



Article

Sustained Rise in Retractions in the Life Sciences Literature during the Pandemic Years 2020 and 2021

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Abstract: The COVID-19 pandemic has been devastating to all human endeavors, and scientific research has not been spared. We queried how the retraction of publications might have been affected during the pandemic years 2020–2021. Searches performed with Retraction Watch Database (RWD) revealed that the total number of retractions (as proxied by retraction-related notices) rose steadily from 2013 into the pandemic years 2020–2021. Interestingly, while retractions in the physical and social sciences tapered during 2020–2021, those of the basic life sciences and health sciences showed robust increases in 2020, with the former maintaining a steep rise in 2021. This rise in retractions belied a tapering of total relevant publications in the same year and is confirmed with a complementary search strategy in Scopus. The retraction rate in the medical sciences, particularly those relating to infectious disease, is clearly affected by the anomalous high retraction rate of COVID-19-related papers. However, the sustained increase in the retraction rate of the basic life sciences papers, could be due, at least partly, to retraction spikes in several journals. The rise in retractions in the life and medical sciences could be attributed to heightened post-publication peer review of papers in online platforms such as PubPeer, where numerous problematic papers have been revealed.



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Keywords: COVID-19; life sciences; medical sciences; peer review; PubPeer; retraction

1. Introduction

The global COVID-19 pandemic presented tremendous challenges in all aspects of our lives. For scientists and researchers, the closure of laboratories during lockdowns and the loss of field accessibility resulting from mobility/travel restrictions and workers who were taken ill inevitably had a direct impact on research productivity. Several recent analyses have drawn attention to the negative impacts in this regard [1–3]. Although there are some indications that, in the short term, the total number of publications did not drop [4], whether research output can be further sustained in the immediate years to come is in doubt [3]. Furthermore, the longer-term impact of disruptions and delays due to the pandemic on research is yet to be seen since the process of research from planning to manuscript publication often spans years.

The urgent rushed and focused effort to understand the epidemiology and etiopathology of the disease and its infectious agent, SARS-CoV-2 [5] and to find prophylactics or therapeutics have changed our research culture and landscape significantly [6–8]. COVID-19-related research elevated the intensities of those already in related research fields of infectious disease and healthcare and many more have seized the opportunity to enter these fields. This has resulted in a flurry of research papers on COVID-19 in the past 2 years. A PubMed (<https://pubmed.ncbi.nlm.nih.gov/> accessed on 27 July 2022) search with the phrase “COVID-19” returned more than 281,000 hits to date. Given the often-chaotic changes in research activities and their focuses during the years where populations are plagued by a pandemic, we wonder how publication retraction rates in the biosciences

have changed in 2020 and 2021 compared to previous years. The unusually high retraction rate of COVID-19-associated papers [9,10] also prompted us to examine how this might have affected retraction trends in other areas of life and health sciences research.

2. Results

2.1. Changes in Retraction Rates during the COVID-19 Pandemic Years of 2020 and 2021

The analysis of retractions from the biomedical literature has been previously reported [11,12], and it is widely noted that the occurrence of retraction continues to be on the rise [13]. In fact, analysis by Fang and colleagues in 2012 further showed that about two-thirds of retractions in PubMed-indexed biomedical and life sciences publications could be attributed to some form of scientific misconduct [14]. We sought to understand how the retraction rate of life and medical sciences may have changed with the onset and duration of the global COVID-19 pandemic. A search of the Retraction Watch Database (RWD, <http://retractiondatabase.org> accessed on 1 January 2022) [15,16] returned the total number of “retraction or other notices” from 2013 to 2021 (Figure 1). It should be noted that these figures obtained from RWD includes notices of several natures, including “Expressions of Concern”, “Corrigenda” and “Withdrawals”, and certainly not all of these could be attributed to research misconduct. The numbers indicate that the rise in total number of retractions has robustly continued, even in 2020 and 2021. Searches under seven RWD-defined *subject groups*, however, revealed that while retractions in some disciplines, such as the “Physical sciences”, “Business/Technology” and “Social sciences”, visibly dropped or tapered during 2020 and 2021, the retractions of the “Basic life sciences” and “Health sciences” showed robust increases in 2020 (Figure 1B). In fact, those in the “Basic life sciences” continued to increase steeply into 2021.

Of note, the broad field of “Environment” showed a rather unusual retraction trend, of a moderate reduction in retractions and other notices from previous years in 2020 but a very anomalous spike in retraction-related notices in 2021. This prominent spike could be attributed exclusively to a mass retraction/expression-of-concern exercise [17] by the Springer Nature journal *Arabian Journal of Geosciences* in 2021 (which returned a total of 755 items from RWD, constituting 19.3% of total retraction-related notices in the year 2021). When the retractions from the *Arabian Journal of Geosciences* are excluded, the “Environment” field shows only a slight increase in retractions and other notices in 2021 when compared to 2020. Items stemming from the abovementioned mass retraction could also be found in other fields in 2021, albeit in very much smaller numbers and hence did not significantly contribute to their retraction trends.

