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Article retraction rates in selected MeSH term categories in PubMed published between 2010 and 2020

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ABSTRACT

Background: Academic article retractions occur across all disciplines, though few studies have examined the association between research topics and retraction rates.
Objectives: We assessed and compared the rate of retraction across several important clinical research topics.
Methods: Information about the number of publications, the number of retractions, the retraction rate, and the time to retraction was collected for articles identified by 15 Medical Subject Headings (MeSH) terms. These articles were published between 1 January 2010 and 31 December 2020. The searches took place between 18 September 2021 and 24 October 2021. The MeSH terms were selected based on our clinical experience with the expectation that there will be multiple publications during the timeframe to use for the searches. Additional topics were selected based on the frequency of controversy in the public media and were identified by the Altmetric Top 100 report.
Results: The mean number of publications for all categories was 181,975 ± 332,245; the median number of publications was 67,991 [Q1, Q3; 31951.5, 138,981.5]. The mean number of retractions was 100.3 ± 251.3, and the median number of retractions was 22 [Q1, Q3; 6.5, 53]. The mean time to retraction ranged from 114 days to 1,409.5 days; the median was 857.3 days [Q1, Q3; 684.7, 1098.6], depending on the topic. The various MeSH term categories used in this study had significant differences in retraction rate and time to retraction. The "Neoplasms" category had the highest total number of retractions (993) and one of the highest retraction rates (75.4 per 100,000 publications).
Discussion: All PubMed categories analyzed in this study had retracted articles. The median time to retraction was 857 days. The long delays in some categories could contribute to potentially misleading information which might have adverse effects on clinical decisions in patient care and on research design.
Conclusion: Rate of retraction varies across research topics and further studies are needed to explore this relationship.

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KEY POINTS

- Article retractions occurred in all subsets of articles classified by the 15 PubMed MeSH terms used in this study.
- The time to retraction and the rate of retraction differed significantly across research topics classified by these MeSH terms. This suggests that research content and visibility affect retraction rates.
- As an example, the "Neoplasms" category had the highest total number of retractions (993) and one of the highest retraction rates (75.4 per 100,000 publications).
- Readers, editors, and authors need to understand that retractions do occur following publication in the medical literature. These retractions potentially have important consequences and require attention from all individuals involved in the multiple steps needed to create high-quality medical and scientific information.

Introduction

Academic publishing in life sciences and medicine has grown tremendously during the last half-century, with the number of scientific publications doubling about every 15 years (Fortunato et al. 2018). With this growth in research output, research quality has become an area of interest and concern for funding agencies and researchers, and reviewing retracted or withdrawn research articles provides some insight into the quality of research (Mousavi and Abdollahi 2020). Retracted articles may indicate a serious flaw in research methodology, research fraud, or unethical practices, or may represent other less serious or perhaps unintentional deviations from standard publication guidelines, such as duplicate publications by large research groups.

Several studies have examined retraction rates across time (Bhatt 2021; Grieneisen, Zhang, and von Elm 2012; Cokol, Ozbay, and Rodriguez-Esteban 2008; Steen, Casadevall, and Fang 2013b). The time to retraction varies from 1 to 5 years (Bar-Ilan and Halevi 2017; Cassão et al. 2018; Dal-Ré and Ayuso 2019; Elizabeth and Maria 2016; Furman, Jensen, and Murray 2012; Gaudino et al. 2021; King et al. 2018; Mott, Fairhurst, and Torgerson 2019); one study suggested that the time to retraction has decreased more than 50% since 2002 (49.82 vs 23.82 months, $p < 0.0001$) (Steen, Casadevall, and Fang 2013b). Some studies have reported an increase in retraction rates over the past several decades (Al-Ghareeb et al. 2018; Bozzo et al. 2017; Cokol, Ozbay, and Rodriguez-Esteban 2008; Fanelli 2013; Grieneisen, Zhang, and von Elm 2012; He 2013; Lu et al. 2013; Moylan and Kowalczuk 2016; Steen, Casadevall, and Fang 2013a; Wager and Williams 2011; Wang et al. 2017), but this may not reflect increasing rates of misconduct (Fanelli 2013). Several studies have also examined rates of retractions in non-medical disciplines

