td></td>
<td>-0.554*** (0.127)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore &gt;p90</td>
<td></td>
<td></td>
<td>-0.521*** (0.089)</td>
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</tr>
<tr>
<td>Post * Treatment * Altscore 3rd quintile</td>
<td></td>
<td></td>
<td>-0.607*** (0.082)</td>
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</tr>
<tr>
<td>Post * Treatment * Altscore 4th quintile</td>
<td></td>
<td></td>
<td></td>
<td>-0.919*** (0.072)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore 5th quintile</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Article FE</td>
<td>Y Y Y Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age FE</td>
<td>Y Y Y Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year FE</td>
<td>Y Y Y Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudo R2</td>
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<td>0.702 15438 966 16711</td>
<td>0.702 15438 966 16711</td>
<td>0.702 15438 966 16711</td>
</tr>
<tr>
<td>N clusters</td>
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<td>966 16711</td>
<td>966 16711</td>
<td>966 16711</td>
</tr>
<tr>
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<td>16711 16711</td>
<td>16711 16711</td>
<td>16711 16711</td>
<td>16711 16711</td>
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</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for the year of retraction and all subsequent years. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation $(1 - \exp(\beta)) \times 100 = x$ coefficients can be interpreted as elasticities (i.e. $x\%$ loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. 

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Table A.12: Retracted papers penalty with early mentions (actively cited papers)

<table>
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<th>(3) Citations</th>
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</thead>
<tbody>
<tr>
<td>Post * Treatment</td>
<td>-1.036***</td>
<td>-1.078***</td>
<td>-1.064***</td>
</tr>
<tr>
<td></td>
<td>(0.089)</td>
<td>(0.086)</td>
<td>(0.090)</td>
</tr>
<tr>
<td>Post * Treatment * Early mentions</td>
<td>-0.428**</td>
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<td></td>
<td>(0.198)</td>
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<td></td>
</tr>
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<td>Post * Treatment * Early blog mentions</td>
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</tr>
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<td>(0.238)</td>
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</tr>
<tr>
<td>Post * Treatment * Early news mentions</td>
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<td></td>
<td>-0.399**</td>
</tr>
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<td></td>
<td></td>
<td>(0.165)</td>
</tr>
<tr>
<td>Article FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Age FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Pseudo R2</td>
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<td>0.733</td>
<td>0.733</td>
</tr>
<tr>
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<td>7308</td>
<td>7308</td>
</tr>
<tr>
<td>N clusters</td>
<td>466</td>
<td>466</td>
<td>466</td>
</tr>
<tr>
<td>N full</td>
<td>7662</td>
<td>7662</td>
<td>7662</td>
</tr>
</tbody>
</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp[\beta]) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.13: Retracted papers penalty with any media coverage (actively cited papers)

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<th>(4)</th>
</tr>
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<td>Citations</td>
<td>Citations</td>
<td>Citations</td>
</tr>
<tr>
<td>Post * Treatment</td>
<td>-0.739***</td>
<td>-0.785***</td>
<td>-1.010***</td>
<td>-0.892***</td>
</tr>
<tr>
<td></td>
<td>(0.124)</td>
<td>(0.113)</td>
<td>(0.093)</td>
<td>(0.113)</td>
</tr>
<tr>
<td>Post * Treatment * Any social media</td>
<td>-0.577***</td>
<td>(0.162)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Any news-blog</td>
<td>-0.618***</td>
<td>(0.162)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Any news</td>
<td></td>
<td>-0.387***</td>
<td></td>
<td>-0.494***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.139)</td>
</tr>
<tr>
<td>Post * Treatment * Any blog</td>
<td></td>
<td></td>
<td></td>
<td>-0.494***</td>
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<td>(0.171)</td>
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<td>Y</td>
</tr>
<tr>
<td>Age FE</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Year FE</td>
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<td>Y</td>
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<td>Y</td>
</tr>
<tr>
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<td>0.733</td>
<td>0.733</td>
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<tr>
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<td>7662</td>
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</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Any social media/news/blog is an indicator for papers with at least one overall mention in any of the indicated outlets. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \( (1 - \exp(\beta)) \times 100 = x \) coefficients can be interpreted as elasticities (i.e. \( x\% \) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.14: Retracted papers penalty and attention score (actively cited papers)