What underlies the discrepancies between the retraction-related notices for the life and medical sciences in 2020 and 2021 compared to those of other fields? To better address this point, one would need to examine the differences between research publication output from these fields. We searched Scopus (www.scopus.com accessed on 1 January 2022) with the terms “physical”, “chemical”, “biological”, “medical”, “environmental” and “sociological”, which are terms associated most closely with the subject criteria of RWD. Understandably, search returns with these terms would not substantially approximate the total number of papers in the respective fields but would offer a relative comparison. The plot in Figure 1C indicates that there is a gradual increase in publication numbers in all fields up to 2020 which in some cases tapered, but not significantly, in 2021. These rather flat trends in total publication output in the various fields are therefore at odds with the robust rise in retractions for the basic life sciences and medical sciences in 2020, and the continuous rise in retractions for the basic life sciences even in 2021.

RWD provides a further classification of sub-disciplines stemming from the seven subject groups, and a closer look at selected sub-disciplines under the umbrella of “Basic Life Sciences” and “Health Sciences” showed that the changes in retraction trend in 2020 and 2021 differ between the sub-disciplines (Figure 2A,B). Under “Basic Life Sciences (BLS)”, the sub-disciplines “Biology-Cellular”, “Biology-Cancer”, “Biology-Molecular” and “Genetics” showed a similar pattern of a steep and sustained rise in retractions throughout 2020 and

2021, whereas the sub-disciplines “Biology-General”, “Neuroscience” and “Microbiology” did not. For the sub-disciplines under “Health Sciences (HS)”, most show some increase between 2019 and 2020 but a decrease in 2021. Notably, “Medicine-Infectious disease” showed a steep increase in retraction rate in 2020, with only a slight drop in 2021. These numbers indicate that only certain sub-disciplines in the basic life sciences and medicine fields have a sustained increase in retraction rate during the pandemic years 2020 and 2021.