(Ajiferuke and Adekannbi 2020; Rosenkrantz 2016; Rubbo et al. 2019; Van Leeuwen and Luwel 2014), including engineering (Rubbo et al. 2019) and the humanities (Lu et al. 2013), but most studies have focused on biomedicine and physical sciences (Grieneisen, Zhang, and von Elm 2012; He 2013; Zhang and Grieneisen 2013). Academic retractions continue to be an issue, as highlighted by concerns over the large increase in COVD-19 related publications and retractions (though overall retraction rates remained the same) (Peterson, Alexander, and Nugent 2022; Yeo-Teh and Tang 2021). The unusually rapid rate of retraction for these publications has raised questions about the quality of COVID-19 research and has contributed to a discussion about research quality and ethics (Bramstedt 2020). Indeed, some have suggested that increased retractions indicate deteriorating research quality and integrity, while others argue that other factors, such as increased publisher vigilance (Fanelli 2013) and "heroic acts" of self-reporting (Vuong 2020), may be involved. It is also possible that research quality, integrity, and publication/editorial practices differ significantly among fields, so that some disciplines may have significantly different rates of and time to retraction (Rafael and Carmen 2019). Particular topics within a discipline may attract more attention and scrutiny, and this could contribute to retraction rates.

Considering the breadth of publications in medicine and related fields indexed by the National Library of Medicine, we performed an exploratory study examining article retraction times and rates across several research topics to determine if these rates vary. The frequency of retraction and the variations in these retraction rates should alert editors, readers, and researchers to the possibility that certain research areas may have higher retraction rates and may warrant future studies to examine the reasons driving these differences. It may also encourage researchers and editors working on these topics to address issues of research integrity.

Methods

The following Medical Subject Heading (MeSH) terms were used to select articles for this study: "Aging," "Alzheimer Disease," "Analgesics, Opioid," "Climate Change," "Drug Resistance, Microbial," "Environmental Pollution," "Exercise," "Health Care Reform," "Heart Diseases," "HIV," "Measles-Mumps-Rubella Vaccine," "Neoplasms," "Obesity," "Organisms, Genetically Modified," and "Stem Cells." These topics were selected based on our clinical experience with the expectation that there would be multiple publications during the timeframe used for this literature search. In addition, we selected topics that are frequently associated with controversy in public media, including newspapers, radio, television, and social websites. To identify topics that would meet this criterion, we used topics in the Altmetric Top

100, an annual report measuring social and news media attention of research articles (Altmetric Top 100 2021), as a uniform and quantitative gauge of topic popularity. Reports were available from 2013 to 2020 and were used to help determine relevant topics. Potential topics were narrowed further based on the available MeSH terms in PubMed; topics without a corresponding MeSH term were excluded from further consideration. An additional inclusion requirement was that each MeSH subgroup should include at least 1000 articles within it to provide an adequate sample to estimate retraction rates.

Using the selected MeSH terms, articles were searched in PubMed for the period 1 January 2010 to 31 December 2020. The "Retracted Publication" filter was then applied, and the retraction total was determined from the PubMed search results. Automatic Term Mapping was not used. Each individual search was executed with the following format, with the MeSH term "Analgesic, Opioid" used as an example here:

"Analgesics, Opioid" [MeSH] AND 2010/01/01:2010/12/31 [DP]
"Analgesics, Opioid" [MeSH] AND 2011/01/01:2011/12/31 [DP]
"Analgesics, Opioid" [MeSH] AND 2012/01/01:2012/12/31 [DP]
[etc]

The appropriate term and date range were substituted as necessary. Each MeSH term required 11 separate searches, one for each year, to make the manual removal of irrelevant articles less cumbersome and reduce human error.

Because many journals publish both in print and online, often at different times, dates were based on the earliest date of publication and retraction available. Articles that were retracted outside of the timeframe, duplicate articles, and articles with a time to retraction of "zero" were excluded manually. Articles were not limited to English. Searches were conducted and data collection took place between 18 September 2021 and 24 October 2021.