<table>
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<tr>
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<th>(2) Citations</th>
<th>(3) Citations</th>
<th>(4) Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post * Treatment</td>
<td>-0.704***</td>
<td>-0.805***</td>
<td>-0.967***</td>
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<tr>
<td></td>
<td>(0.132)</td>
<td>(0.106)</td>
<td>(0.080)</td>
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</tr>
<tr>
<td>Post * Treatment * Altscore &gt;p50</td>
<td>-0.583***</td>
<td></td>
<td></td>
<td>-0.769***</td>
</tr>
<tr>
<td></td>
<td>(0.163)</td>
<td></td>
<td></td>
<td>(0.149)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore &gt;p75</td>
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<td>-0.590***</td>
<td></td>
<td>-1.123***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.157)</td>
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<td>(0.119)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore &gt;p90</td>
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<td></td>
<td>-0.544***</td>
<td>-1.317***</td>
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<td>(0.175)</td>
<td>(0.102)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore 3rd quintile</td>
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<td></td>
<td></td>
<td>-0.769***</td>
</tr>
<tr>
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<td></td>
<td>(0.149)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore 4th quintile</td>
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<td></td>
<td>-1.123***</td>
</tr>
<tr>
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<td></td>
<td>(0.119)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore 5th quintile</td>
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<td></td>
<td>-1.317***</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>(0.102)</td>
</tr>
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<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Age FE</td>
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<td>Y</td>
<td>Y</td>
<td></td>
</tr>
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<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.733</td>
<td>0.733</td>
<td>0.734</td>
<td>0.733</td>
</tr>
<tr>
<td>N</td>
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<td>466</td>
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<tr>
<td>N full</td>
<td>7662</td>
<td>7662</td>
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</tbody>
</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation $(1 - exp(\beta)) \times 100 = x$ coefficients can be interpreted as elasticities (i.e. $x\%$ loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. 

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### Table A.15: Retracted papers penalty and attention score by discipline

<table>
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<td>Citations</td>
<td>Citations</td>
<td>Citations</td>
</tr>
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<td></td>
<td></td>
</tr>
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<td>(0.650)</td>
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<td></td>
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<td></td>
<td></td>
</tr>
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<td>-1.485**</td>
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<td></td>
<td>(0.649)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Post * Treatment * Altscore &gt;p50 * Hard sciences</td>
<td>-0.494*</td>
<td></td>
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<td></td>
<td>(0.283)</td>
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<td>Y</td>
</tr>
<tr>
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<td>Y</td>
<td>Y</td>
</tr>
<tr>
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<td>0.709</td>
<td>0.718</td>
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<td>12980</td>
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</tr>
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<td>2835</td>
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</tbody>
</table>

Note: Estimates derive from pseudo Poisson specifications. Hard sciences: life sciences, environment, health and physical sciences. Social sciences: business and technology, humanities, other social sciences. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp(\beta)) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\)% loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.16: Retracted papers penalty and attention score by severity of misconduct

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<th>Moderate</th>
<th>Severe</th>
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<td>Citations</td>
<td>Citations</td>
<td>Citations</td>
</tr>
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<td>0.013</td>
<td>-0.023</td>
<td>0.381**</td>
<td>-0.519***</td>
</tr>
<tr>
<td></td>
<td>(0.174)</td>
<td>(0.165)</td>
<td>(0.182)</td>
<td>(0.172)</td>
</tr>
<tr>
<td>P * T * Altscore &gt;p50 *</td>
<td>0.361</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate misconduct</td>
<td>(0.249)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P * T * Altscore &gt;p50 *</td>
<td>-0.547**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Severe misconduct</td>
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<td></td>
<td></td>
</tr>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.710</td>
<td>0.594</td>
<td>0.694</td>
<td>0.738</td>
</tr>
<tr>
<td>N (N clusters)</td>
<td>15438 (966)</td>
<td>4312 (295)</td>
<td>3857 (256)</td>
<td>7269 (415)</td>
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<td>4157</td>
<td>7695</td>
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</tbody>
</table>