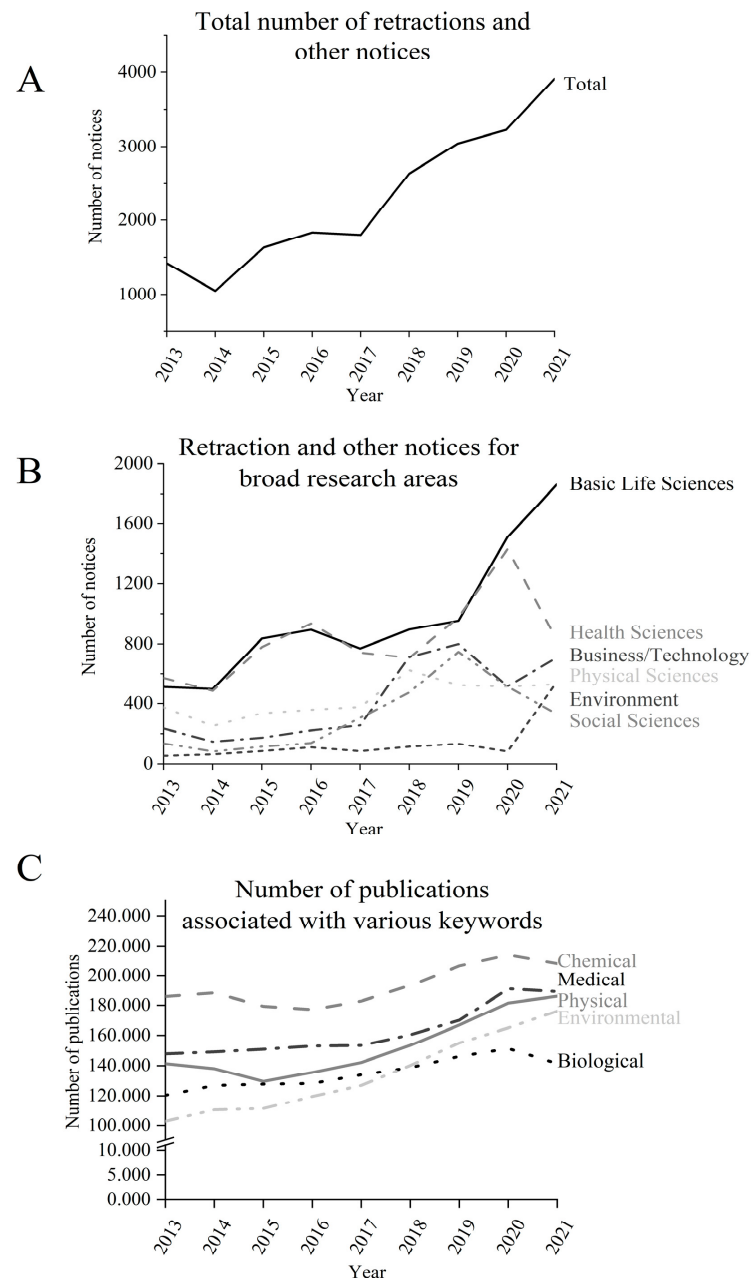


Figure 1. Returns from Retraction Watch Database (RWD) searches for “Retraction or other notices”. Total numbers (A) and for the various broad research area/disciplines for the years 2013–2021 (B). (C) illustrates search results from Scopus (www.scopus.com accessed on 1 January 2022) searches with the terms “physical”, “chemical”, “biological”, “medical”, “environmental” and “sociological” for the years 2013–2021.

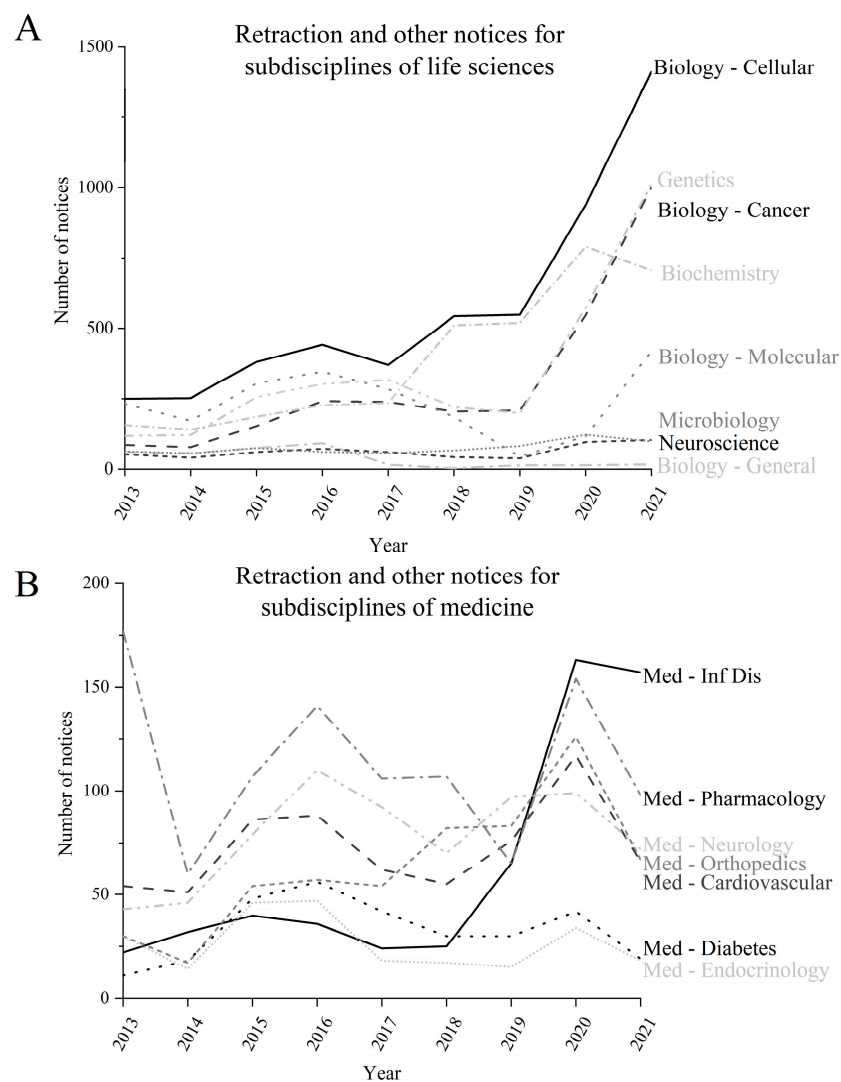


Figure 2. Returns from RWD searches for “Retraction or other notices” for the various sub-disciplines under the broader category of “Basic Life Sciences” (A) and “Health Sciences” (B).

To augment the observations above, we sought other search strategies to gauge changes in retraction trends relative to publication numbers. We performed searches with Scopus (for inclusion in “title, abstract and keywords”) with a combination of “cell” or “medicine” in conjunction with “retraction”, for the years 2013–2021, as presented in Figure 3. The search term “cell” would constitute a broad sampling of papers in the basic life sciences, and “medicine” for the medical sciences. Importantly, the combination of the search terms with “retraction” would give an estimate of number of publications in conjunction with number of retractions. As such, we could calculate a retraction index (RI) for these search terms; the number of publications with a “retraction” tag per mill (%) over the total number of search term returns.