Descriptive statistics are used to report the number of retracted articles and the time to retraction in each subgroup. The mean, standard deviation, median, and interquartile range are reported for the total number of publications, the number of retracted publications, and the time to retraction in each subgroup. In addition, the retraction rate per 100,000 articles is also calculated. Specifically, the time to retraction for the retracted publications was defined as the time interval between the publication date and the retraction date. To analyze both the timing and rate of retractions, a cumulative incidence plot was generated (subgroups that have less than 20 retractions were not included, for better visualization). The number of retractions was calculated as frequency based on the total number of articles in the MeSH subset over an 11-year period and the time to retraction was calculated using mean, standard deviation, median, and interquartile ranges. A Fisher's exact test was used to determine whether the proportions of retraction were the same across subgroups, and a Kruskal–Wallis rank-sum test was used to evaluate whether the distributions of the time to retraction were the same across subgroups. In addition, the cumulative incidences of the retractions were also compared by incorporating both the data for retraction incidence and time to retraction simultaneously. For the other publications, we defined that they were not retracted at the time of data analysis. A log-rank test was used to compare different disciplines. The statistical significance level was set at 0.05. Analyses were performed using SAS (Windows version 9.4; SAS Institute, Cary, NC) and the statistical program R version 4.0.2 (https://cran.r-project.org/).

Results

The time to retraction and the rate of retraction differed significantly across groups ($p < 0.01$). The mean number of publications across all disciplines was 181,975 ± 32,245; the median number of publications across these disciplines was 67,991 with an IQR of [31,941.5, 135,981.5] (Table 1). The mean number of retractions across disciplines was 100.3 ± 251.3; the median number was 22 with an IQR of [6.5, 53]. "Neoplasms" had both the highest total publications (1,316,818) and total retractions (993) during the timeframe, and "Stem Cells" had the highest rate of retraction (110.4 per 100,000 publications). Both "Climate Change" and "Measles, Mumps, and Rubella" had the fewest number of total publications (21,641 and 1,236, respectively) and retractions (1 each).

The total publications for the search period differed significantly across groups and ranged from 1,236 publications ("Measles, Mumps, and Rubella") to 1,316,818 ("Neoplasms"). The mean time to retraction also varied from 114 days ("Health Care Reform") to 1409.5 days ("Stem Cells") (Table 2). The mean number of days to retraction was 811.5 ± 382.5; median number of days was 857.3 with an IQR of [684.7, 1098.6].

The cumulative incidence of retraction differed significantly across the disciplines ($p < 0.001$) (Figure 1). Various patterns for retraction are plotted in the figure.

Cumulative incidence of retraction on plotted on the Y-axis and the day of retraction on the X-axis for the various topics identified by MeSH terms in this project. Topics with less than 20 retractions were excluded from this figure for improved visualization. (See a figure with all topics included in the Appendix.)

Table 1. Total publications and retractions for various MeSH terms listed in PubMed.

Subgroup	Retractions per 100,000	Total	Retracted	P-value
Stem Cells	110.4	143,112	158	<0.001
Measles Mumps Rubella Vaccine	80.9	1,236	1	
Neoplasms	75.4	1,316,818	993	
Organisms Genetically Modified	73.4	35,435	26	
Alzheimer Disease	37.4	50,781	19	
Heart Diseases	30.4	404,926	123	
HIV	30.3	36,315	11	
Environmental Pollution	26.6	270,397	72	
Obesity	26.4	128,851	34	
Aging	25.3	86,929	22	
Exercise	22.7	123,175	28	
Drug Resistance Microbial	19.1	67,991	13	
Health Care Reform	7.4	13,575	1	
Analgesics Opioid	7	28,448	2	
Climate Change	4.6	21,641	1	

Table 2. Time to retraction.