Note: Estimates derive from pseudo Poisson specifications. Causes of retractions are classified based on [Woo and Walsh (2021)]. The dependent variable is the total number of citations (exclusive of self-citations) received by each paper in a particular year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp[\beta]) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citations). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.17: Misconduct classification from [Woo and Walsh (2021)]

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<th>Classification</th>
<th>Coded Retracted Reasons from Retraction Watch database</th>
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<td>Moderate misconducts</td>
<td>'Concerns/Issues About Authorship', 'Concerns/Issues About Data', 'Concerns/Issues About Image', 'Concerns/Issues About Results', 'Contamination of Cell Lines/Tissues', 'Contamination of Materials (General)', 'Contamination of Reagents', 'Error in Analyses', 'Error in Cell Lines/Tissues', 'Error in Data', 'Error in Image', 'Error in Materials (General)', 'Error in Methods', 'Error in Results and/or Conclusions', 'Error in Text', 'Investigation by Company/Institution', 'Investigation by Journal/Publisher', 'Investigation by ORI', 'Investigation by Third Party', 'Lack Of Balance/Bias Issues', 'Miscommunication by Author', 'Miscommunication by Company/Institution', 'Miscommunication by Journal/Publisher', 'Miscommunication by Third Party', 'Misconduct by Third Party'</td>
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<tr>
<td>Severe misconducts</td>
<td>'Fake Peer Review', 'Falsification/Fabrication of Data', 'Falsification/Fabrication of Image', 'Falsification/Fabrication of Results', 'Forged Authorship', 'Hoax Paper', 'Manipulation of Images', 'Manipulation of Results', 'Misconduct – Official Investigation/Finding', 'Misconduct by Author', 'Misconduct by Company/Institution', 'Results Not Reproducible', 'Sabotage of Materials', 'Sabotage of Methods', 'Unreliable Data', 'Unreliable Image', 'Unreliable Results'</td>
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Table A.18: Selected summary statistics: title ngrams

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<th>Most frequent (selected) ngrams</th>
<th>Relevant selected ngrams</th>
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</table>

Note: N-grams represent the number of times the selected expression appears in the title of a research article. All n-grams in the table were selected by one of the lasso procedures. N=20755.
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<th>Logit</th>
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<td>AICC</td>
<td>CV</td>
<td>EBIC</td>
<td>AICC</td>
</tr>
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<td>0.093***</td>
<td>0.092***</td>
<td>0.067***</td>
<td>0.044**</td>
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<td>(0.035)</td>
<td>(0.035)</td>
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<td>(0.017)</td>
</tr>
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<td>(0.050)</td>
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<td>-0.035***</td>
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<td>(0.007)</td>
<td>(0.034)</td>
<td>(0.033)</td>
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Note: Estimates from OLS (columns 1-4) or Logit regression (columns 5-8). The dependent variable Media coverage is an indicator for whether a paper attracted online coverage at publication. In column (1)-(4) predictors are selected based on lasso while column (5)-(8) predictors are selected based on lassologit. Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.20: Likelihood of retraction and media coverage (Logit)

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<td>(0.006)</td>
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</tr>
<tr>
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<td>-0.085***</td>
<td>-0.054***</td>
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<tr>
<td></td>
<td></td>
<td>(0.033)</td>
<td>(0.038)</td>
<td>(0.016)</td>
<td>(0.021)</td>
<td>(0.017)</td>
</tr>
<tr>
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</tbody>
</table>

Note: Estimates from Logit equation. The dependent variable Retraction is an indicator for whether a paper was retracted. Media coverage is an indicator for whether a paper attracted online coverage at publication. Predicted media is media coverage as predicted from the respective lasso logit procedures. Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.