Of course, there are several caveats associated with this simple search strategy, and notably its hit ranges would differ from the earlier RWD search. Firstly, the search terms are not the same, and would not be as well-confined as those categorized under different disciplines in RWD. Secondly, not all returns with a “retraction” tag would be a retraction-related notice, as a small number of these may contain the word “retraction” in other contexts, similar to how this manuscript would appear in a search with the term “retraction”. As such, the hits returned would likely be an overestimate of the true number of retractions. However, this overestimation would be applied equally across the search terms and the years searched. From Figure 3, it is apparent that the total publications tagged with “cell”

and “medicine” rose steadily over the years, with a slight decline in 2021 for the latter. However, there is a visibly steeper rise for both search terms tagged also with “retraction” from 2019 going into 2020. For the search utilizing the term “cell”, this rise continues in 2021 despite a slight tapering in total publication increase. As a result, the calculated RI values show a steep increase for both the search terms “cell” and “medicine” in both 2020 and 2021. Importantly, these Scopus search results, albeit distinct from the RWD results, corroborated the trends observed for the retractions in the basic life sciences and health sciences from searches in the RWD and indicate that the total number of retractions are not excessively biased by the background changes in the total number of publications.

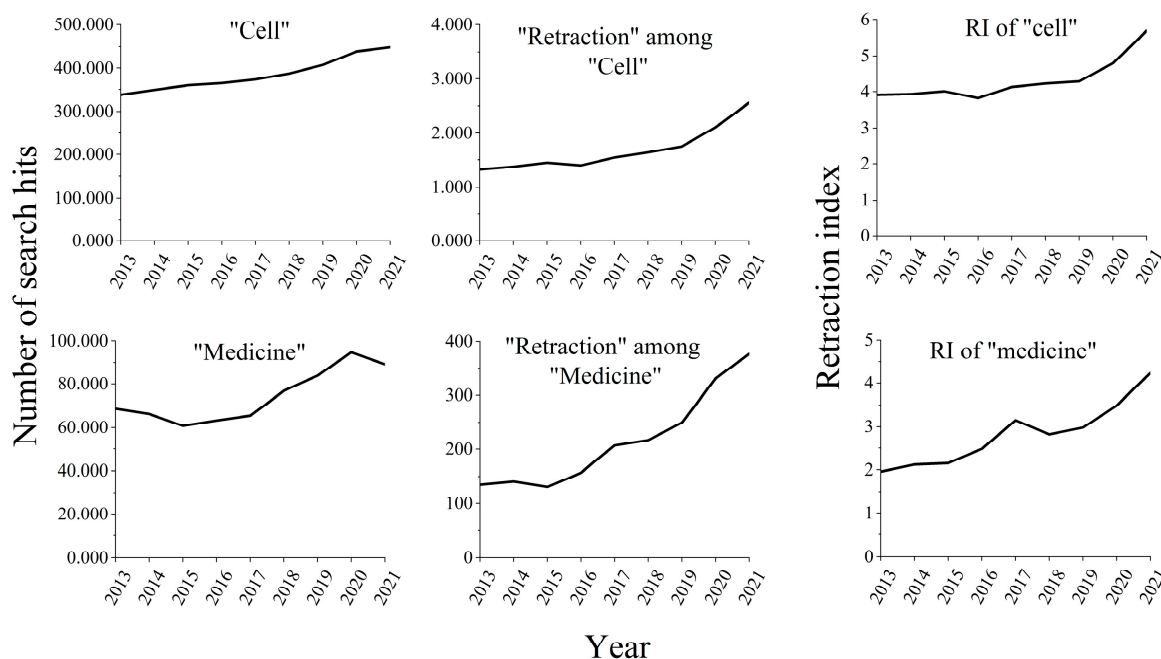


Figure 3. Returns from Scopus (title, abstract and keywords) searched with a combination of either of the search terms “cell” or “medicine”, with the term “retraction” for the years 2013–2021. The retraction index (RI), as presented in the third column, is calculated as per mill (‰) of papers tagged with “retraction” over the total number of papers returned under “cell” or “medicine”, respectively.

As a paper’s retraction usually sees a time lag from its original date of publication, it is likely that most of the retractions in 2020 and 2021 are papers from earlier years. A manual count of the latest 600 retraction-related notices in RWD estimated that a quarter of these notices for subjects aggregated under “Biology” are for papers published in 2020 or 2021. Interestingly, notices for those subjects clustered under “Medicine” have close to half from papers published in 2020 or 2021. This indicates that the “Medicine” retractions in 2021 are of a higher immediacy than those under “Biology” and might reflect an influence by pandemic-associated factors.