Subgroup	Mean	Standard deviation	Median	Interquartile range-Q1, Q3*	P-value
Stem Cells	1409.5	936.8	1261.5	610.3, 2112.8	<0.001
HIV	1231.9	1158.5	524.0	215.0, 2184.0	
Exercise	1135.4	793.8	1111.5	419, 1537.3	
Alzheimer Disease	1113.3	753.2	1004.0	452.0, 1474.0	
Neoplasms	1083.8	817.7	851.0	461.0, 1491.0	
Obesity	911.8	815.9	646.0	346.0, 1168.8	
Organisms Genetically Modified	888.3	732.7	664.5	391.3, 1333.5	
Heart Diseases	857.3	780.9	617.0	318.0, 1075.0	
Environmental Pollution	826.4	686.7	613.0	406.0, 1035.8	
Drug Resistance Microbial	783.2	701.3	470.0	303.0, 1147.0	
Aging	761.8	565.1	563.0	363.5, 913.3	
Analgesics Opioid	607.5	228.4	607.5	526.8, 688.3	
Climate Change	275	-	-	-	
Measles Mumps Rubella Vaccine	174	-	-	-	
Health Care Reform	114	-	-	-	

*The Q1, Q3 values are inclusive [Q1, Q3].

Discussion

In the MeSH term-based subsets of articles reviewed in this analysis, we found that the retraction rates ranged from 4.6 per 100,000 to 110.4 per 100,000 and the time to retraction ranged from 114 days to 1409.5 days. These results agree with prior studies that reported that retraction rates and time to retraction vary widely across disciplines. Lu et al. reported higher retraction rates in physical, biomedical, and multidisciplinary sciences than in the humanities and social sciences (Lu et al. 2013). The "Neoplasms" category in our study had the highest total number of retractions (993) and one of the highest retraction rates (75.4 per 100,000 publications). Only a few

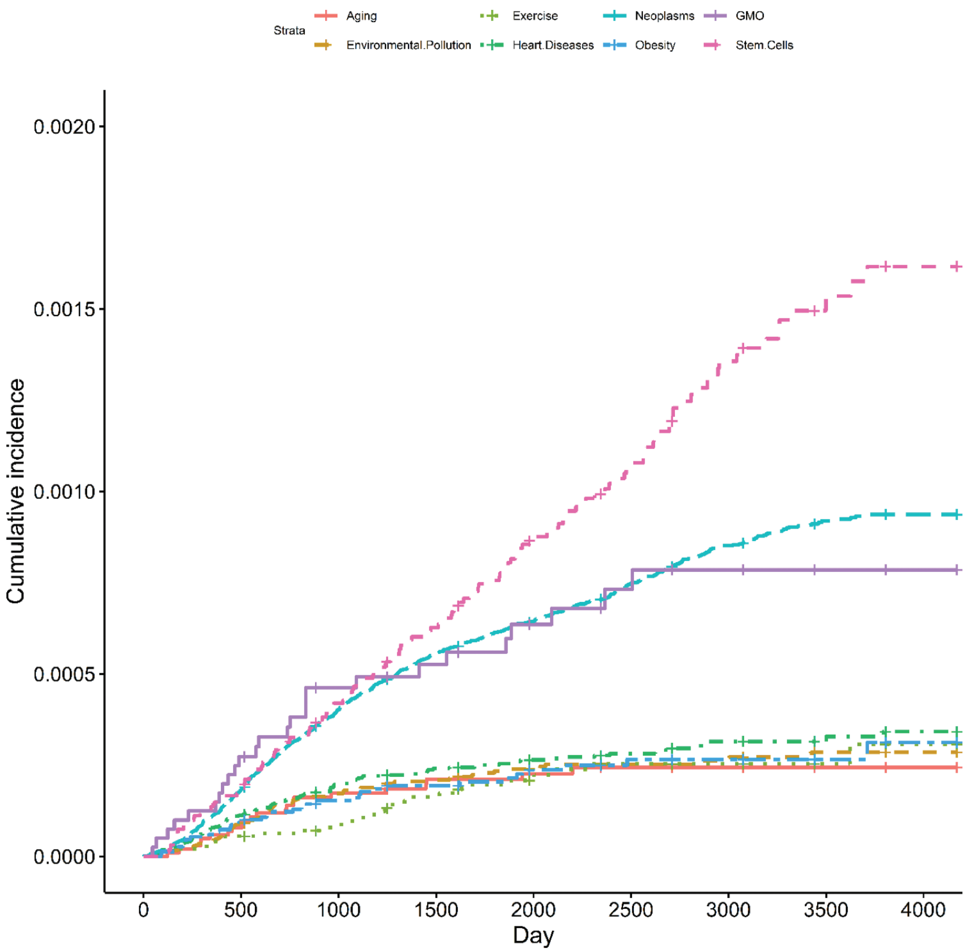

Figure 1. Cumulative retraction incidence across time.