Table A.21: Likelihood of retraction and media coverage (selection within subjects, publication years and excluding retractions)

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<th>Media coverage</th>
<th>Retraction</th>
<th>EBIC</th>
<th>AICC</th>
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<th>Rigourous</th>
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<tr>
<td></td>
<td></td>
<td>0.016***</td>
<td>0.021***</td>
<td>0.018***</td>
<td>0.022***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.005)</td>
<td>(0.007)</td>
<td>(0.005)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Predicted media</td>
<td>Media coverage</td>
<td>-0.056***</td>
<td>-0.071**</td>
<td>-0.061***</td>
<td>-0.074***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.017)</td>
<td>(0.028)</td>
<td>(0.015)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>Pub. year FE</td>
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</table>

Note: Estimates from OLS regression. The dependent variable Retraction is an indicator for whether a paper was retracted. Media coverage is an indicator for whether a paper attracted online coverage at publication. Predicted media is media coverage as predicted from the respective lasso procedures. Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
### Table A.22: Months to retraction and Journal-year average visibility

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<td>Sh. news</td>
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<td>Sh. Tweets</td>
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<tr>
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<td>(1.117)</td>
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<td>Tweets count</td>
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</tr>
<tr>
<td></td>
<td>(0.645)</td>
<td></td>
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<tr>
<td>Sh. early blog</td>
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<td></td>
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<td></td>
<td>(1.995)</td>
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<tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td>(1.262)</td>
<td></td>
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</tr>
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<td>24.21</td>
<td>24.21</td>
<td>24.21</td>
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</tr>
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</table>

Note: The dependent variable is the time intercurring between an article publication and its retraction, expressed in months. Covariates represents different measures of journal visibility, measured as the average of non-retracted papers that appear in the same journal and year of the retracted one. All covariates are standardized and outliers trimmed. Controls include the number of non-retracted articles within same journal and year of the treated, the average Euclidean distance of those from the retracted paper, and the level of (non-self) cumulative citations of the retracted paper before retraction. Publication year fixed effects are included. Journal clustered standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
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<th>(6)</th>
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<tbody>
<tr>
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<td>-1.111***</td>
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<td>-1.327***</td>
<td>-1.830***</td>
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<tr>
<td><strong>R-squared</strong></td>
<td>0.120</td>
<td>0.171</td>
<td>0.165</td>
<td>0.230</td>
<td>0.158</td>
<td>0.236</td>
<td>0.152</td>
<td>0.231</td>
</tr>
<tr>
<td><strong>Sh. Blog</strong></td>
<td>-1.698**</td>
<td>-1.643**</td>
<td>-1.595**</td>
<td>-1.440**</td>
<td>-1.746**</td>
<td>-1.548**</td>
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<td>0.139</td>
<td>0.188</td>
<td>0.182</td>
<td>0.241</td>
<td>0.175</td>
<td>0.246</td>
<td>0.167</td>
<td>0.239</td>
</tr>
<tr>
<td><strong>Sh. News</strong></td>
<td>-1.611***</td>
<td>-1.365***</td>
<td>-1.795***</td>
<td>-1.325**</td>
<td>-1.952***</td>
<td>-1.852**</td>
<td>-1.995***</td>
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</tr>
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<td>-0.194</td>
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<td>835</td>
<td>835</td>
<td>835</td>
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<tr>
<td><strong>R-squared</strong></td>
<td>0.125</td>
<td>0.173</td>
<td>0.169</td>
<td>0.228</td>
<td>0.167</td>
<td>0.238</td>
<td>0.161</td>
<td>0.233</td>
</tr>
<tr>
<td><strong>Sh. Tweets</strong></td>
<td>-0.650**</td>
<td>-0.540**</td>
<td>-0.764***</td>
<td>-0.558**</td>
<td>-0.856**</td>
<td>-0.601**</td>
<td>-0.894**</td>
<td>-0.627**</td>
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<tr>
<td><strong>R-squared</strong></td>
<td>0.123</td>
<td>0.173</td>
<td>0.164</td>
<td>0.229</td>
<td>0.156</td>
<td>0.234</td>
<td>0.149</td>
<td>0.228</td>
</tr>
<tr>
<td><strong>Pub. year FE</strong></td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
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<td>N</td>
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<tr>
<td><strong>Controls</strong></td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Note: The dependent variable is the individual loss in citations obtained comparing each retracted paper to its selected controls for different pre- and post-time windows. Covariates represent different measures of journal visibility, measured as the average of non-retracted papers that appear in the same journal and year of the retracted one. All covariates are standardized and outliers trimmed. Controls include the number of non-retracted articles within same journal and year of the treated, the average Euclidean distance of those from the retracted paper, and the level of (non-self) cumulative citations of the retracted paper before retraction. Publication year fixed effects are included. Fixed effects for age of the article at retraction are added in even comuns. Journal clustered standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.
### Table A.24: Citation statements and early mentions