2.2. Influence of Retraction Rate of the Medical Sciences by COVID-19-Related Retractions in 2020 and 2021

We had earlier pointed out a worrying trend of anomalously high retraction rates for COVID-19-related publications [9,18], which is corroborated by more recent analyses by others [10]. The number of COVID-19-related papers have increased more than 12-fold since our previous analysis, along with the number of retractions (Table 1). Notably, the calculated retraction rate of COVID-19-related papers has also grown from 0.074% to 0.096%, and is starkly higher than a general estimate of about four retractions for every 10,000 papers (~0.04%) [16]. A RWD search for “COVID-19” in the title for retraction-related notices in area of “Basic Life Sciences” returned numbers that con-

stitute 0.3% of total in 2020 and 2021 combined. However, for “Health Sciences”, the fraction is much larger, constituting about 7.6% of total. In the sub-discipline of “Medicine-Pharmacology” this amounts to 9.1%, while for “Medicine-Infectious disease”, up to 53.8% of the retraction notices in 2020 and 2021 are papers with COVID-19 in their titles. Clearly, COVID-19-related retractions have negatively impacted certain sub-disciplines of the medical sciences, constituting the majority of retractions in research areas, such as infectious disease.

Table 1. An update of COVID-19-related retractions (the sum of “retractions” and “expression of concern” with “retractions” numbers in brackets) from Retraction Watch’s “Retracted coronavirus (COVID-19) papers <https://retractionwatch.com/retracted-coronavirus-covid-19-papers/> accessed on 1 January 2022) (upper row), compared to that reported in Yeo-Teh and Tang, 2021 (lower row)).

Keywords Used for Search	PubMed (Title/Abstract)	Items in RWD (Title)	Retraction Rate (%; 3 Decimal Places)
COVID-19 (as per 1 January 2022)	213.354	214 (205)	0.100 (0.096)
COVID-19 [9]	17.559	17 (13)	0.097 (0.074)

To further assess the impact of COVID-19-related retractions on the overall retraction trend in the medical sciences, we again sought to complement the RWD searches with Scopus searches. The terms “medicine”, together with other major medical research subject terms, such as “diabetes”, “cardiovascular” and “infection”, were searched in conjunction with the terms “retraction” and “COVID-19”. The changes in total publications as well as “retraction”, including or excluding the “COVID-19” tag, are shown in Figure 4, as well as the calculated Retraction Indexes (RI).

From the plots, it is apparent that COVID-19-related retractions contributed to those tagged with “medicine”, as well as those tagged with medical research terms with a large number of returns (>30,000 per year). COVID-19-related retractions contributed to the retraction in these other papers to varying degrees. Not unexpectedly, these contributed the most to papers tagged with “infection”, to the extent that the retraction trend with “COVID-19” papers included represented a major departure from that without, both in 2020 and 2021. Both the analyses with RWD and Scopus data are thus in agreement with regard to how COVID-19-related retractions have impacted the trends of retractions in the health or medical sciences. The high retraction rate of COVID-19 research-related publications may reflect a reduced stringency in paper publication and peer review processes, a heightened scrutiny of these papers post-publication or, most likely, a combination of the above.

2.3. What Factors Underlie the Persistence of High Retraction-Related Notices in Certain Sub-disciplines of the Basic Life Sciences in 2020 and 2021?

If the changes in the retraction rate of medical science publications in 2020 and 2021 could be at least partly attributed to COVID-19-related retractions, this is unlikely the case for the retractions in the basic life sciences since the number of COVID-19 papers under this category is far too small. Particularly anomalous is the continuous and robust rise in the retraction numbers and trend in 2021 (Figure 1), when total publications slightly tapered (Figures 1C and 3). We noted earlier that a small number of retraction-related notices issued *en masse* by the *Arabian Journal of Geosciences* in 2021 [17] is counted under the broad category of “Basic life sciences”, but these numbers are small and did not infiltrate the retractions associated with the sub-disciplines “Biology-Cellular”, “Biology-Cancer”, “Biology-Molecular” and “Genetics”, which showed the steepest sustained rise in retraction number in 2021. A retraction notice immediacy estimation of the original publication dates of the latest 600 retractions in 2021 also indicates that only about a quarter of these are published in 2020 or 2021. As such, the sustained rise in retraction-related notices cannot be explained by a sudden increase in papers with inherently poor quality/reproducibility or hastened peer review, as those often associated with COVID-19-related retractions [9,19,20].

