Citation of retracted research: a case-controlled, ten-year follow-up scientometric analysis of Scott S. Reuben’s malpractice

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Abstract
A major problem in scientific literature is the citation of retracted research. Until now, no long-term follow-up of the course of citations of such articles has been published. In the present study, we determined the development of citations of retracted articles based on the case of anaesthesiologist and pain researcher Scott S. Reuben, over a period of 10 years and compared them to matched controls. We screened four databases to find retracted publications by Scott S. Ruben and reviewed full publications for indications of retraction status. To obtain a case-controlled analysis, all Reuben’s retracted articles were compared with the respective citations of the preceeding and subsequent neighbouring articles within the same journal. There were 420 citations between 2009 and 2019, of which only 40% indicated the publication being retracted. Over a 10-year period, an increasing linear trend is observed in citations of retracted articles by Scott S. Ruben that are not reported as retracted ($R^2 = 0.3647$). Reuben’s retracted articles were cited 92% more often than the neighbouring non-retracted articles. This study highlights a major scientific problem. Invented or falsified data are still being cited after more than a decade, leading to a distortion of the evidence and scientometric parameters.

Keywords Retraction of publication · Scientific misconduct · Ethics research · Scott S. Reuben · Pain · Anaesthesiology · Anaesthetist

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Introduction

Scientific research is the foundation of technical, economic, socio-political, and medical decisions; accuracy, high quality, and integrity are therefore essential requirements (Kretser et al., 2019). In contrast, the scientific community is confronted with the fact that these ideals are not being met by all researchers. Scientific misconduct is a major problem (Gross, 2016, Hesselmann et al., 2017). Such scientifically unethical practices may be motivated by a variety of reasons, including financial gain, scientific recognition or pressure to publish (George, 2016).

Ethical misconduct can be attributed to an adverse influence of socio-organizational factors (Parlangeli et al., 2020). In some countries, as well as in some scientific institutions, the pressure to publish is also linked to the maintenance of scientific careers, resulting in the danger of more manipulated or falsified scientific work being produced (Aspura et al., 2018; Davies, 2019). The institutional use of evaluation metrics and incentives as pay per paper have been linked to data fabrication and fraudulent publications (Ma, 2019).

If, however, a violation of these basic scientific and ethical principles is discovered, a publication must subsequently be retracted and can thus not be regarded as valid evidence. The number of retracted publications has risen substantially in recent years across all scientific disciplines (Steen et al., 2013). Scientific misconduct is the cause of the majority of the retractions (Campos-Varela & Ruano-Raviña, 2019, Craig et al., 2020). Nevertheless, compared to the total number of publications, only a tiny proportion are retracted (Grieneisen & Zhang, 2012, Aspura et al., 2018).

One challenging issue with publications that have been retracted is the fact that they continue to be cited—even 5 years later—without any indication that they have been retracted (Bornemann-Cimenti et al., 2016). A large-scale analysis of over 12,000 retractions revealed that more than half of the retracted papers are cited at least once (Sharma, 2021). This allows erroneous or invented conclusions to be disseminated through the scientific ecosystem. However, the extent to which retracted research also persists in the long term remains unclear.

In 2009, Scott S. Reuben, a formerly highly reputed anaesthesiologist and pain researcher, was convicted of large-scale data fabrication (Shafer, 2009a, b, c). He was sentenced to six months imprisonment and more than $400,000 of fines and restitution (U.S. Attorney’s Office, 2010). Consequently, 25 of his publications were retracted, most from highly esteemed journals in his research field (Shafer, 2009a, b, c). At the time, this was the highest number of retractions due to scientific misconduct by a single researcher. Even though others have since exceeded the extent of his misconduct (e.g., Fujii (Dyer, 2012) and Boldt (Dyer, 2011)), a detailed examination of Reuben’s case can be useful in understanding how the scientific community deals with retracted work.

In this article, we use his case to provide the first long-term follow-up of citations of retracted articles using a case-controlled approach. We focused on three research questions. What is the long-term trend of citations of retracted work and are these citations indicating that the references have been retracted? How do retracted work perform compared to a matched control? Is there a difference in the citation of retracted articles between high-impact and low-impact journals?
Method

We examined all scientific publications in a period of 10 years respectively between 2009 and 2019 citing publications by Scott S. Reuben. For this purpose, we consulted the following sources: Web of Science (Clarivate™ Analytics, Philadelphia, Pennsylvania), PubMed (U.S. National Library of Medicine, National Institutes of Health) and Google Scholar (Google LLC).