<table>
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<th>(1) Cit. statements</th>
<th>(2) Cit. statements</th>
<th>(3) Mentioning</th>
<th>(4) Mentioning</th>
<th>(5) Contrasting</th>
<th>(6) Contrasting</th>
<th>(7) Supporting</th>
<th>(8) Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post</td>
<td>0.033 (-0.038)</td>
<td>0.038 (-0.038)</td>
<td>0.040 (0.040)</td>
<td>-0.108 (0.236)</td>
<td>-0.132 (0.263)</td>
<td>0.035 (0.100)</td>
<td>0.031 (0.109)</td>
<td></td>
</tr>
<tr>
<td>Post * Treatment</td>
<td>-1.215*** (0.086)</td>
<td>-1.165*** (0.093)</td>
<td>-1.231*** (0.095)</td>
<td>-1.175*** (0.093)</td>
<td>-1.147*** (0.339)</td>
<td>-1.184*** (0.348)</td>
<td>(0.197) (0.209)</td>
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</tr>
<tr>
<td>Post * Early mentions</td>
<td>0.247*** (0.063)</td>
<td>0.171*** (0.066)</td>
<td>0.238*** (0.065)</td>
<td>0.167** (0.068)</td>
<td>0.738** (0.317)</td>
<td>0.745** (0.347)</td>
<td>(0.158) (0.170)</td>
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</tr>
<tr>
<td>Post * Treatment * Early mentions</td>
<td>-0.411** (0.164)</td>
<td>-0.466*** (0.170)</td>
<td>-0.396*** (0.167)</td>
<td>-0.478*** (0.173)</td>
<td>-0.595 (0.684)</td>
<td>-0.416 (0.730)</td>
<td>(0.414) (0.440)</td>
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<td>N Y N Y N Y N Y</td>
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<td></td>
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</tr>
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</tr>
<tr>
<td>Age FE</td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations statements received by each paper in a particular year, even columns exclude self citations. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Early mentions is an indicator for papers with at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp[\beta]) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citation statements). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.