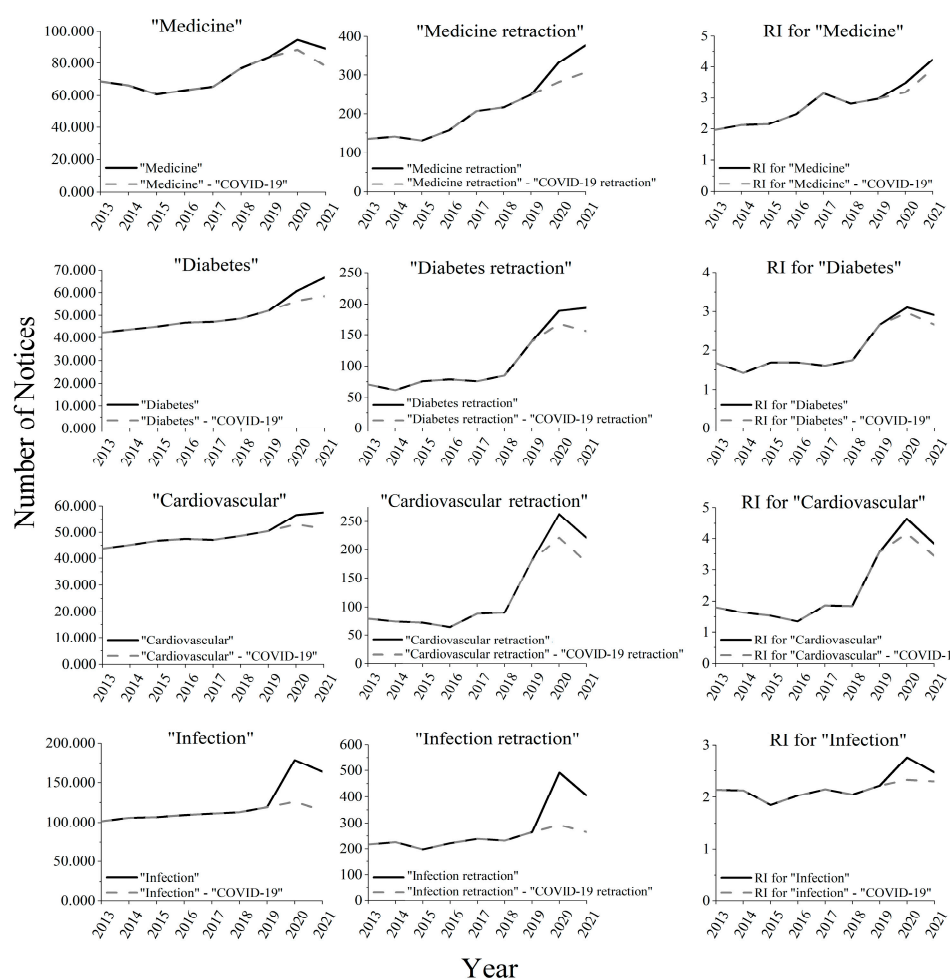


Figure 4. Returns from Scopus (title, abstract and keywords) searched with a combination of the search terms “medicine”, “diabetes”, “cardiovascular” or “infection” with the terms “retraction” and “COVID-19”. Solid lines indicate total publications or retractions, while the broken lines exclude those tagged with “COVID-19”. The resultant Retraction Indexes (RI) are shown in the column on the far right.

To find possible explanations for the sustained rise in retraction-related notices above, we queried RWD for retraction and related notices issued by the major publishers of life and health sciences papers in the 4 years leading up to and including 2021. In general, the number of life and health sciences associated retractions from the major publishers have increased in 2020 (Figure 5A,B).

However, there is a difference between the trends in basic life sciences retractions and health sciences retractions. For the former in particular, retraction numbers associated with a number of publishers, including Wiley, Taylor & Francis, SAGE and Frontiers, appear to be anomalously high in 2021 compared to the immediately preceding years. In fact, the trends obtained with the search under the broad category “Basic Life Sciences” could be recapitulated by a search with the aggregated sub-disciplines of “Biology-Cellular”, “Biology-Cancer”, “Biology-Molecular” and “Genetics”. A closer examination of the retraction-associated notices identified several journals from these publishers that issued an atypically large number of retraction-related notices associated with basic life sciences papers in 2021. These are illustrated in Figure 5C, together with those for the journals *PLoS One*, *Scientific Reports* and *The Journal of Biological Chemistry* (which together publish a substantial fraction of papers in these fields) also shown in comparison. For example, the periodicals *Journal of Cellular Biochemistry* and *Journal of Cellular Physiology* (both under Wiley), have issued 157 and 56 retraction related notices in 2021, respectively. These,

together with other journals exhibiting an unusual spike in retractions in 2021 (Figure 5B), contributed significantly to the steep rise in retractions in specific sub-disciplines of the life sciences in 2021, despite the tapering of total publications.