studies have been analyzed retraction rates in oncology and cancer research; one study reviewed oncology retractions between 2000 and 2018 and found 1512 retracted publications. The higher number of retractions in this report may be due to the authors' using broader PubMed search design (Pantziarka and Meheus 2019). Another study examined the time to retraction in radiation oncology journals, and it ranged from 32.9 to 44.0 months (Wasiak et al. 2018). This is comparable to our observed time-to-retraction of 36.1 months. The cumulative incidence data in our study in Figure 1 indicate that the retraction pattern varies. Many retractions appeared to plateau at 1500 days post-publication. However, some continued to increase.

Multiple reasons likely explain the differences in the number of retractions and the time to retraction in various disciplines. These differences may be related to the total number of publications for a particular topic.

A topic with a higher publication rate may have both increased visibility and scrutiny, leading to more retractions, if problems are identified (Pantziarka and Meheus 2019). For example, several studies have noted that retraction rates increase with Journal Impact Factor (Cokol et al. 2007; Fang, Casadevall, and Morrison 2011; Fang, Steen, and Casadevall 2012; Lu et al. 2013). However, Fang et al. found that this applied only to incidents of fraud or error and that the majority of retractions occur in journals with lower citation metrics (Fang, Steen, and Casadevall 2012). Retraction rates also increase with the total papers published (Nagella and Madhugiri 2020), possibly due to increased review and analysis by specialists in that research area. Research topics with more publications per year may have a different ratio of experienced and inexperienced researchers, which may result in a different proportion of high- and low-quality studies.

Pressure to publish may also affect research integrity and quality (Grimes, Bauch, and Ioannidis 2018; Kornfeld 2012). For example, a survey of 434 research trainees at The University of Texas MD Anderson Cancer Center in Houston, Texas, reported that 18.6% of respondents had experienced pressure to publish findings they had doubts about and 31.4% experienced pressure from a mentor to prove a hypothesis correct (even though it might be unsupported by data) (Mobley et al. 2013). Although this pressure is likely universal, variations in the amount of external and internal pressure to succeed in academic publishing may differ across disciplines, topics, and institutions, and might be worth examining in future studies.

The COVID-19 pandemic produced a remarkable influx of research and retractions (Anderson, Nugent, and Peterson 2021). One meta-analysis, for example, found that 186 of 233 studies on the relationship between smoking and COVID-19 were poor quality, due to issues with methods and data collection (Simons et al. 2021). The rate of publication, driven in part by the urgent demand for new information about an evolving pandemic, may have contributed to poor quality publications (Schonhaut et al. 2022). Finally, inherent challenges in study methods across particular fields may make certain research results more challenging to reproduce. For example, a survey of over 1,500 scientists found that 73% believed that at least half of papers within their field were reproducible, with confidence varying across disciplines (Baker 2016). For example, the number of retractions appears to be increased in genetic research (Rafael and Carmen 2019). This may reflect the inherent difficulties in doing the studies.

Topics with increased interest to the scientific community and general public, such as a global pandemic, may have increased scrutiny by both an informed public and specialists. In this study, several research categories, such as stem cells and antimicrobial resistance, have attracted significant media attention during the past decade, and this may have actual benefits.

The possible adverse effects of the MMR vaccine, in particular, alarmed the public following the publication and subsequent retraction of the paper by Wakefield et al., which fraudulently reported a link between MMR vaccination and autism (Rao and Andrade 2011). However, despite or due to this media attention, the number of retractions related to MMR vaccination remains low, with only a single retraction (other than Wakefield et al.) during the study period for this project. Media attention and high-profile retractions probably do not reflect the research quality in a field or for a particular topic and may have unexpected benefits by alerting researchers to this concern both in the published literature and their ongoing investigations. While this association cannot be confirmed here, future studies might explore this possibility. This would require surveys of established investigators to determine their responses to retractions in their field of research.