### Table A.25: Citation statements and attention score

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<th>(2) Cit. statements</th>
<th>(3) Mentioning</th>
<th>(4) Mentioning</th>
<th>(5) Contrasting</th>
<th>(6) Contrasting</th>
<th>(7) Supporting</th>
<th>(8) Supporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post</td>
<td>-0.023 (0.052)</td>
<td>0.024 (0.055)</td>
<td>-0.022 (0.053)</td>
<td>0.024 (0.056)</td>
<td>0.050 (0.344)</td>
<td>0.352 (0.360)</td>
<td>0.045 (0.131)</td>
<td>0.115 (0.142)</td>
</tr>
<tr>
<td>Post * Treatment</td>
<td>-1.001*** (0.119)</td>
<td>-0.941*** (0.121)</td>
<td>-0.993*** (0.139)</td>
<td>-0.923*** (0.634)</td>
<td>-1.698*** (0.681)</td>
<td>-1.972*** (0.681)</td>
<td>(0.351) (0.373)</td>
<td></td>
</tr>
<tr>
<td>Post * Altscore &gt;50</td>
<td>0.173*** (0.060)</td>
<td>0.090 (0.063)</td>
<td>0.170*** (0.060)</td>
<td>0.991 (0.064)</td>
<td>0.048 (0.350)</td>
<td>0.367 (0.368)</td>
<td>0.149 (0.151)</td>
<td>0.009 (0.159)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore &gt;50</td>
<td>-0.415*** (0.155)</td>
<td>-0.441*** (0.155)</td>
<td>-0.417*** (0.155)</td>
<td>-0.477*** (0.153)</td>
<td>-0.480 (0.704)</td>
<td>-0.808 (0.756)</td>
<td>(0.403) (0.428)</td>
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</tr>
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<td>Self cit. excluded</td>
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<td>N Y N Y N Y N Y</td>
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<tr>
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<tr>
<td>Year FE</td>
<td>Y Y Y Y Y Y Y Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pseudo R2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>N</td>
<td>14594 14158 14536 14089 14089 14089 14089 14089</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td></td>
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Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations statements received by each paper in a particular year, even columns exclude self citations. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation \((1 - \exp[\beta]) \times 100 = x\) coefficients can be interpreted as elasticities (i.e. \(x\%\) loss in yearly citation statements). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
Table A.26: Citation statements and attention score extremes

<table>
<thead>
<tr>
<th></th>
<th>(1) Cit. statements</th>
<th>(2) Cit. statements</th>
<th>(3) Mentioning</th>
<th>(4) Mentioning</th>
<th>(5) Contrasting</th>
<th>(6) Contrasting</th>
<th>(7) Supporting</th>
<th>(8) Supporting</th>
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<tr>
<td>Post</td>
<td>0.043</td>
<td>0.074</td>
<td>0.046</td>
<td>0.074</td>
<td>0.262</td>
<td>0.567</td>
<td>0.070</td>
<td>0.177</td>
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<tr>
<td></td>
<td>(0.056)</td>
<td>(0.059)</td>
<td>(0.056)</td>
<td>(0.060)</td>
<td>(0.373)</td>
<td>(0.355)</td>
<td>(0.146)</td>
<td>(0.157)</td>
</tr>
<tr>
<td>Post * Treatment</td>
<td>-1.103***</td>
<td>-1.002***</td>
<td>-1.007***</td>
<td>-0.984***</td>
<td>-1.940***</td>
<td>-2.203***</td>
<td>-1.226***</td>
<td>-1.265***</td>
</tr>
<tr>
<td></td>
<td>(0.156)</td>
<td>(0.153)</td>
<td>(0.155)</td>
<td>(0.150)</td>
<td>(0.769)</td>
<td>(0.820)</td>
<td>(0.467)</td>
<td>(0.484)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore 3rd qntl</td>
<td>0.428**</td>
<td>0.287</td>
<td>0.438**</td>
<td>0.286</td>
<td>1.369</td>
<td>1.523</td>
<td>0.203</td>
<td>0.315</td>
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<tr>
<td></td>
<td>(0.211)</td>
<td>(0.217)</td>
<td>(0.212)</td>
<td>(0.216)</td>
<td>(1.254)</td>
<td>(1.342)</td>
<td>(0.654)</td>
<td>(0.664)</td>
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<td>-0.105</td>
<td>-0.087</td>
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<td>0.466</td>
<td>0.476</td>
<td>0.743</td>
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<td>(0.205)</td>
<td>(0.205)</td>
<td>(0.204)</td>
<td>(0.204)</td>
<td>(1.288)</td>
<td>(1.338)</td>
<td>(0.546)</td>
<td>(0.566)</td>
</tr>
<tr>
<td>Post * Treatment * Altscore 5th qntl</td>
<td>-0.456**</td>
<td>-0.510***</td>
<td>-0.472**</td>
<td>-0.538***</td>
<td>0.513</td>
<td>0.899</td>
<td>-0.224</td>
<td>-0.024</td>
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<td>(0.197)</td>
<td>(0.193)</td>
<td>(0.196)</td>
<td>(0.191)</td>
<td>(0.849)</td>
<td>(0.907)</td>
<td>(0.534)</td>
<td>(0.554)</td>
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<tr>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Pseudo R2</td>
<td>0.714</td>
<td>0.717</td>
<td>0.712</td>
<td>0.716</td>
<td>0.142</td>
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</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variable is the total number of citations statements received by each paper in a particular year, even columns exclude self citations. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Altscore is an aggregate measure of weighted online mentions. All models incorporate article fixed effects, a full suite of calendar-year effects and article age indicator variables. Using the following transformation $\left(1 - \exp(\beta)\right) \times 100 = x$ coefficients can be interpreted as elasticities (i.e. $x\%$ loss in yearly citation statements). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.
<table>
<thead>
<tr>
<th>Table A.27: Impact on authors’ careers (split samples)</th>
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<tr>
<td><strong>Media</strong></td>
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<tr>
<td>All</td>
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<td>H-index &gt;p50</td>
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### Panel A: N articles