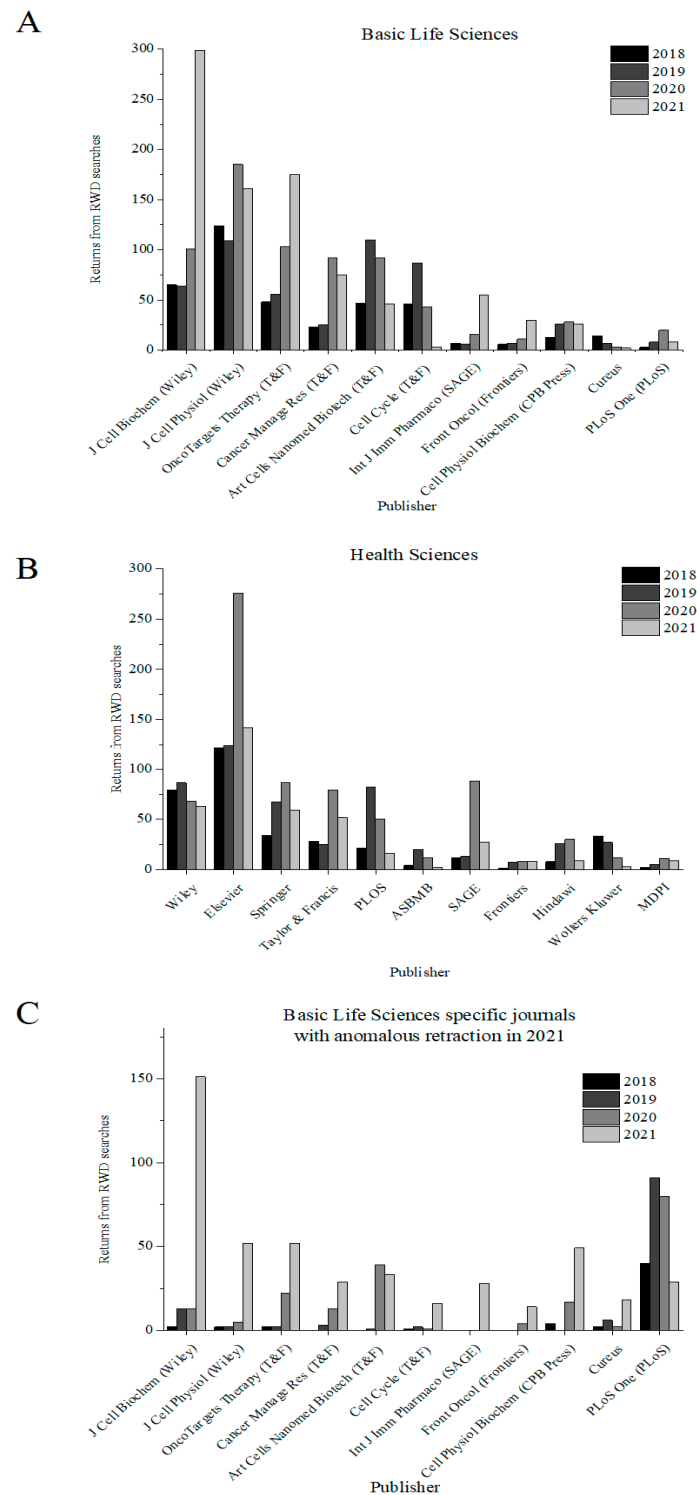


Figure 5. Returns from RWD searches (retraction-related notices for 2018–2021) for either publishers “Retraction or other notices” for the broad fields of “Basic Life Sciences” (A) and “Health Sciences” (B) or specific journals with anomalously high retraction numbers in 2021 (C).

3. Discussion

Retractions Spikes and Post-Publication of Scrutiny of Papers in the Life and Medical Sciences

The spike in retraction-related notices of multiple journals in 2021 may appear to be typified by that occurring with the *Arabian Journal of Geosciences*, which completely skewed the retraction number associated with the environmental studies area. For this case, a large number of papers have already been retracted and there may be more to come, apparently because of a systematically compromised peer review of a topical collection or special issue. Some of the retracted papers are clearly nonsensical in content and should not have passed legitimate peer review. Nonsensical papers [21] that are algorithmically generated [22] are known to exist in the literature. The editors of the *Journal of Nanoparticle Research* have described how an organized, rogue editor network had exploited the editing of special issues to get low quality manuscripts published [23]. The scamming of journals via special issues has been noted as an emerging issue [24]. Mass retractions akin to that by the *Arabian Journal of Geosciences* have also occurred previously for the life sciences. In 2017, the journal *Tumor Biology* retracted 107 papers at once, which was also due to severely compromised peer review [25].