Authorship and collaboration may also affect retraction rates. Zhang et al. noted an inverse relationship between the number of authors and plagiarism, but an increase in data falsification, manipulation, or unreliability with more authors (Zhang, Abraham, and Fu 2020). Differences in the number of authors between academic disciplines have been observed (Mallapaty 2018). Furman et al. noted that papers with institutional prestige (i.e., an author from a top 25 university) and increased citations resulted in a greater likelihood of retraction (Furman, Jensen, and Murray 2012). Some academic fields and research topics may also have a small number of researchers who contribute to a significant number of retractions (Grieneisen & Zhang, 2012; Steen, Casadevall, and Fang 2013a). A 2018 study found that 278 retracted articles in anesthesiology were from three authors (Nagella and Madhugiri 2020).

A major concern regarding academic article retractions (and why their retractions have become a topic of study in itself) is the reason for retraction. Articles may be retracted for several reasons, including errors that do not necessarily affect the integrity of the research, such as authorship issues or duplicate submissions. More serious errors involve issues with data integrity and analysis, which may range from unintentional errors on the part of the authors to explicit fraud. While outside of the scope of this study, misleading or fraudulent information can have serious negative impacts both on the academic fields relying on this research (Avenell et al. 2019; Stern et al. 2014) and on public trust in science. As long as these concerns exist, the study of academic retractions provides a useful tool for quantifying and hopefully preventing academic dishonesty. Paper mills, peer review rings, and artificial intelligence will likely increase the difficulty in evaluating the validity of research publications and raise important concerns about the integrity of global research (Candal-Pedreira et al. 2022; Conroy 2023; Dondio et al. 2019). Future studies might concentrate on the downstream effects of retractions, including their impact on public trust in science and research practices in the particular research category.

This study is limited by the observed delay in article retraction, which typically takes 1–3 years and can take more than a decade after publication (Furman, Jensen, and Murray 2012). Future retractions of the articles published during this project period may alter retraction rates, but this is a limitation inherent to most retraction studies. This study is also limited to searching a single database (MEDLINE using the PubMed interface) and the use of PubMed MeSH terms as indicators of a field or topic. The articles represent a cross section of categories or topics and provide an overview of retractions for a combination of medical and scientific topics. Articles identified by other PubMed MeSH terms might have different retraction characteristics, including higher or lower retraction rates and shorter or longer retraction times. Topics were also selected by the authors based on perceived public interest and visibility, impact, and the need to develop a broad but manageable survey for an exploratory study. Other authors might select different terms based on interest and expertise. The study did not focus on repeat offenders and did not rank journals according to the frequency of retraction. A more systematic selection of articles focused on a particular field of study or journals which limit publications to a particular discipline might be used for future studies. This approach would have particular value for editors and clinician-scientists involved in that study discipline. In fact, editorial boards for individual journals might review retractions in their journals to better understand and evaluate the review processes used by their journals. As an example, Wiley has a formal policy for making decisions about retractions (see supplement).

Searching databases other than MEDLINE probably would produce different publication and retraction totals. MEDLINE data may also change over time as new journals are indexed. The MEDLINE database lists retracted articles by their year of original publication. This provides a better estimate of research quality for a given year, but it excludes retractions for articles first published outside of our search range. Finally, the differences in publication rates among various disciplines and the inherent differences in research methodology probably affect retraction rates. The rates across disciplines may vary for several reasons, including study design, grant funding, discipline-specific journals, and publication visibility, and may not necessarily be indicative of quality within a field or research topic. Some fields or topics may be so different that they are not readily comparable.

In summary, retractions occur in multiple scientific disciplines. The number of retractions, the delay in article retraction, and the retraction rates differed across research topics. These retractions have important implications since these articles may have provided misleading or fraudulent information, may have stimulated research based on faulty premises, and may undermine valid research efforts with results different from the retracted article. Researchers, editors, and reviewers need to understand that retractions occur in all scientific disciplines and that certain fields may experience different rates of retractions.

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Data availability statement

All the data used in this study are reported in the tables and are available from the studies in the reference list. Information regarding specific publications used to complete this study is available from the authors upon request.

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