Further characteristics were extracted from Journal Citation Report (Clarivate Analytics, Philadelphia, Pennsylvania), such as journal subject and average journal impact factor (JIF) percentile (Yu & Yu, 2016), and journal impact factor. In order to do this, Journal Citation Reports Web of Science (Clarivate™ Analytics, Philadelphia, Pennsylvania) was used. All papers citing Scott S. Reuben were content analysed for an indication of a retraction. Four procedures were used to determine whether Scott S. Reuben’s papers that were cited had an “official” retraction. We first verified whether the cited paper was listed as retracted by the journal it was published. In addition, we searched the referenced paper in the Web of Science (Clarivate™ Analytics, Philadelphia, Pennsylvania), PubMed U.S. National Library of Medicine, National Institutes of Health) and Google Scholar (Google LLC) for a retraction. If Scott S. Reuben’s paper was indicated as retracted in at least one of the sources, the status “retracted” was assessed for this paper (Addendum 1). Two investigators (IZS, HBC) independently carried this out. Non-English publications that we found were in the French language and were also analysed and included in our study. Figure 1 illustrates a flowchart showing all of the steps that were taken.

To allow a case-controlled analysis, we followed the methodology used by Mott et al. (2019). All of Reuben’s retracted articles were compared with their previous and subsequent neighbouring articles in the journals in which they were published. For this purpose, only articles of similar categories (e.g., original articles, reviews) were selected as neighbouring articles. If the previous or subsequent article had a different category (e.g., an editorial or case report instead of an original article), the next article of the same category as Reuben’s publication was used (Mott et al., 2019). To control for different study designs (randomized controlled trial, retrospective analysis), the closest article with a comparable design was chosen. The mean citation of the two neighbouring articles was used as a matched control. Comparing the citations of a publication with its neighbours has been proposed method to measure the success of research output (Franceschini et al., 2012).

In order to get insights on the role of the journals ranking we calculated the proportion of high vs. low-impact journals defined by the 50th Journal Impact Factor Percentile. Chi-square was used to determine the frequency distribution of cited retracted and non-retracted papers in relation to the quartile classification of the journals. Correlations were performed to determine possible contributors to a “retraction” indication.

The results were analysed and evaluated descriptively Microsoft Office 365—Microsoft Excel (Microsoft Corp., Redmond, Washington) and SPSS (IBM, Armonk, New York).

Results

Scott S. Reuben’s articles were cited a total of 420 times over a 10-year period or between 2009 and 2019. Of these, retracted articles were cited 360 times. In 60% of the publications that cited Scott S. Reuben retracted papers, no indication was made that the cited paper
had been retracted. A 10-year comparison of citations since 2009 shows a declining trend in total Reuben citations, but a significant increasing trend in citations of retracted articles that are not cited as retracted. The respective coefficient of determination has a value of $R^2 = 0.3647$ (Fig. 2).

When comparing the percentage of citations with the citations of the neighbouring articles over the last 10 years, it appears that ten articles retracted by Reuben were cited more often than the neighbouring non-retracted articles. On average, all of Reuben’s articles received 92% more citations than their matched control.

To examine, whether the impact of journals has an influence on the occurrence of non-indicated citation of retracted work, citations in journals with Journal Impact Factor Percentile (JIF) above 50 were compared to the journals with a JIF below 50. A significant higher proportion of non-indicated citations was published in journals with lower Impact Factors (30.9% vs. 21.2%, $p = 0.0271$). In other words, there is a clear tendency for journals with a higher average JIF percentile to indicate that Reuben’s articles have been retracted. This is also evident when we use the quartile ranking of the journals in which Reuben’s papers were quoted. Higher quartile ranked journals tend to indicate that Scott S. Reuben’s
articles were retracted. A respective chi-square test reveals a highly significant frequency distribution $X^2(3, N=420) = 61.174, p = p < 0.01$ (Fig. 3). We were able to determine the following factors influencing the indication of a retraction: the year of citation, average journal impact factor, and journal quartile ranking of the citing article (Table 1).

**Discussion**

Our results clearly show that, despite the tendency for citations to decline, retracted articles are still cited even after 10 years without indication of their retraction status. This has many negative effects: The conclusions of systematic reviews can be distorted, the arguments of other studies are based on invalid data, and methods are regarded as established although they have not been carried out in this form (Avenell et al., 2019). This list could be continued. In Reuben’s case, an analysis of review articles showed that the majority of qualitative reviews citing his retracted publications were distorted by his fraudulent data (Marret et al., 2009). Accordingly, it is essential for the reliability of science to create increased awareness of the problem of citing retracted papers.

When interpreting our results, the context of the “life cycle” of scholarly publications, which is related to the particular field of research, has to be taken into consideration. In medicine, publications have approximately 35% of their citations within the first 5 years of publication, and the annual citation rate decreases thereafter (Galiani & Gálvez, 2019). In Reuben’s case, the mean age of the publications at the point of retraction was $5.4 \pm 3.3$ years. This means that for the major part of Reuben’s publications, the majority of citations occurred at a time when the publication had not yet been retracted. However, since the citations were made as a common science before the retraction, we did not include them in our analysis.
Our data shows that only a minority of publications that cited Reuben’s articles indicated that the work had been being retracted: only about a quarter of the referring literature included such a statement. The exact reason why authors cite retracted literature was not yet fully investigated. It might be explained by authors not recognizing that an article was retracted because it came from an outdated source (e.g., paper files, online repositories), or authors considering the described methodology or conclusions useful despite retraction (Da Silva & Dobránszki, 2017). We experienced large differences in the indications of a retraction when analysing for retractions through four different approaches. However, we assume that other authors also experience similarly (Addendum 1).