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<tbody>
<tr>
<td>**</td>
<td>Media: N articles</td>
<td>No Media</td>
</tr>
<tr>
<td><strong>Post * Treatment</strong></td>
<td>0.212*** (0.085)</td>
<td>0.102 -0.187* (0.05)</td>
</tr>
<tr>
<td><strong>Pseudo R2</strong></td>
<td>0.583</td>
<td>0.479</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>6055</td>
<td>2082</td>
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<tr>
<td><strong>N clusters</strong></td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td><strong>N authors</strong></td>
<td>760</td>
<td>266</td>
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</tbody>
</table>

### Panel B: N articles with grant

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<th>Post * Treatment</th>
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<tr>
<td>**</td>
<td>Media: N articles with grant</td>
<td>No Media</td>
</tr>
<tr>
<td><strong>Post * Treatment</strong></td>
<td>-0.207** (0.091)</td>
<td>-0.165 (0.122)</td>
</tr>
<tr>
<td><strong>Pseudo R2</strong></td>
<td>0.552</td>
<td>0.516</td>
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<td><strong>N</strong></td>
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<tr>
<td><strong>N authors</strong></td>
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<td>255</td>
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### Panel C: Avg. n coauthors (x article)

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<th>Post * Treatment</th>
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</tr>
</thead>
<tbody>
<tr>
<td>**</td>
<td>Media: Avg. n coauthors (x article)</td>
<td>No Media</td>
</tr>
<tr>
<td><strong>Post * Treatment</strong></td>
<td>-0.090*** (0.080)</td>
<td>-0.019 (0.082)</td>
</tr>
<tr>
<td><strong>Pseudo R2</strong></td>
<td>0.384</td>
<td>0.384</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>6055</td>
<td>2082</td>
</tr>
<tr>
<td><strong>N clusters</strong></td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td><strong>N authors</strong></td>
<td>760</td>
<td>266</td>
</tr>
</tbody>
</table>

Note: Estimates derive from pseudo Poisson specifications. The dependent variables are: N. published articles x author x year; N. published articles with grant support x author x year; or Avg. n collaborators across all author’s publications x year. Treatment is an indicator for retracted papers. Post is an indicator for all years strictly after the year of retraction. Media is an indicator for cases where the original publication (either retracted or control papers) had at least one mention (in newspapers and/or blogs) within two weeks from publication. All models incorporate author fixed effects, a full suite of calendar-year effects and career length indicator variables. Using the following transformation \(1 - \exp[\beta] \times 100 = x\) coefficients can be interpreted as elasticities (e.g. x% loss in publication rate). Standard errors in parentheses, clustered around retraction cases. *p < 0.10, **p < 0.05, ***p < 0.01.