However, the spikes in the retraction number of multiple journals in the life sciences sub-discipline in 2021, exemplified by those in the *Journal of Cellular Biochemistry* and the *Journal of Cellular Physiology*, differ somewhat in nature from the mass retraction events discussed above. These retracted papers by and large do not belong to specific collections in special or topical issues, and there are no apparent systematically arranged, fake peer review discovered retrospectively. On the contrary, many of these papers have been subjected to intensive post-publication peer review [26], in the form of comments shared on PubPeer (<https://pubpeer.com> accessed on 1 January 2022). Started in 2012, PubPeer is branded as an online journal club or a moderated platform for the discussion of scientific publications by anyone, providing the user the choice of making comments pseudonymously or with their name tagged with their comments [27,28]. A recent analysis showed that “more than two-thirds of comments are posted to report some type of misconduct” [29], with the most discussed research areas being the life and health sciences. Such negative post-publication peer review or scrutiny would have therefore contributed to the rise in retractions in both these research areas. The analyses also revealed “super commenters”, who access the platform at exceptionally high frequencies to systematically review publications [29]. One such super commenter is the famed image-manipulation detective, Dr Elisabeth Bik [30,31]. A good number of the retracted papers in the life sciences in 2021 bear comments of image irregularities highlighted by Bik and another PubPeer author with the pseudonym Hoya Camphorifolia.

The type of papers that are most likely to fall under the scrutiny of post-publication peer review are those with detectable irregularities in figures and images that would show up under close and meticulous examination. In this group are those generated by paper mills [32,33], which consist of manuscripts with a high degree of data/result fabrication templated by collections from banked figures and images. A search of RWD showed that the term “paper mill” noted as a reason for retraction/concern and searchable under “Notes” began to emerge in the database in 2017, and their spike in numbers in 2020–2021 made them major contributors to retraction-related notices in these years (see Table 2). These appear to be exclusively restricted to papers categorized under “Basic life Sciences” and “Health Sciences”. In fact, almost all of these come under the aggregated sub-disciplines of “Biology-Cellular”, “Biology-Cancer”, “Biology-Molecular” and “Genetics”, which showed the steepest increases in retraction-related notices in 2020 and 2021. The molecular cell biology type of papers, with modular montaged figures, such as those of microscopy images, Western blots and flow cytometry scatter plots, appear to be the type that are most amenable to fabrication and detection. Fraudulent papers from paper mills are profoundly damaging to the sub-disciplines of basic life sciences, not simply with regard to a tarnished reputation, but also in terms of effort and resources spent in attempting to verify or replicate findings that are inherently false.

Table 2. Returns from RWD searches for “Retraction or other notices” with a “Paper mill” entry under “Notes” for the different fields.

Field	2017	2018	2019	2020	2021
Total	2	1	3	186	60
Basic life sciences	2	1	3	186	60
Health sciences	0	0	3	153	35
Biology (Cellular + Cancer + Molecular) + Genetics	2	1	3	184	59

Retractions stemming from revelations of irregularities in publications in online platforms such as PubPeer have undoubtedly contributed to the sharp rise in the recent number of retractions in the life and health sciences, and the cleansing of the literature of fraudulent papers in this manner can be expected to continue. If so, Fanelli’s earlier argument that growing retractions are (mostly) a good sign [34] is one imbued with foresight. However, while it is generally agreed that post-publication peer reviews on platforms such as PubPeer have benefited research, there are dissenting opinions, particularly regarding the pseudonymous nature of postings [35,36]. There are also examples of retaliations by disgruntled authors against post-publication peer reviewers [37,38]. It is thus of critical importance for journals, editors and peer reviewers to up their game in upholding stringency and imposing rigor during peer review.

4. Concluding Remarks

Unlike the other fields, retractions in the basic life sciences and health/medical sciences have increased in the pandemic year 2020, and for the basic life sciences, the rise in retraction continue robustly in 2021. For the health/medical sciences, particularly in the sub-discipline of infectious disease, the retraction rate is clearly affected by papers related to COVID-19, which has an anomalously high retraction rate. However, this is not so for the basic life sciences. The sustained increase in the retraction rate of the basic life sciences papers through the pandemic times is instead associated with large retraction spikes in a number of journals, particularly in 2021. The latter can be traced to problematic papers being increasingly picked up by post-publication peer review, and some of these are fabricated by paper mills.

Challenges posed by the pandemic, including uncertainties in individual career development and funding in sub-disciplines of life sciences research, shall continue to confront researchers in the years to come. While it remains to be seen if these challenges will significantly affect research integrity or reproducibility, it is now more important than ever for scientists and researchers to maintain a high level of ethics in their professional pursuits. Likewise, it is more prudent than ever for the gatekeepers of the quality of scientific output (journals, editors and reviewers) to exercise a high degree of vigilance.

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