**Fig. 3** Global indication of all officially retracted papers according to the quartile classification of the journals

**Table 1** Factors influencing indicated retractions

| Possible influencing factors          | Retraction indicated |
|--------------------------------------|----------------------|
| Year of citation                     | \( r = -0.165, p < 0.001 \) |
| Average journal impact factor        | \( r = 0.234, p < 0.001 \) |
| Journal quartile ranking             | \( r = 0.265, p < 0.001 \) |
| “Official” retraction                | \( r = -0.078, p > 0.05 \) |

\( R \) correlation coefficient, a measure of the degree of linear relationship between characteristics
To improve retraction procedures and the quality assurance of scientific work, the Committee on Publication Ethics (COPE Council, 2009) developed retraction guidelines that recommend a set of clear criteria of notes on retraction (Wager et al., 2009; Council, 2019). An analysis from 2019 shows that not all of Reuben’s retractions fulfill the COPE criteria, and they are therefore often not recognized by authors using the citations, as having been retracted (Mchugh & Yentis, 2019). Likewise, the content of retraction notes is frequently lacking relevant information (Vuong, 2020). The usage of printed versions or non-updated online repositories are other possible factors that mislead to refer to publications that have been retracted (Da Silva & Bornemann-Cimenti, 2017; Davis, 2012).

Our data demonstrate that the ranking of the journal influences the occurrence of inappropriate citations. Journals with higher JIF percentiles indicate the retracted status of a cited article significantly more often. These findings may mean that high-ranking journals have effective mechanisms, such as more robust peer review or more vigilant editors, to reduce the incidence of such citations. Of course, it may also mean that the authors published in top journals are less likely to use such problematic sources. Regardless, more than 1/3th of the citations without a retraction indication were published in high-ranking journals, which clearly shows that there is still room and need for improvement, even among top journals.

Our study uncovers a main issue. It shows that a large number of Reuben’s retracted articles continue to be cited more frequently than the non-retracted control articles, which might produce an undesirable effect whereby falsified data continues to be widely disseminated (Fig. 3, Fig. 4). This may be due in part to the fact that Reuben’s falsified data were very appealing and his conclusions fit a variety of successive publications.

It is an essential responsibility of the entire scientific community to take measures against the continued citation of retracted papers, as readers, authors, editors, and reviewers alike (Da Silva & Bornemann-Cimenti, 2017; Teixeira Da Silva et al., 2020). Only by this means, a potential loss of confidence in the sciences as a whole can be avoided.

![Fig. 4](image_url) Top 5 most cited retracted papers from Scott S. Reuben that were not indicated as retracted among the 28 studied
We have previously pointed out a possible solution to avoid the perpetuation of retracted research by incorporating an electronic “retraction check” in reference management software, as well as in the submission or review process (Bornemann-Cimenti et al., 2016; Da Silva & Bornemann-Cimenti, 2017). As one may suppose that citation of retracted work is far more often a result of carelessness and inadvertence than of conscious malpractice, such automated systems could be a suitable way to reduce incidence. Several good approaches already exist that implement what we propose. For example, the open source software “Zotero” already provides a way to automatically match the references with the database “Retraction Watch” (retractiondatabase.org), which also represents a very comprehensive source (Berenbaum, 2021; Stillman, 2019). Further “Scite” (scite.ai) analyses scientific publications regarding certain topics, provides an overview of citations and has also an integration to “Zotero”. As well as ReTracker, an open source plugin designed for the literature management software “Zotero” to detect retracted scientific journal articles (Dinh et al., 2019).

The manuscript review software “retractcheck” compares a Digital Object Identifier (DOI) within the manuscript with the database “OpenRetractions” (http://openretractions.com/), a database of reiterations drawn only from CrossRef and Pubmed (Hartgerink et al., 2019). These projects raise the hope that citation of retracted papers will become less prevalent in the future.

In conclusion, our study reveals a major scientific problem. Invented or falsified data continues to be cited over a decade later, resulting in a distortion of evidence. Our study offers results that quantify this problem over a ten-year period with a case–control. The handling of retracted articles is still a challenge for the scientific community, and the optimization of retraction procedures and the implementation of automatic rejection checks in references managers and submission systems are needed to reduce the dissemination of falsified data to an unavoidable minimum.

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**Declarations**

**Conflict of interest** Authors have no conflict of interest relevant to this article.
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